MINE**X**CHANGE

2023 SME ANNUAL CONFERENCE & EXPO
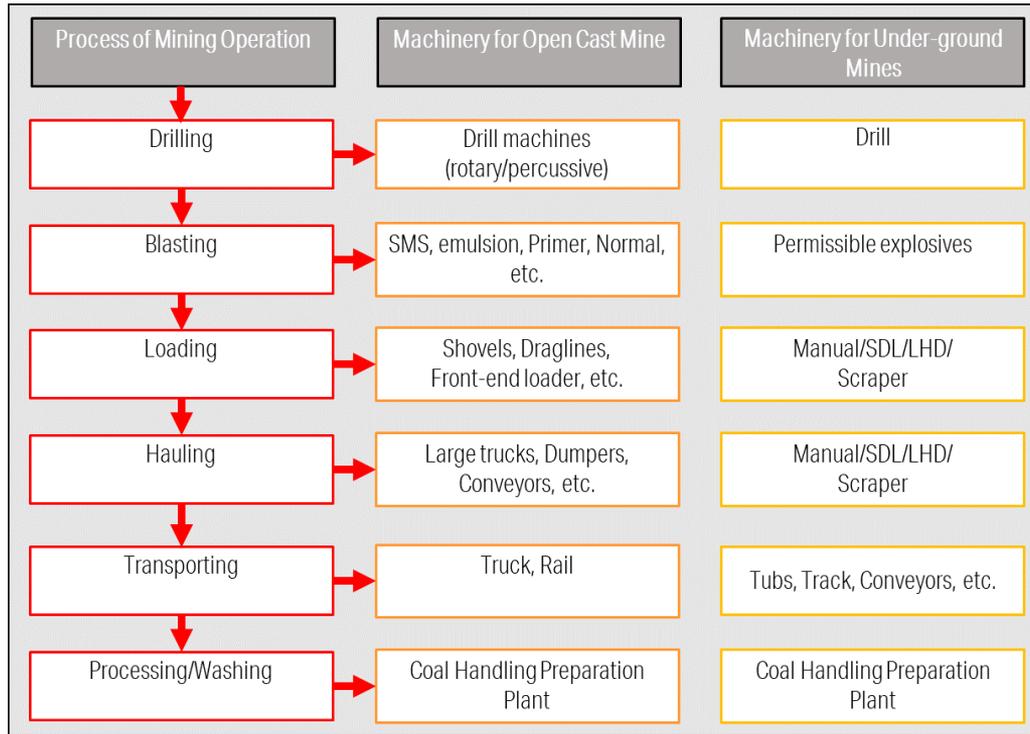
CMA 125th National Western Mining Conference

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PROCESSES OF A MINING OPERATION

Process of Mining Operation	Machinery for Open Cast Mine	Machinery for Under-ground Mines
Drilling	Drill machines (rotary/percussive)	Drill
Blasting	SMS, emulsion, Primer, Normal, etc.	Permissible explosives
Loading	Shovels, Draglines, Front-end loader, etc.	Manual/SDL/LHD/ Scraper
Hauling	Large trucks, Dumpers, Conveyors, etc.	Manual/SDL/LHD/ Scraper
Transporting	Truck, Rail	Tubs, Track, Conveyors, etc.
Processing/Washing	Coal Handling Preparation Plant	Coal Handling Preparation Plant

ELEMENTS OF MINING VALUE CHAIN

Exploration and Planning
Optimize planning and improve sustainability.

Extraction
Autonomous and higher productivity systems.

Process
Smart process control systems that improve product quality.
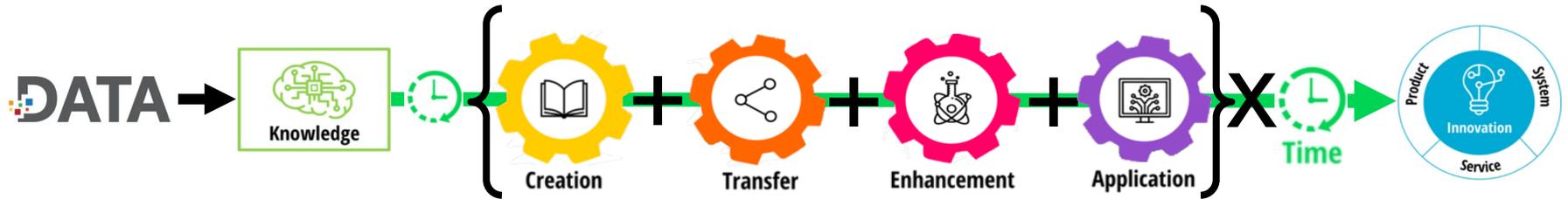
Logistics
Intelligent scheduling and automated loading.

Customers
Meet customer demands by using advanced energy-efficient systems.

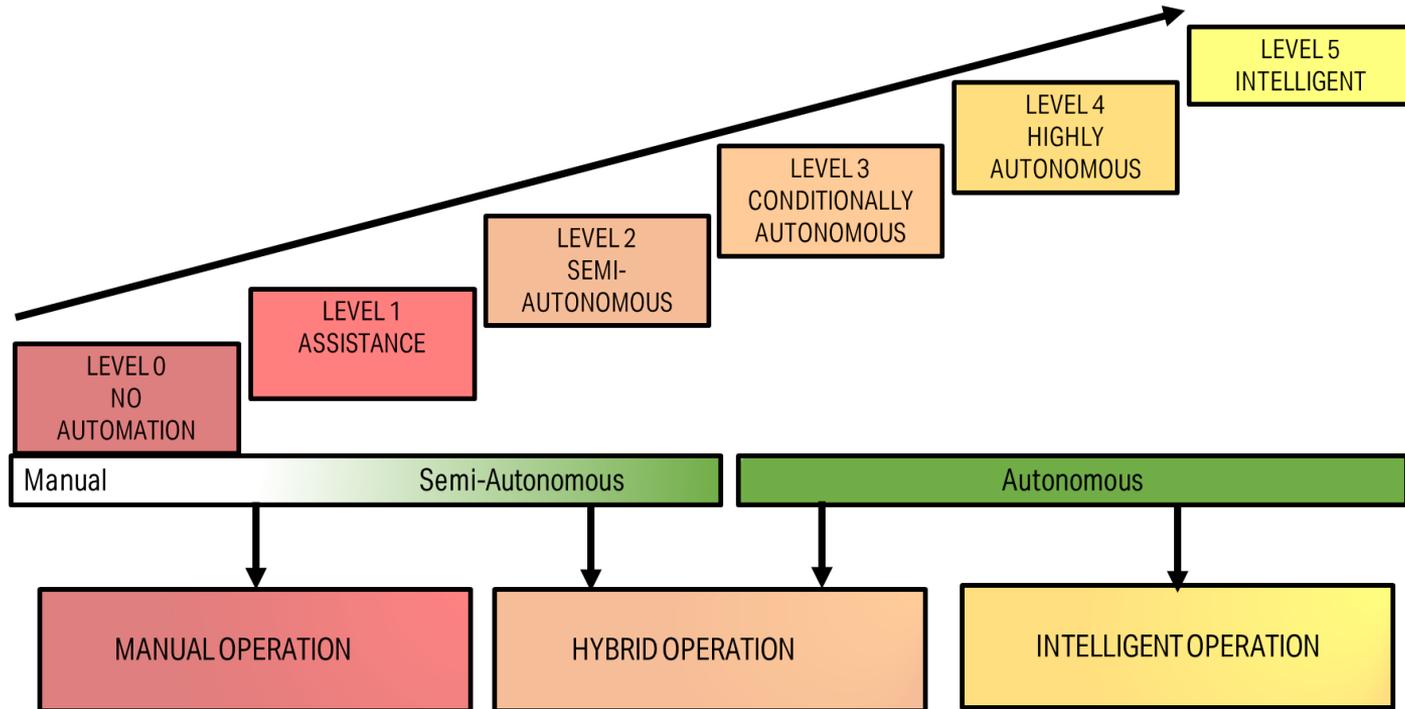# THE INNOVATION EQUATION

Innovation is now considered imperative for the mining industry. Yet, for many, the formula for successful innovation remains obscure.

DATA → Knowledge { Creation + Transfer + Enhancement + Application } × Time → Innovation (Product, System, Service)

This approach set out to build on an understanding of knowledge-related capabilities using a dynamic equation formula. Results indicate that the **four** components – creation, transfer, enhancement, and application – have a significant impact on innovation performance in different mining sectors. Those qualities assist in the modernization, automation, and robotization of mining exploration, development, and production operations by creating a robust mine.

LEVELS OF AUTONOMY

LEVEL 5
INTELLIGENT

LEVEL 4
HIGHLY
AUTONOMOUS

LEVEL 3
CONDITIONALLY
AUTONOMOUS

LEVEL 2
SEMI-
AUTONOMOUS

LEVEL 1
ASSISTANCE

LEVEL 0
NO
AUTOMATION

Manual | Semi-Autonomous | Autonomous

MANUAL OPERATION | HYBRID OPERATION | INTELLIGENT OPERATION

THE 5S MINING INNOVATION MODEL

The **innovation model** is true to the mining industry in general, regardless of the mining method used or the mineral commodity being extracted.
The **five** operational conditions are:

- Achieving maximum **safety**.

- **Simplifying** systems.

- Using **smart**-intelligent solutions.

- Designing **stealth** operations.

- **Sustaining** an environmental-wellbeing economic model.

Safe · Simple · Smart · Stealth · Sustainable

1 SAFETY

The 5S Mining Innovation Model — Sustainable, Safe, Simple, Smart, Stealth

- ✔ VR/AR Training.
- ✔ Biosensors.
- ✔ Fatigue Detection.
- ✔ Health Monitoring.

What needs to be done to achieve it?

Drilling	Blasting	Loading/Hauling/ Transporting	Crushing, Conveying, Smelting, Refining
1. Directional Drilling 2. Advisors located outside hazardous zones.	1. Productive Workforce (remote operation). 2. Operational safety knowledge share.	1. Interactive simulation model of human drivers' autonomous haulage systems. 2. Optimized miners' health by removing the operators from hazardous environments.	1. VR based training program. 2. Wireless internet connection to improve miner safety. 3. Machine learning to minimize human error.

2 SIMPLICITY

The 5S Mining Innovation Model

- Modular Systems.
- Lean Mining Optimization.
- Theory of Constraints.
- Total Productive Maintenance.
- AGILE iterative approach.

What needs to be done to achieve it?

Drilling	Blasting	Loading/Hauling/ Transporting	Crushing, Conveying, Smelting, Refining
1. Day Rate Model Effect. 2. Integrator for Drilling Systems Automation.	1. Multi Attribute Decision Making. 2. Data Envelopment Analysis. 3. Intelligent Design System for Mine Blasting.	1. Tasks involved in autonomous loading: Excavation, Navigation, Obstacle detection, Obstacle avoidance. 2. Trajectory studies of bucket motion. 3. Computer modelling of excavation. 4. Computer simulations.	1. Intellectualization of production process. 2. Collaborative mining production.

3 SMART

The 5S Mining Innovation Model: Sustainable, Safe, Simple, Smart, Stealth

- ✔ Artificial Intelligence.
- ✔ Machine Learning.
- ✔ Big-Data Analytics.
- ✔ Embedded Sensors.
- ✔ IoT based communication.

What needs to be done to achieve it?

Drilling	Blasting	Loading/Hauling/Transporting	Crushing, Conveying, Smelting, Refining
1. Auto-Driller. 2. Remote Data Centers. 3. Smart Alarms.	1. Android Application for Bench Blasting. 2. ANN to Analyze Blast Performance. 3. ANN to predict peak particle velocity. 4. Fuzzy-logic to characterize blasting performance.	1. Use pLTE as medium of communication in the mine. 2. DSRC for autonomous mining vehicles. 3. Hybrid simulator in Development and Testing.	1. Machine learning and AI to maximize plant objective. 2. Neuro-fuzzy systems, ANN.

4 STEALTH

- ✓ Footprint minimization.
- ✓ In-mine recovery.
- ✓ Incremental pit mining.
- ✓ New gen mine caving.

The 5S Mining Innovation Model

What needs to be done to achieve it?

Drilling	Blasting	Loading/Hauling/Transporting	Crushing, Conveying, Smelting, Refining
1. Wellsite Monitoring Systems. 2. Drilling Dynamics Diagnostic Systems. 3. MPD Control Systems. MWD Rotary Steerable Systems. 4. Stick-Slip Surface Control.	1. Quality Control in Ground Control Management System. 2. Quality Assurance in Ground Control Activities. 3. Quality Assurance in Blasting Inspection and Monitoring.	1. Permission control to prevent dump trucks getting in each other's way.	1. Real-time implementation of micro-controllers to monitor and control Plant operations. 2. Monitoring of metallurgical performance.

4 SUSTAINABILITY

The 5S Mining Innovation Model — Sustainable, Safe, Simple, Smart, Stealth

✓ Social responsibility.
✓ Promoting economic growth.
✓ Community involvement.
✓ Sustainability through tech.

What needs to be done to achieve it?

Drilling	Blasting	Loading/Hauling/ Transporting	Crushing, Conveying, Smelting, Refining
1. Reduction in Fuel Consumption. 2. Reduce Power Consumption. 3. Optimization of well footprint.	1. Efficient recovery of mineral by reducing the amount of waste. 2. Predictable outcomes from precision blasting. 3. Minimize use of explosives.	1. High level of driving and handling performance. 2. Improve performance characteristics of the trucks. 3. Increase NPV. 4. Decrease in fuel consumption. 5. Increase tire lifetime. 6. Increase production. 7. Reduce fleet with less employed AHS.	1. Climate-smart mining. 2. Recycling. 3. Efficient smelting processes. 4. Eco-efficiency in milling processes.

SURFACE COAL MINING

SAFE
1. VR training for the operation of unmanned equipment.
2. Reduce driver fatigue and attrition.
3. Improved work conditions.

SIMPLE
1. Autonomous mine mapping.
2. Smart Spatial-temporal analyses of surface coal mines.

SMART
1. Decision support system for post-mining land use of abandoned surface coal mine.
2. Autonomous vehicle localization.
3. Smart communication.
4. Use of robotics.

STEALTH
1. Autonomous Haulage and Load Haul Dump operations.
2. Global Navigation Satellite System technologies for positioning and localization.
3. Automation and Remote Control of Continuous mining system.

SUSTAINABLE
1. Sustainable rehabilitation using predictive models.
2. Operating costs reduction.
3. Fuel consumption reduction.
4. GHG reduction (Net zero carbon).
5. Unscheduled Maintenance reduction.

UNDERGROUND COAL MINING

SAFE
1. Automated longwall mining.
2. Internet connectivity for better mine safety supervision.
3. WiFi access to facilitate. communication
4. Smart PPE.

SIMPLE
1. Human health and safety risks management using TOPSIS.
2. AI for assessment and management of roof fall risks.
3. GIS-based monitoring and management system for safety.
4. AI for identification of safety hazards.

SMART
1. Rock bolt monitoring using smart sensors.
2. Localization and smart data transmission.
3. Low power smart helmet for real-time remote monitoring.
4. Intelligent mine based on 5G wireless communication system.
5. Smart refuge-alternative systems.
6. Intelligent gas monitoring (Arduino).

STEALTH
1. Intelligent mine monitoring.
2. Mining equipment management.
3. Real-time positioning.
4. IoT to predict communication and tracking system performance.
5. Autonomous shuttle car and roof bolter operations.

SUSTAINABLE
1. Environmental sensing.
2. Coal seam water monitoring.
3. Mine safety management and disaster forecasting.
4. Accident analysis.
5. GHG reduction (Net zero carbon).
6. Predictive energy optimization, such as ventilation on demand.

# MANAGEMENT OF THE PERFORMANCE INDEXES BASED ON TECHNOLOGY TRENDS

Implementation of the <u>E-mine</u>
The concept allows for:

- ✔ Online management.
- ✔ Intelligent monitoring operations.
- ✔ IoT based communication of tracking system performance.
- ✔ Remote diagnostics.
- ✔ Smart equipment sensing.
- ✔ Mine safety management and disaster forecasting.

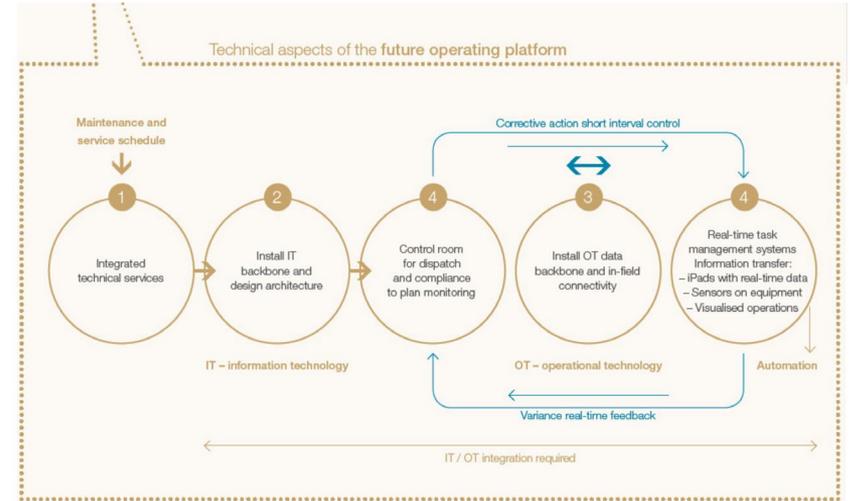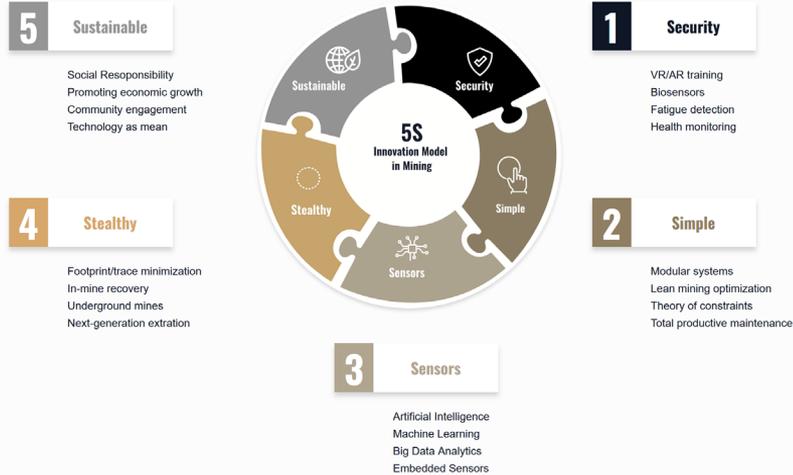# MANAGEMENT OF THE PERFORMANCE INDEXES BASED ON TECHNOLOGY TRENDS
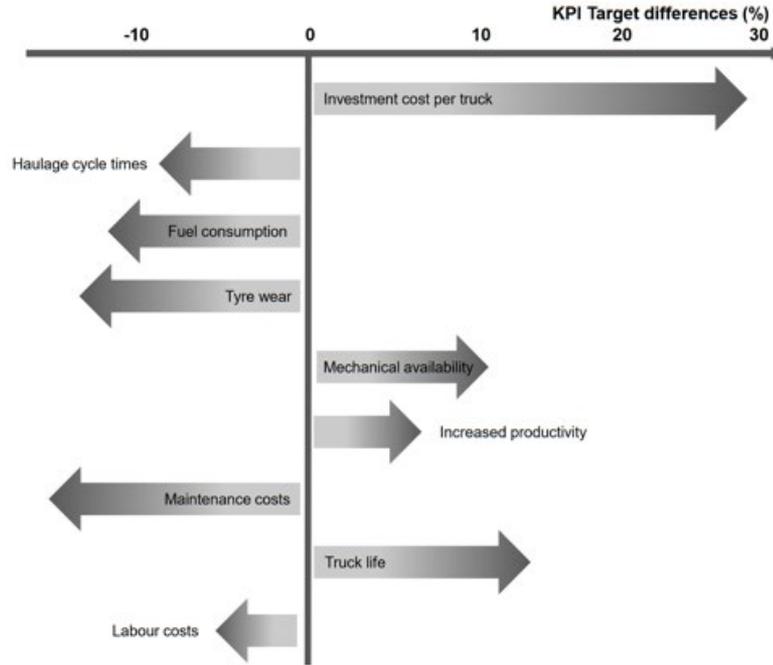
Example of the Autonomous Hauling Operation
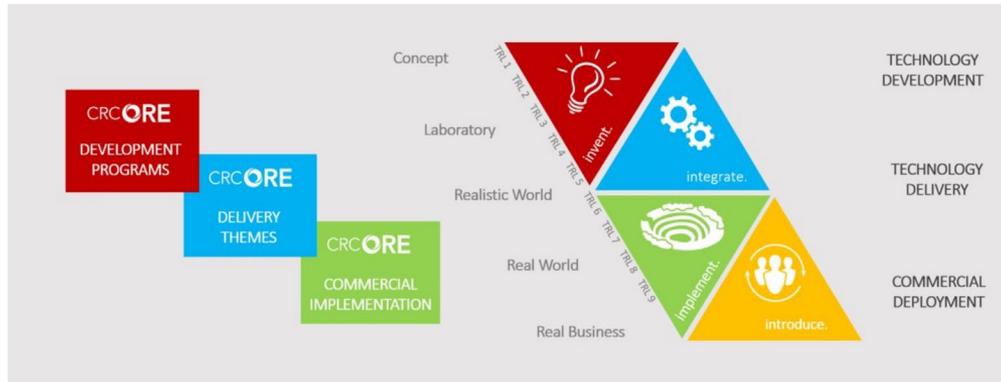
WORLDWIDE ACCEPTANCE

WORLDWIDE ACCEPTANCE

OUR INNOVATION PATHWAY

CRC ORE's Innovation Pathway was based on a pipeline of activities that span the widely used Technology Readiness Level (TRL 1-9) scale of technology maturity.

- Invent (TRL3-5)
- Integrate (TRL5-7)
- Implement (TRL7-9)
- Introduce (TRL1-9)

GPS and Google Earth based 3D assisted driving system for trucks in surface mines

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Abstract: To reduce the surface mining accidents related to low visibility conditions and the truck blind spots, to provide the 3D information for the truck drivers and real time monitored truck information for the remote dispatcher, the 3D assisted driving system (3D-ADS) based on the GPS, the mesh-wireless networks and the Google-Earth engine as the graphic interface and mine-mapping server was developed at Virginia Tech. The research results indicate that 3D-ADS system potentially increases reliability and reduces uncertainty in open pit mining operations by customizing the local 3D digital mining map, constructing the truck 3D models, tracking vehicles in real time using a 3D interface and indicating available escape routes for driver safety.
Keywords: surface mining safety; 3D simulation; assisted driving system; Google earth; GPS