F. No. CPAM-55020/10/2020-CPIAM-Part(2) (ii)
Government of India
Ministry of Coal
(CPIAM Section)
***

Shastri Bhawan, New Delhi
Dated 29th June 2022

OFFICE MEMORANDUM

Subject: Seeking comments on Draft Smart Coal Logistics Plan submitted by SBICaps/Primus Partners -reg.

The undersigned is directed to enclose herewith the Draft Smart Coal Logistics Plan submitted by SBICaps/ Primus Partners.

2. All stakeholders are requested to provide their comments on the above draft report to this Ministry within 30 days from the date ofplacing on the website of this Ministry at e-mail id: hitlar.singh85@nic.in. Comments received thereafter shall not be considered.

Encl.: As above.

(Hitlar Singh)
Under secretary to the Government of India
Email: hitlar.singh85@nic.in

To,

1. NIC - for placing on website of MoC for stakeholder consultation
2. All Stakeholders (CIL and its subsidiaries/SCCL/NLCIL/Captive block allocatees)

Smart Coal Logistics Plan – Final Report

10 May 2022

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Table of Contents

LIST OF TABLES

LIST OF FIGURES

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ABBREVIATIONS

AI	Artificial Intelligence
API	Application Programming Interface
BCCL	Bharat Coking Coal
CAGR	Compound Annual Growth Rate
CAMC	Comprehensive Annual Maintenance Contracts
CCL	Central Coalfields
CCR	Coarse Coal Refuse
CCTV	Closed-circuit television
CHP	Coal Handling Plant
CIL	Coal India Limited
CMPDI	Central Mine Planning and Design Institute
CRIS	Centre for Railway Information Systems
CSIR	Council of Scientific & Industrial Research
CVC	Central Vigilance Commission
DIOM	Donimalai Iron Ore Mine
DVR	Digital video recorder
ECL	Eastern Coalfields
EN	European Standards
ERP	Enterprise Resource Planning
ETA	Estimated time of arrival
FBDI	Freight Business Data Integration
FCR	Fine Coal Refuse
FOIS	Freight Operations Information System
GB	Giga Byte
GeM	Government e Marketplace
GIS	Geographic Information System
GLONASS	Global Navigation Satellite System
GPIO	General Purpose Input/Output
GPRS	General Packet Radio Service
GPS	Global Positioning System
GST	Goods and Services Tax
BBPS	Bharat Bill Payment System
HDD	Hard Disk Drive

HDMI	High-Definition Multimedia Interface
HQ	High Quality
IEC	International Electrotechnical Commission
IIoT	Industrial Internet Of Things
IIT	Indian Institutes of Technology
IO	Input/Output
IoT	Internet of Things
IP	Internet Protocol
IPA	International Phonetic Alphabet
IRNSS	Indian Regional Navigation Satellite System
IWAI	Inland Waterways Authority of India
KIOM	Kumaraswamy Iron Ore Mine
KPI	Key Performance Indicator
LAN	Local Area Network
LiDAR	Light Detection and Ranging
LTL	Less Than Truckload
LVM	Laser Volume Measurement
LVS	Load Volume Scanner
MAC	Media Access Control Address
MDO	Market Development Organisation
MeitY	Ministry of Electronics and Information Technology
MGR	Merry Go Round
MIS	Management Information System
ML	Machine Learning
MoC	Ministry of Coal
MPLS	Multiprotocol Label Switching
MSHA	Mine Safety and Health Administration
MSS	Mobile Satellite Services
MTSS	Mine Transport Surveillance System
NCL	Northern Coalfields Limited
NMDC	National Mineral Development Corporation
OCM	Organizational Change Management
OCP	Opencast Coalmine Project
OITDS	Operator Independent Truck Dispatch System
PANI	Portal for Assets and Navigational Information
PCS	Port Community System
PCSIx	Port Community System 1x
PLC	Programmable Logic Controllers
PTZ	Pan–Tilt–Zoom
RFID	Radio Frequency Identification

RMS	Resource Management System
SC2	Smart Coal
SECL	South Eastern Coalfields
SMART	Specific, Measurable, Achievable, Relevant, Time-bound
SSD	Solid-State Drive
UI	Universal Interface
USB	Universal Serial Bus
UV	Ultraviolet
VDC	DC Voltage
VGA	Video Graphics Array
VHF	Very High Frequency
VM	Vehicle Monitoring
VPN	Virtual Private Network
VTMS	Vessel Traffic Management System
VTS	Vehicle Tracking System
WAGONTOSAT	Wagon to Satellite
WB	Weighbridges
WBC	Weighbridge Centering System

EXECUTIVE SUMMARY

1.1 Introduction

Government of India and the Ministry of Coal have taken historical policy initiatives in freeing up the coal sector as a market-based industry. It is expected that coal production will rise to one billion tons per annum by 2024. Even as India continues a path of appropriate energy transition, the coal sector will be available as the backbone of reliable grid energy for fuelling India's growth aspirations.

Coal ministry has also embarked upon a targeted coal evacuation plan to ensure there are no bottlenecks that hamper the movement of coal from mines to end consumers. Projects target both first mile connectivity, as well as main line transport on rail, road, and port infrastructures to aid multimodal transport of coal.

1.2 Objective of the Report

The Ministry of Coal have desired to implement a smart coal logistics system, that aids in the planning of new projects, debottlenecking of existing infrastructure and assets, and facilitate real-time decision-making for smooth operation of coal supply chain.

1.3 Our Approach for the Preparation of the Report

There are two important events in play:

- Industry is rapidly transitioning from Industry 4.0 to the next step of Industry 5.0. We can use technology for monitoring both moving and fixed assets connected by sensors, operating in an Internet of Things environment for delivering real time data for decision making.
- Path breaking policy changes in the coal sector have brought multiple new entrants as miners, free from the shackles of captive mining and ready to supply coal to commodity markets.

Our approach considers both these important events. The report recommends data automation using sensors and APIs, adopting a platform approach, and establishing a complete view of the coal supply chain from mine mouth to consumption centers. A risk-based management approach allows the smart system to flag inefficiencies in real time, as well as build up database for short- and medium-term actions.

1.4 Recommendations for Implementation

- CMPDI or suitable organization as Custodian of the platform.

- CSIR/suitable IIT for assisting CMPDI in establishing hardware device standards, software modules, and API specifications
- Private sector entity selected through appropriate procurement for setting up and maintaining the platform.
- Miners will install hardware at site, based on the specific modules that may be needed.
- The platform is financed by levying user fees on miners, and Ministry users.
- The Smart Coal Logistics platform has the potential to scale up to provide services to the entire mineral mining sector in India.

INCREASING USE OF SMART TECHNOLOGIES

2.1 SMART Mining Sector

The term "smart" originally comes from the acronym "Self-Monitoring, Analysis and Reporting Technology" but become widely known as "smart" because of the notion of allowing previously inanimate objects—from wagons to weighbridges to even heaps of loose materials - to talk back and guide actions. It uses data acquisition, artificial intelligence, machine learning, and big data analysis to provide cognitive awareness to objects that were in the past considered inanimate.

Smart is a catch all phrase for a wide variety of technology that is made possible by the convergence of two trends that is profoundly reshaping the world around us.

First, thanks to the proliferation of cheap, powerful sensors, the most commonplace objects can understand what we do with them—from umbrellas that know it's going to rain to shoes that know they're wearing out—and alert us to potential problems and programmed priorities. These objects are no longer just "dumb" passive matter. With some help from artificial intelligence, they can be taught to distinguish between efficient and inefficient behaviour, and then flag for actions in real time.

Second, there is public information on associated events occurring that will potentially affect the supply chain. Conventional systems may register these events only on impact, leading to post facto analysis, but Smart AI and RMS-based systems will start raising alerts in advance.

These two features are the essential ingredients of a new breed of so-called smart technologies. The main devices in its armoury include:

- Antennae
- Sensors
- Data Acquisition
- Analytical tools
- Risk-based Management Information Systems

2.2 Internet of Things in the Mining Industry

IoT utilizes devices such as actuators and sensors. Typically, an IoT system would consist of endpoint devicesconnected to an edge gateway, which in turn would connect to cloud services. IoT technologies are often deployed in commercial or even consumer environments, but when applied to industrial applications, they are referred to as the **Industrial Internet of Things (IIoT)**.

The Internet of things (IoT) is the extension of Internet connectivity into physical devices and everyday objects. Embedded with electronics, Internet connectivity,

and other forms of hardware, these devices can communicate and interact with others over the Internet, and they can be remotely monitored and controlled

From extraction to delivery, mining companies use many different transportation modes, with requirements for specialized equipment and expertise. Inbound moves can include a mix of LTL, full truckloads, flatbeds and multi-axle trailers. Outbound moves to processing plants and ports can use rail, barge and trucks. Coordinating and synchronizing these moves is difficult and requires expertise across all modes.

2.3 Asset Utilization For Railway Wagons and Other Vehicle Fleets

Mining companies need to control rail assets but purchasing rail wagons is not always a priority given the expenses involved. The options include leasing wagons or using railway- owned, free-running wagons. Either way, managing rail equipment is a difficult and time-consuming challenge.

When using railways assets, "free running" doesn't mean zero cost. Railway rates will include "rent" on the wagon being used. While it may make sense to use and pay for wagon capacity as needed, there is no guarantee that a regular supply of empties will always be available. Leasing or Captive wagon fleet owned by coal companies addresses this capacity issue but increases pressure to squeeze value from the leasing agreement. That means close attention to asset utilization – a challenge for mining companies who lack the required systems and processes.

2.4 Tracking Goods Movement

Tracking rail freight is challenging, but SMART systems can get regular updates on each move and isolate exceptions for further action. In addition, they can send automated data feeds on ETAs of inbound and outbound moves. This allows mining companies and their customers to plan loading and unloading to reduce labour costs, avoid demurrage, and keep assets moving.

Minimizing mine-to-cash cycle depends on timely pickups by rail partners, regardless of whose assets are used. Without systems and processes to effectively manage these assets and intervene when problems arise, delays can have a domino impact on supply chain, from mine site to customers.

Considering the numerous incentives it brings, many large mining companies are planning and evaluating ways to start their digital journey and digitalization in mining industry to manage day-to-day mining operations. For instance:

- **Cost optimization & improved productivity** through the implementation

of sensors on mining equipment and systems that monitor the equipment and its performance. Mining companies are using these large chunks of data – 'big data' to discover more cost-efficient ways of running operations and also reduce overall operational downtime.

- **Ensure the safety of people and equipment** by monitoring ventilation and toxicity levels inside underground mines with the help of IoT on a real-time basis. It enables faster and more efficient evacuations of manpower or conducting safety drills.
- **Moving from preventive to predictive maintenance**
- **Improved and fast decision making** The mining industry faces emergencies almost every hour with a high degree of unpredictability. IoT helps in balancing situations and in making the right decisions in situations where several aspects will be active at the same time to shift everyday operations to algorithms.

IoT technologies are used to monitor the location and state of freight units and vehicles. As a result, real-time data, such as location and other IoT sensor data, can be used in managing the logistics decision-making, which is directly used to control the freight transportation activities. In this way, tailored real-time optimization algorithms can be implemented in order to allow for reacting dynamically to deviations. Ease of deployment is a key design goal for IoT data collection mechanisms.

2.5 Cloud: Democratization of Data - Market Developer – especially important with mining auctions for smaller players

India is firmly established on the path of auction of commodity assets, including mines and minerals. While this is opening markets, and increasing the number of mine developers, there is a need to democratize the use of technology in favor of the smaller miners.

Large organizations have conventionally enjoyed advantages in terms of the availability of technology specialists and technical superiority. Cloud computing eliminates the advantage and helps in creating a level playing field. Small and medium enterprises that take advantage of infrastructure providers to support their technology requirements and provide specialized platforms for development and testing can build an infrastructure that is innovative and enable entry into the marketplace, with just as much capability as the market demands. Smaller enterprises can leverage service providers that develop software such as supply chain management, enterprise resource planning, customer relationship management, and business analytics which are traditionally available only to large enterprises and organizations. Being able to access infrastructures, platforms, and software services based on need basis, and paying for only what is used, enables and empowers small and medium MDOs, by giving them an advantage in the market and an equal position with much larger enterprises.

2.6 Trends in cloud computing in mining

Listed below are the key trends impacting cloud computing in mining, as identified by GlobalData:

Supply chain
As mining moves into ever more remote areas and less developed countries, greater challenges arise around infrastructure and supply chain efficiency. Access to the essential resources of mining, water and internet connectivity, is becoming increasingly expensive, and building infrastructure is not commercially viable. Miners must find ways to import these assets more cheaply to keep costs down and maintain the running of mines.

Digitalization
The productivity of mines has traditionally been poor due to the ineffective use of inputs and lack of data integration across the mining process. Mining has been reluctant to invest heavily in new technologies, instead opting to focus on volume over efficiency. However, this is changing as increased digitalization of mining processes and automation are supporting improvements in the productivity and lowering cost per unit output of mines. By harnessing the potential of data resources, mining is beginning to see the vast benefits to all areas of the industry.

Data resources
As companies have adopted new technologies, the amount of data produced has increased. Data is quickly becoming an asset, as it can help effective decision making. However, if it is to be useful, data must be stored and managed securely and efficiently.

Cost control
Declining commodity prices, longer haul distances, falling ore grades, and rising material and labour costs place a greater emphasis on cost control to maintain margins. These margins are often squeezed further by lowering exploration funds as investors move away from the industry.

Resource development
Identifying new viable mines is becoming harder with the backdrop of declining ore grades, rising development costs, and more remote deposits. Declining resource quality has forced miners to drill deeper to find commercially viable ore grades, further increasing cost considerations for new mines.

Sustainability
Sustainable practices are vital to maintaining a mining company's license to operate as societal and investor pressure mounts to transition to a low carbon economy. With sustainability becoming a critical metric that investors now consider, improving mining efficiency and minimizing environmental impact is becoming more critical to attract investment.

Some of the key benefits of using smart technology are as follows:

Situational Automation – not wait for checking data. Never has it been possible to do so many tasks simultaneously with minimal effort, such as just using your voice, as it is today. This has become possible due to smart technology. Whether it be adjusting the lighting of a shaft, securing your periphery, or requisitioning transport, smart technology takes convenience and efficiency to a whole new level.

What's even better is that the latest smart technologies are well-equipped to understand preferences by analysing them in order to provide an automated, bench-marked service. It is able enough to take into account external factors such as traffic and weather to inform and suggest for possible disruptions.

2.7 SMART IoT - Multiple technologies Come Together

RFID

Mining operations are generally spread over a vast area in remote locations and harsh environmental conditions. Ore extraction is a high cost and increasingly high technology venture that requires the utmost operational efficiency as well as uninterrupted workflow and delivery cycles. Operations cannot afford to be impacted due to lack of visibility as to the location and status of machinery, equipment and vehicles, since this causes delays, increased cost and mounting losses and is also an open invitation to theft and misuse. Real-time location tracking and monitoring, especially of moveable assets such as the vehicle fleet transporting the ore, is thus of critical importance to the mining industry. RFID technology not only fulfils these needs but offers substantial benefits in various deployments within the mining sector.

RFID provides automated solutions that monitor trips made by vehicles transporting ore from pit to port, tracking the vehicles and their ore quantities from loading source at the mine to the unloading destination. Tagged vehicles are automatically tracked by RFID antenna and readers mounted at gates and weighbridges. RFID-enabled weighbridges automate calculation of vehicle tare weight and laden weight, update databases at remote servers and transmit this data to the destination weighbridge for verification of trip made and delivered ore quantity. Wi-Fi based RFID systems seamlessly integrate disparate locations spread over long distances, enabling tracking and data availability in real-time.

Drones

CMPDI has planned to deploy drones at Coal India mines for specialised survey applications such as generation of high-resolution images, 3D terrain mapping and volumetric measurement of excavation, the official said.

In mining, drones have several applications like mine surveying, inventory

management, stockpile estimation and hot spot detection etc. Mine surveying can be done using drones to provide detailed information about the sites before starting with mining projects and document their progress to visualize changes in site overtime.

To reconcile the amounts of ore, waste, and overburden generated by mining operations, sites utilize surveying technologies which yield 3D models profiling each stockpile. Ground-based surveying methods, including GPS, total stations, and laser scanners, have been the industry standard for generating digital 3D stockpile models, the cornerstone of stockpile management. These methods, however, are slow and often require surveyors to scale hazardous slopes to collect data. Drones - using photogrammetry or LiDAR - are significantly more accurate, efficient, and prevent endangerment of personnel. The updated 3D surface models provide recurring snapshots of changes in the life of the stockpile. For mine operators, this data plugs directly into any mining or GIS software suite for further analysis and evaluation.

Drones can access highly toxic hard-to-reach areas for providing better insights for mine planning. In coal mines, drones can be used to detect hot spots in coal stockpiles to assess potential spontaneous combustion areas and enable personnel take pre-emptive measures. Drones can further aid in watershed management, blast planning, haul-route surface optimization and emergency response.

They can monitor road conditions too, provide birds eye view for security and situational awareness.

Load Cells for Weighment

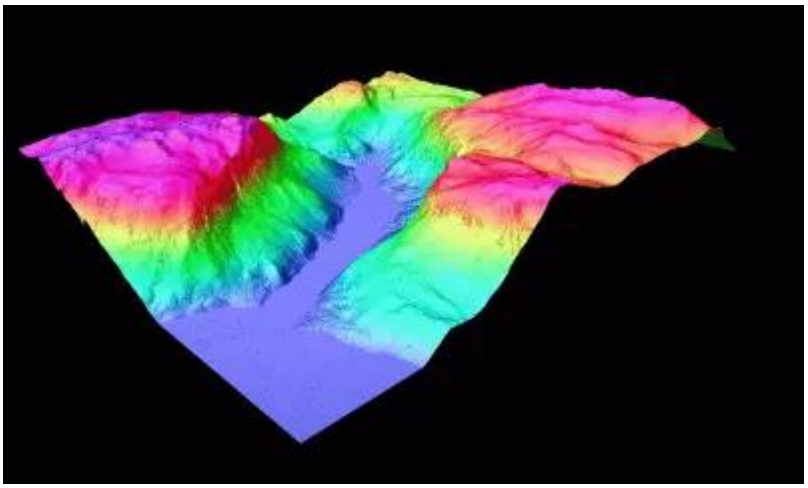
Accurate consignment weights can be measured and recorded both with static weighbridge as well as in-motion weighbridge. Static Weigh Bridges are installed below Loading Chutes, and in-motion ones can be installed over rail tracks to record weights for railway trains as they move at pre-defined speeds.

Figure 1 Load Cells for Weighment

LIDAR – Stockpile Measurement

A lidar-based 3D stockpile modelling system can be designed and implemented, which allows the operator to quickly obtain a 3D stockpile model with detailed features by simply carrying a portable scanning device to circle around the target stockpile or appropriately fixed to a drone. The system uses a line scanning lidar to scan a stockpile with high-precision sensors to measure the position and attitude of itself in real time, and then integrates discrete scanning points to form a 3D point cloud of the stockpile. In data processing, the algorithm was optimized according to the measurement characteristics of the line scanning lidar and the structural characteristics of the stockpile. Noise reduction for the scanning points and ground points removal was performed concurrently in the measurement process. In addition, the point cloud was projected onto a 2D plane for a quick Delaunay triangulation, thus improving the speed of 3D stockpile modelling effectively. Field experiments showed that the system can complete 3D modelling of large stockpiles within a few minutes. The modelling time mainly depends on the walking speed of the operator who circles around the stockpile, and the waiting time for the 3D modelling after the measurement is generally less than 30s. (2019 International Conference on Intelligent Computing, Automation and Systems).

Figure 2 3D Stockpile Model



3D data surveyed by airborne lidar for mine development site in Greenland. Data is coloured by height

LIDAR scanners can measure quantity loaded in vehicles like dumpers and flatbed trucks, as they pass beneath a static scanner placed at an appropriate height. These drone and fixed scanner systems can transmit stockpile volumes, right from mine mouth stocks to commodity in transit in specific vehicles, right up to the loading point for long distance movements.

The result is a complete picture of inventories in first mile transit, and identification of points of inefficiencies, as well quantity deficits on account of theft enroute.

2.8 Clear Advantages of SMART Systems

Lean, error-free, and disturbance-free processes are the goals that the industry is continually striving for. To achieve these goals, integrating field operations with planned production schedules is critical to ensure that the customer-focused supply chain is on track to deliver to set KPIs, and that events that signal potential failures are identified early on to find timely solutions. A marginal 2% decrease reported by a LIDAR speed sensor can indicate a likely belt failure; and a difference in weights between dispatch from mine mouth to arriving at a loading point can indicate pilferage – all in real time.

Sensor and imaging-based data acquisition through IoT devices offer to achieve these goals in a low cost, high efficiency scenario, and enable mining companies to establish robust supply chains, with beneficial impacts for both miner and consumers.

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USE OF IT MINING MANAGEMENT SYSTEMS IN INDIA

3.1 Current Scenario

CSIR-CIMFR had developed and filed patent application entitled “Mine Transport Surveillance System (MTSS)” under a R&D project sponsored by Ministry of Electronics and Information Technology (MeitY), Government of India.

This is the proprietary and indigenous product of CSIR-CIMFR, which has been recommended by MeitY to NMDC, CIL, Ministry of Coal, Ministry of Mines and others for its implementation in mines under „Digital India‟ and „Make in India‟ programs. NMDC Limited had sponsored the project for installing MTSS in Kumaraswamy Iron Ore Mine (KIOM), Donimalai Iron Ore Mine (DIOM) and Pellet Plant at Donimalai Complex of NMDC Limited for following purposes:

- Controlling unauthorized transportation of iron ore from mines using RFID devices, boombarrier, GPS, radar etc. at the mine entry and exit,
- Monitoring production and dispatch of mineral from mines to reduce discrepancy andimproving production,
- Proper positioning of trucks on weighbridge for accurate weighing using radio frequencysensors and boom barriers,
- Fast weighing process using automated PLC-based process and RFID tags,
- Controlling overloading of trucks based on registered laden weight,
- Scanning of front, rear and top views of empty and loaded trucks as per the CVC guidelines,
- Uploading of weighing data to a central server as well as transparent and fool-proofweighing,
- Virtual fencing of mine/plant boundary to control intrusion,
- Long range proximity devices for improving safety of dumpers/tippers,
- On-line monitoring and surveillance of mining activities as well as dumpers/tippers, and
- Improving safety, production and productivity in mines.

MTSS consists of 8 modules for different purposes, namely:

- Weighbridge automation module for fast, accurate and automated weighing process; Centralized billing, monitoring and software solution for secure and transparent on-line
- dispatch and production monitoring with independent website of each mining company;
- Long range proximity warning device for safety of heavy earth moving machinery;
- GPS and RFID-based vehicle tracking and production monitoring module for keeping continuous watch on the vehicles on geo-fenced transportation routes, and monitoring of production as well as providing advice on optimum use of shovels and dumper and other auxiliary equipment to minimize their idling time;
- Periphery surveillance using virtual fencing for detecting intrusion of vehicles with the intention of illegal transportation of mineral through unauthorized routes as well as identifying human intrusion into an industrial area;

- Close circuit television cameras and thermal imaging cameras for keeping different mining activities under day-and-night sharp surveillance, particularly to watch vehicles carrying mineral.
- In-motion weighbridge for weighing of mineral produces from mine, and Wireless networking for effective deployment of the system and centralized monitoring for overseeing all mining activities as well as transport surveillance from a central location.

3.2 Indian Bureau of Mines: Surveillance System to Curb Illegal Mining

MSS is a satellite-based monitoring system which aims to establish a regime of responsive mineral administration, through public participation, by curbing instances of illegal mining activity through automatic remote sensing detection technology.

In the MSS, geo-referenced mining leases are superimposed on the latest satellite remote sensing scenes obtained from WAGONTOSAT. The system checks a region of 500 meters around the existing mining lease boundary to search for any unusual activity which is likely to be illegal mining. States may adopt this system for minor minerals as well.

The MSS has already been put in place and 1,710 working major mineral mines have been plotted on the system. The government has so far received 296 triggers generated through the software from Rajasthan, Karnataka, Madhya Pradesh, Tamil Nadu and Odisha. The triggers are studied at a remote sensing control centre of IBM and transmitted to the concerned district officers for onsite verification.

A user-friendly mobile app (Khan Prahari) Mobile Applications has been developed, which is a part of the system, for reporting any illegal coal mining incident through geotagged photographs as well as textual information by any individual.

Khan Prahari also aims to establish a participative monitoring system where the citizens also can use this app and report any unusual or illegal coal mining activity. The identity of the reporter will not be revealed by the system.

3.3 Current Systems at CIL

Coal India Ltd (CIL) has engaged Accenture Solutions Private Ltd as consultant, for digitalisation of mine process in seven of its selected opencast mines for accelerated performance and enhancing output. The consultant would lead and support the implementation of digitalisation and process excellence while assuring an increased coal output of 100 million tonnes (MT) from the identified mines.

The seven identified mines are Kusmunda, Gevra, Dipka of South Eastern Coalfields Ltd (SECL) and Nigahi, Jayant, Dudhichua, Khadia of Northern Coalfields Ltd (NCL).

These high yielding mines accounted for nearly 32 per cent or 188 MT of CIL's total coal output of 596 MT during FY21. While the three mines of SECL contributed around 112 MT the remaining (76 MT) came through four of NCL's mines.

BHARAT COKING COAL LIMITED (BCCL)

1. **CCTV Surveillance System:** CCTV surveillance System (at Areas) have been commissioned and made operational at 136 vulnerable points of BCCL like Area Offices, Stores, Magazines, Major Coal Dumps, Hospitals etc. As the surveillance system is also necessary for the **monitoring of Railway sidings of BCCL**, CCTV surveillance system have been installed & commissioned at 23 nos. of railway sidings of BCCL.
2. **RFID Based Boom Barrier System at Road Weighbridges:** Presently, RFID based boom barrier system is installed and commissioned at 48 nos. of Road Weighbridges at BCCL for weighbridge automation & surveillance purposes. To cater the requirement of RFID surveillance system at 15 nos. of upcoming road weighbridges, supply order has been placed on 09/12/2019 for the implementation of the same.
3. **GPS Based Vehicle tracking system:** As the rental period of present GPS Based Vehicle Tracking System installed for internal coal transportation is going to complete on 31.03.2020. Work order for supply, installation, commissioning, implementation, training & maintenance of GPS based Vehicle Tracking System has been issued on 28.01.2020 and it has been installed and it is under trial run.

CENTRAL COALFIELDS LIMITED (CCL)

1. GPS/GPRS based Vehicle Tracking System and RFID with CCTV based Weighing Control and Monitoring System across CCL Command areas
2. CCTV surveillance at Vulnerable points of CCL Command Areas

EASTERN COALFIELDS LIMITED (West Bengal Area)

1. **CCTV Surveillance System:** CCTV system has been established at mine viewpoint in Sonepur Bazari Area and is in operation. At present, the live feed of CCTV system established at the weighbridges and coal heaps of Rajmahal Area is operational and monitored at CIL level. Seventy-two (72) nos. of CCTVs are installed in Pandaveswar Area. Eighteen (18) nos. of CCTVS are online i.e., can be access from anywhere through internet.
2. **Weighbridge Automation System:** ECL has successfully taken a step to implement "Weighbridge Automation System" for all the 105 road weighbridges of ECL with RFID based boom barrier access control system
3. **GPS based vehicle monitoring system** introduced at all the Areas is a step to curb theft of coal.
4. **GPS enabled VTMS** system is fitted in Coal transportation vehicle for live tracking of vehicle
5. CCTV cameras are installed at each railway siding and other sensitive locations for surveillance and supervision.

WCL (M.P and Maharashtra)

1. **GPS/ GPRS based Vehicle Tracking System (VTS)** with 1370 nos. of GPS sets and Geofencing of Mine Areas is in place for effective live monitoring of movement of coal carrying vehicles in Mines and prevent pilferage of coal

2. Increased electronic surveillance with **Centralized CCTV surveillance system** at all vulnerable points like Weighbridges, entry/ exit points, stock yards, magazines, stores etc.
3. Implemented RFID based weighment integration of all the Road weighbridges.
4. **RFID based Boom barrier** access control system is implemented at Check posts to prevent entry of unauthorized vehicles in mines
5. IP Radio Network with the state-of-the-art technology established for integration of all above systems from remote units to the Area HQ Servers.
6. Established surveillance system through **PTZ cameras** at Coal stocks, Railway sidings and for OC Mine Surveillance

MAHANADI COALFIELDS LIMITED (Odisha):

1. **GPS/GPRS based Vehicle Tracking System:** GPS based VTS (Vehicle Tracking System) units have been installed by your company in 2970 private trucks/ tippers, HEMM's, and other vehicles engaged in production and internal transportation of coal and OB, as well as vehicles used by Security Department for patrolling. Live tracking of these vehicles along with viewing of various reports related to violation of geo fences, trip, long stoppages, distance traveled etc are available on the web enabled link i.e., http://mclvts.in. T
2. **Geo-fencing of the mine boundary along with the routes have been done**
3. **Operator Independent Truck Despatch System (OITDS):** OITDS Installed in three open cast projects of MCL i.e., Balram, Lingaraj and Bharatpur OCP is running successfully. A total of 137 HEMMs have been installed with the equipment for OITDS.
4. Installed still-shot IP cameras installed at 90 in-motion and static road weighbridges
5. **VHF communication:** Installed VHF communication network in different mines for communication at the Projects up to the Coal Faces. The same is being enhanced every year for increased operational efficiency
6. **Underground Communications System** has been installed in all underground projects for fast and safe communication.

SECL (Chhattisgarh Area):

1. **CCTV Camera Surveillance System:** SECL has procured 596 numbers of CCTV cameras centrally in August 2020 and installed them at different vulnerable points of Areas like Coal Stocks, Weighbridges, Mines Entry-Exit gates,

   CIL Eye app for real time monitoring of mine activities: The CCTV cameras installed at Gevra , Dipka , Kusmunda and Manikpur OCM has been integrated with CIL Eye App for real time monitoring from anywhere including through mobile phone

2. **GPS-GPRS (Global Positioning System- General Packet Radio Service) based Vehicle Tracking System:** A fresh CAMC for the maintenance of VTS for the period of 03 years has also been concluded in November 2020 for seamless operation of this system. In this system, the GPS/GPRS devices are installed in all **internal coal transportation vehicles** and the same are tracked on real-time by 24x7 basis. Location of the vehicle is ascertained by signals received from Navigation Satellites and its coordinates are transmitted to VTS Server located at SECL HQ through GPRS. Actual

location of the vehicle is displayed on the digital map using customized application software.

3. **Geo Fencing:** All mine boundaries, coal patches, unloading points like sidings, stocks, feeder breakers, crusher and bunker, internal coal transportation routes are geo-fenced.

4. **RFID based Automatic Boom Barriers:** RFID based Automatic boom barriers are installed at all the entry and exit points of Mines and Railway Sidings so that only authorized vehicles/tippers can enter/exit into the mine premises which eliminate the possibility of any coal pilferage and helps to regulate vehicle traffic. A fresh CAMC contract for a period of 02 years has been concluded in November 2020 for smooth maintenance and seamless operation of this system. 04 (Four) more Boom Barriers have also been installed in addition to the existing 136 numbers of Boom Barriers. The authorized vehicles deployed for internal coal transportation are affixed with RFID tags on the wind shield of the vehicle whereas the road sale vehicles are issued with temporary tags at Boom Barrier at the time of entry and collected back while leaving the barrier. These tags contain the details of vehicles, DO and transporter etc. **Boom barrier will not open if any vehicle bypasses the weighbridge during its cycle**

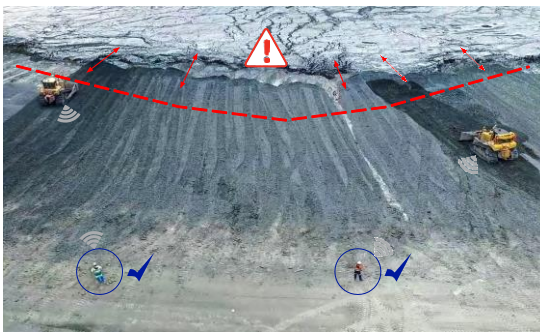
5. **Electronic Rail and Road Weighbridges (WBs):** Electronic In-motion Rail weighbridges and Road weighbridges are installed for weighment of input as well as output coal of SECL mines. Five numbers of new In-motion Rail weighbridges have been installed at different sidings in place of old static Rail weighbridges. All the In-motion Rail WBs have been upgraded for integration with Freight Operation Information System (FOIS) of Railways

   (a) **Weighbridge Centring System:** All the road weighbridges are equipped with Weighbridge Centring System (WBC). This system would allow the weighment of trucks only if the vehicle is properly placed within the weigh platform otherwise would not allow. The RFID Readers installed at WBs automatically read the Vehicle and Transporter / DO details etc. from RFID Tag & facilitate faster weighment (tare/gross) process. **This has resulted in increase in number of trips with less operator intervention.**

ALLIANCE RESOURCES – RIVER VIEW COAL, UNIONTOWN, KENTUCKY

Alliance Resource Partners' River View Coal Mine in Uniontown Kentucky is the largest mine of its type in USA.

It has a preparation plant on site with a throughput capacity of 2,721 tons of raw coal per hour which produces a waste product of coal material. This material (otherwise known as coarse coal refuse CCR and slurry FCR), is used to construct an earthen dam that contains the FCR that is pumped to the dam. The CCR is hauled to the site and dumped then spread with dozers. In the interest of human safety, Mine Safety and Health Administration (MSHA) ordered the mine pushing CCR into tailing pond to find a solution to remove the operator from the dozer.



The dozer operators can now perform the task from a stand-off position with improved situational awareness. The solution involves a modified vehicle control unit, connected vial LAN to operating consoles and the corporate MIS servers. Smart technologies were leveraged by the firm RCT Global (www.rct-global.com) to implement remote dozer control and monitoring solutions, enhancing efficiencies and safety.

(b) **Electronic Rail WB - Static and In-motion:** All the operational Static Rail WBs are now replaced with In-motion Rail WBs as per latest guidelines of Railways. Weighment in Railway sidings are now done only through FOIS enabled In-motion Rail WBs.

6. **Wide Area Network (WAN) based on MPLS-VPN technology & LAN:** Currently, WAN Network with 100/10/02 MBPS Bandwidth is established by M/s. RailTel covering 228 nodes/locations at SECL HQ, Area HQ, Regional stores & Weighbridges. This provides dedicated backbone data connectivity for LAN based applications like Coal-Net modules, E-office, File Tracking System, Bill Tracking System etc. Video Conferencing System among SECL HQ & Areas is also operational through this Network only.

This WAN Network is being extended up to data generation points of mines such as MTK, explosive magazines, weighment system of SILO, Conveyor belt etc. for implementation of ERP in SECL. A separate work order for additional 301 WAN nodes/locations is placed on M/s. RailTel on February 2021 for this purpose.

3.4 Tapping Data from Systems Used by Logistics Providers in Coal Sector

Freight Operations Information System (FOIS)

The Indian Railways carries nearly 1200 million tonnes of freight in a year. This translates to about 5000 freight trains daily. Freight trains bring two thirds of the Indian Railway revenues and are referred to as the bread earners for the Railways. The major commodities carried by Indian Railways are Coal, Iron Ore, Food grains, Iron & Steel, Cement, Petroleum products, Fertilizer and Containerized Traffic. There are specialized wagons to handle the transportation needs of the different types of commodities. Unlike passenger carrying trains, freight trains do not run to a fixed schedule and thus making freight operations a highly information intensive activity. Based on this information managers make allocation decisions continually to dynamically optimize utilization of resources like wagons, locomotives, crew and paths on the network. Real time information allows good decision making and thus ensures high levels of mobility within the system.

Apart from monitoring the movement of freight trains, the system calculates freight and other charges based on complex rules of business and generates the Railway Receipt, the bill payable by the shipper. The system has the capability of tracking and tracing consignments and publication of information to the end users. Electronic Registration of Demand is also now a part of FOIS which brings convenience, speed and ease to customers through online registering of indents for Rakes and Wagons.

Centre for Railway Information Systems (CRIS) carries our design, development, Implementation and O&M for various IT projects awarded by Railway Board. Further, CRIS also undertakes Freight Business Data Integration (FBDI), for FOIS, to develop APIs for customers to integrate with their internal MIS networks.

For faster and customised automated access to data through Freight Operations Information System (FOIS) of Indian Railways, which would help Coal India Limited (CIL) monitor movement of coal laden rakes and coal despatch activity, CIL has entered into a Memorandum of Understanding (MoU) with the Centre for Railway Information Systems (CRIS) on Monday. The first-of-its-kind data sharing offers CIL a bouquet of benefits which will help it in rationalising the entire coal supply matrix via rail mode. It provides precise details of loading, weighment and unloading details along with turnaround time of rakes. The MoU is a collaboration on freight operation information between the networks of CIL and CRIS regarding CIL's rail movement of coal.

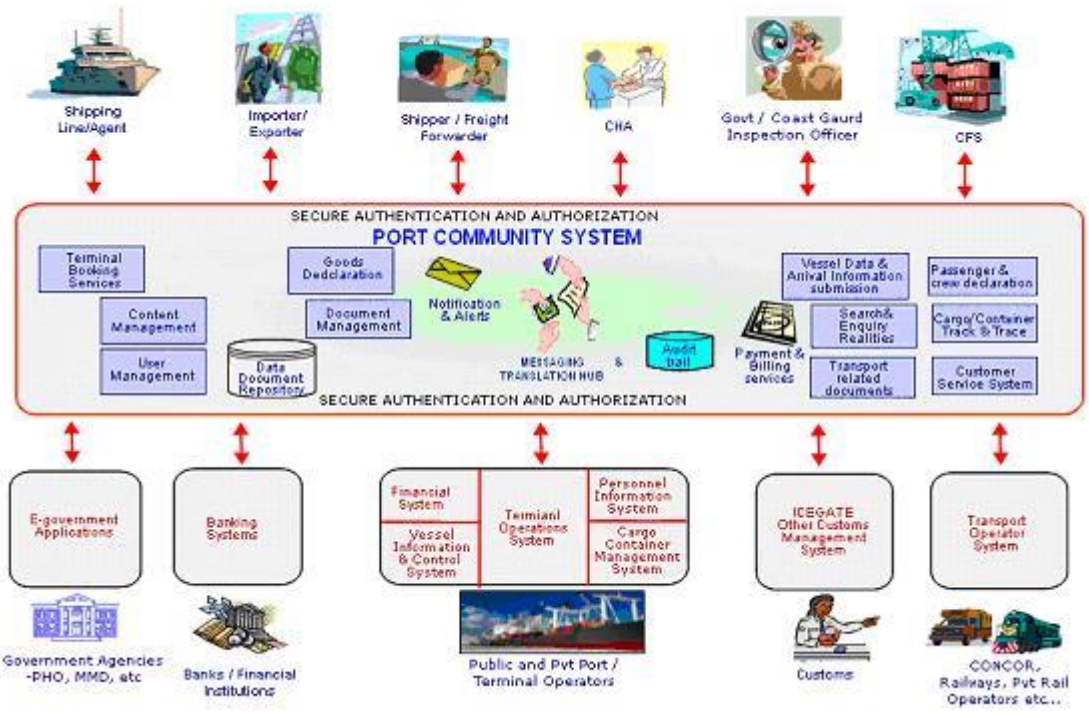
The FBDI allows the extraction of relevant logistics details from the FOIS system via an API, that will be developed by CRIS. The data on coal transport and events enroute on consignments can be ported into Coal Sector Smart Logistics systems for real time information and decision making.

Port Community System

Centralized Port Community System (PCS) is an initiative by Indian Ports Association (IPA) intended to provide a single window system for the Port communities in India to securely exchange the documents and information electronically with their stakeholders involved in the maritime transport and logistics chain including the trading partners and government agencies. It also expected to provide global visibility and access to the central database to all its stakeholders through internet-based interfaces.

PCSIx, a cloud-based new generation system, brings together the different stakeholders of the maritime sector on a single platform, facilitating government-to-business, business-to-government, and business-to-business transactions even as it ensures extreme levels of cyber security. As PCS architecture is built on an open platform, the technology can integrate any new concept or module available in the industry without disturbing the existing ecosystem.

Figure 3 Port Community System – an integrated snapshot



Various ports are in the process of adopting PCS1x at present and these include the country's minor ports.

Currently, the following ports operate the PCS:

Table 1 List of Ports and Operating System

Registered Ports	Their Port Operating System
Kolkata (ex-Calcutta)	Haldia
Paradip	Mumbai (ex-Bombay)
Visakhapatnam	Jawaharlal Nehru
Chennai (ex-Madras)	Kandla
Ennore	Mundra
Tuticorin	Pipavav (Victor) Port
Kochi (ex-Cochin)	Krishnapatnam
New Mangalore	Magdalla
Marmagao (ex-Marmugao)	Kakinada

Indian Ports Association (IPA) and PCS have published n API specifications sheet and assist users in API integrations to avail of services and information.

The PCS offers a critical look at the coal supply chain:

- With 150MTPA of annual imports of coal, in-sight import coal supplies to the country can be integrated into the overall coal supply database.

- It is expected that in addition to the current 60MTPA, an additional 60 MTPA of domestic coal will avail the use of coastal shipping in the future, both to decrease transport emissions as well as to take advantage of reduced total landed cost of coal to consumers in Southern India, and those customers who can be supplied via the major and minor ports on the western coast,

Porting of data from the port community system will therefore be an essential part of developing a Smart Coal logistics that implements a holistic view of coal supply that opens windows on import coal, as well as domestic coal moving via coastal shipping.

The API specifications for PCS have been published, and a synopsis is at Annexure.

IWAI data systems offer a similar potential of data porting from PANI | Portal for Assets and Navigational Information (iwai.nic.in) .

3.5 Current Status and Next Steps

Databased mine management systems in India have made good advances. Technologies inducted include GPS, satellite imagery, RFIDs, and electronic weighbridges, amongst others. Further development is suggested along the following lines to lay strong foundations before a smart call logistics system:

- There is need for integration of various data streams in a manner where discrete events can be correlated to produce efficiency parameters. As an example, the system should be able to track specific vehicles and specific staff, who match with shift duties that report short inventories, therefore identifying potential points of pilferage.

- Mining management systems must adopt sensor-based data acquisition, with the stated objective of dispensing with keyboard and data entry operator-based inputs. The paradigm should also involve porting of data from related logistic systems through application programming interfaces. This step ensures fidelity of data, ease of collection, and real time processing for decision-making.

- The next step is to establish a regime of key performance indicators that are derived from multiple discrete data points. An important component for building in this possibility is the view of the entire movement from mine mouth to customer unloading as a smart coal logistics pipe, with tracking systems that monitor efficiencies.

- Conventional systems are targeted to implementation by large corporate entities, with each one building its own system. However, with change in policy, and the entry of relatively smaller mining entities through the auction system, there is a clear need to democratize technology-based coal logistics and make it available to the entire coal mining industry. This will require a modular approach to develop various components of the smart logistic system. These modules can then be selected by miners as per specific needs; the components would be plug and play and facilitate less costly and quicker deployments.

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THE CASE FOR SMART COAL CORRIDORS

4.1 SMART allows many advantages

Integration

In today's connected environment, many public authorities and corporations have access to multiple datasets. However, these data states are discreetly captured and analyzed for specify workflows, to answer the narrow requirements of the sponsoring group. However, it has been increasingly realized that it is essential to design systems that layer multiple data stacks that allows for cross comparisons. Such a design allows for establishing coherent and meaningful data relationships that may have been missed within separate and discreet information systems.

A prime example is India's smart city program. Earlier digitalization exercises produced separate data files for sanitation and solid waste management, as distinguished from the data set on diseases like diarrhoea, cholera, and tuberculosis. With the setting up of integrated command and control centres, where these datasets are placed together for a locality, it became easier to see that as sanitation and solid waste management improved, disease burden on this locality cholera went down. These insights provided critical direction to further municipal actions.

Within the systems implemented in the mining sector in India, it would be advantageous to attempt an integration on these lines. A smart logistic system would superimpose pithead stocks and movements within the mine, and further for transport on first mile connectivity and stocks at loading points, inventories in transit over mainline systems like railways, right up to the final receipt of the mineral commodity by consumers.

The integrated system would therefore see the entire logistics pipeline from coal production to final receipt at customer premises as a continuum of a pipeline, allowing objective key performance indicators to be established, and permit real time information and actions for any deviations.

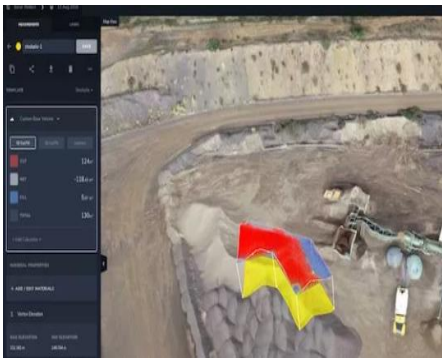
API and Sensor-based inputs, no data keyed in

The availability of reliable and inexpensive sensors permits today's smart systems to dispense with the requirement of physical data collection and inputs via keyboards and data entry operators.

The estimation of mineral quantity in a stack, the amount loaded in a specific vehicle, the movement of that vehicle along with the measurement of the quantity while on move, and the final quantity unloaded at the railway station - all this data can be acquired by sensor-based devices and automatically ported to data collection systems.

Accurate Stockpile Inventory Boral, Victoria

Founded in Australia and operating approximately 700 sites in Australia, the United States, and across Asia, Boral manufactures and supplies building and construction materials. Boral's Victorian Metro region consists of six quarries servicing the booming market for concrete aggregates and construction materials in the greater Melbourne area.



A drone-mapping and analytics solutions (provided by Australian firm Propeller) give the sites in his region the ability to measure and manage their stockpiles, report on inventory, and share easy-to-understand visual information for planning and tracking work. This includes a picture of the stockpile, volume, tonnage, and the material. Site managers can then take that report out in the field to check that reporting volumes are physically matching up, and there is no inventory write downs reported now.

The system should also leverage the availability of logistics information with transport service providers and use APIs do extract appropriate information of the commodity in transit.

It is therefore possible that the entire smart system for tracking coal logistics does not have any keyboard inputs ensuring fidelity, reliability, and real time nature of the data being acquired. The available data set can then be subject to established KPIs, and the entire logistics pipeline can be managed on a risk-based management system approach. The system therefore does not need any monitoring; it is self-monitoring to predefined benchmarks and calls for attention when the benchmarks are not being met.

Logistics Paradigm

Analysis reveals that the coal value chain is made up of distinct and discreet components:

- Miners: mining companies see their prime activity as mineral production and stacking it at nominated points for further transport.
- Transporters: this comprises of transporters like railways, trucking companies and others who move the commodity from point A the point B.
- Consumers: they unload the coal at the unloading point for consumption and are the arrangers of transport.

Ideally, coal mining companies must see the coal consumer as their customer and negotiate with the transporter on behalf of their customers. Individual customers, even when they are large sized thermal power plants, only form a small set of the railways total revenue and do not possess the bargaining power in the transport market. A large mining company, on the other hand, can effectively negotiate with the railways and trucking companies, and provide greater value to their customers through cheaper and reliable mineral transport.

Take the example of Coal India limited. CIL is the world's largest coal producer, and additionally, the largest customer by a large margin for Indian Railways. If CIL will negotiate coal freight rates with Indian Railways on a net ton kilometre basis on behalf of the consumers of coal, significant cost benefits can flow to coal consumers. Instead of a power plant that

consumes 5 million tons per annum of coal, if the freight rate was to be negotiated by CIL, who offers 500 million tons of business, the Railways may be more amenable to discounts.

Assets across the value chain

Mineral logistics chains have multiple fixed and moving assets in play round the clock. Examples are conveyor belts, loaders, dozers, tipper trucks, weighbridges, gates, boom barriers, the coal handling plants, railway wagons, terminal loading chutes, and others.

The proposed system would track all these assets across the value chain and determine inventories on the move with regard to the mineral asset, as well as track the efficient use of fixed and moving infrastructure that is being used in the service of mineral transport.

4.2 Potential Use Cases

New mine development

The progress in the development of newly auctioned mines, in accordance with committed timelines, can be monitored using satellite imagery. Remote sensing images can be collected on a periodical basis, say once a month, with automatic cataloguing in a database. The system will compare the progress against committed timelines and raise alerts when deviations are seen. It will be possible to track any potential delays in mine development, as well as ensure that the development undertaken is in accordance with mandated approvals.

Inventory Management:

A real time view of inventories in stockpiles at mine mouth, in first mile transit, in stockpile at railway terminals, in transit on trains- can all be available. The system can compare and raise warnings when departures are noticed from the program production, loading, and in transit coal logistics pipelines.

Theft Prevention:

With a complete view of entire logistics pipe, the system will correlate short deliveries and facilitate the identification of points of pilferage. For example, the tracking systems would correlate that short delivery to power plant A is recorded whenever the train stops at station B. Such analysis will be possible as the smart system develops these correlates and will assist both Coal India and the Railways in taking appropriate action to plug the leakages.

It can be seen that the entire coal logistics corridors can transition into smart pipes, be programmed to smart analytics, and permit corrective actions based upon risk-based management system. The integrated command and control view then assists in ensuring consignment security, monitored productivity, speed of flow, and identification of bottlenecks for corrective action in real time.

The Smart Coal Logistics initiative upgrades the mining and transport operation to a knowledge-based ecosystem of people, processes, assets, and data – all tracked in real time for optimization.

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SMART COAL CORRIDOR SOLUTION

5.1 Objectives

Ministry of Coal aims to improve the end-to-end logistics supply chain associated with evacuation of coal throughout the country. Transportation of coal fromproduction point to consumption point may include multiple modes of transport and hence a unified view of coal-in-store and coal-in-transit will greatly enhance the efficiency and transparency of the end-to-end logistics supply chain.

Coal evacuation infrastructure typically comprises of the following logistics segments:

- First mile logistics
- Trunk mile logistics
- Last mile logistics

As compared to the first mile and last mile, the trunk mile is more organized and there are existing mechanisms available to track consignment movement during the trunk stage of logistics, for example: the Freight Operations Information System (FOIS) provided by Indian railways and Indian Port Community System (PCS).

However, very limited real-time information is available regarding first mile logistics, last mile logistics, and coal stockyards. Due to this limitation, there is no “single consolidated source of truth” to track coal stocks across the end-to-end supply chain.

As a part of the digitization initiatives in the mining industry, we recommend creation of a “Smart Coal Supply Chain” system to track and trace coal at every stage in the supply chain.

Smart Coal Supply Chain (SC2) Digital Platform

The SC2 digital platform will be a dedicated system comprising of a cloud-based digital platform and physical infrastructure components for data collection. The system shall be custom built to meet the specific digitalisation objectives of the MoC.

The SC2 platform shall enable the collection of data from multiple devices and sources in order to provide a consolidated view to the decision makers and policy makers. The SC2 platform covers all possible means of coal movement within the supply chain so that coal movement can be automatically monitored right from first mile to last mile movement.

The platform shall comprise of the following components for coal data collection at various points along the segments of the logistics supply chain:

- Integration with Smart weighbridge to collect coal despatch details at entry and exit points
- Integration with Silo weighing device to collect coal despatch details when MGR is the mode of transport
- Volume scanning of coal at exit points

- Volume scanning of coal moving through conveyors
- Volume scanning solution for volume information of coal in stockyards
- Tracking of vehicles wagons carrying coal when the means of transport is roadways
- Integrating with pre-existing vehicle tracking systems to track coal movement

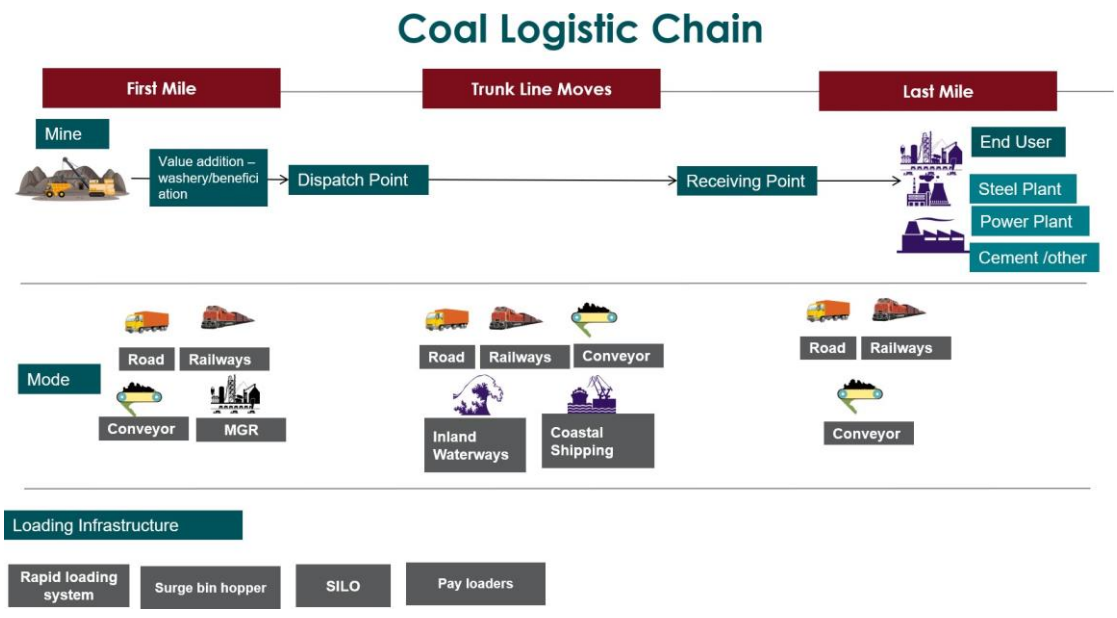
through roadways

- Integrating with FOIS of Indian railways to track coal movement through railway
- Integrating with Port Community System (PCS) to track coal movement using shipping lines

The SC2 digital platform shall ingest data from the above sources. Stream analytics shall be performed on the data in order to enable real-time insights and decision-making. The data shall also be stored in a data warehouse in order to create dashboards and metrics as required by the MoC. The figure below shows a conceptual representation of the SC2 digital platform.

The figure below provides a top-level view of the segments, modes and components related to a typical coal logistics chain:

Figure 4 Diagram of Coal Logistics Chain



The table shown below provides an overview of the applicability of the different measurement integrations for different modes of transport within the coal logistics supply chain.

Table 2 Applicability of Different Integrations with Different Modes

	In mine	Road	Road-Rail-Road	Road-Ship-Road	Road-Rail-Conveyor	Conveyor	MGR
Volume scanning in stockyards	A						
Volume scanning at exit points		A	A	A	A		
Weighbridge integration		A	A	A	A		
Rail Weighbridge integration			A		A		
Silo Measurement integration							A
Volume scanning on conveyors					A	A	
Vehicle tracking		A					
FOIS integration			A		A		
PCS integration				A			

*A: Applicable

IOT adapter devices:

To minimize the capital expenses and to maximize reuse of existing infrastructure, wherever possible, existing infrastructure such as weighting bridges, RFID reader, Cameras shall be re-used. Additional, IOT adapter devices shall by connected in in series with these devices. IOT adapters shall act like bridge between existing hardware and data collecting servers.

The IoT adapter devices (SC2 IoT gateways) shall have capability to locally store 2 hours of operational data in case of loss of connectivity to the platform. This data shall be synced with the platform whenever connectivity is restored.

Internet:

Devices which shall be installed at static locations and buildings shall utilize the existing internet connection either through LAN ports or WiFi. For devices which may be installed on trucks, 4G data connections shall be leveraged.

Data Security:

In order to ensure data security and to avoid unauthorized access of data, following mechanisms shall be employed:

1. Data flow across the network shall be encrypted.
2. Data shall have hardware specific (MAC, HDD, etc.) binding.

3. All network switches shall have whitelist filtration mechanisms where only whitelisted devices shall be allowed (IP + MAC).
4. USBs as well as other storage media shall be completely blocked for all available machines.
5. Operating system ported on all machines shall be Linux based with reduce

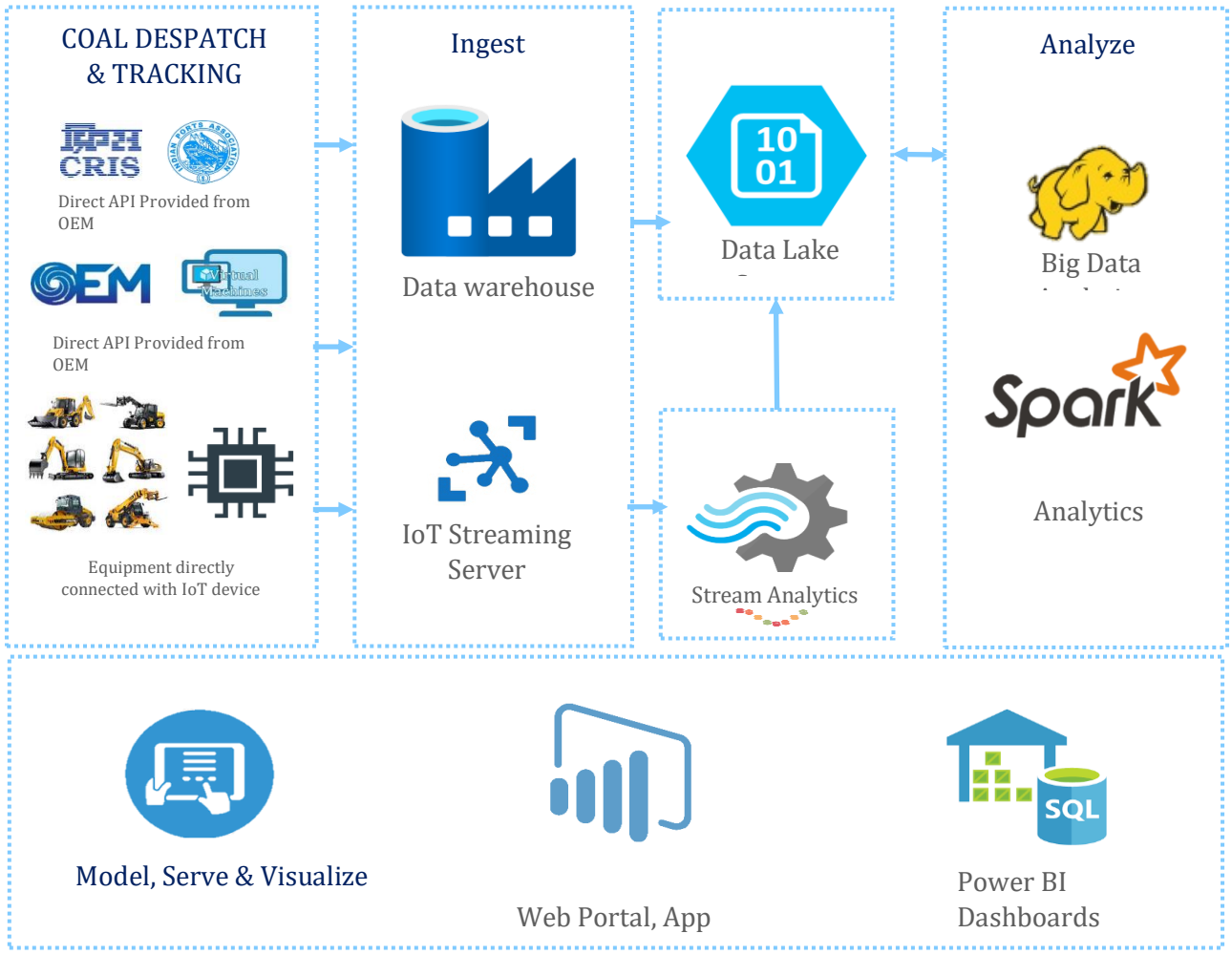
footprints.

6. All elements shall have user identity management to ensure only authorised users can access the element.

Power supply:

Devices which shall be installed at static locations and buildings shall draw power from existing power sources available at the specific location. For devices which may be installed on trucks, power shall be drawn from the vehicle itself.

Figure 5 Framework of SC2 Platform

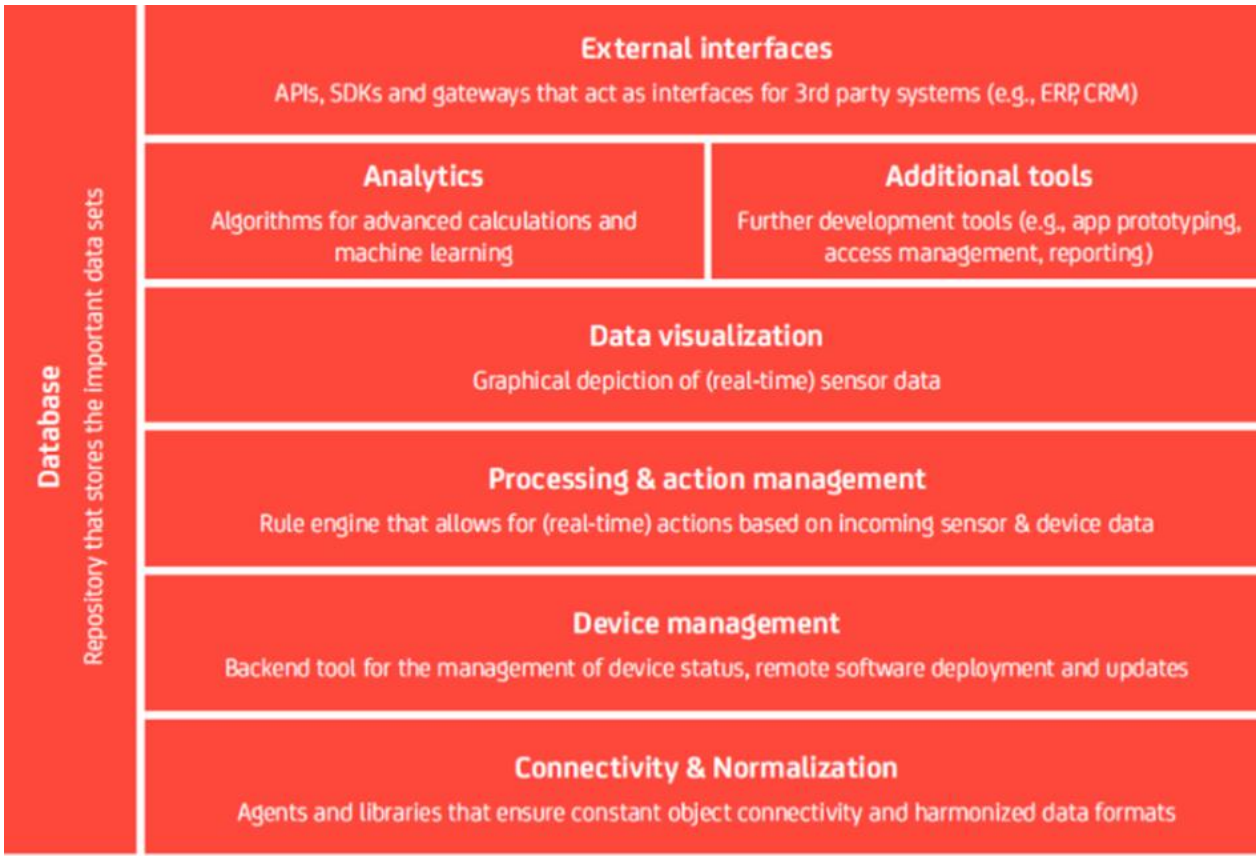


SC2 platform concept includes:

- Polling coal related data from various sensors installed across mines, CHP's, coal handling vehicles, rail wagons and port transportation container.

- Data shall also be collected from other sources such as FOIS API's, PCS API's (Integration with any other existing systems that provide API for ingesting coal related information).
- These data shall be constantly made available on data servers installed.
- Further this data shall be effectively analysed to generate customized single point dashboards for tracking and decision making.
- Portal designed and developed for Coal supply chain shall have various such Dashboard based on user logins and roles.
- Different roles and logins shall be defined to ensure only relevant information is available to each portal user. However, ministry shall have a master login, which shall have all access.
- This portal shall hence enable ministry to have run time tracking of coal logistic chain. Additionally, ministry shall also have estimation of coal volume at each stage.
- Further this collected data shall be used to run various analytics and AI/ML algorithms to enable ministry with various performance indicators such as effective supply-demand estimations, consumption patterns and identificationof persistent bottlenecks.
- The platform shall also enable ministry to effectively manage all contributors in value chain. The platform can potentially integrate with invoice management solutions to consolidate the same across sub-contractors and vendorsassociated with the logistics activities.
- Proposed solution is based on eliminating manual data entries to ensure accurate data collection.

Figure 6 Conceptual Flow of SC2 Platform



Infrastructure and Sensors to be installed

Dispatch Weighbridge

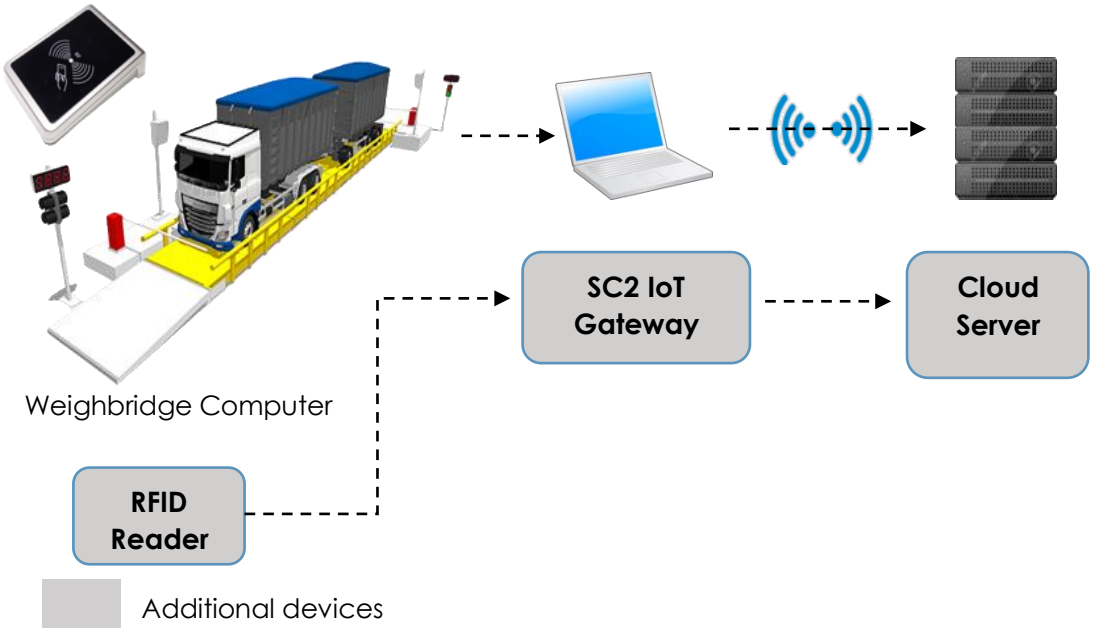
Weighbridges are the standard means of coal weighment at the point of despatch. Different types and makes of weighbridges may have been installed, over time, at various locations. The weighment data from the weighbridge needs to be made available to the SC2 platform in order to maintain track of coal despatched from the mine.

The following additional equipment needs to be added at the weighbridges to collect despatch information:

- **SC2 IoT gateway device:** The SC2 IoT gateway device shall consist of hardware and software to connect to the existing weighbridge device to collect the weighment data.
- **RFID reader:** The RFID reader shall be used to read the RFID tags attached to

the vehicles, thereby providing identification details of the vehicle.

Figure 7 Schematic of Smart Weighbridge



Every measurement made by the weighbridge shall be collected and sent to the SC2 cloud platform along with the following data:

- Time of despatch
- Vehicle registration number
- Type of vehicle
- Registered laden weight of the vehicle in tonne or kg
- Details of the transporting work order such as:
  - Work order number
  - Work order date
  - Party details
  - Quantity of transportation or sale
  - Coal grade
  - Destination of supply

Specifications:

RFID Antenna:

- Circularly polarized
- Rugged, ultra heavy duty construction
- IP 67 rated
- Weather and UV resistant radome

RFID reader:

- Operating Frequency: 865~867 MHz
- Ingress protection: - IP 66
- Communication interface: RJ45

SC2 IoT gateway:

- Processor: Intel Core i3 or equivalent
- RAM: 4 GB or more
- Storage: 64 GB SSD or more
- LAN (RJ45): 2 or more
- USB: at least 1
- Serial: 2 x RS232/422/485
- Power: 12~24VDC
- IO: at least 6 x GPIOs
- HDMI / VGA output

Operating Temperature: -20ºC to +55º

Silo Weighment Device

When transportation is done through MGR trains, coal is loaded into the wagons through Coal silos. In order to capture despatch through the MGR system, weighment data from the silo needs to be made available to the SC2 platform in order to maintain track of coal despatched.

The following additional equipment needs to be added at the weighbridges to collect despatch information:

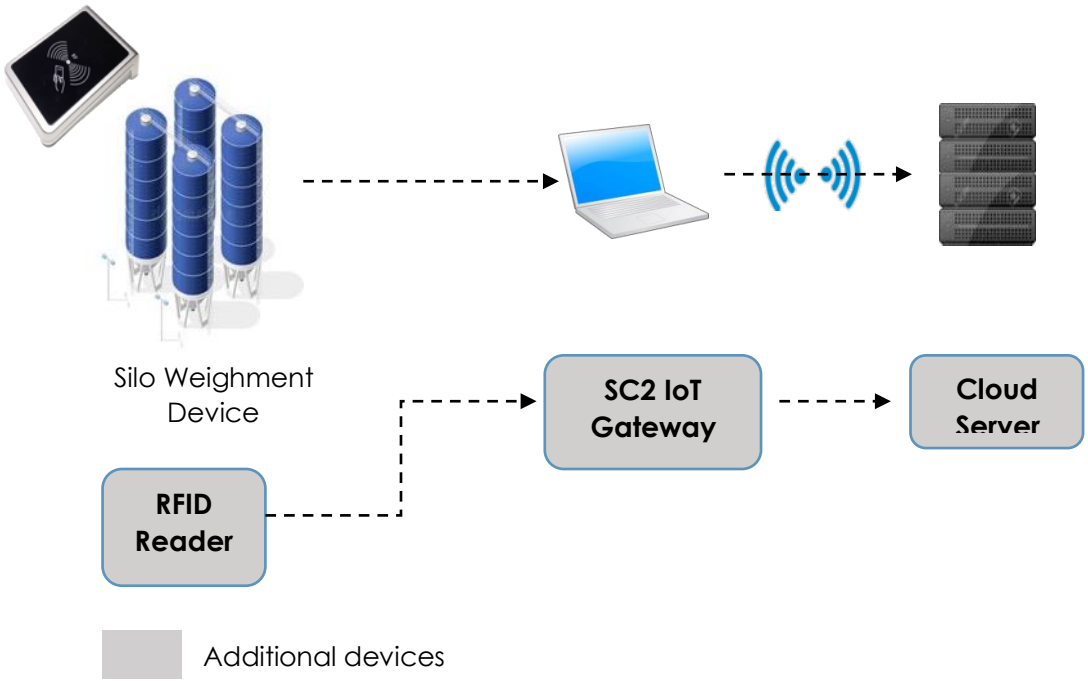
- **SC2 IoT gateway device:** The SC2 IoT gateway device shall consist of hardware and software to connect to the existing weighbridge device to collect the weighment data.
- **RFID reader:** The RFID reader shall be used to read the RFID tags attached to the wagons, thereby providing identification details of the wagon.

Every measurement made by the silo weighment mechanism shall be collectedand sent to the SC2 cloud platform along with the following data:

- Time of despatch
- Details of the transporting work order such as:

- Work order number
- Work order date
- Party details
- Quantity of transportation or sale
- Coal grade
- Destination of supply

Figure 8 Schematic of Smart Silo Weighment



Specifications:

SC2 IoT gateway:

- Processor: Intel Core i3 or equivalent
- RAM: 4 GB or more
- Storage: 64 GB SSD or more
- LAN (RJ45): 2 or more
- USB: at least 1
- Serial: 2 x RS232/422/485
- Power: 12~24VDC
- IO: at least 6 x GPIOs
- HDMI / VGA output
- Operating Temperature: -20ºC to +55ºC

Railway Weighbridge

The weighment data from the weighbridge needs to be made available to the SC2 platform in order to maintain track of coal despatched. There are two options to collect weighment data from rail weighbridge into the SC2 platform.

Option 1 – API integration: In case the rail weighbridges provide an API to collect the weighment information over the web, these APIs can be used to fetch the relevant information from the weighbridge into the SC2 platform.

Option 2 – Through SC2 IoT Gateway: The SC2 IoT gateway device shall consist of hardware and software required to connect to the existing weighbridge computer to collect the weighment data and provide the same to the SC2platform.

Specifications:

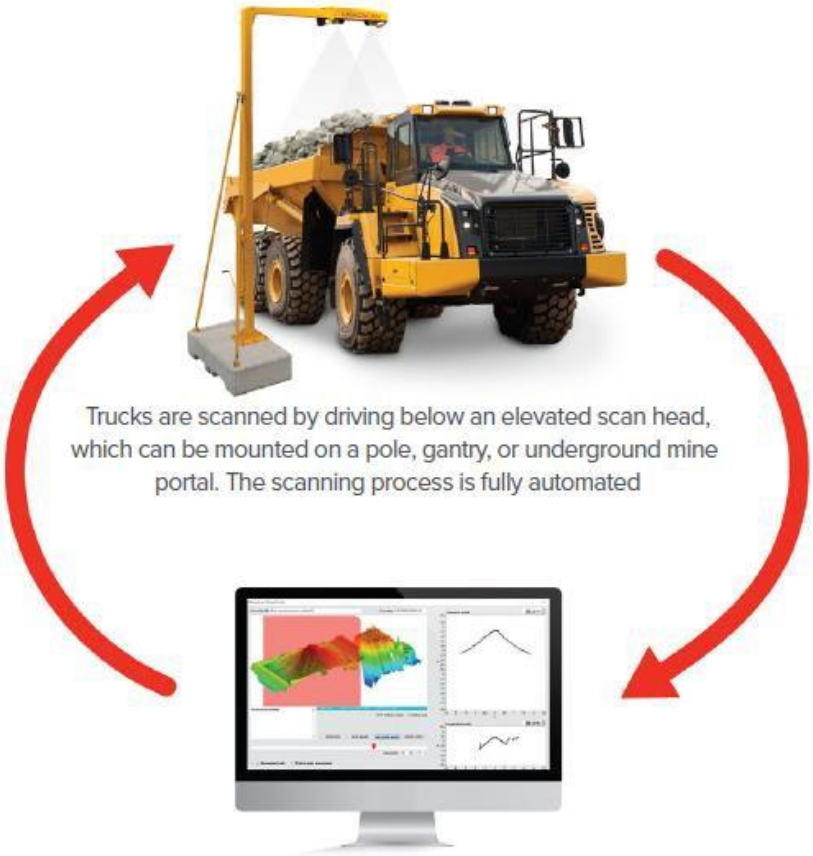
SC2 IoT gateway:

- Processor: Intel Core i3 or equivalent
- RAM: 4 GB or more
- Storage: 64 GB SSD or more
- LAN (RJ45): 2 or more
- USB: at least 1
- Serial: 2 x RS232/422/485
- Power: 12~24VDC
- IO: at least 6 x GPIOs
- HDMI / VGA output
- Operating Temperature: -20ºC to +55ºC

Volume scanning of coal at exit points

Volume scanning of coal despatched through trucks can be used to complement the weight measurement from the weighbridges. These LIDAR based volume measurement devices can also be used to measure coal volume at other intermediate points as well.

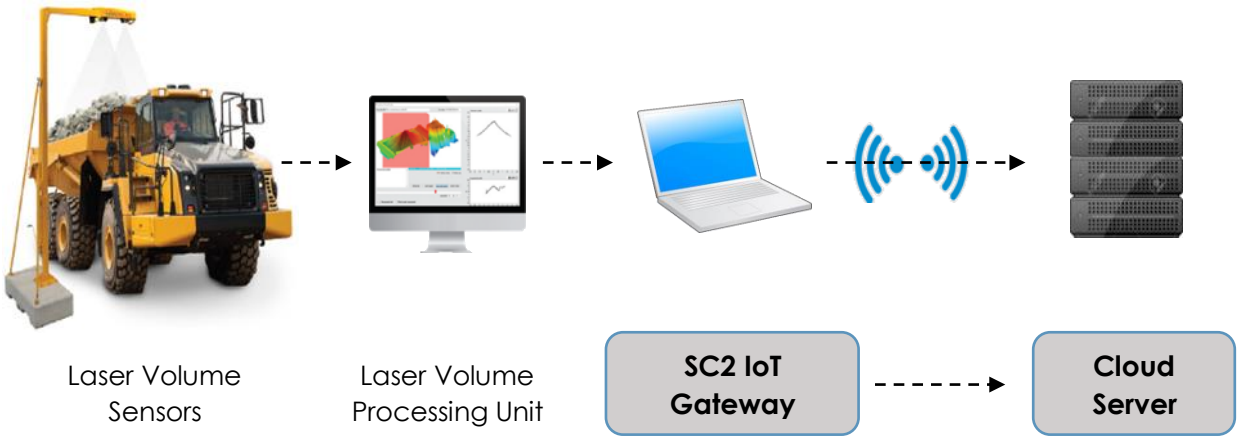
Figure 9 Schematic of Volume Scanning of Coal on Trucks



Some of the benefits of the load scanning mechanism are as given below:

- Weighbridges may need the truck to be static in order to accurately measure the weight of the load. Dynamic weighbridge measurements may be susceptible to slight movement in scale foundations due to heavy trucks, which may impact the accuracy of the measurement. A LIDAR based volume measurement can be used to reduce the measurement time and this also provides a complementing data point at despatch points.
- Optimise loading for every truck despatch, thereby improving the trucking factors.

Figure 10 Schematic of Volume Scanning at Exit Points



Specifications:

LVM Sensor:

- Type: 2d LIDAR
- Light source Infrared (905 nm)
- Laser class 1 (IEC 60825-1:2014, EN 60825-1:2014)
- Aperture angle - Horizontal: 190°
- Scanning frequency: up to 100 Hz
- Working range: 0.7m to 80m
- Response time: ≥ 10 ms
- Interfaces: Ethernet, Serial
- Ingress protection: - IP 67
- Installation height (overhead) 5m to 8 m, at least 1m higher than the maximumvehicle height
- Operating Temperature: -20ºC to +55ºC
- Number of sensors: 2 or more

Specifications:

LVM Processing Unit:

- Processor: Intel Core i7 or equivalent

- RAM: 8 GB or more
- Storage: 256 GB SSD or more
- LAN (RJ45): 2 or more
- USB: at least 1
- Serial: 2 x RS232/422/485
- Power: 12~24VDC
- IO: at least 6 x GPIOs
- Operating Temperature: -20ºC to +55ºC

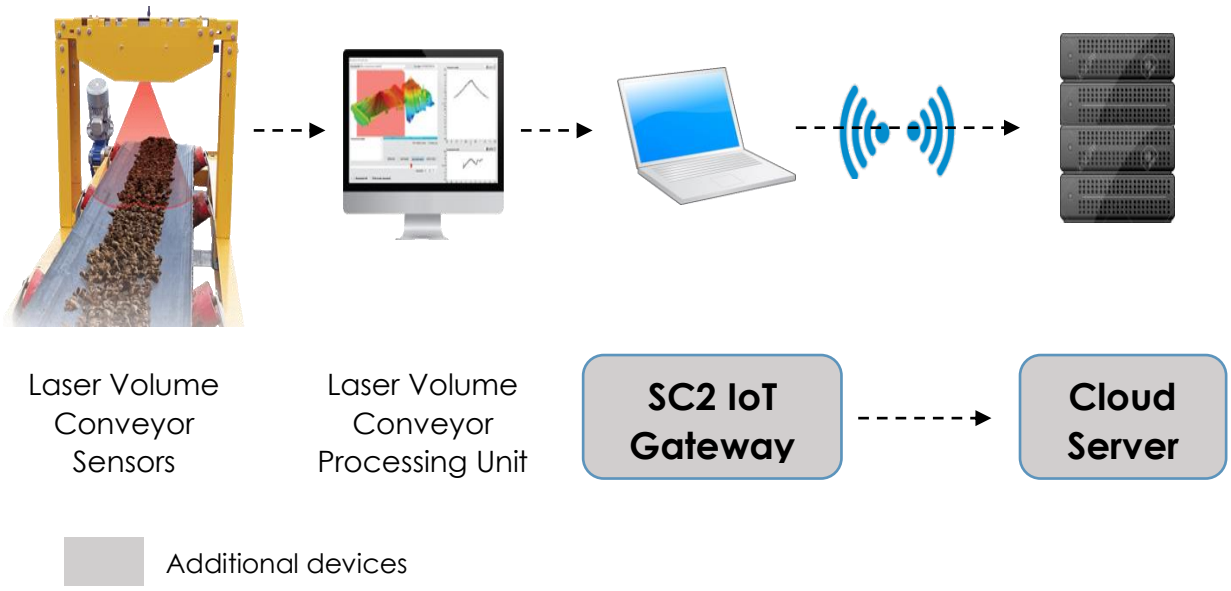
SC2 IoT gateway:

- Processor: Intel Core i3 or equivalent
- RAM: 4 GB or more
- Storage: 64 GB SSD or more
- LAN (RJ45): 2 or more
- USB: at least 1
- Serial: 2 x RS232/422/485
- Power: 12~24VDC
- IO: at least 6 x GPIOs
- HDMI / VGA output
- Operating Temperature: -20ºC to +55ºC

Volume scanning up cold moving through conveyors

Volume scanning of core movement should be done through above belt LIDAR measurement systems. This methodology will allow the tracking of core movement using conveyors at various points within the logistics supply chain.

Figure 11 Schematic of Volume Scanning at Conveyor



Specifications:

VM Conveyor Sensor:

- Type: 2d LIDAR
- Light source Infrared (905 nm)
- Laser class 1 (IEC 60825-1:2014, EN 60825-1:2014)
- Aperture angle - Horizontal: 190°
- Scanning frequency: up to 100 Hz
- Working range: 0.7m to 80m
- Response time: ≥ 10 ms
- Interfaces: Ethernet, Serial
- Ingress protection: - IP 67
- Installation height: at least 1m above conveyor
- Operating Temperature: -20ºC to +55ºC
- Number of sensors: 1

VM Conveyor Processing Unit:

- Processor: Intel Core i7 or equivalent

- RAM: 8 GB or more
- Storage: 256 GB SSD or more
- LAN (RJ45): 2 or more
- USB: at least 1
- Serial: 2 x RS232/422/485
- Power: 12~24VDC
- IO: at least 6 x GPIOs
- Operating Temperature: -20ºC to +55ºC

Specifications:

SC2 IoT gateway:

- Processor: Intel Core i3 or equivalent
- RAM: 4 GB or more
- Storage: 64 GB SSD or more
- LAN (RJ45): 2 or more
- USB: at least 1
- Serial: 2 x RS232/422/485
- Power: 12~24VDC
- IO: at least 6 x GPIOs
- HDMI / VGA output
- Operating Temperature: -20ºC to +55ºC

Volume scanning solution for volume information of coal in stockyards

In some mines, aerial lidar survey techniques are used in order to perform volume surveys for stockpile estimation. However, aerial lidar surveys have the following dis-advantages:

- Requirement of a skilled drone operator
- Manual intervention increases the time required to perform survey
- Does not give a daily volume estimate as these surveys may be performed onlyon a weekly or monthly basis

As an alternative fixed terrestrial lidar scanners can be used in order to scan and track the volume of coal that is stored in stockyards. Multiple terrestrial lidarscanners can be installed in order to create complete coverage of the stockyardwithout any blind-spots. The lidar scans provide a 3d point cloud. The 3d point cloud from multiple scanners can

be fused and processed to generate the volume estimate of coal stored in the stockyard.

Specifications:

VM Stockyard Sensor:

- Type: True 3d LIDAR
- Horizontal Scan angle range: 0 to 360°
- Vertical Scan Range: – 40° to + 40°
- Scanning Frequency: 15 Hz or better
- Measurement Range up to 100 meters with target reflectivity of 5-10% for scanning coal surface day/night.
- Accuracy: 15 mm
- Angular Resolution: 0.05° or better
- Max Distance: at 100% re-emission: 250 m
- Measuring Rate: 10000 pts / sec or more
- IP Protection Class: IP 65 or Better
- Power Supply: 24 V DC/ 230 V AC UPS
- Light source Infrared: (905 nm)
- Laser class: 1 (IEC 60825-1:2014, EN 60825-1:2014)
- Interfaces: Ethernet, Serial
- Ingress protection: - IP 67
- Installation height: at least 1m above conveyor
- Operating Temperature: -20ºC to +55ºC
- Number of sensors: based on area of stockyard

VM Stockyard Processing Unit:

- Processor: Intel Core i7 or equivalent
- RAM: 8 GB or more
- Storage: 256 GB SSD or more
- LAN (RJ45): 2 or more
- USB: at least 1
- Serial: 2 x RS232/422/485

- Power: 12~24VDC
- IO: at least 6 x GPIOs
- Operating Temperature: -20ºC to +55ºC

Specifications:

SC2 IoT gateway:

- Processor: Intel Core i3 or equivalent
- RAM: 4 GB or more
- Storage: 64 GB SSD or more
- LAN (RJ45): 2 or more
- USB: at least 1
- Serial: 2 x RS232/422/485
- Power: 12~24VDC
- IO: at least 6 x GPIOs
- HDMI / VGA output

Operating Temperature: -20ºC to +55ºC

5.2 Infrastructure and Sensors to be installed on Vehicles

Console:

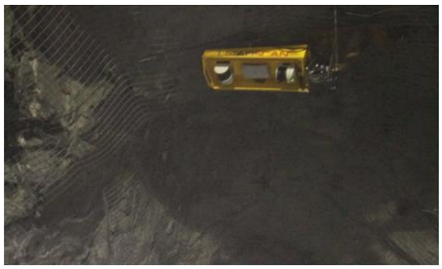
Each vehicle shall be installed with a user-console and following sensors.

1. Biometric sensor for device / vehicle login.
2. RFID tags for effective vehicle tracking in known areas. This sensor shall also be useful for trip computation and automated invoicing. Defined Truck terminals should have RFID receivers for tracking.
3. GPS Receivers shall be used to:
    a) Get vehicle current position
    b) Enable geo fencing and alert generation
    c) Identify on route vehicle halts (Planned / Unplanned)
    d) To track driver performance and productivity
    e) Automated trip calculation and invoicing
4. In order to ensure uninterrupted power supply even when the vehicle is OFF, console shall be powered directly from vehicle battery.
5. Maps shall be used to assist driver with mapping information to reach destination
6. For vehicles operating within the mine, the console shall enable the co- ordination of vehicles for various operations such as ensuring availability of dump trucks at the right place at right time to pick-up the material.

Hindustan Zinc

Volume Scanning for Trucks to monitor material

At its Rajpua-Dariba mine, Hindustan Zinc's oldest mine, they have a custom- mounted Loadscan **underground** to measure ore, where it's crushed before taken to the surface by lift. Within this mine there's also a block- mounted portable unit **(LVS-3BMP),** which is positioned at their portal to measure trucks as they come to the surface.



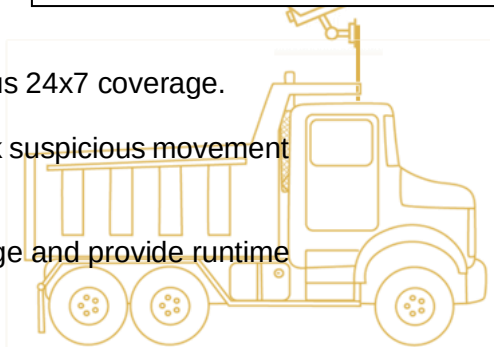
As the target vehicle drives under the scanner, the LVS precisely scans the Load and creates a 3D model or "surface profile". By comparing this profile with that stored on file for the same vehicle when empty, the LVS is then able to calculate the Load volume to a proven accuracy of+/- 1% or to the point of resolution which is $1m^3$.

The company says that

Production gains have also been achieved for Hindustan Zinc due to increased trucking factors. We've achieved lower cost per ton of material hauled, optimizing truck loading, and improving productivity.

Cameras [Optional]:

1. Each vehicle's load section shall be monitored using CCTV and night vision cameras.
2. Combination of day and night cameras shall provide us 24x7 coverage.
3. Various video algorithms shall be implemented to track suspicious movement during transportations.
4. Digital Video Recorder shall store vehicle video footage and provide runtime video monitoring.



5. Camera system shall have 30 minutes power backup provision.

Data Security:

1. Data flow across the vehicle shall be encrypted.
2. Data shall have hardware specific (MAC, HDD, etc.) binding.
3. All network switches shall have whitelist filtration mechanisms where only whitelisted devices shall be allowed (IP + MAC).
4. Special algorithms shall be installed to detect and flag hacking attempts, if any.
5. USBs as well as other storage media shall be completely blocked for all available machines.
6. Operating system ported on all machines shall be Linux based with reduce footprints.
7. System shall only have 1 (Proposed solution UI) application and associated services running in it.

VMU (Vehicle Monitoring Unit):

1. This unit shall be mainly responsible for collecting entire vehicle sensor dataand posting it to cloud server.
2. This unit shall also be responsible for local health monitoring and decision making. Few of the health monitoring parameters are listed below.
    a) Link with different sub systems such as Console, CCTV and Night visioncameras.
    b) Low battery indication for Console
    c) Power cut indication for camera system
    d) Low volume indication
    e) Suspicious movement detection

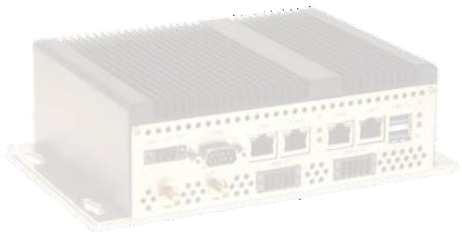
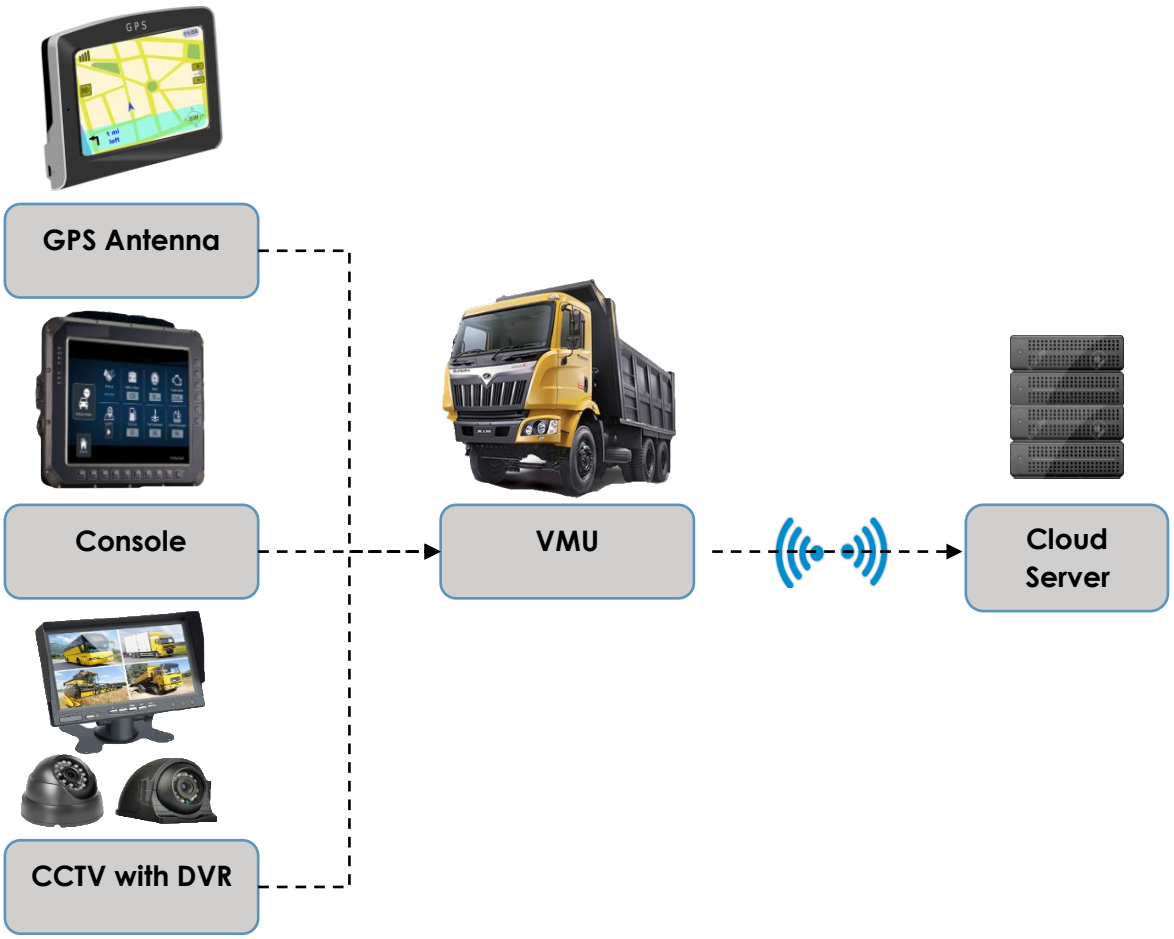


Figure 12 Components of Vehicle Monitoring Unit



VMU:

- Processor: Intel Core i3 / Arm Cortex M7 / equivalent
- RAM: 4 GB or more
- Storage: 64 GB SSD or more
- LAN (RJ45): 2 or more
- USB: at least 1
- Serial: 2 x RS232/422/485
- CAN: 1 port
- IO: at least 6 x GPIOs
- GPS / GLONASS / IRNSS receiver
- Rugged 4.3 inch / 7-inch capacitive touch
- Power: 12~24VDC
- Operating Temperature: -20ºC to +55ºC

SMART COAL CORRIDOR IMPLEMENTATION

6.1 Strengthening of Coal Market in India

The coal mining sector in India has been undertaking dynamic reforms, to move the sector to an open and market-based commodity approach.

The nationalization of coal in 1973 meant that domestic coal could be mined only by public sector companies. While state-owned coal companies have endeavored to raise production and safety and prioritized employee welfare, coal demand continued to grow at a much faster rate and imported coal growing at CAGR of +20%. Since 2015, policy actions like the transparent mechanism to commence mine auctions have helped, and domestic coal component in total supply has been ramped up. Even in the short term, mine developers can now extract their coal assets and sell without restrictions, allowing domestic companies to address a potential market sized at 150 million tons per annum, through the replacement of imported coal by domestic supplies.

The government has now amended rules with a view to allow 50 per cent sale of coal from captive mines. The move is likely to benefit over 100 captive coal and lignite blocks with over 500 million tonnes per annum peak rated capacity as well as all coal and lignite bearing states. This action has paved the way for releasing of additional coal in the market by greater utilization of mining capacities of captive coal and lignite blocks, which were being only partly utilized owing to limited production of coal for meeting their captive needs.

6.2 Impact on Coal Logistics

These are clearly market defining moves and we'll see rapid achievement of the target of producing 1 billion tons of coal by 2024-25. The critical factor needed is that evacuation infrastructure is in place to the move coal from mines to consumption centers. While on the one hand, there is in need to ensure the building of the infrastructure, on the other hand, it is essential the evacuation logistics be efficient and impart cost competitiveness to the coal value chain. This aspect is essential to ensure that the energy consumption of Indian industry comes at a reasonable cost, imparting competitiveness to domestic products in global markets.

The Government of India has also embarked upon evacuation projects in road, rail, ports, and inland waterways to serve the mineral mining geographies in India, including for coal. The ministry of railways has works in progress and works sanctioned but yet to be taken up, with a plan to build adequate capacity for evacuating the enhanced production from India's coal mines. Projects include line capacity enhancement works, new railway lines, new national highways, and special focus on first mile connectivity for evacuation from mines to loading terminals, and onwards to consumption centers.

The Ministry of Coal has prepared Coal Evacuation plan, in consultation with the ministries of Railways, Road Transport and Highways, and Ports and Shipping.

6.3 Smart Coal Logistics – aiding supply chain and efficiencies

In the earlier part of the report, the advantages of sensor-based data acquisition, integration of various data stacks, the ability to correlate supply chain events to identify current and potential bottlenecks, and flag them for action has already been brought out.

Technology must answer the task at hand. To quote the famous words of the architect Louis Henry Sullivan, “Form follows Function.” Since the policy view of the coal market has changed from one that was tightly controlled to a sector that functions on marketplace principles, with participation from a much larger the cohort of private sector investors, it is essential that the method of acquiring data for coal logistics, data analysis, and decision support must also reflect that changed reality.

6.4 A New Approach

Instead of implementing unitary and large systems that are designed to serve large corporations, this report advocates a modern smart coal logistics system based on the following changed realities of the coal sector in India:

- Larger private sector participation
- Entry of new entrants to the sector
- Small size entrepreneurs are entering the mining sector
- Non-captive, sell anywhere approach
- Multi-modal approach to coal transport

This report advocates an open standards-based design, development of modules that address specific and different parts of the coal logistics value chain, and developed around a platform approach. Physical data entry is avoided, and data acquisition is either through sensors and other IoT devices or extracted from service provider platforms through appropriate APIs.

The entire suite of modules and APIs will be available to all miners, and they will be permitted to use them in accordance with their requirements.

6.5 Suggested Modules

Mine Area:

- Estimation of stockpile quantity
- Project progress (new mines)

First Mile Connectivity

- Conveyor Belt – Speed and Quantity
- Vehicles - Movement tracking, Quantity, Logging of Stops, geo-fenced

Terminal:

- Conveyor Belts – Quantity delivered to terminal/CHP
- Vehicles – Movement Tracking, geo-fenced, Quantity
- Loading on trains: Loading time, weighment, train departure from terminal

Infrastructure Projects:

- Physical project progress to established milestones and time targets – intelligence-enables satellite and drone imagery for periodical reports.

APIs:

- Indian Railway FOIS
- Port Community System,
- IWAI – PANI
- GPS-enabled systems of road transport providers

APIs extract data for tracking of movement, logging of stoppages, calculation of speeds, and related events

RMS-based systems, builds up instances:

- Short delivery related to train stops, identify specific station for theft. Correlate number of stops to short quantity deliveries
- Build up record performance of transport service providers – average speeds, on time deliveries
- Track inventories in transit at various points in the supply chain, identify hierarchy of bottlenecks, and aid decisions to better direct investments

6.6 Implementation

Three broad levels of users are envisaged: Ministry of Coal, Coal Mining Companies, and Coal Consumers.

Ministry of Coal and Coal Mining companies will likely have overlapping use cases from the data, with the major difference that the Ministry will concern itself with national snap shots of the entire coal sector, while Mining Companies will be concerned with the supply chain for their specific mines, other assets, and coal consignments. Broadly, these requirements will be:

- Track the progress of mine development, and various infrastructure projects under execution.
- A real time Coal Supply Chain map that includes:
    - Inbound imported coal
    - Coal stocks at mine mouth
    - Coal quantity in first mile transit
    - Coal quantity at loading terminals awaiting dispatch
    - Coal inventories in transit on road, rail, and waterways – on way to consumption points
    - Coal quantities delivered at consumption centres

Coal Consumers will largely be concerned with tracking their inbound quantities, with this data also being available to them from their respective transport service providers. From this perspective the envisaged Smart Coal Logistics system has targeted relevance for the Ministry of Coal and the Mining Companies as the prime users.

6.7 Implementation Methodology

By the very nature of this initiative, a centralized agency will need to play the role of system custodian, who will set standards for the platform, data definitions, as well as the modules. The custodian will also be the single point contact for mining industry to approach for procuring modules and integration with the Smart Coal Logistics platform.

The custodian will need a technology partner to define the standards for hardware devices like sensors and drones etc, that will become standard plug and play devices for commencing data acquisition and porting to the national coal logistics platform.

While standardized hardware will be purchased and installed by the mining companies at their own expense, the national platform can be established and managed as an at cost enterprise. This could be entrusted to an appropriate private sector entity, as has been the case with GeM and GST platforms, to be financed by the user charges from Ministry of Coal and Mining Companies, who are the prime users.

It is recommended that:

- CMPDI can be entrusted the role of Smart Coal Logistics platform custodian
- An IIT or CSIR can be the systems and component standards developer
- An appropriate private sector entity can be appointed after observing due procedure to set up and maintain the platform.

While the system is recommended for Coal Logistics, there is a potential that the platform can develop as a national Mineral Logistics Platform, serving the entire mining industry and its consumers.

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