Unmanned transportation technologies promote the sustainable development of the mining industry

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TAGE IDRIVER    Jul, 2021
300,000 years ago, the homo sapiens
Obtained resources by gathering

10,000 years ago, humans after the
agricultural revolution
Obtained resources by agriculture and
 gathering

Today, WE
Obtaining resources by
agriculture and gathering STILL!

Mining is our primary means
of gathering.

70% agricultural resources come from mining
85% raw material comes from mining
95% energy comes from mining

Why does mining matter?
Why do open-pit mines need unmanned solution

4 prominent pain points, unmanned solution is urgently needed

<table>
<thead>
<tr>
<th>Pain Point</th>
<th>Description</th>
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<tbody>
<tr>
<td>Labor Shortage</td>
<td>Remote and harsh working condition causes labor shortage</td>
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<td>Rising cost</td>
<td>High labor and management cost, High operation and maintenance cost</td>
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<tr>
<td>Low Efficiency</td>
<td>Low intelligence level, lack of data-based management means</td>
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<td>Frequent Safety incidents</td>
<td>Harsh working environment, frequent safety incidents</td>
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Mining area is the ideal scene for autonomous driving

- Enclosed, and well controlled
- Semi-fixed lane
- Low speed, P2P

Mining area characteristics

- Safety
- Cost
- Efficiency

Mining area is ideal for unmanned vehicle
旷谷™ Unmanned Valley

幽谷空旷，唯机械朝夕而作
无人，无险，旷古而烁今

“Unmanned Valley”，TAGE’s unmanned solution for open pit mines, is a complete set of unmanned transportation system consists of:

- Onboard system – “Rationalist”,
- Ground system – “Watchman”,
- Cloud based fleet management system – “Dubhe”.
Overview of the “Unmanned Valley”

1. Parking lot: Automatic depart & return
2. Testing field: Static/dynamic test
3. On the road: Following
4. On the road: Collision avoidance
5. Crusher: Fixed location dumping
6. Loading area: Cooperation via V2V
7. Dumping field: Dynamic location dumping
8. RSU: Hazard warning
9. RSU: Blind spot perception
10. RSU: Dual network redundancy
11. 5G Base station
12. RTK reference station

Other scenes:
- Blast sheltering
- Rain/Snow
- Refueling
- Malfunction

“Unmanned Valley”
The “Vehicle – Ground – Cloud” system structure

Cloud based platform “Dubhe”

Ground system “Watchman”

Onboard system “Rationalist”

**Production Plan**
- Intelligent Dispatching
  - Task schedule
  - Right-of-way
  - Data analysis
- Route planning
- Safety forecast
- System configuration

**Maintenance Plan**
- Monitor
  - Real time monitoring
  - History replaying
- HD Map
  - Map maker
  - Map Publish/update

**Modification Plan**
- Management
  - Production monitor
- Equipment
  - Emergency response

**Engineering design**

**Dispatching Center**

**Field Terminals**
- Vehicle Management
- Equipment Management
- Status Display

**Field**

**RSU**
- Network redundancy
- Hazard Warning
- Traffic Management

**TAGE unmanned transport system “Unmanned Valley”**

**Manned vehicles OBU**
- Emergency processing
- Position report
- Collision Warning

**Unmanned truck OBU**
- Environment perception
- Task execution
- Route Planning
- Fault diagnosis

**Auxiliary OBU**
- Cooperative operation
- Collision Warning
- Positioning

**Auxiliary Tools**
- UAV GIS mapping
- Truck parameter calibration

**Non-production vehicles**

**Unmanned truck**

**Auxiliary vehicles**

**On-site operators**
The onboard system "Rationalist" consists of unmanned truck terminal, auxiliary vehicles’ terminals (excavator, dozer, etc)
HW configuration has been optimized to adapt to the open-pit mining environment.
"Rationalist" unmanned truck OBU

- V2X and Positioning
- Perception
- MainBox with Huawei 5G Module
- Remote stopper
- Wire controlled chassis
- Vbox
- HMI
- Steering robot
- Braking robot
"Rationalist" auxiliary vehicle OBU

- GNSS
- V2X
- TBox
- Excavator terminal
- Dozer terminal
- Manned/unmanned composite fleet terminal
- Other vehicle monitor and protection
The ground system "Watchman" includes road side units (RSU) and various ground control terminals (refueling area, crushing station, maintenance area, etc.) which are the safeguards for the stable operation of the system.
"Watchman" ground system

- **MainBox**
  - GNSS
  - V2X
  - Lidar/Rader
  - Camera

- **Roadside unit (RSU)**
  - HD video monitoring via 5G
  - Intersection blind area perception
  - Regional dispatching based on edge computing
  - Relay station for dual network redundancy

- **Crusher**
  - Crusher status management
  - Unloading position dynamic allocation
  - Parking area queuing management
  - Remote emergency braking
As the intelligent management center of the unmanned transportation system, the cloud based platform "Dubhe" is managing dispatching planning, right-of-way command and centralized monitoring to provide safe and reliable cloud services for the unmanned transportation system.
"MineSIM" simulation system
SIL / HIL / DIL / VIL for agile iteration
Dynamic auto loading

Dynamic auto dumping

Remote takeover

Automatic depart/return
Business cases

**Bayan Obo Iron Mine**
17 unmanned mine trucks, China’s 1st national unmanned mine truck demonstrator plot.

- **2018, Oct** Launched the 1st unmanned truck
- **2019, Sep** Passed expert group review Signed commercial contract
- **2019, Dec** Stage I Acceptance of 4 trucks’ fleet
- **2020, Oct** Stage II Acceptance of 6 trucks’ fleet 7x24h
- **2021, Aug** Final Acceptance of 17 unmanned trucks fleet
**Erdos Yongshun coal mine**

Signed commercial operation contract of 200 unmanned non-rigid dumper with one of the largest mine transportation EPC - Inner Mongolia ZHXL

- **2019, Sep** Signed commercial contract
- **2020, July** Stage I Acceptance of 8 unmanned dumpers fleet
- **2021, Feb** Stage II Acceptance of 20 unmanned dumpers fleet
- **2022, July** Final Acceptance of all 200 unmanned dumpers
SPIC Huolin river coal mine
The 1st open tendering project of coal mine unmanned transportation in China

- 2019, Sep: Signed commercial contract
- 2019, Nov: Phase 1 acceptance
- 2020, May: Realized night shift work
- 2020, Jun: Final acceptance
1015 days 0 accident operation
Cumulative driverless operation 71406km
Cumulative freight volume 564325tons