

# IoT & SENSORES INALÁMBRICOS EN ENTORNOS MINEROS

Activities in the illuMINEation project



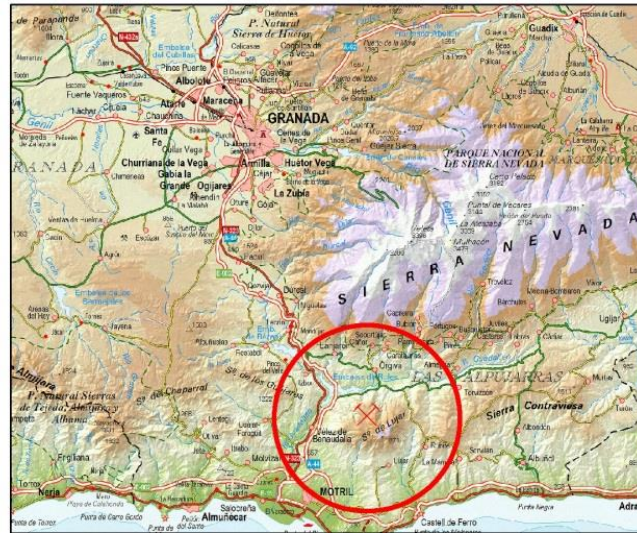
Dr. Rafael Navarro (Senior Geologist)

WEBINAR 4. CONCEPTOS INNOVADORES PARA UNA MINERÍA DEL FUTURO DIGITAL, SEGURA Y SOSTENIBLE.

22 de junio de 2022



# MINERA DE ÓRGIVA, S.L.

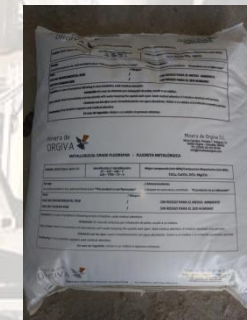


Local mining company placed in Órgiva (Granada, S of Spain)

Small and Medium-Sized Enterprise (SME) (50-70 workers)

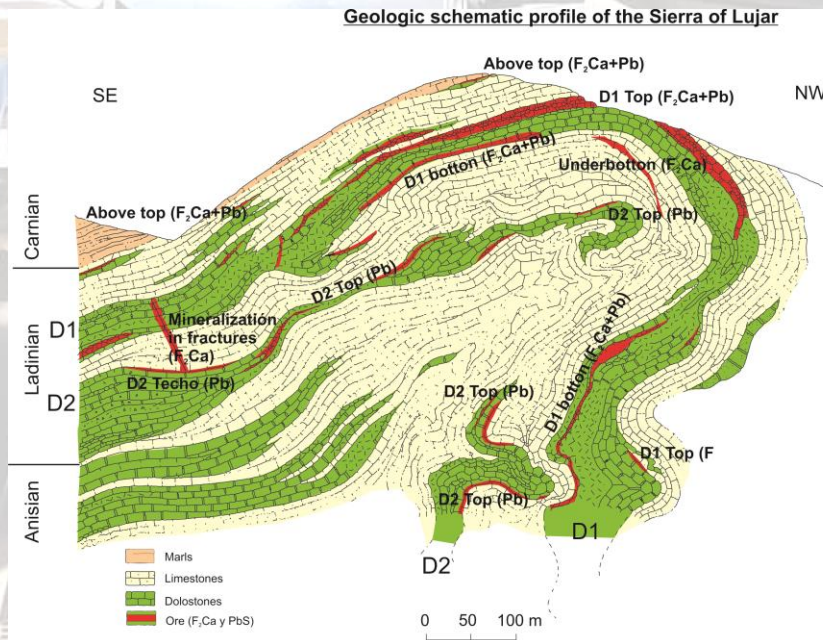
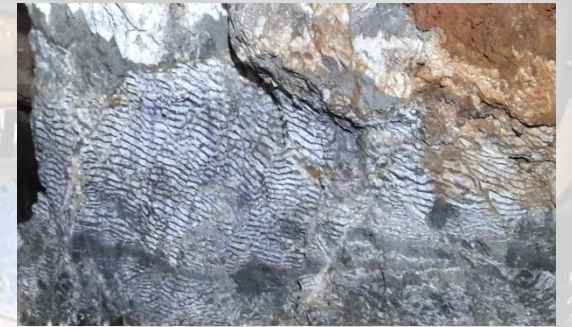
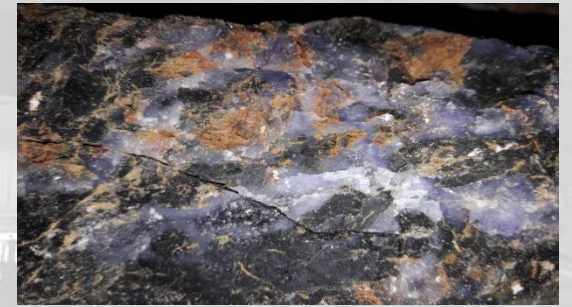
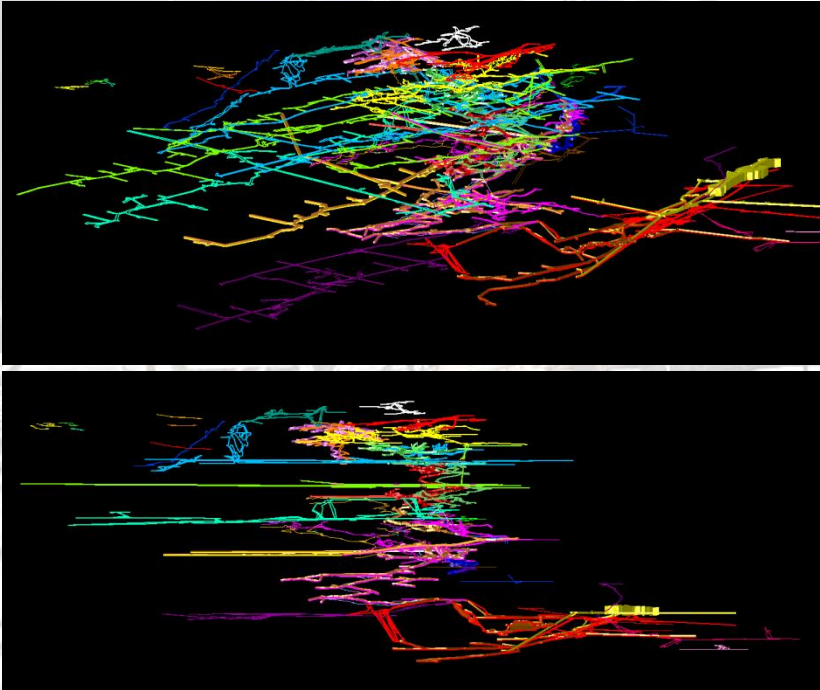
Metallurgic Fluorspar

- Grade (%  $\text{CaF}_2$ ) 75-85%
- Production (tons/month) 2000



# MINE LÚJAR (C.E. LÚJAR Nº30.411)

- Old mine (Romans and Muslim remains)
- Continuous operation since the end of the 19<sup>th</sup> century
- 140 km galleries
- F-Pb deposit - MVT deposit (subtype Alpine)
- Hosted in Triassic carbonates (Ladinian-Carnian)
- Stratabound and veins filling fractures
- Complex structure (recumbent fold - Alpine)
- Average grade 35%  $\text{CaF}_2$  and 2% galena



# MINE LÚJAR (C.E. LÚJAR Nº30.411)

Underground facilities:

- Crushing and grinding
- Froth Flotation plant
- Drying
- Packaging: in bulk (big bags), 25kg bags and pressed pellets





**illUMINEation**  
THE FUTURE OF MINING



# BRIGHT CONCEPTS FOR A SAFE & SUSTAINABLE DIGITAL MINING FUTURE



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**WEBINAR 4. CONCEPTOS INNOVADORES PARA UNA MINERÍA DEL FUTURO DIGITAL, SEGURA Y SOSTENIBLE. 22 de junio de 2022**



## Role & main tasks in the project

### **WP2 - Use cases for the mining industry**

- Task 2.2 - Fluorite mine

### **WP5 - Sustainable & intelligent mineral resource extraction**

- Task 5.1-Measurement-while-drilling (MWD)
- Task 5.3-Analysis-while-drilling (AWD) for geochemical data

# WP2 - Use cases for the mining industry

## IoT & WIRELESS SENSORS IN MINING ENVIRONMENTS

LoRa system: Antenna and gateways to send the signal to the internet.

- Tested at the mine and the benefit plant
- Installed at the benefit plant

Inclinometers

- To check possible movements in hazardous areas: pillars
- Two units in the benefit plant area

Air-quality control system:

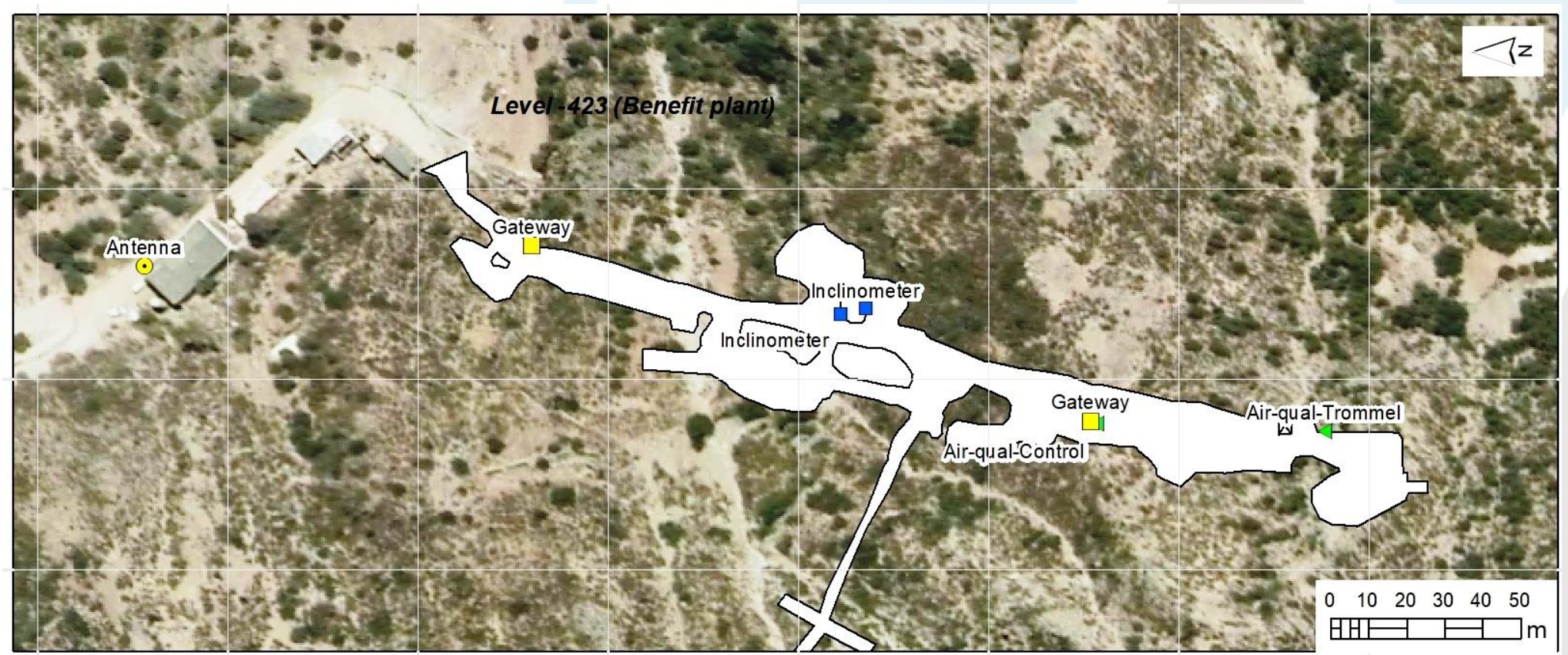
- Air-quality, VoC, CO<sub>2</sub>, Atm. Pressure, temperature, humidity
- Two units:
  - Close to the trommel (very harsh condition): high temperature, dust, gases from combustion....
  - Close to the control office (less harsh condition)

Platform in the cloud to collect data



# WP2 - Use cases for the mining industry

## IoT & WIRELESS SENSORS IN MINING ENVIRONMENTS







Antenna



## WP2 - Use cases for the mining industry

### IoT & WIRELESS SENSORS IN MINING ENVIRONMENTS

Air quality sensors



Inclinometers



Gateways  
(LoRa system)



# WP2 - Use cases for the mining industry

## IoT & WIRELESS SENSORS IN MINING ENVIRONMENTS

### DATA PLATFORM

CMT Edge

Networks Status Configuration

### Networks

| Id    | Name  | Nodes |
|-------|-------|-------|
| 23625 | 23625 | 2     |



CMT Edge Networks Status Configuration

### Network: 23625

Comments

Compacted custom CSV files [compacted-custom-readings-23625-cambios\\_inclinacion-current.dat](#)

Signal coverage test map

### Nodes

Id, name, serial or model Search

All 0 nodes selected of 2

| Id                             | Name | Status | Model       | Serial |
|--------------------------------|------|--------|-------------|--------|
| <input type="checkbox"/> 19809 |      | OK     | LS-G6-INC15 | 19809  |
| <input type="checkbox"/> 24488 |      | OK     | LS-G6-INC15 | 24488  |

Change sampling rate Cancel sampling rate changes

CMT Edge Networks Status Configuration

### Node 19809

Installation date

Comments

Model LS-G6-INC15

Firmware version 2.43

Serial number 19809

Health CSV files [19809-health-current.csv](#)

LS-G6-INC15 CSV files [19809-readings-current.csv](#)

Last readings and Time series graphs

| Channel | Temperature (°C) | Axis A (°) | Axis B (°) | ΔA (°)    | ΔB (°)   |
|---------|------------------|------------|------------|-----------|----------|
| 1       | 21.1             | 1.4767     | -2.6937    | -0.008423 | 0.001413 |

Received on 2022-06-20 13:00:34 CEST

Status

Metadata

Last messages

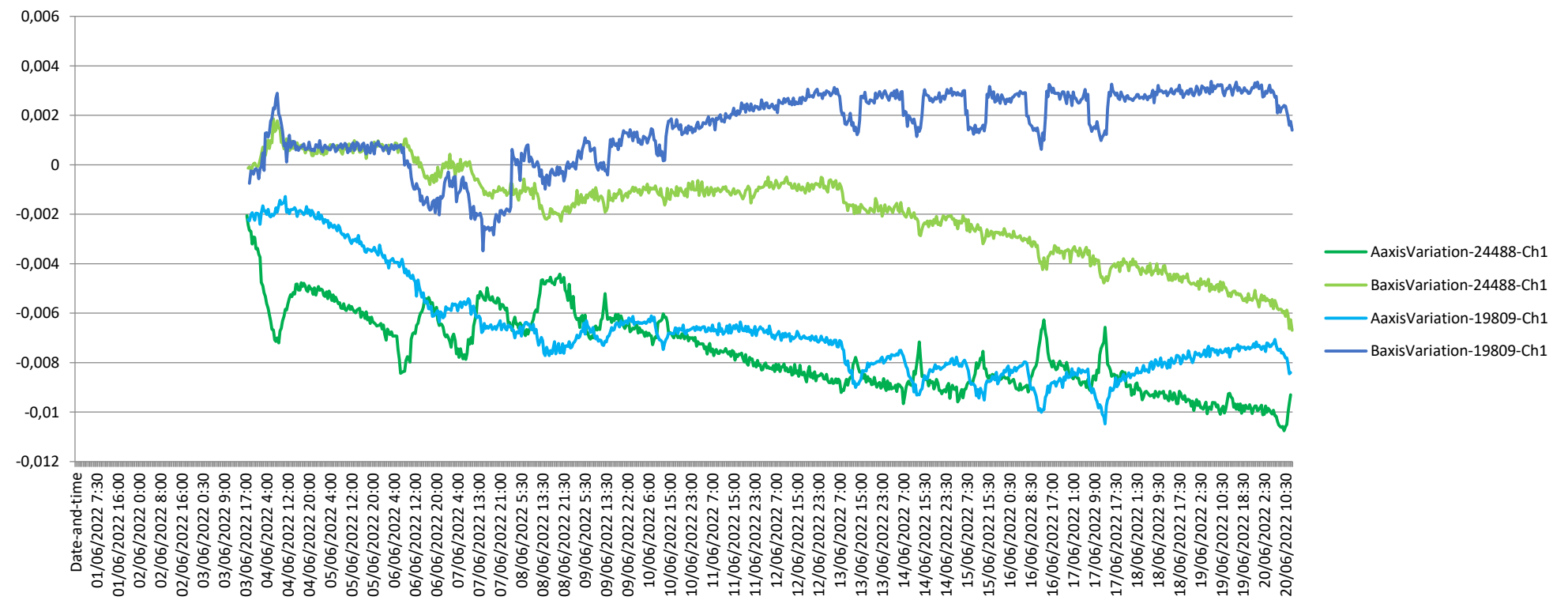
|   |  |  |  |
|---|--|--|--|
| Node ID,19809   |  |  |  |
| Gateway ID,23625  |  |  |  |
| Model,"LS-G6-INC15"   |  |  |  |
| Hw version,   |  |  |  |
| Fw version,   |  |  |  |
| Location Lat,   |  |  |  |
| Location Lon,   |  |  |  |
| Created time,"2022-06-01 00:00:41"                            |  |  |  |
| Timezone,"UTC"  |  |  |  |
| Date-and-time,"Temp-19809-Ch1","Aaxis-19809-Ch1","Baxis-1     |  |  |  |
| 2022-06-03 20:30:00,20.4,1.4829,-2.6929,-0.002216,-0.000748,, |  |  |  |
| 2022-06-03 21:00:00,20.1,1.4828,-2.6924,-0.002264,-0.000246,, |  |  |  |
| 2022-06-03 21:30:00,20.1,1.4831,-2.6924,-0.002019,-0.000274,, |  |  |  |
| 2022-06-03 22:00:00,20.0,1.4832,-2.6925,-0.001941,-0.000376,, |  |  |  |
| 2022-06-03 22:30:00,19.8,1.4830,-2.6923,-0.002092,-0.000201,, |  |  |  |
| 2022-06-03 23:00:00,19.4,1.4829,-2.6923,-0.002247,-0.000154,, |  |  |  |
| 2022-06-03 23:30:00,19.8,1.4831,-2.6924,-0.001961,-0.000240,, |  |  |  |
| 2022-06-04 00:00:00,19.9,1.4831,-2.6927,-0.001962,-0.000564,, |  |  |  |
| 2022-06-04 00:30:00,19.7,1.4831,-2.6923,-0.002006,-0.000146,, |  |  |  |
| 2022-06-04 01:00:00,19.4,1.4827,-2.6922,-0.002409,-0.000096,, |  |  |  |
| 2022-06-04 01:30:00,19.3,1.4832,-2.6917,-0.001943,0.000482,,  |  |  |  |
| 2022-06-04 02:00:00,19.4,1.4834,-2.6924,-0.001659,-0.000232,, |  |  |  |
| 2022-06-04 03:30:00,18.1,1.4832,-2.6909,-0.001872,0.001272,,  |  |  |  |
| 2022-06-04 04:00:00,18.3,1.4832,-2.6909,-0.001865,0.001295,,  |  |  |  |
| 2022-06-04 04:30:00,18.1,1.4831,-2.6910,-0.002011,0.001120,,  |  |  |  |
| 2022-06-04 05:00:00,18.0,1.4833,-2.6909,-0.001806,0.001292,,  |  |  |  |
| 2022-06-04 05:30:00,17.6,1.4830,-2.6904,-0.002055,0.001770,,  |  |  |  |
| 2022-06-04 06:00:00,17.6,1.4830,-2.6903,-0.002106,0.001883,,  |  |  |  |
| 2022-06-04 06:30:00,17.3,1.4831,-2.6898,-0.001998,0.002300,,  |  |  |  |
| 2022-06-04 07:00:00,16.9,1.4830,-2.6899,-0.002064,0.002263,,  |  |  |  |
| 2022-06-04 07:30:00,16.7,1.4831,-2.6895,-0.001975,0.002695,,  |  |  |  |
| 2022-06-04 08:00:00,16.6,1.4834,-2.6892,-0.001740,0.002898,,  |  |  |  |
| 2022-06-04 08:30:00,16.8,1.4832,-2.6901,-0.001920,0.002053,,  |  |  |  |
| 2022-06-04 09:00:00,17.1,1.4835,-2.6902,-0.001646,0.001930,,  |  |  |  |



# WP2 - Use cases for the mining industry

## IoT & WIRELESS SENSORS IN MINING ENVIRONMENTS

Axis variation (°)



# WP2 - Use cases for the mining industry

## IoT & WIRELESS SENSORS IN MINING ENVIRONMENTS

### Node 2021

/ Networks / 21843 / Node 2021

|                                |   |
|--------------------------------|---|
| Name                           |   |
| Installation date              |   |
| Comments                       |   |
| Model                          | LS-G6-DIG-1-EU                                  |
| Firmware version               | 2.68  |
| Serial number                  | 64  |
| Health CSV files               | <a href="#">2021-health-current.csv</a>         |
| Errors CSV files               | <a href="#">2021-reading-errors-current.csv</a> |
| LS-G6-DIG Modbus RTU CSV files | <a href="#">2021-11-readings-current.csv</a>    |

| Last readings and Time series graphs |              |                |                    |                    |              |            |                  |
|--------------------------------------|--------------|----------------|--------------------|--------------------|--------------|------------|------------------|
| Sensor ID                            | Accuracy N/A | AirQuality N/A | VoC Equivalent ppm | Co2 Equivalent ppm | Pressure hPa | Humidity % | Temperature degC |
| 1                                    | 0            | 25             | 0.49               | 500                | 1011.54      | 37.1       | 22.95            |
| Received on 2021-12-20T14:56:14Z     |              |                |                    |                    |              |            |                  |
| Status                               |              |                |                    |                    |              |            |                  |
| Metadata                             |              |                |                    |                    |              |            |                  |
| Last messages                        |              |                |                    |                    |              |            |                  |



# WP2 - Use cases for the mining industry

## IoT & WIRELESS SENSORS IN MINING ENVIRONMENTS

Last readings and Time series graphs

| Sensor ID | Accuracy N/A | AirQuality N/A | VoC Equivalent ppm | Co2 Equivalent ppm | Pressure hPa | Humidity % | Temperature degC |
|-----------|--------------|----------------|--------------------|--------------------|--------------|------------|------------------|
| 1         | 0            | 25             | 0.49               | 500                | 1011.54      | 37.1       | 22.95            |

**Accuracy:** precision of measures

**AirQuality:** It is a measurement that the sensor calculates using an algorithm that is proprietary to Bosch (the manufacturer of the sensor)

**VoC: Volatile organic Compounds**

**CO<sub>2</sub> equivalent**

| IAQ Index              | Air Quality         | Impact (long-term exposure)  | Suggested action   |
|------------------------|---------------------|--|--|
| 0 – 50                 | Excellent           | Pure air; best for well-being  | No measures needed   |
| 51 – 100               | Good                | No irritation or impact on well-being                                    | No measures needed   |
| 101 – 150              | Lightly polluted    | Reduction of well-being possible   | Ventilation suggested  |
| 151 – 200              | Moderately polluted | More significant irritation possible                                     | Increase ventilation with clean air  |
| 201 – 250 <sup>9</sup> | Heavily polluted    | Exposition might lead to effects like headache depending on type of VOCs | optimize ventilation   |
| 251 – 350              | Severely polluted   | More severe health issue possible if harmful VOC present                 | Contamination should be identified if level is reached even w/o presence of people; maximize ventilation & reduce attendance |
| > 351                  | Extremely polluted  | Headaches, additional neurotoxic effects possible                        | Contamination needs to be identified; avoid presence in room and maximize ventilation  |

| Molar fraction | Compound               | Production tolerance | Certified accuracy |
|----------------|------------------------|----------------------|--------------------|
| 5 ppm          | Ethane                 | 20%                  | 5%                 |
| 10 ppm         | Isopropene /2-methyl-1 | 20%                  | 5%                 |
| 10 ppm         | Ethanol                | 20%                  | 5%                 |
| 50 ppm         | Acetone                | 20%                  | 5%                 |
| 15 ppm         | Carbon Monoxide        | 10%                  | 2%                 |

| CO <sub>2</sub> [ppm] | Air Quality   |
|-----------------------|---|
| 2100                  | <b>BAD</b><br>Environment highly polluted.<br>Ventilation is required |
| 2000                  |   |
| 1900                  |   |
| 1800                  |   |
| 1700                  |   |
| 1600                  | <b>POOR</b><br>Environment polluted.<br>Ventilation is required       |
| 1500                  |   |
| 1400                  |   |
| 1300                  |   |
| 1200                  | <b>NORMAL</b>   |
| 1100                  |   |
| 1000                  |   |
| 900                   | <b>GOOD</b>   |
| 800                   |   |
| 700                   | <b>EXCELLENT</b>  |
| 600                   |   |
| 500                   |   |
| 400                   |   |

## Conclusions

- ❑ The installation of wireless sensors in mining environments is a fundamental tool in modern mining
- ❑ It allows real-time monitoring of parameters directly related mainly to the safety and health of workers and the establishment of an alert system when a threshold is exceeded.
- ❑ However, they must meet some basic requirements for this system to be operational:
  - Cheap
  - Robust
  - Easy to install
  - Able to work in harsh conditions of dust, humidity, temperature, vibrations, etc.
- ❑ Although the LoRa system is considered an excellent solution to establish communication inside the mine, since it has a greater range and is less susceptible than other systems such as WiFi to the presence of obstacles, curves, etc..., it still has several drawbacks, such as the low volume of data it can transmit.
- ❑ To solve this and other problems that may arise, the **IlluMINEation** project tries to find appropriate solutions to improve the health, safety and sustainability of mining companies.

# Thanks for your attention

