Addressing Climate Change Proactively: The Application of Intelligent Vehicles and Artificial Intelligence in Mining

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the Chief Scientist of WAYTOUS

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## Background of mining development in China

### The ultimate goal of intelligent mining development

**Safety**

**Energy-saving**

**Environment-friendly**

**Efficient**

### Difficulties in transportation

<table>
<thead>
<tr>
<th>High losses due to accidents</th>
<th>Labor shortage</th>
<th>Operation modes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal-Accident from 2018 to 2022</td>
<td>The proportion of post-90s employees</td>
<td>Inefficient scheduling</td>
</tr>
<tr>
<td>~2.3K</td>
<td>&lt; 5%</td>
<td>Traditional technology</td>
</tr>
</tbody>
</table>

### Policy

- Ensuring coal supply and energy security are two major political tasks. Equipment upgrading and intelligent development are two major means to expand supply.

- The primary goal is to transform mechanized operations into digitized, automated, and intelligent processes, with safety as the core foundation.

### Huge size

- The Number of mines: 58K
- Large mines: 4,324

### Meaning

- The Proportion of GDP: ~7%
- The Coal production in 2022 hits a new peak: 4.56B T, 8%↑
Intelligence is the only way for the high-quality development of mines

The 4IR is coming
The technology of 5G、AI、Big Data, etc. have been widely used in the industry
The industrial innovation is now being triggered

By the year 2023, the development of intelligent mines is still in its infancy.

1、The number of intelligent mining faces increased from 494 to 1019, with a year-on-year growth of 42%.
2、The number of unmanned mines increased from 242 to 572, with production capacity increasing from 850M Tons to 1.936B.
3、The number of types of underground mining robots increased from 19 to 31.

2020-First Year
The national policy provided a clear plan for the development of intelligent mines for the first time.

2021-Short Term
71 demonstration coal mines with intelligent construction have completed preliminary acceptance.

2025-Mid-Term
The large-scale coal mines and coal mines with severe disasters will be mostly intelligent.

2035-Long Term
Comprehensive intelligence will be achieved in all aspects. The workforce will be reduced by more than 80%. 

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**Insights into sustainability of AI for mining operations**

**Waste recycling**
AI can help to build modeling of mineral waste generation and improve decision making on waste recycling and reduction.

**Autonomous transportation**
AI technology can support the development of low carbon systems and thus reduce energy consumption during mining operations such as mining transportation. **Mining autonomous transportation** enabled by self-driving technology can contribute to fuel consumption reduction thanks to the more efficient route and smooth control offered.

**Monitor activities**
Remote sensing and machine learning technologies are applied to **monitor illegal mining activities**, which have a greater risk of environmental pollution.

**Assess environmental risks**
AI models have been used to assess environmental risks to nearby ecosystems of **blast-induced dust emissions**, making decisions on distance range and time interval of mine blasting to minimize disruption to the nearby community.

**The Use of Intelligent Vehicles and Artificial Intelligence in Mining Operations: Ethics, Responsibility, and Sustainability**

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WAYTOUS utilizes autonomous transportation to empower the high-quality development in the mining industry.
Core Technology: CPSS-Based Parallel Intelligence

- Autonomous Fleet Management System
- Autonomous Mining Truck System
- Parallel Mine Simulation System
- Collaborative Loading Management System
- Avatar Driver System
- Intelligent Roadside Cooperative System

Parallel Intelligence
Intelligent technologies are tested on virtual and real mines to guide vehicles to complete various scenario-based tasks in real-world through single-vehicle operation, multi-vehicle collaborative systems, and vehicle-road collaborative systems.

Real-Virtual Interaction
The parallel mining system utilizes machine learning algorithms to complete virtual operations and guide real vehicles. The remote monitoring center supervises the state of the whole mines and provides remote control functions.

Collaborative Operation
The entire system ensures resource scheduling and guarantees the efficient running through the collaborative work of various subsystems.
Applications

ZHANG'ER Coal Mines Project, China Energy Group

- 36 vehicles
- Maximum speed 40km/h
- Unmanned capacity 461,400 m³/ Month
- The average monthly transportation volume of manual driving is 450,000 m³/month

BAOTOU Coal Mine Project, China Energy Group

- 38 vehicles
- Maximum speed 40km/h
- It has been over 24 months since the first safety supervisor disembarked from the vehicle, marking the longest duration in China.

YINHAI Coal Mine Project, China Huaneng Group

- 8 NHL Trucks in operation
- Maximum speed 35km/h
- Achieved 93% efficiency of manned vehicles

HESHANGQIAO Iron Mine, China Baowu Steel Group

- Fully unmanned

HUALIAN Zinc-Indium-Tin Mine, Yunnan Tin Group

- Fully unmanned
The first pure electric, digitized, and environmentally friendly smart mine in the domestic cement industry

Jidong Cement Mine, Yangquan, Shanxi

It is the first demonstration project in the domestic cement industry to achieve a pure electric, digitized, and environmentally friendly smart mine. With the integration of 5G technology and intelligent mining, this project replaces 12 fuel-powered mining trucks with 8 fully electric unmanned wide-body vehicles, ensuring safe and efficient production in open-pit mining operations.

✓ Addresses the challenge of unmanned driving positioning in crushing stations with no or weak GNSS environment
✓ Updates the complex geologic HD map in real-time
✓ Establishes the first collaborative intelligent unloading system
✓ Reaches an average operating efficiency of 90%
✓ Saves monthly > ¥30000
Huarun Cement Mine: Dual improvement in cost reduction and carbon emission reduction

Huarun has replaced all 9 manual mining trucks with 5 fully electric mining trucks and has implemented unmanned driving technology on these electric vehicles. This enables the entire logistics process of loading, transportation, and unloading to be operated autonomously.

- 83% Annual operating costs reduction
- 68% Annual CO2 emissions reduction
Technological Innovation Facilitates the “Belt and Road”: China's Autonomous Driving Technology Implemented in Thailand's Mining Area

**Mines profile**

- Cement Mine (Khao Wong Mining)
- Yearly output: 9 Million Tons, large production
- Total operation equipment 24+ unit, 7*24

**The first 5G+ autonomous driving smart green mine project in Thailand**

Thailand's first 5G+ autonomous driving smart green mine project is located in SCG Salaburi mining area, with a total investment of 10 million US dollars. Relying on the comprehensive application of 5G, artificial intelligence, autonomous driving, cloud computing, new energy power batteries and other cutting-edge technologies, the mining area will be built into a green, intelligent, efficient and safe new mine. It has become a leading model of mines in Thailand and even Southeast Asia.
CarMo - The New Energy & Intelligent Platform

Forward-design 24-hour electric autonomous truck

- Battery (kwh): 525
- Climbing: 35%
- Power (kw): 450
- Speed (km/h): 40
- Dimension (mm): 8980×3550×3420
- Carrying (kg): 60000
- Turning Mode: Electro-hydraulic steering
- Charge Mode: Dual fast charge

Full perception Multi-scenarios control mode GNSS
High-performance platform Digital management
CarMo- Forward-design for Autonomous Driving

- Convergent design towards complete autonomous driving
- Feature adding and system upgrading uninterruptedly, and it continues to optimize over time

- high-capacity battery enables long-distance driving and heavy-duty climbing
- precise energy control strategy maximizes performance and extends the life of the power unit

- capability of intelligent shifting gears in motion
- torque compensation strategy to avoid shifting shocks and power interruptions

- intelligent electro-hydraulic steering system supports steering following, stable steering at a low speed, and achieving accurate steering control within 0.3°

- full vehicle wire control technology and safety control strategy make the vehicle safety and reliable
**CarMo- More economical, more efficient, safer and smarter**

<table>
<thead>
<tr>
<th>Manual Fuel-base Truck</th>
<th>CarMo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>0</td>
</tr>
<tr>
<td>Consumption (¥/km)</td>
<td>0</td>
</tr>
<tr>
<td>Safe</td>
<td>0</td>
</tr>
<tr>
<td>Green</td>
<td>0</td>
</tr>
<tr>
<td>Intelligence</td>
<td>0</td>
</tr>
<tr>
<td>Efficiency</td>
<td>0</td>
</tr>
</tbody>
</table>

- **Manual Fuel-base Truck Costs**:
  - >800K
  - 16.16
- **CarMo Costs**:
  - 0
  - 5.20

- Difficult to eliminate hidden dangers
- 1 truck ≈ 655 vehicles

**The whole energy cost saves**

**67.8%**

Compared to traditional manned fuel mining trucks

- Suitable for unmanned systems
- CO2 emissions per truck per year: -1200 tons
- Loading volume: 5%↑
- Tire consumption: 8%↓
- Scheduling efficiency: 15%↑
In 2023, WAYTOUS and China University of Mining and Technology (Beijing) established a collaborative base of smart mines that integrates production, academia, and research. The goal is to cultivate a group of researchers and engineers with strategic vision and outstanding capabilities in the field of mining, promote technological innovation and industrial development, and push the development of intelligent mining into a new era.

In Aug. 2022, WAYTOUS, in collaboration with the Chinese Automation Society, established the Smart Mine Professional Committee and held the first academic forum, the Smart Mine Innovation and Development Forum. In Jun. 2023, WAYTOUS deeply participated in the "Key Technologies and Application Demonstration of Large-scale Open-pit Mine Robotized Autonomous Transport and Transportation System” held by the intelligent robotics project, the National Key R&D Program.

In Jun. 2023, the National Mine Safety Administration officially released the "Intelligent mine data fusion and sharing standard". WAYTOUS played a significant role in the development of 11 standards, contributing to the standardization of intelligent mines in the country. Up to now, WAYTOUS has taken the lead or participated in the formulation of more than 50 standards.

Technological Innovation and Sustainable Development
Future Intelligent Mining

Mining Robotics supported by Control and Management Platform

Hybrid Enhance Parallel Intelligence

**Autonomous Mode**
Under normal circumstances
All equipments running without human

**Parallel Mode**
Under special circumstances
Mixed operation of manual intervention and unmanned mode

**Emergency Mode**
In an emergency
Emergency response team handled it manually

Core Capability

**System**
Fully Autonomous with high Stability, high Safety, high Efficiency

**Platform**
Intelligent Command and Control + Strong Data Capability

**Vehicles**
new Unmanned Transportation Terminals for AHS
Building a Modern Harmonious Human Society with Nature