

The role of PI System in the machinery efficiency improvement program in JSW

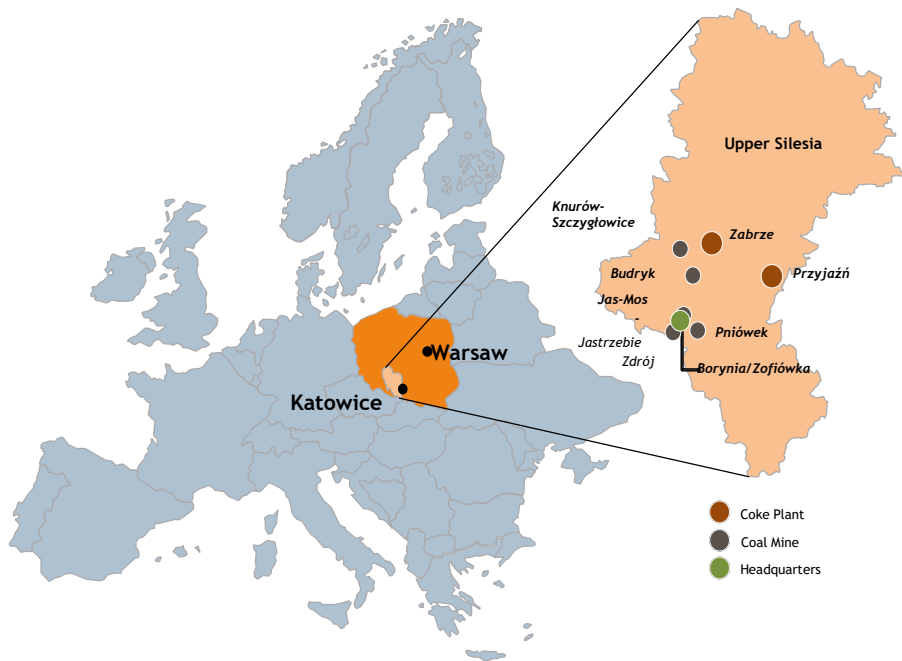
Jacek Kwaśnica



Agenda

- About JSW
- Mining core principles
- JSW challenges
- CTDS Central Technology Data Server
- Implementation details
- Future with PI
- Summary

Jastrzębska Spółka Węglowa – Capital Group



Located in the industrial heartland of Europe

- 4 coal mines
- 3 coking plants
- headquartered in Jastrzębie-Zdrój, Poland

Coking coal focused

- Holds 14% of the global coke trade market

Long mine life

- 30–40 years expected life of mines

Solid total resources and reserves

- Total resources of approx. 5.497 billion tonnes
- Reserves of 0.952 billion tonnes

Advanced Data Analytics Center

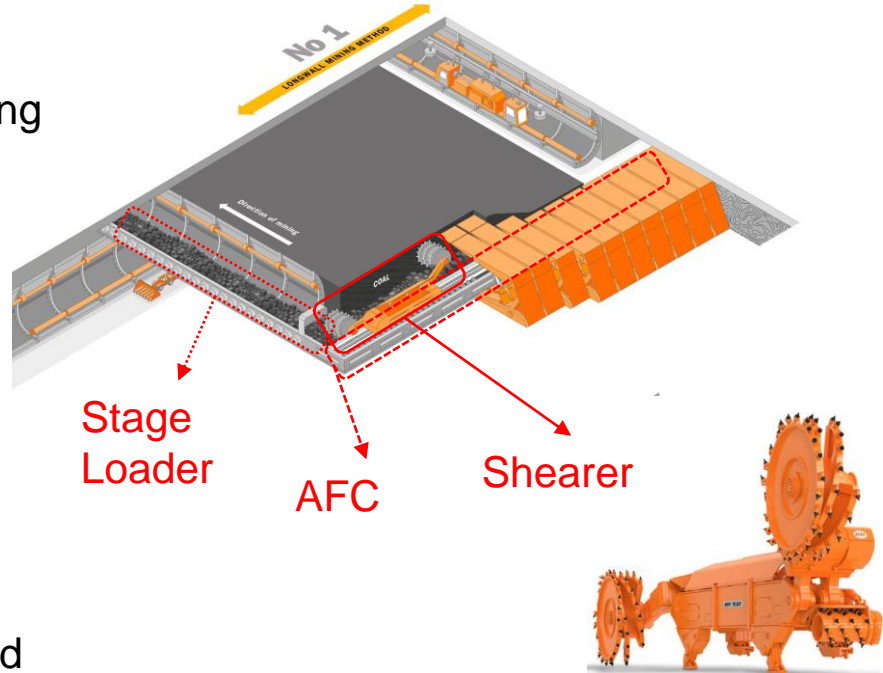


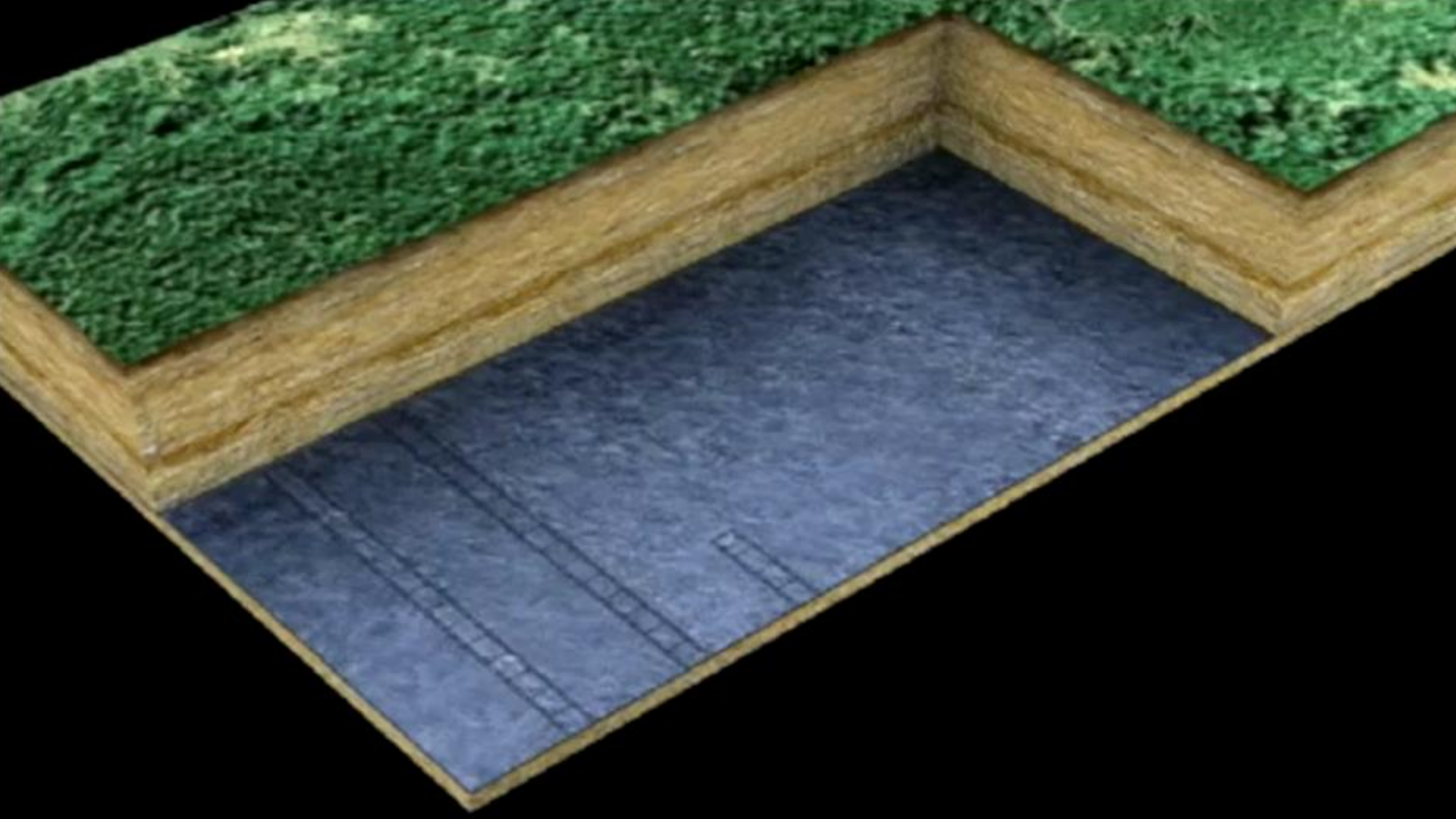
JSW Program: Improving mining efficiency

- Reduction unplanned downtimes
- Improving uptime in a challenging operational environment

Mining core principles

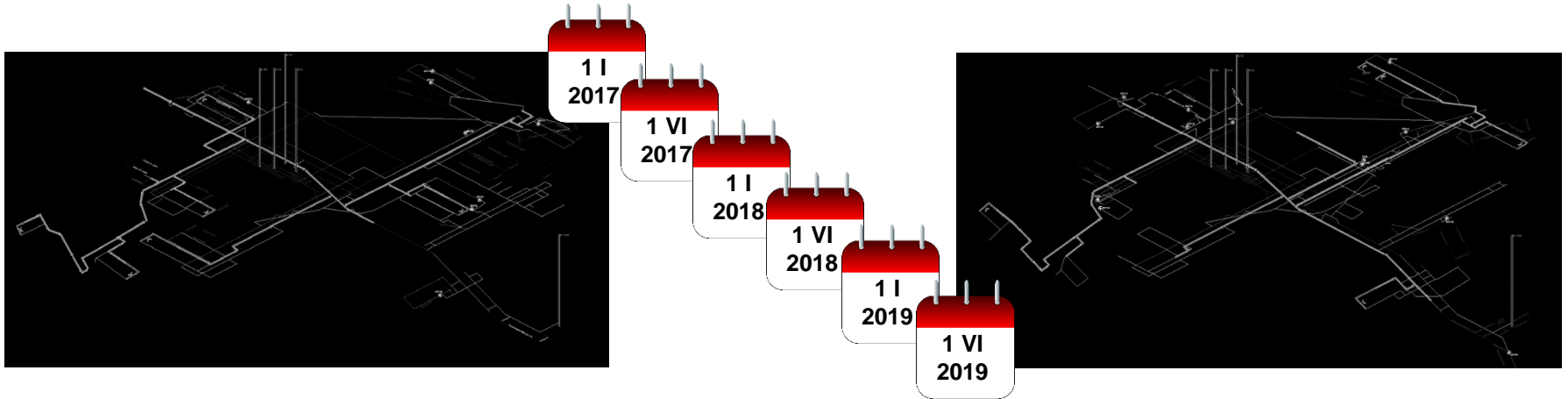
- Mining method – underground longwall mining
- Longwall machines
 - Shearer
 - Armored Face Conveyor (AFC)
 - Stage Loader
 - Roof Supports
 - Conveyor belt
- Longwall exploitation for several months
- Difficult wireless communications, interrupted data transmissions



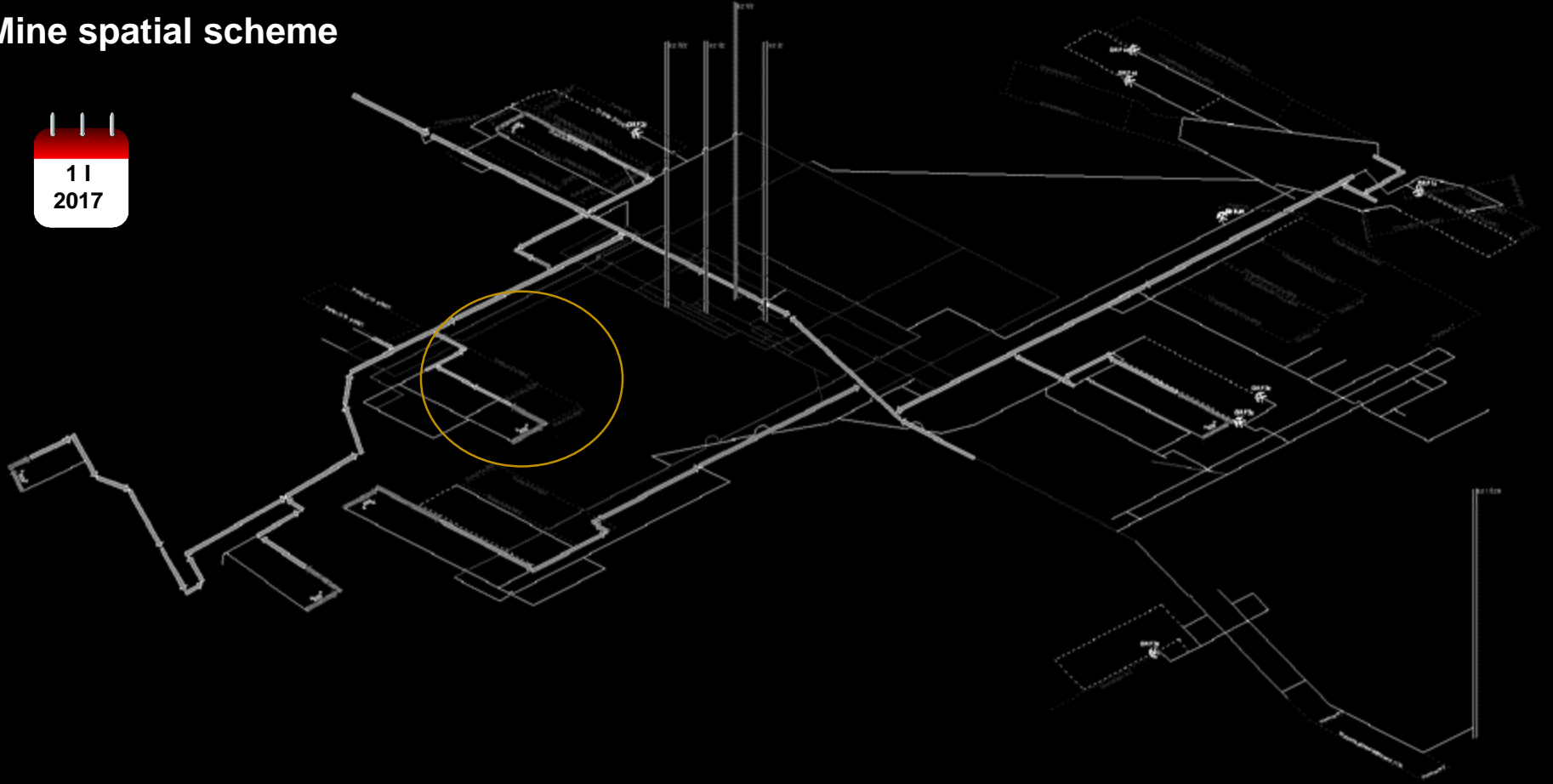


Mining core principles

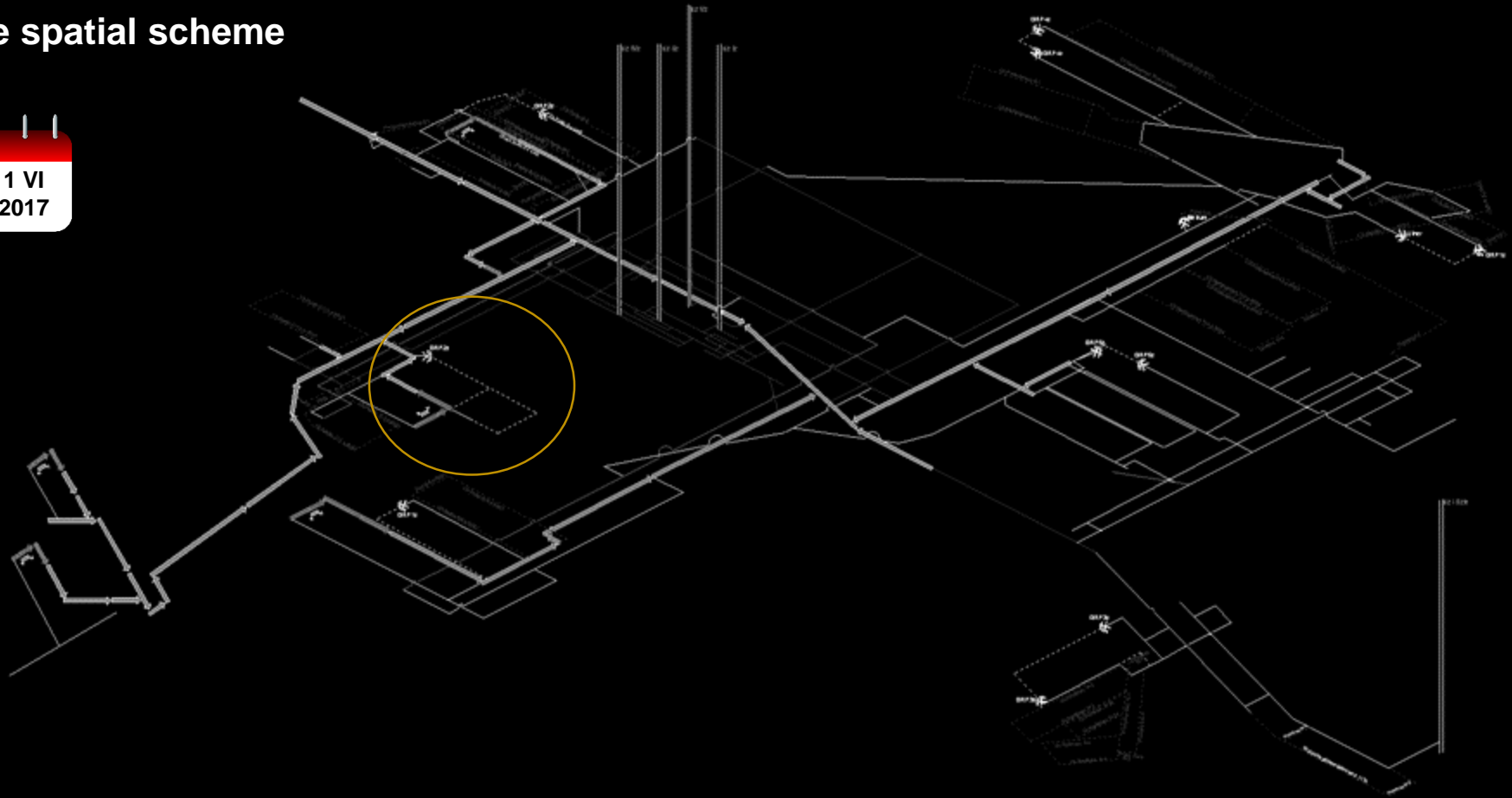
- Production processes follow the coal
- Workplaces appear and disappear



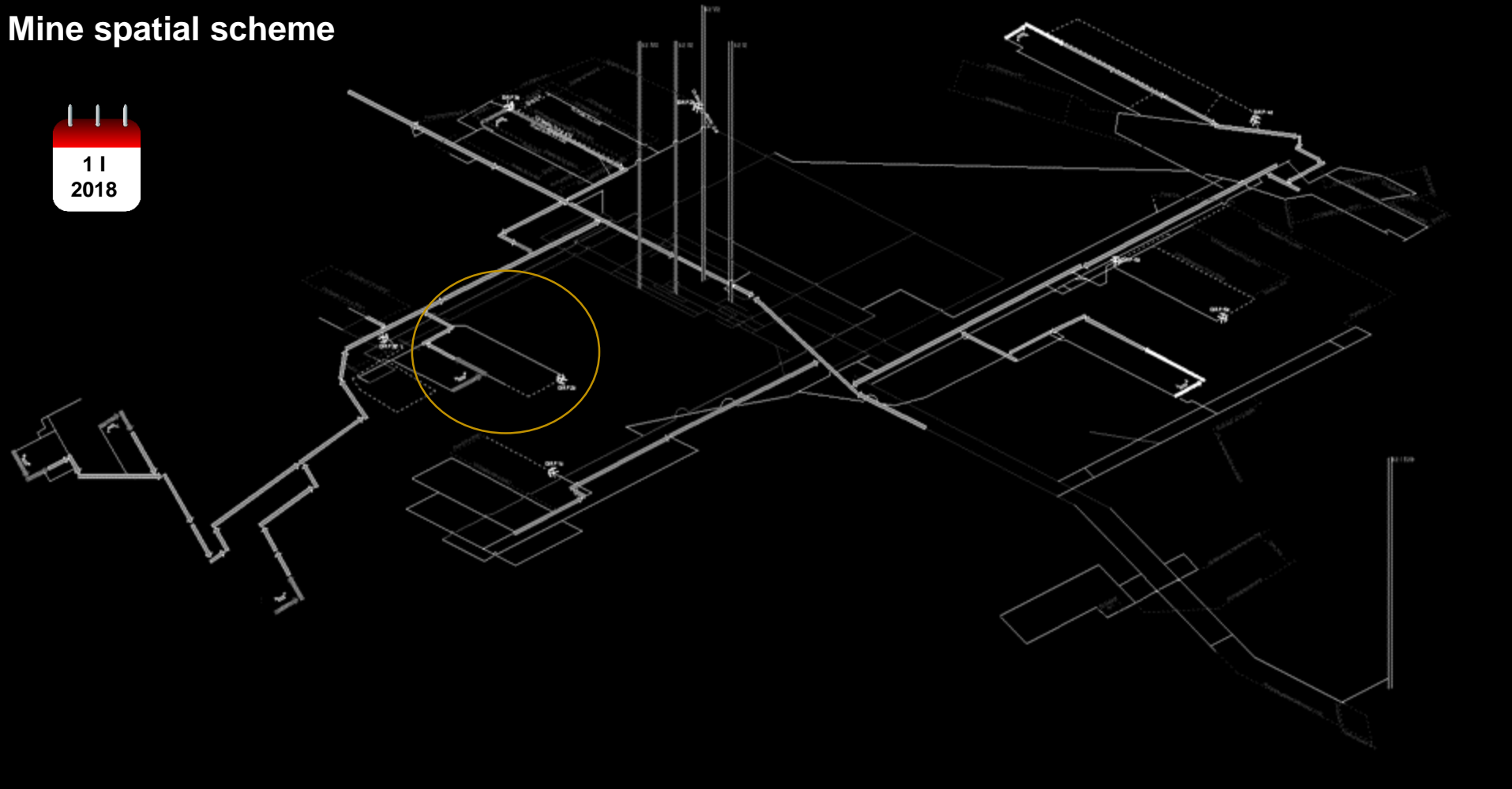
Mine spatial scheme



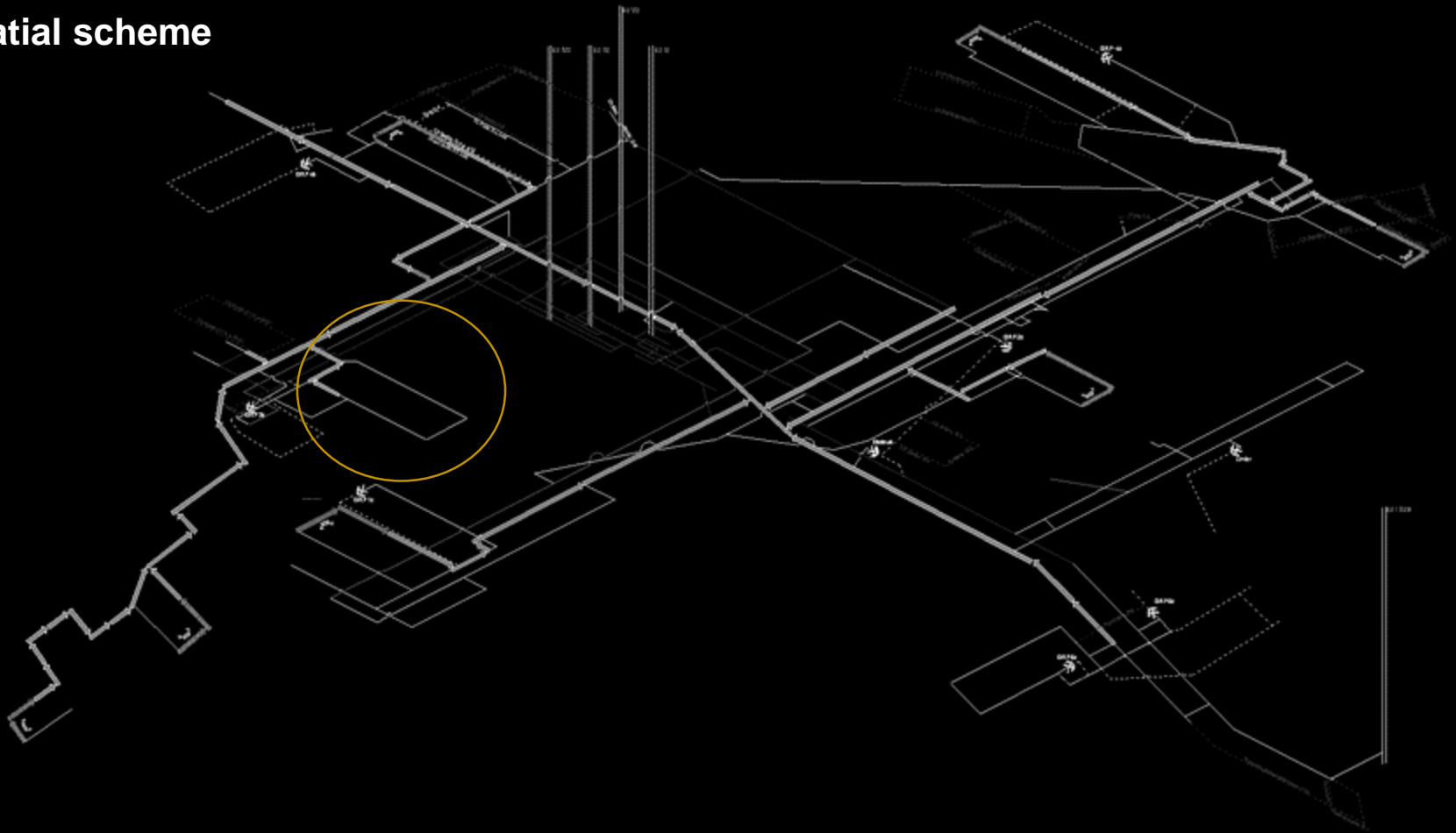
Mine spatial scheme



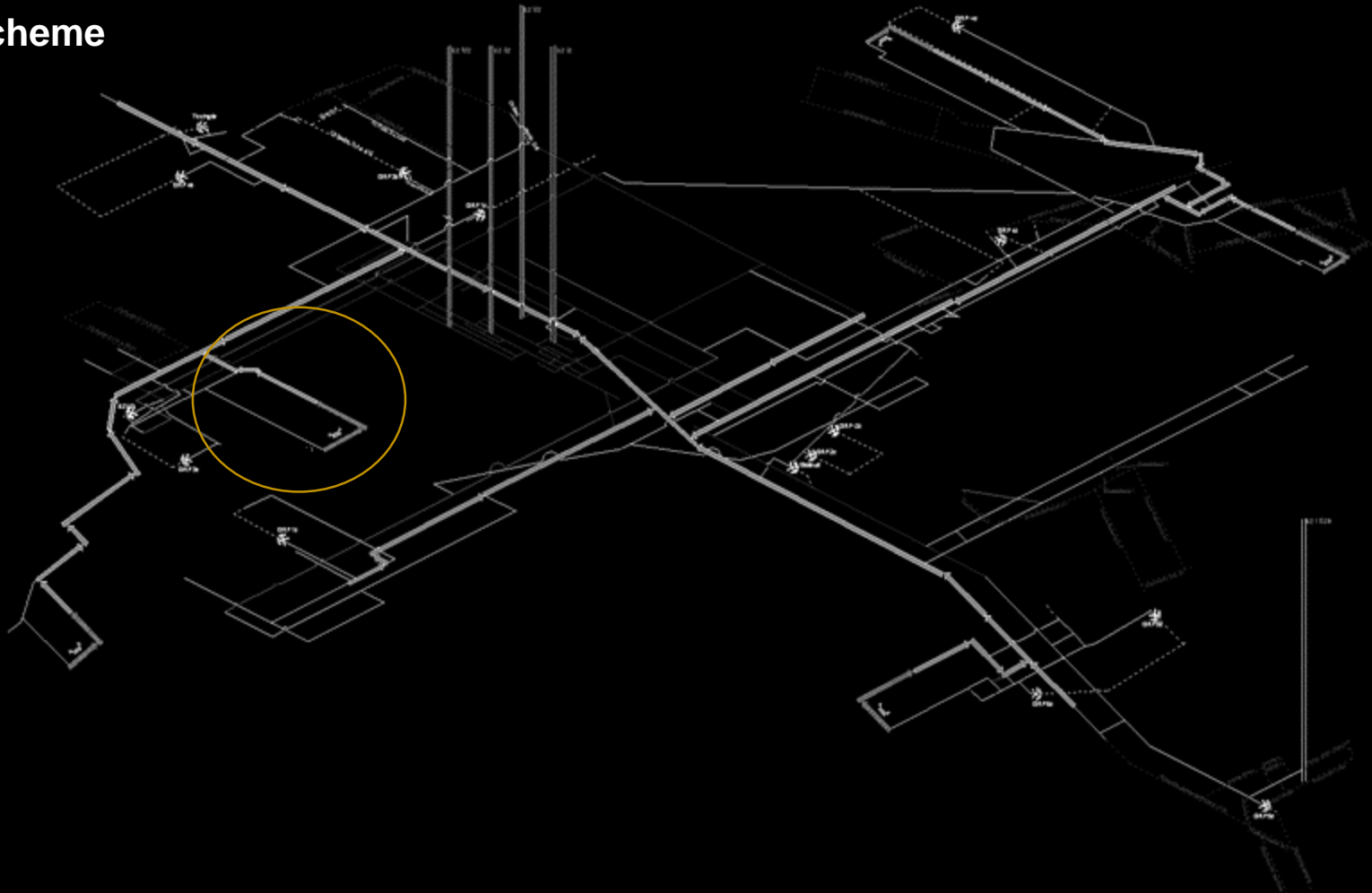
Mine spatial scheme



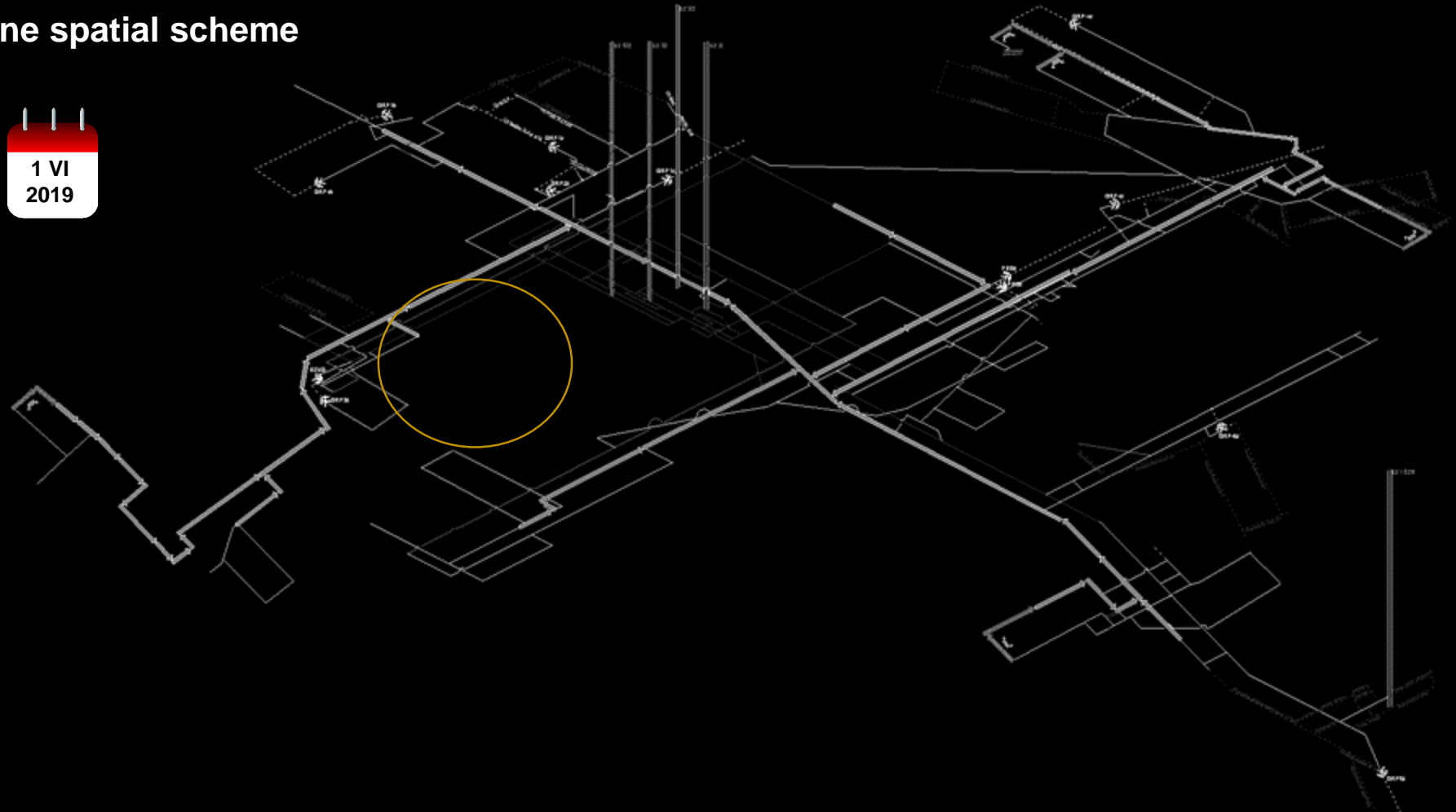
Mine spatial scheme



Mine spatial scheme

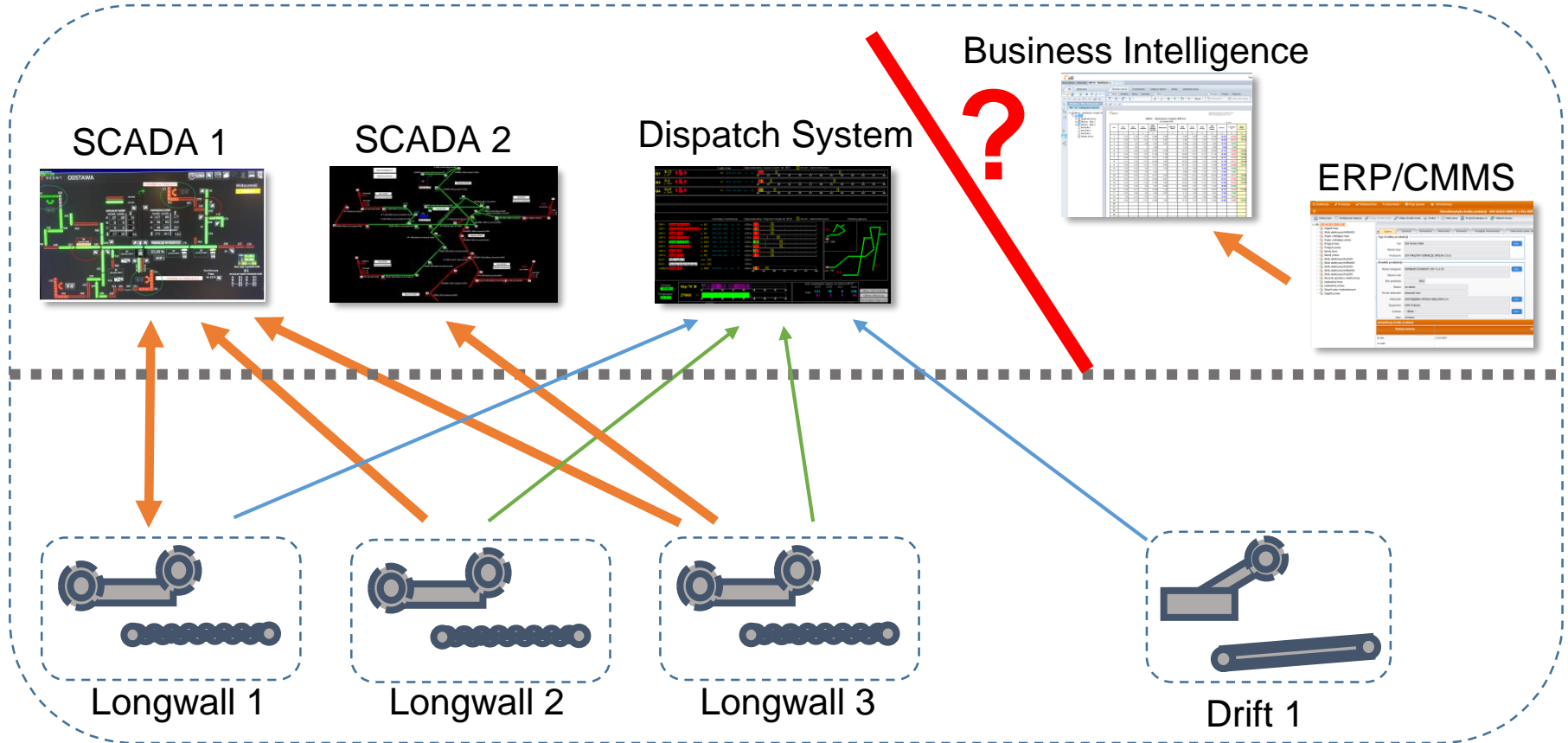


Mine spatial scheme



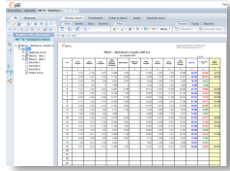
JSW challenges

JSW typical mine

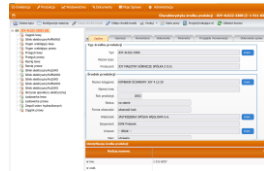


Solution -> Central Technology Data Server

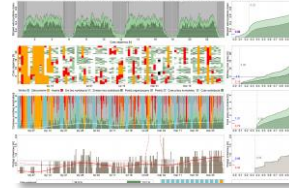
Business Intelligence



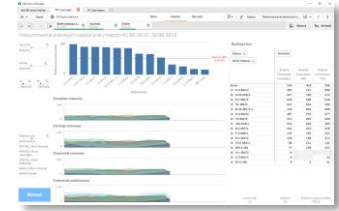
CMMS



Longwall Reporting System



Analytics



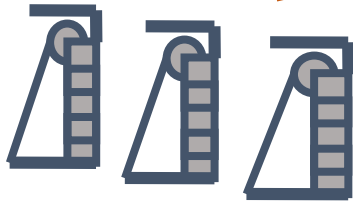
Interfaces

- Modbus
- OPC (UA)
- RDBMS
- UFL

CTDS



Underground
fiber optic
network



B-Z-J



Budryk



Pniówek

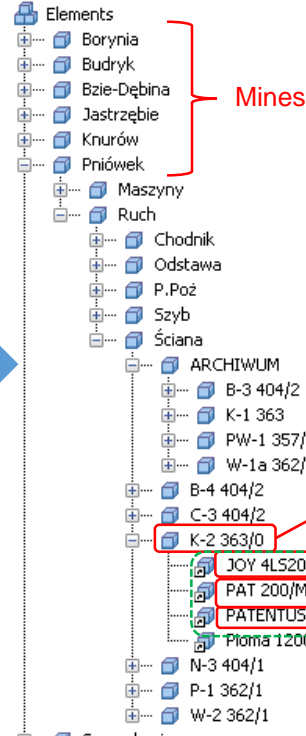
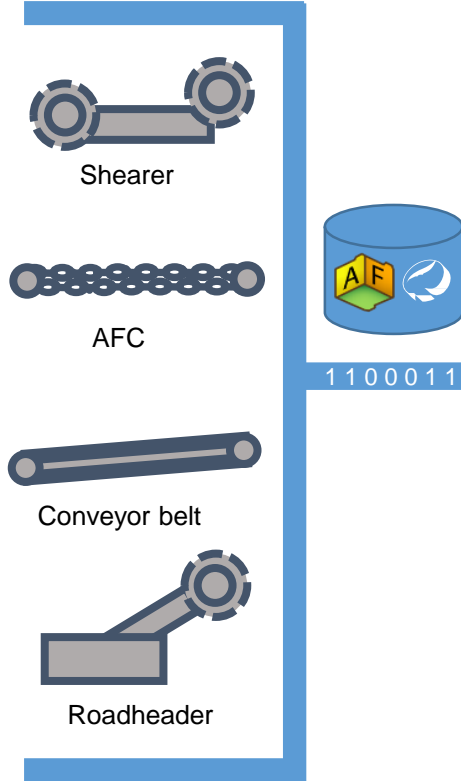


K-S

Transforming mine data into practical information

- Case 1. AF structure reflecting mine topology
- Case 2. Logical relations between machines
- Case 3. Rollup calculations – mine, corporate KPI's
- Case 4. Automatic downtimes recognition
- Case 5. Haulage system optimization

Case 1 - AF structure reflecting mine topology



Machine technical parameters from CMMS

| Category: Dane SZYK GŚP | | |
|-------------------------|------------------------|-------------------------|
| | Typ maszyny | JOY-4LS20-1000 |
| | Pracuje od dnia | 01.06.2019 00:00:00 |
| | Oddział | G-4 |
| | Nr inwentarzowy | 1-511-6703 |
| | Nr fabryczny | LWS503 |
| | Nr ewidencyjny | |
| | Faza pracy | praca |
| | AssetID | 500003510 |
| | Aktualne miejsce pracy | ŚCIANA K-2 POKŁAD [363] |

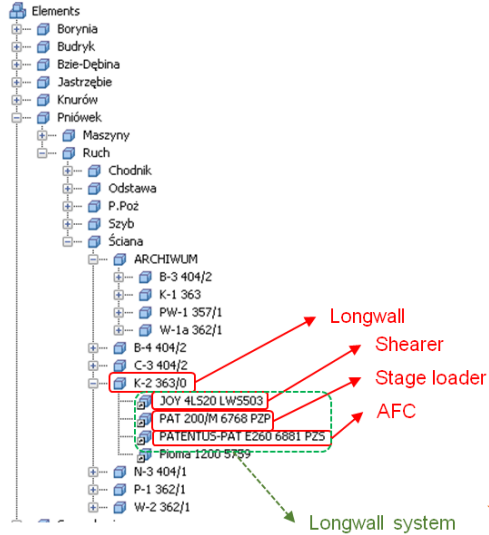
Machine workplace history

| Time Stamp | Value |
|---------------------|---------------------------------------|
| 01.01.1970 00:00:00 | No Data |
| 11.12.2017 00:00:00 | ŚCIANA K-2 POKŁAD[362/1]LIKWIDACJA |
| 09.01.2018 08:32:00 | ŚCIANA N-9 POKŁAD[404/2] EKSPLOATACJA |
| 02.07.2018 07:58:00 | ŚCIANA K-1 POKŁAD[363] |
| 10.04.2019 11:42:00 | ŚCIANA K-2 POKŁAD [363] ZBROJENIE |
| 17.04.2019 06:28:00 | ŚCIANA K-2 POKŁAD [363] |
| 31.12.9999 23:59:59 | No Data |

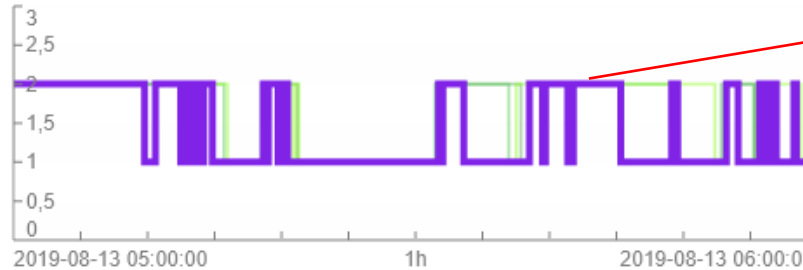
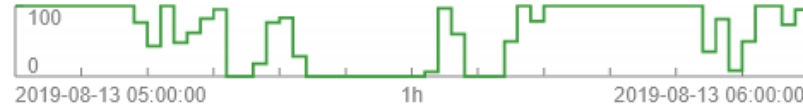
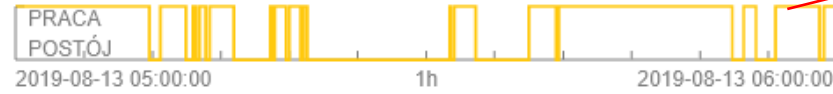
Longwall system (LS)

Case 2 - Logical relations between machines

AF analysis



Complexity



Case 3 - Rollup calculations – mine, corporate KPI's

Elements

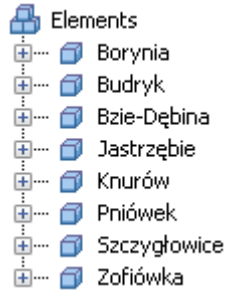
- Borynia
- Budryk
- Bzie-Dębina
- Jastrzębie
- Knurów
- Pniówek
- Maszyń
- Ruch
 - Chodnik
 - Odstawa
 - P.Poż
 - Szyb
 - Ściana
 - ARCHIWUM
 - B-4 404/2
 - C-3 404/2
 - K-2 363/0
 - N-3 404/1
 - P-1 362/1
 - W-2 362/1
- Szczygłowie
- Zofiówka

Working time usage (average for all longwall systems) within one mine



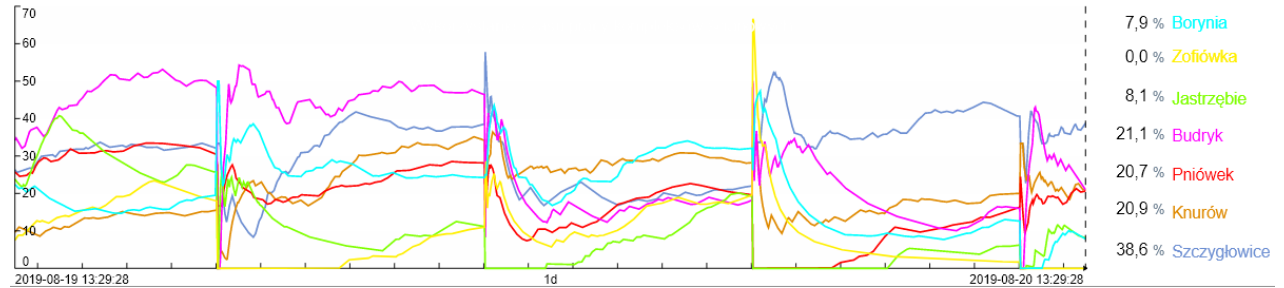
Longwalls

Case 3 - Rollup calculations – mine, corporate KPI's



Mines

Working time usage (average for all longwall systems) within all mines



Case 4 - Automatic downtimes recognition

LS downtimes go to CMMS

Red trend –
LS downtimes
longer then 30min

Event frames
generated

Event log in
CMMS
(integration
example)



| Nazwa zdarzenia | Zasób | ▼ Czas początku | Czas końca | Czas trwania | Przyczyna |
|---|-----------|---------------------|---------------------|--------------|-----------|
| Postój MP (PN) C-3 404/2 2019-08-13 00:20:390 | C-3 404/2 | 2019-08-13 00:20:39 | 2019-08-13 01:24:49 | 1h 4m | |
| Postój MP (PN) C-3 404/2 2019-08-12 21:43:180 | C-3 404/2 | 2019-08-12 21:43:18 | 2019-08-12 22:24:08 | 40m 50s | |
| Postój MP (PN) C-3 404/2 2019-08-12 18:30:020 | C-3 404/2 | 2019-08-12 18:30:02 | 2019-08-12 19:35:43 | 1h 5m | |
| Postój MP (PN) C-3 404/2 2019-08-12 13:21:330 | C-3 404/2 | 2019-08-12 13:21:33 | 2019-08-12 14:44:39 | 1h 23m | |
| Postój MP (PN) C-3 404/2 2019-08-12 06:00:000 | C-3 404/2 | 2019-08-12 06:00:00 | 2019-08-12 08:19:05 | 2h 19m | |

| Nr MP maszyny | Miejsce pracy maszyny | Typ maszyny (nr inw./ewid./fab.) | Rodz. masz. | Data od | Data do | Nr MP postoju | Miejsce postoju | Przyczyna |
|---------------|--------------------------|----------------------------------|-------------|------------------|------------------|---------------|--------------------|--|
| | C-3 | | | | | | | |
| 157 | ŚCIANA C-3 POKŁAD 404/2 | JOY-4LS22-3300 (7539) | KBS | 2019-08-13 00:20 | 2019-08-13 01:24 | 157 | ściana C-3 (404/2) | Międzyzmiana |
| 157 | ŚCIANA C-3 POKŁAD 404/2 | JOY-4LS22-3300 (7539) | KBS | 2019-08-12 21:43 | 2019-08-12 22:24 | 157 | ściana C-3 (404/2) | Przekładka dolnego napędu + budowa wneki |
| 157 | ŚCIANA C-3 POKŁAD 404/2 | JOY-4LS22-3300 (7539) | KBS | 2019-08-12 18:30 | 2019-08-12 19:35 | 157 | ściana C-3 (404/2) | Międzyzmiana |
| 157 | ŚCIANA C-3 POKŁAD 404/2 | JOY-4LS22-3300 (7539) | KBS | 2019-08-12 13:21 | 2019-08-12 14:44 | 157 | ściana C-3 (404/2) | przekładka górnego napędu PZS |
| 157 | ŚCIANA C-3 POKŁAD 404/2 | JOY-4LS22-3300 (7539) | KBS | 2019-08-12 06:00 | 2019-08-12 08:19 | 157 | ściana C-3 (404/2) | Międzyzmiana |

Case 5 - Haulage system optimization

Events based on relations between machines

1'st Conveyor belt

Longwall system



Case 5 - Haulage system optimization

Events based on relations between machines



Event 1: Overloading 1'st conveyor belt

| Nazwa zdarzenia | Zasób | ▲ Czas początku | ▼ Czas końca | ▼ Czas trwania |
|--|-----------|---------------------|---------------------|----------------|
| Zasypywanie PT D-2 358/1 2019-08-07 14:53:47 | D-2 358/1 | 2019-08-07 14:53:47 | 2019-08-07 14:54:37 | 49,985s |
| Zasypywanie PT D-2 358/1 2019-08-08 09:59:37 | D-2 358/1 | 2019-08-08 09:59:37 | 2019-08-08 10:00:43 | 1m 5s |
| Zasypywanie PT D-2 358/1 2019-08-08 10:09:59 | D-2 358/1 | 2019-08-08 10:09:59 | 2019-08-08 10:11:23 | 1m 24s |
| Zasypywanie PT D-2 358/1 2019-08-08 14:17:03 | D-2 358/1 | 2019-08-08 14:17:03 | 2019-08-08 14:17:57 | 54,048s |
| Zasypywanie PT D-2 358/1 2019-08-08 14:18:03 | D-2 358/1 | 2019-08-08 14:18:03 | 2019-08-08 14:19:03 | 59,997s |

Event 2: Running empty on 1'st conveyor belt

| Nazwa zdarzenia | Zasób | ▲ Czas początku | ▼ Czas końca | ▼ Czas trwania |
|---|-----------|---------------------|---------------------|----------------|
| Praca nieefektywna PT D-2 358/1 2019-08-07 17:47:11 | D-2 358/1 | 2019-08-07 17:47:11 | 2019-08-07 18:07:27 | 20m 16s |
| Praca nieefektywna PT D-2 358/1 2019-08-08 11:30:43 | D-2 358/1 | 2019-08-08 11:30:43 | 2019-08-08 11:49:13 | 18m 29s |

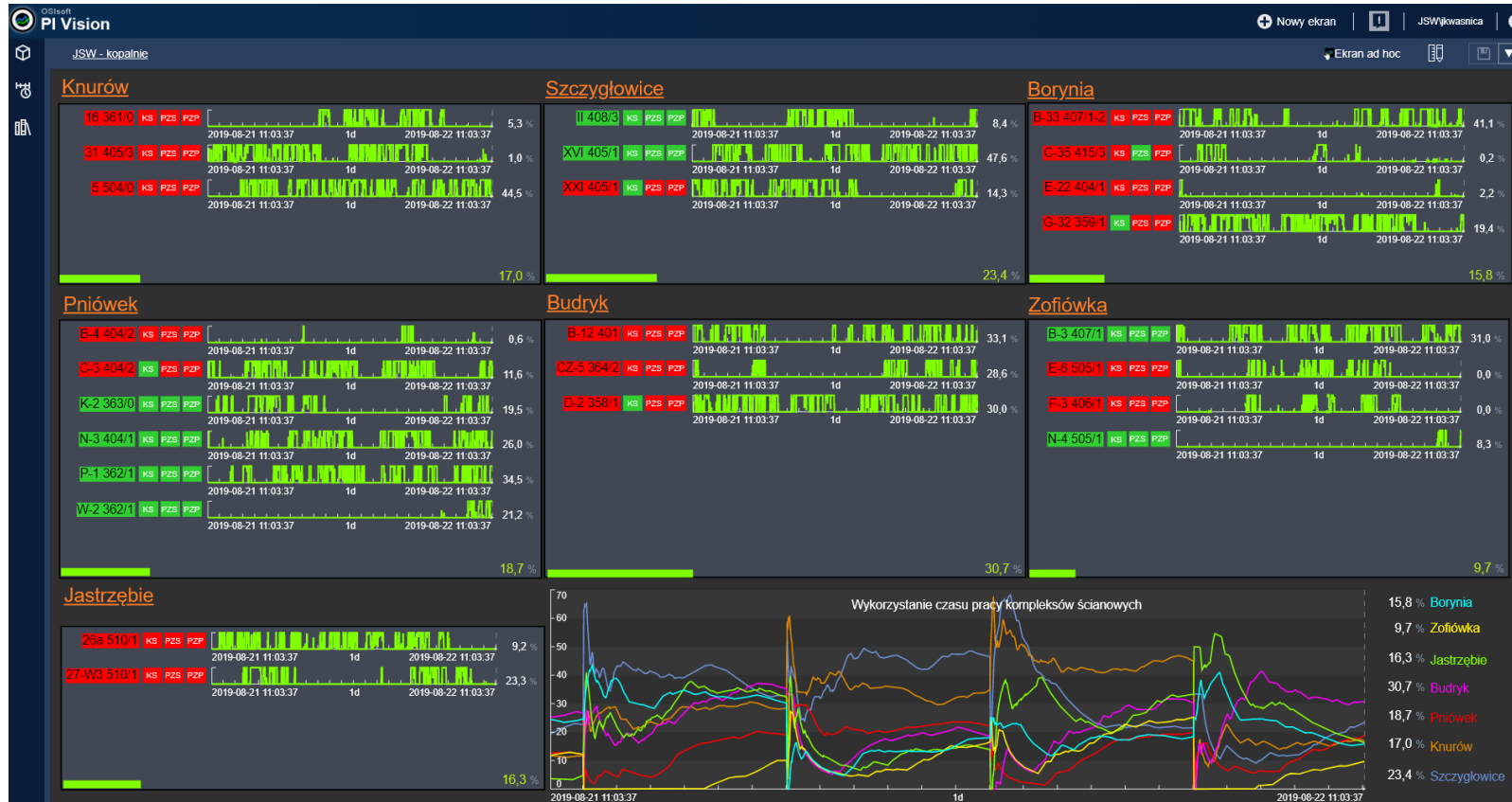
BO reports for mine staff

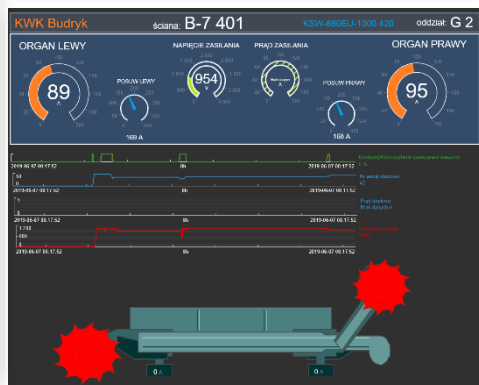
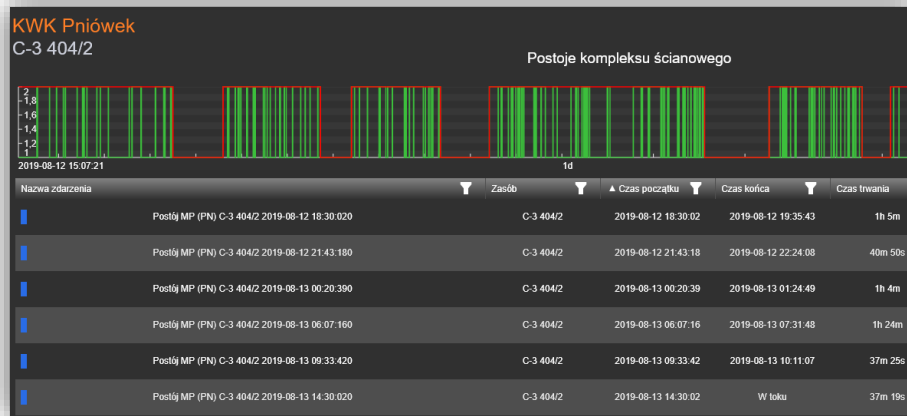
KWK Budryk

Data wygenerowania: 2019-08-11

| Ściana | Data | Praca nieefektywna PT | | Zasypywanie PT | |
|------------|---------------------|-----------------------|-------|----------------|-------|
| | | Czas | Ilość | Czas | Ilość |
| CZ-5 364/2 | | 10:33:27 | 27 | 0:01:58 | 0 |
| | 2019-07-10 23:25:22 | 0:15:30 | 1 | | |
| | 2019-07-11 05:10:14 | 0:24:30 | 1 | | |
| | 2019-07-11 11:20:19 | 0:16:24 | 1 | | |
| | 2019-07-17 03:16:44 | 0:16:12 | 1 | | |
| | 2019-07-19 22:05:13 | 0:17:30 | 1 | | |
| | 2019-07-20 08:43:53 | 0:38:46 | 1 | | |
| | 2019-07-22 05:17:07 | 0:26:32 | 1 | | |
| | 2019-07-22 13:43:02 | 0:26:41 | 1 | | |
| | 2019-07-23 10:30:30 | 0:33:19 | 1 | | |
| | 2019-07-23 20:49:07 | 0:24:02 | 1 | | |
| | 2019-07-24 23:11:31 | 0:19:26 | 1 | | |
| | 2019-07-26 15:51:19 | 0:18:54 | 1 | | |
| | 2019-07-29 22:27:45 | 0:30:36 | 1 | | |
| | 2019-07-30 20:21:15 | 0:19:14 | 1 | | |

CTDS – management dashboard





| Costs | | Gears | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|-------|--|---------------|--|---------------|--|-----------|--|-----------|--|-----------|--|---------------|--|-----------|--|------------|--|------------|--|------------|--|------------|--|------------|--|------------|--|------------|--|-----------|--|-----------|--|-----------|--|-----------|--|
| | | Internet 1400 | | Internet 1400 | | Poma 1400 | | Poma 1400 | | Poma 1400 | | Internet 1200 | | Poma 1400 | | Gears 1400 | | Gears 1400 | | Gears 1200 | | Gears 1200 | | Gears 1200 | | Gears 1200 | | Gears 1400 | | Poma 1400 | | Poma 1400 | | Poma 1200 | | Poma 1200 | |
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CTDS – integration details

- **Downtimes from PI to CMMS**

AF analyze PI Point → EF → **PI OLEDB ENT View** → MS SQL Linked server → Pentaho Integration Process → Oracle View (CMMS)

- **Technical machine parameters from CMMS to PI**

Oracle View (CMMS) → **Linked Table in AF** → Table Lookup in AF

- **Plant calendar from ERP to PI**

Oracle View (ERP) → **PI RDBMS Interface** → PI Point

- **Aggregated (by shifts) machines work times**

PI OLEDB ENT View → Linked Table in AF → Table Lookup in AF

- **Machine Work Times from PI to SAP Business Objects**

PI SQL RTQP View → Pentaho Integration Process → SAP Business Objects Database

Future with PI

- **New use cases implementation**
 - Entire haulage system
 - Ventilation, drainage processes
- **Extending monitoring to other areas**
 - Coal Processing Plant
 - Coking Plant
- **Step towards Predictive Maintenance (PdM)**



Mining efficiency improvement



CHALLENGES

- Increase working time at the coal face

SOLUTION

- AF structure
- RT Analysis
- AF Event Frames
- PI Vision dashboards
- Integration with CMSS
- PI SQL RTQP

BENEFITS

- Improved OEE for mine machines
- Increased awareness of process issues
(about 3 times more downtimes registered and annotated)
- New options for haulage optimizations
- Shared and transparent technical data
- Reduced report preparation time
(preparation of monthly uptime report was reduced from 1h to 1m)



Our Central Technology Data Server has gave us greater awareness of underground coal mine processes despite their high variability



The role of PI System in the machinery efficiency improvement program in JSW



- Jacek Kwaśnica
- PI System coordinator
- JSW S.A.
- jkwasnica@jsw.pl

Questions?

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the **microphone**

State your
name & company



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