VG Karier Mine Fleet Management System
More than 25 years in the market

Flexible solutions with guaranteed quality

Own development of Software and Hardware

More than 100 highly qualified employees involved in design, development, deployment and support

Member or the Russian Silicon Valley Skolkovo with the Intelligent Mine project

Russian Government Award for VG Karier Mine Fleet Management System in 2009

More than 50 Mine Fleet Management Systems deployed
# HISTORY

## 25 YEARS on the market

### 1988-1994
- Foundation of the company
- Geological and planning systems sales, implementation and support
- Geological services
- Partners with DATAMINE, MINCOM, GEMCOM

### 1995-2001
- The development of the Mine Fleet Management System
- Partnership with BELAZ mining trucks manufacturer
- First several implementations of the Mine Fleet Management System

### 2002-2008
- Opening of wide range of regional offices and companies in Russia, Belarus, Ukraine
- New implementations of the VG Karier System and continuous development of the features of the system.
- Development of the VG Railway automation for control and management of the railway station

### 2009-2010
- Developments of the VG Safety system for managing and control of the safety on the mines. (Environment, health and safety system)
- The remote controlled (tele-operated) mining truck (BELAZ 130t) was developed and tested.
- VG Farming system for managing the agriculture vehicles were developed.
- New version of VG Karier system is developed.
- The Russian Government Award for the VG Karier system

### 2011-2014
- Diagnostic system for the electric shovels is developed to supply to the manufacturer of the shovels
- New version of VG Karier system is developed.
- Development of the Autonomous mining truck and successful testing on the factory.
- The members of the Russian innovative foundations – Skolkovo with Intelligent Mine project.
- Supporting of Russian government institution for wide industrial deployment and international expansion

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VIST GROUP NOW

THE OWNERS AND TEAM

Private company

Among the team:
- 5 PhD
- 6 laureate of governmental award
- Doctor of Science

ISO 9001 accreditation

Supported by:

Ministry of trade

Ministry of economical development

Ministry of Natural resources

Safety regulation authority

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**VIST Group:**

**Headquarter** - Moscow

**Branch Offices**
- Kemerovo, Mezhdurechensk, Stary Oskol, Kovdor, Olenegorsk, Zheleznogorsk, Magnitogorsk

**Subsidiary companies**
- VIST Group Tekhnicheskiy Centr, Kryvyi Rih (Ukraine)
- VIST Sensor, Minsk (Belarus)
- BV International, Danvers, Mass., (USA)
- Kazakhstan
- Morocco (project 2015)

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## PRODUCTS AND SERVICES

### Mining companies

- **VG Karier**
  - Mine Fleet Management System

- **VG MINETRUCK**
  - Web-based service for mining companies with OEM systems to monitor the activities of the fleet

- **VG HOLDING**
  - System for headquarters provides the deep analysis and comparison of the operations of the mines

### Manufacturers of the mining equipment and dealers

- **VG SERVICE**
  - Web-based service monitoring system for dealers and manufacturers of the mining equipment

- **IDS**
  - Diagnostic system for the electric shovels is developed

### Industrial companies

- **VG Railway**
  - Automation systems for control and management of the railway stations

- **VG Safety**
  - System for managing and control of the safety on the mines and factories

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ВИСТ Групп
Внедрение Информационных
Систем & Технологий

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### PRODUCTS AND SERVICES

<table>
<thead>
<tr>
<th>Products</th>
<th>Services</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fleet monitoring</strong></td>
<td><strong>VG FLEET</strong></td>
</tr>
<tr>
<td></td>
<td>Fleet monitoring system for vehicles on public roads</td>
</tr>
<tr>
<td><strong>Agriculture</strong></td>
<td><strong>VG FARMING</strong></td>
</tr>
<tr>
<td></td>
<td>System for managing the agriculture vehicles</td>
</tr>
<tr>
<td><strong>Services</strong></td>
<td><strong>Audit of mining operation</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Service and maintenance</strong></td>
</tr>
<tr>
<td><strong>Intelligent Mine</strong></td>
<td><strong>Autonomous and tele-operated mining equipment management system</strong></td>
</tr>
</tbody>
</table>
VIST Group MINE FLEET MANAGEMENT SYSTEM IS INSTALLED ON MORE THAN ON 50 MINES

- OCP Group
- Severstal
- Magnitogorsk Iron and Steel Works
- LUTEK
- Siberian Coal Energy Company
- SDS
- SIBUGLEMET
- EVRAZ
- METALLOINVEST
- ArcelorMittal
- Joint Venture "ERDENET"
- Mechel
- POLIMETALL (Gold)
- Eurochem
- ENRC
- SSGPO
- KuzbassRazrezUgol
- Metinvest Holding
- POLUS Gold
- NLMK
- DGK
- UGMK
- EN+
- SMR
- SUEK

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 PRODUCTS ARE INDEPENDENT FROM THE TYPE OF MINERALS
PRODUCTS AND SERVICES

VG Holding – reporting and KPIs for headquarters

VG Drill – drill high precision guidance

VG Scarex – excavators high precision guidance

VG Railway – railways automation and dispatching

VG Fleet – public and auxiliary transport monitoring

Payload, diagnostic systems, additional sensors

Audit of mining activities and performance of VG Karier system

Collision avoidance systems Orlaco

Software for work orders and safety instruction management

Reutech slope stability monitoring radars

VG Karier Mine fleet management system

VG MineTruck

Autonomous and tele-operated systems for mining equipment
VG Karier

Mine Fleet Management (Dispatch) System
Benefits of the system

- Increased Mining Fleet Productivity
- Increased Mining Equipment Availability and Life Cycle
- Improved Mineral Quality Management
- Increased Safety of Mining Works
- Reduced operational costs and fuel consumption
Increase of productivity 5-20%

Reduce of the operational and maintenance costs 5-10%

Increase the level of safety

Increase the responsibility and work culture of workers

The average efficiency of VG Karier calculation is based on approved statistics from mining enterprises

• Fleet and excavators efficiency and productivity increase by 8-17%
• Operation costs decrease by 2,5 – 9%
• Fuel consumption decrease by 10-20% (fuel economy and improper use)
What is the increase of productivity?

- **Optimization and automatic dispatching**: 10-15%
- **Payload optimization**: \( \frac{190 \text{ t}}{175 \text{ t}} \approx 8\% 
- **Stops and delays reducing (shift changing, repairs)**: 4%
- **Availability of mining equipment**: 

Use less trucks for the same hauling volumes and use same truck to haul more!

VG KARRIER Mine Fleet Management System
### Efficiency and productivity

<table>
<thead>
<tr>
<th>Trucks</th>
<th>Absolute increase</th>
<th>Av. for last 3 months</th>
<th>feb</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>Sept.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usage of the load capacity</td>
<td>6%</td>
<td>%</td>
<td>92%</td>
<td>94%</td>
<td>94%</td>
<td>94%</td>
<td>93%</td>
<td>96%</td>
<td>98%</td>
<td>98%</td>
</tr>
<tr>
<td>Average productive time</td>
<td>14%</td>
<td>hour</td>
<td>6,36</td>
<td>6,66</td>
<td>6,69</td>
<td>6,5</td>
<td>6,52</td>
<td>6,92</td>
<td>6,81</td>
<td>7,22</td>
</tr>
<tr>
<td>Average fuel consumption</td>
<td>-14%</td>
<td>g\tkm</td>
<td>119,18</td>
<td>117,62</td>
<td>108,72</td>
<td>110,04</td>
<td>110,56</td>
<td>103,86</td>
<td>100,13</td>
<td>103,09</td>
</tr>
<tr>
<td>Feature</td>
<td></td>
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<tr>
<td>Automatic dispatching and optimization</td>
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<tr>
<td>Quality management as well including the high precision navigation</td>
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<tr>
<td>for excavators</td>
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<tr>
<td>Real-time management and reporting for each type of vehicles</td>
<td></td>
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<tr>
<td>High Precision Drills guidance</td>
<td></td>
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<tr>
<td>Tires management and diagnostics</td>
<td></td>
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<tr>
<td>Road quality monitoring</td>
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<tr>
<td>Repairs and maintenance management</td>
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<tr>
<td>Overall fuel monitoring</td>
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<tr>
<td>Remote diagnostics</td>
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</tr>
<tr>
<td>Additional features (gas monitoring, water pipes monitoring etc)</td>
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</tr>
</tbody>
</table>
Planning, Real time management, Statistics

- Real time proved statistics
- Real time management
- Period statistics
- Integration
Structure

Mining Equipment

Sensors, Health monitoring systems
On-board PC, Navigation

Wireless Communications

ERP, MES, EAM, Geological etc.

System Server

LAN
On-board equipment
On-board equipment

- Industrial Rugged PC with 7” LCD Touch Screen
- Wireless Communication Unit
- Sensors, Diagnostic and Control Systems
- Navigation System

Trucks
Excavators
Loaders
Drills
Trains
Dozers
Refuellers
Auxiliary Transport
**KARIER On-Board Equipment**

**Intelligent Panel IP-01**

- 2 x CAN
- 2x RS232 or RS485
- 1x Ethernet
- Audio output
- USB (optional)
- DVI (optional to connect external monitor)

**Analog to digital converter**

- Input type: mV, V, mA
- Output type: RS-485

**MESH WiFi modem with antenna**
# KARIER On-Board Equipment

## Navigation unit NB-04 – GPS + GLONASS

<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receiver + antenna</td>
<td>In one housing</td>
</tr>
<tr>
<td>Max length of cable</td>
<td>100 m between the IP-01 and NB-03</td>
</tr>
<tr>
<td>Interfaces</td>
<td>CAN</td>
</tr>
<tr>
<td>Power supply</td>
<td>18...32 V DC Protected for overvoltage and changing the polarity</td>
</tr>
<tr>
<td>Max. consumption</td>
<td>1A on 24VDC</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>-40°C...+85°C</td>
</tr>
<tr>
<td>Housing</td>
<td>Plastic, IP67</td>
</tr>
</tbody>
</table>

## DC-DC Converter

### Operation hours calculating sensor

### Basic equipment
On-board equipment

- No data can be lost
  - all data is being stored on on-board PC and sent to server

- Voice automatic playing of the messages as well as displaying on the screen
  - Operator will be informed twice

- Rugged design and metallic housing of on-board equipment
  - wide range of operating conditions

- Ability for operator to send messages
  - communication with a dispatch manager
On-board equipment

Remote setting and upgrade of SW

- Availability to do maintenance even from headquarters and vendor site

RS 232, 485, CAN, Ethernet, DVI available

- Many additional external devices can be connected

GLONASS\GPS receiver with internal antenna and CAN interface

- Mount without coax cable – less distortions and high quality signal
On-board equipment

Wide ability to extend number of inputs /outputs

Motorola MESH Connex WiFi

Ethernet Switch

Video Camera

Intelligent Panel IP-01

Inclination sensors

Navigation unit

Weighing system

Fuel sensors

Analog to digital converter

Signal concentrators

Operating hours Bucket opening Etc.
## Options available

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weighing system for trucks</td>
<td></td>
</tr>
<tr>
<td>Fuel level sensor (for every type of equipment) &amp; cable kit</td>
<td></td>
</tr>
<tr>
<td>Tires pressure monitoring system</td>
<td></td>
</tr>
<tr>
<td>Hydraulic Excavator On-board Equipment for cycle counting and fuel monitoring</td>
<td></td>
</tr>
<tr>
<td>Electric Excavator and Dragline On-board Equipment for cycle counting and fuel monitoring</td>
<td></td>
</tr>
<tr>
<td>Tanker On-board Equipment for filling monitoring and fuel level in the tanker</td>
<td></td>
</tr>
<tr>
<td>Dozer On-board Equipment for work types monitoring (pressure of turbo charger and engine) and fuel monitoring</td>
<td></td>
</tr>
<tr>
<td>On-board scales for loader</td>
<td></td>
</tr>
<tr>
<td>High precision navigation for Drills and sensors for monitoring of drilling process</td>
<td></td>
</tr>
<tr>
<td>High precision navigation for Shovels to improve the quality</td>
<td></td>
</tr>
</tbody>
</table>
On-board equipment

GPS/GLONASS navigation

Weighing, Fuel and Tire pressure monitoring system

Or using VIMS, PLM etc.

Trucks equipment

Sensors

Wireless

Intelligent panel
Features of the system

- Load measuring – the accuracy is 2-3%
- Fuel level and consumption measuring – the accuracy is 3-4%
- Trip counting
- Tire pressure and monitoring
- Intuitive driver graphical interfaces
- Three level payload light signaling to excavator operator – lamps or digital display
- Data storage and transmission to the server (optional)
- Hydraulic cylinders charging assistance

Sustainability

- More than 4500 systems IN USE
- Trucks manufacturer BELAZ approval
- Industrial Rugged Design

Can be installed to CAT, Komatsu, Hitachi, Terex etc.
General technical description of the system

Installation of on-board equipment to the truck
## On-board equipment

### Trucks - Data

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Interface</th>
<th>Description</th>
<th>Data available</th>
<th>Specific dev.</th>
</tr>
</thead>
</table>
| PLM      | Payload system                       | RS 232    | PLM 3rd version - connection     | • Pressure in the suspensions  
• Angle of inclination  
• Current weight  
• Current speed  
• Status of digital signals (position of the platform/body etc.)  
• State of the truck (engine on\off, loading, unloading, stop, moving, loaded\empty)  
• Number of trips | Not required |
| Schrader | Tyres pressure and temperature       | RS232     | Need the special update for the SW – the protocol exists | - Pressure of the tyres  
- Temperature of the tyres  
- Alarms | Not required |
| Statex   | GE wheels drives                     | RS232     | Get the connection. The description protocol is required | Possible:  
Digital inputs status from controller of wheel drives  
Analogue inputs from controller of wheel drives | Required |
| Cummins  | Engine                               | CAN J1939 |                                  | Fuel consumption  
Motohours  
Diagnostic message codes | Not required |
Wireless system
Wireless system

- Motorola MESH Connex
- ABB Tropos MESH
- Rajant
- GSM
- PTP and PMP links
- Satellite Communications

Enterprise Area
COMBINING
Railways
Public Roads

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On-site visit is required for exact design of the wireless system.
Servers and software architecture
Servers Architecture

Process Example

On-board equipment

Servers Communicator

Message generation and processing software (framework + processors)

Event Log

Event via TCP

Screen

Touch panel

Sensors

Sensors drivers

Event

Wireless Network

Server Communication Software

Configuration (XMI)

Event

Log Writer

Event

Trip Detector

Event

Truck Driver push the button "Trip Begin" or "Trip End"
Real time management and Optimization

Business messages

Dispatch Manager

Business Messaging Software

• Stop reasons
• Breakages
• Directions
• Notifications
  • Filling
  • Automatic dispatching
  • etc

Driver – Voice and Text Messages

Engineers

Operator – Voice and Text Messages

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Basic backup:
- Database server
- Application Server
Shift Planning
**VG KARIER** Mine Fleet Management System

**KARIER Shift plans for equipment**

- **Truck activities**
  - Working
  - Short maintenance
  - Full-shift maintenance
KARIER Shift task for shovels and trucks

### Truck Task
- driver
- starting route
- length of route
- number of trips

### Shov Task
- machinist
- helper
- load types
- assigned unloads
- volumes

VG KARIER Mine Fleet Management System
**VG KARIER**

**Mine Fleet Management System**

### Shov activities
- volume-based task
- time-based task
- short maintenance
- full-shift maintenance

### Dozer activities
- geo-based task
- time-based task
- short maintenance
- full-shift maintenance

---

**VG KARIER** Mine Fleet Management System
KARIER Shift task for shovels and draglines
Real time management and Optimization
Submodules

• Online management tool
• Static optimization
• Dynamic optimization
• Graph of roads
• Statistic & Standards
Real time management and Optimization

Map possible info:
- Coordinates
- Current route/activity
- Current speed
- Current fuel
- Current load
- Number of trips
- Total length
- Total volume
- Links to reports

Map possible alerts:
- Overspeed
- Overload
- Out of route
- Long Stoppage
Real time management and Optimization

Truck control
- manual and automatic redirecting (to routes, to maintenance areas)
- idle stoppages management
- violations control
- text-messaging

Shov control
- work type change
- idle stoppages management
- text-messaging

Unload control
- load type change
- offline/online status change
Functions of the OMI

- Display of actual tasks for trucks
- The task of groups of routes for trucks (the module of dynamic optimization in the further can distribute trucks only inside of group)
- The task of a variant of work for routes/groups of routes (with use of the module of dynamic optimization or without use, a choice of a configuration for the module of dynamic optimization)
- Distribution of trucks on routes/groups of routes by means of the module of static optimization
- Notification of drivers of trucks about changes by means of text messages
- Distribution of trucks on routes/groups of routes in a manual mode
- Distribution of trucks on routes/groups of routes by means of the module of static optimization the Notification of drivers of trucks about changes by means of text messages
Static optimization – tasks and criteria

The primary goals
• Calculation of optimum amount of trucks on a route/group of routes
• Distribution of trucks on groups of routes
• Recommendation on exception of "superfluous" trucks which use will not lead to increase in the general productivity

Criteria of static optimization:
• Maximization of productivity
• Proportional achievement of planned volumes or maximum productivity of a shovels or crachers
• Shift changing optimization
Dynamic optimization – tasks and criteria

Dynamic optimization distributes trucks on routes inside optimization groups automatically at approach of the certain events (for example, unloadings)

Criteria of dynamic optimization
- Averaging of quality of ore
- Maximization of productivity
- Uniform distribution

Trucks are distributed on routes for achievement of optimum parameters by these criteria. Criteria are used together, its weight (a degree of importance) is compared with each criterion.
Dynamic optimization: a tree of distributions of trucks on routes

State of the mine at the time of truck waiting for distribution

Possible states of the mine after distribution of the truck to one of the four of available routes

Possible states of the mine after distribution of the truck to one of the four of available routes and next waiting for decision truck to one of the four of available routes
Dynamic optimization: queue planning

The constant control of a current state of the mine, fixation of this status at the moment of decision-making
Estimation of time of movement of a distributed truck to the shovel
Definition of trucks which should come to the shovel before arrival of a distributed truck
Definition of trucks which should finish loading before arrival of a truck
Definition of % of loading of a truck which will be under loading at the moment of arrival of a distributed truck
Definition of a waiting time for a distributed truck
Calculation of total time of a cycle (movement empty – wait of loading - loading - movement loaded - unloading)
Calculation of final productivity of the enterprise for the set moment of time
Dynamic optimization: points of decisions

• **After unloading**
• **After loading**
• **External events:**
  • Changing inside the optimization group (add or remove truck or shovel)
  • Idle of excavator or unloading
  • Change of a kind of a load type for shovel or crasher
• **Special zone**
Dynamic optimization: destination points

- Shovel
- Unloading (stock or cracher)
- Shift changing area
Real time management and Optimization

Tree (Graph) of roads

Nodes:
A, B, C, D, E, F, G

Edges:
(A,D), (B,D), (C,D), (D,E), (E,F), (E,G)

VG KARRIER Mine Fleet Management System
Real time management and Optimization

Statistics and standards

Definition of times of loading, movement loaded, unloading, movements unloaded

Collecting of data on each route and model of trucks

Operative recalculation for reflection of the changed conditions in mine

Estimation of an arrival time of each truck on loading and recalculation of an arrival time at intermediate stops of a truck

VG KARIER Mine Fleet Management System
Statistics and standards: time of the cycle calculation

Time of moving from shovel11 to unload 2 = AD+DE+EF

Time of movement on each edge is calculated independently according to statistic or norm

VG KARIER Mine Fleet Management System
On-board interfaces
On-board interfaces

Current state
Current Weight
Current task
Day/Night Mode

Alarms & Messages
Work with idles
Report
Diagnostics

Wait for load
Load begin
Unload begin
Load/Unload End

Traveled Distance
Cycles Number
Avg loaded distance
Fuel level
On-board interfaces

- **Current Height**
- **Current task**
- **Transverse incline**
- **Longitude incline**

**Alarms & Messages**

**Work with idles**

**Inform about trouble**

**Activity type select**

- **Cycles Number**
- **Current Quality**
- **Current State**
- **Sensors state**

**Report**

**Dispatcher call**

**Diagnostic & Setup**

- **16:28:43**
- **12.11.13**
On-board interfaces

Hours

Trucks
Events and Alerts
- Event – every change of the state of the mine, equipment etc.
- Alert – some very important events that need to be especially shown to users

Server communication software

Event Detector 1

Event Detector n

For Alerter Events

Alerter

- Alert 1 description
- Alert N description

Alert info

Map

OMT

Event Log

E-mail, sms

On-board

Forms Interface

Raw on-board events and telemetry

For Alerter Events
### Events and Alerts

<table>
<thead>
<tr>
<th>Trucks</th>
<th>Shovels/Draglines</th>
<th>Dozers</th>
<th>Auxilary</th>
<th>Subcontractor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long cycle</td>
<td>Long Stoppage</td>
<td>Long Stoppage</td>
<td>Long Stoppage</td>
<td>Long Stoppage</td>
</tr>
<tr>
<td>Long Stoppage</td>
<td>Low fuel</td>
<td>Low fuel</td>
<td>Low fuel</td>
<td>Overspeed</td>
</tr>
<tr>
<td>Out of route</td>
<td>Long cycle</td>
<td>Out of area</td>
<td>Out of area</td>
<td>Out of zone</td>
</tr>
<tr>
<td>Big queue</td>
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</tr>
<tr>
<td>Low fuel</td>
<td></td>
<td></td>
<td></td>
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</tr>
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<td>Overspeed</td>
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<td>Popup window “Queue under shove 76. Check and change conditions if needed”</td>
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Reporting and KPI’s
### Reporting

**Trips review**
- unidentified fields qualification (load type, shovel, etc)
- truck movement tracking

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Equipment work time analysis
- table and line-bar representation
- unidentified stoppages qualification
### Shift routes confirmation

- **Editing:**
  - Number of trips
  - Average length
  - Load type
- **New route inserting**

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## Equipment shift statistics

- **editing:**
  - total length
  - fuel levels
  - machine shifts
  - transfers and transitions

### Equipment Shift Statistics Table

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<th>Станок</th>
<th>Ряд</th>
<th>Расход (А), м</th>
<th>Расстояние, км</th>
<th>Топливо на начало (А), л</th>
<th>Топливо на конец (А), л</th>
<th>Заварки (А), п</th>
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### KPIs

#### Trucks
- Motohours
- Availability
- Usability
- Weight
- Fuel Consumption
- Distance
- Number of trips
- Volume and tonnage transported
  - T\(\times\)km
  - T\(\times\)km/h
- Weight and tonnage per quality
- SCM - Effective phosphates volume per quality
- Average cycle
- TRS – motohours/available hours

#### Shovels/Draglines
- Work time
- Stop time
- Availability
- Usability
- Motohours
- Weight/Volume
- Number of buckets – from OEM of shovel or truck
  - Work time
  - Stop time
  - Hours of walking
  - Productivity
  - Fuel consumption

#### Dozers
- Time Moving back
- Time Moving forward
- Average empty time
- Time Pushing - Average loaded time
- Motohours
- Stop time
- Availability
- Usability
- Fuel consumption

#### Aux
- Motohours
- Fuel consumption
- Availability
- Usability
- On/Off
- Location

#### Subcontractors
- Tonnage (gr scales)
- Number of trips
- Overspeeding
- Average speed
- Cycle time
- Tkm
- Location
<table>
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<th>KPIs</th>
<th>Formulas</th>
<th>Units</th>
<th>Frequency</th>
<th>Source</th>
<th>Periods</th>
<th>Mine/Area</th>
<th>Model</th>
<th>Machine</th>
<th>Quality</th>
<th>Level</th>
<th>Driver</th>
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<td>Motohours</td>
<td>Sum (engine work end - engine work start) for shift for every truck, divided by cycles time for loading machine, for quality</td>
<td>hh:mm:ss</td>
<td>every shift</td>
<td>Special sensor or OEM will gave the information about engine on/off</td>
<td>shift, day, period with 1shift step</td>
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<td>Availability</td>
<td>Availability = 100* (std shift time - external – planned and unplanned maintenance) / (std shift time-external)</td>
<td>%</td>
<td>every shift</td>
<td>GPS speed sensor, driver reasons</td>
<td>shift, day, period with 1shift step</td>
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<td>Hours of stopages by types</td>
<td>Hours of stopages by types = list by type, sum(stop end-stop begin) for every type of stop</td>
<td>hh:mm:ss</td>
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<td>GPS speed sensor, driver reasons</td>
<td>period of time, shift, route, quality</td>
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<td>Number of cycles</td>
<td>Sum (cycle)</td>
<td>pcs</td>
<td>every cycle</td>
<td>OEM pressure sensors or driver initial data, server calculation</td>
<td>period of time, shift, route, quality</td>
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<td>Tonnage transported</td>
<td>sum (weight for cycle)</td>
<td>tonns</td>
<td>every cycle</td>
<td>Ground scales or OEM pressure sensors or standard weight for quality and model of truck</td>
<td>period of time, shift, route, quality</td>
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<td>Fuel level chart</td>
<td>list of current values for period</td>
<td>every message</td>
<td>every message</td>
<td>fuel sensor OEM</td>
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<td>Productivity</td>
<td>sum (weight for cycle of a truck) / standard shift available hours</td>
<td>tonns/hour or m3/hour</td>
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<td>Previous calculation of weight for truck, dictionaries</td>
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<td>Volume transported</td>
<td>sum (weight * density for quality)</td>
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<td>every cycle</td>
<td>on server, weight for cycle from previous calculation * standard dencity for quality</td>
<td>period of time, shift, route, quality</td>
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<td>Average Cycle</td>
<td>Average cycle = sum(cycle end-cycle begin)/number of the cycles</td>
<td>hh:mm:ss</td>
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<td>OEM or driver defined cycle begin and end events</td>
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For every truck at some time inside of the shift:

- **Current state**
  - Move or stopped + duration + reason (wait for load, loading, unloading, user, etc....)
  - Loaded or unloaded
  - Points of departure and arrival (machine, stock/crasher, maintenance, refueling zone)
  - Curr geolocation – zone or road (No of road, refueling, maintenance, shift changing zone)
  - Curr weight, speed, fuel
  - Location on the map

- **Factual transported volume, T or M³**
- **Factual distance, Km**
- **Avg loaded length, Km**
- **Number of trips, psc**
- **Fact turn-over of cargo T*Km**
- **Fact productivity, T/h and T*Km/h**
- **Sum difference between Norm & Fact Circle time, %**
- **Total In Cycle Idle Time, hh:mi:ss**
- **Total Out Cycle Idle Time, hh:mi:ss**
- **Details**

In cuts:
- By truck
- By cargo (waste, phosphates by quality)
- By model
- By machine (shovel)
- Total
VG Drill
Drills high precision guidance
Benefits

- Increased productivity of the drills
- Reduced costs of the materials:
  - For drilling
  - For blasting
- Increased the quality of blasting and therefore productivity of the shovels
- Optimize the work of the surveyors
- Reduced the additional drilling and blasting
• Automated Drill Guidance using High Precision GNSS – assistance for operator
• Digital Map Shift Order Showing to Operator – no manual measuring of the grid
• Operation Parameters Control and Visualization (depth, penetration rate, production and utilization statistics such as cumulative meterage, number of holes drilled, time spent drilling, propelling between holes, and rod handling)
• Calculation of the real performance of the drills
• Optimize the grid of blasting
Scheme of the system

VG Drill: System Schematic

- GPS
- GLONASS

GPS / GLONASS Reference Station

Wireless Network MESH / WiFi

- Shift Tasks Performed
- Location and Orientation
- Operator Messages
- Drilling Parameters Executed

- GPS / GLONASS High Precision Navigation
- Shift Work Orders
- Geological Information
- System Messages
- Drilling Parameters

Enterprise Resource Planning Software SAP, Oracle BI, etc.

Server

Drill Management Web - Interface

Geological System

LAN

System Users Web - Interface
Drill's on-board equipment

Lat, Lon, H

Geological server

X, Y, Z

Surveyors

Drill planners

X, Y, Z

VG Drill users

Lat, Lon, H

X, Y, Z

VG Drill VG Karier Server

Geological server

Surveyors

Drill planners

VG Drill users

X, Y, Z

Lat, Lon, H

X, Y, Z
### On-board equipment

#### Dual antenna GPS GLONASS
- 1\2 cm accuracy in 3D (xyz)
- Orientation (pitch, tilt)

#### On-board computer
- Interface for the operator
- Calculation of the statistics
- Comparison of coordinates and guidance
- Storage of data
- External monitor available

#### Wireless system
- Data transmitting:
  - Corrections
  - Projects and work orders
  - Drilling parameters
On-board equipment

**Controller**
- Real time fast data processing
- Receiving the analog\digital data from the sensors
- Transmitting the data to on-board computer

**Sensors**
- Depth
- Inclinations (body and tower)
- Pressures (oil and air)
- RPMs of the drill
- Leveling and position of the jacks
- Currents for electrical drills
- Fuel consumption
On-board high precision navigation by Trimble

**POSITIONING SPECIFICATIONS**

<table>
<thead>
<tr>
<th>Mode</th>
<th>Accuracy</th>
<th>Latency</th>
<th>Maximum Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Baseline RTK</td>
<td>0.008 m + 1 ppm Horizontal</td>
<td>&lt;20 ms</td>
<td>50 Hz</td>
</tr>
<tr>
<td>RTK (&lt;50 km)</td>
<td>0.015 m + 1 ppm Vertical</td>
<td></td>
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</tr>
<tr>
<td>DGPS</td>
<td>0.25 m + 1 ppm Horizontal</td>
<td>&lt;20 ms</td>
<td>50 Hz</td>
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<tr>
<td></td>
<td>0.50 m + 1 ppm Vertical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SBAS</td>
<td>0.50 m Horizontal</td>
<td>&lt;20 ms</td>
<td>50 Hz</td>
</tr>
<tr>
<td></td>
<td>0.85 m Vertical</td>
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</tr>
</tbody>
</table>

**TECHNICAL SPECIFICATIONS**

- Position Antenna based on 220 Channel Maxwell 6 chip:
  - GPS: Simultaneous L1 C/A, L2E, L2C, L5
  - GLONASS: Simultaneous L1 C/A, L2 C/A, L2 P, L3 CDMA
  - BeiDou: B1, B2
  - SBAS: Simultaneous L1 C/A, L5
  - Galileo: Simultaneous L1 BOC, E5A, E5B, E5AltBOC
  - QZSS: L1 C/A, L1 SAIF, L2C, L5
- Vector Antenna based on second 220 Channel Maxwell 6 chip:
  - GPS: Simultaneous L1 C/A, L2E, L2C
  - GLONASS: Simultaneous L1 C/A, L2 C/A, L2 P
  - BeiDou: B1
- Advanced Trimble Maxwell Custom GNSS Technology
- High precision multiple correlator for GNSS pseudorange measurements
- Unfiltered, unsmoothed pseudorange measurements data for low noise, low multipath error, low time domain correlation and high dynamic dynamic response
- Very low noise GNSS carrier phase measurements with <1 mm precision in a 1 Hz bandwidth

**HEADING SPECIFICATIONS**

<table>
<thead>
<tr>
<th>Baseline</th>
<th>Accuracy</th>
<th>Maximum Rate</th>
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</thead>
<tbody>
<tr>
<td>2 m</td>
<td>&lt;0.09°</td>
<td>50 Hz</td>
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<tr>
<td>10 m</td>
<td>&lt;0.05°</td>
<td>50 Hz</td>
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</tbody>
</table>
Guidance process

On-board GNSS

Accuracy types suitable:
RTK fix. – 4
RTK float. – 5

GLONASS, GPS

Reference station

MeSH

Inclination sensors

Tower

body

On-board equipment of a drill

Jacks

LAN

www.vistgroup.ru
**Beginning of the drilling**

- Manually using touch button in the screen
- Automatic using 3 sensors: oil pressure, air pressure, RPMs

**Depth**

Planned and actual with corrections
Interfaces

Project for drilling and guidance

Drilling parameters
Depth sensor
Number or rods counting

Manually

Automatically
Web-interface

Diagrams and plots

Planned and actual holes
### Project Assignment

**Web-interface**

**External additional display**

<table>
<thead>
<tr>
<th>№</th>
<th>Проект</th>
<th>Назначен бурстану</th>
<th>Доставлен на бурстану</th>
<th>Состояние</th>
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</thead>
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**Projects**

<table>
<thead>
<tr>
<th>Проект</th>
<th>Назначен бурстану</th>
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<th>Состояние</th>
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</table>
VG Scarex
Excavators high precision guidance
Benefits of the system

- Increased productivity of the excavators
- Stabilize the quality and optimize the blending on the stockpiles
- Increase the availability of the shovels
- Optimize the work of the surveyors
- Reduced loses according to improper leveling
Features of the system

• Actual shift planning using mineral quality needs
• Visual confirmation of material type and quality while loading trucks
• Calculation of load grade on the trucks – provides ability to dispatch according to material quality, providing accurate blending of material and eliminating misrouted loads.
• Automatic record of shovel progress into the face
• Real-time dispatching and blending - based on high precision data.
• Elevation and angles control
• Road construction assistance
General technical description of the system

Shift planning (contours work off order)

Excavator

Real time position, shift order and geological model visualization to operator

High Precision GNSS and Sensors

Minerals Quality Control and Accounting

Automatic control of shovel progress into the face
VG Railway
Railways automation and dispatching
Benefits of the system

Control of the arrows and light on the railway stations and stages:
- Increase the carrying capacity of the stations
- Increase the safety of railway performance

Dispatching:
- Increase the productivity
- Reduce the costs for the railroad vehicles
Features of the system

- E-counting System of Rail Axes
- Railway Arrows Management with Electrical Drives
- Railway Traffic Lights Management
- Route Control Mode
- Station Dispatch Office
General technical description of the system

- Videowall
- Wireless
- SAP MII and SAP PM
- Reporting and management
- ServerVG Railway
- On-board level
- Ground level
VG Fleet

Auxiliary and public transport monitoring
Benefits of the system

Monitor the real performance of the fleet and get the statistics:
- Routes
- Trips
- Distance
- Fuel consumption

Can be used for haulage the coal on public roads
General technical description of the system
General technical description of the system
Orlaco

Video surveillance and collision avoidance systems
Orlaco
• Eliminate rear blind spot.
• Load placement – assistance with backing to berm.
• Prevent tyre damage by detecting rocks before reversing.
• Confirm load completion / tray empty – resulting in reduced cycle time, increased productivity.
• Keeping the berm intact.
Intelligent mine

Autonomous and tele-operated systems for mining equipment
Intelligent mine

- Increasing of mine fleet productivity by 15-20%
- Allows to operate mining works at harsh climatic conditions and remote regions
- Solve problem with the lack of labor in mining regions
- Allows to decrease operation cost
Intelligent mine

Robotized mining equipment
- Trucks (autonomous)
- Excavators (tele-operated)
- Loaders (tele-operated)
- Drills (tele-operated and autonomous)
- Dozers (tele-operated and autonomous)

Control Center

Wireless system

High Precision Navigation
Implementation process

Engineering and design

Study of existing business processes and equipment

Development the changes in management

Preparation the stages of implementation

Implementation

Hardware, wireless and SW installation

Deployment the changes of the management and training of the personnel

Preparation the legal documents (internally for the mine)

Testing and customization

Signing –off and providing the documentation

After sales management

SLA Contract

Audit

Additional sales

Technical support
Implementation process

1. Preliminary meeting and offer
2. Technical visit on site and Technical project – 1-1.5 month
3. Manufacturing and shipping - up to 4 month
4. Installation and training, signing off – up to 4 month
5. Maintenance and Support

Total duration: 7-9 months
Thank you for your attention!

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