RESYS

Presentation of the system

Wireless mining rescue communication system that can be used in excavations susceptible to firedamp and/or combustible dust.

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PROFIL–MET GROUP

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General information

2RHP was founded to commercialize the **RESYS** project. **RESYS** is an original solution invented in cooperation with the following research facilities: AGH University of Science and Technology (the leader of the consortium), Main Mining Institute and National Institute of Telecommunications.

The functional part of the project was realized under the supervision of the Central Mines Rescue Station – another member of the consortium. Technical quality of the project was ensured by the engagement of highly qualified engineers specialized in electronics, radio transmission, IT and mechanics.

Description of the system

Wireless rescue communication system is the first autonomous, mobile system that enables "full-duplex" communication, working on the most appropriate frequency to use in underground excavations. Our own research of the radio waves propagation in the drifts of coal mines made us choose for our further works, the frequencies between 800 and 900 MHz. The results of our tests found confirmation in recognized professional publications.

In 1970s, US Bureau of Mines financed research on the propagation of radio waves. One of the research projects concerned propagation of UHF band (300–3000 MHz) in drifts 14 feet wide (4,3 m) and 7 feet high (2,1 m).

The relation of radio waves frequency 300–2400 Mhz and the attenuation over a distance of 1000 feet (300 m) is shown on the graph.

The weakest attenuation was achieved with radio frequency between 800 and 1000 MHz.
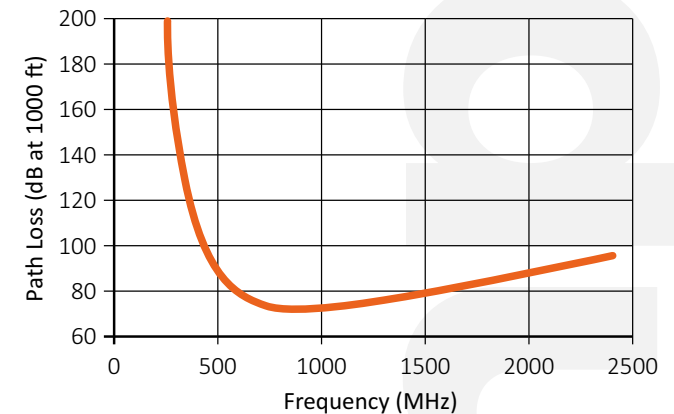
Characteristics of radio waves propagation in coal mine drifts

Basic information about RESYS

- Continuous, two-way (full-duplex) voice transmission among members of a rescue team (without the mediation of any device as long as they are in immediate radio range, or via a network of mobile repeaters whenever they are outside immediate radio range)

- Continuous connection between the rescue team members (or just the foreman) with the base/dispatcher via a network of mobile repeaters created ad-hoc.

- Optionally – connection of repeaters with fiber optic cables with the use of a mediaconverter

- Ability of two-way connection between brigades.

- Work in noisy environment with an option of ambient listening

- Up to 12 h battery time – batteries replaceable in explosion hazard zones

- Voice SMS transmission and playback

- Location of a user based on radio signals from nearest repeaters and pointing the way back (light and sound indication)

- Data transmission: vital sings, device data (e.g. battery level), alarm (heart rate exceeded, immobility – loss of consciousness)

- Transmission, playback and recording of data from the network at the base/dispatcher's room (condition of the network, location, alarms)

- Users' data, plan of drifts updated at the base, ability to create plans in case of their absence, marking repeaters on the plans

- Voice recording during rescue actions (at rescuer's equipment or in the base or management)

- Online data transmission from the base to the management on the surface (fiber optic)

System components

- Communicator
- Repeater
- Base
- Mediaconverter
- PC Software

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Personal communicator

- Housing – Hearing protectors with good sound attenuation, modern design, comfortable, 650 g of weight (including the battery), continuous operation time 12 h

- One-button activation, automatic log-in to the network

- Full duplex communication (simultaneous in both directions)

- Two versions – with a boom microphone or an in-mask wireless microphone

- High sound quality

- Outside noise reduction, with an in-mask microphone also reduction of the inside noise (breath sound)

- Ambient listening

- M1 category battery, replaceable in explosion hazard zones.

- Volume and microphone amplification control

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Repeater

■ Very little radio delays generated by repeaters

■ Localization of the rescuers against the repeaters

■ M1 category battery replaceable in explosion hazard zones

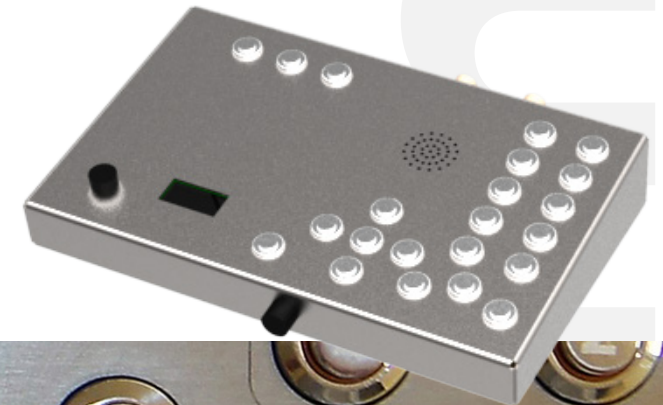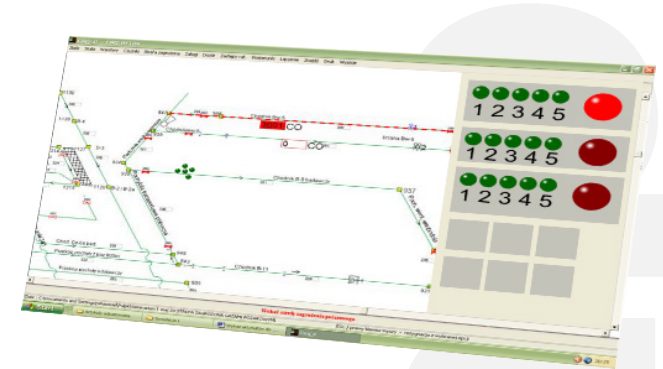■ Average range achieved in real-condition tests – 140 m

■ High mobility – lightweight and functional housing, 440 g weight (including the battery), 15–20 h of continuous operation

■ Ad-hoc network easy to build – audio commands in communicators

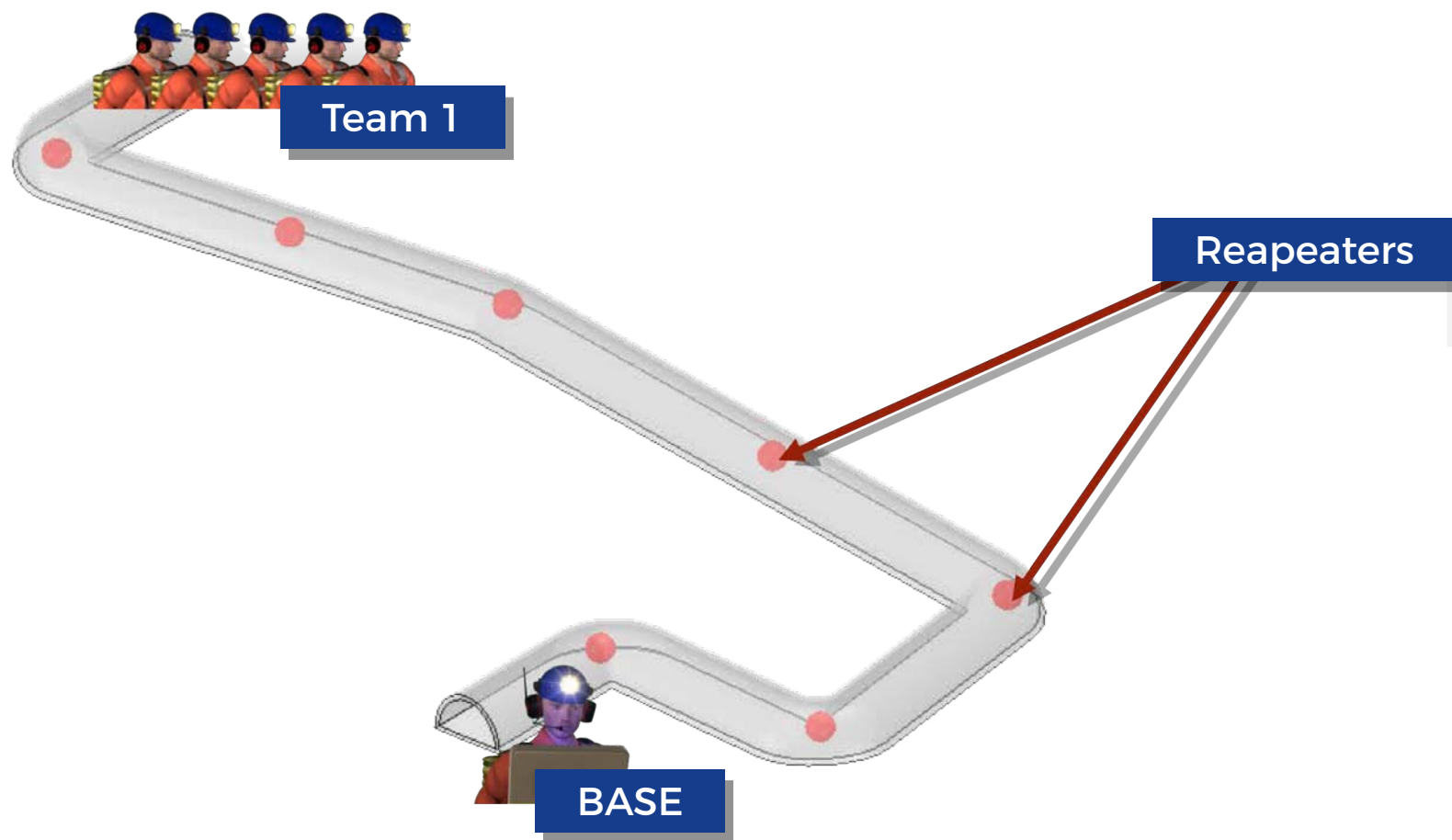■ Two-way and two-band transmission (radio and fiber optic)

Base

- Continuous full duplex communication with five brigades as well as with the Rescue Manager and the management on the surface

- Software for online tracking of: communicator, repeater parameters as well as auxiliary devices (vital signs monitoring)

- Ability to create drift plans and marking location of system components such as repeaters

- Use of drift plans prepared earlier

- Sending voice SMS played back simultaneously on all communicators (e.g. "Retreat" command)

- Voice and data recording (parameters of the network, devices, alarms, SMS sent)

- Connection with the surface via fiber optic network of the mine

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Repeater network scheme

Example scheme of a drift with marked positions of repeaters.

Team 1

Reapeaters

BASE

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RESYS software

- Graphic presentation of data: location of users in a drift, their vital signs, battery levels, other devices data

- Depending on infrastructure, online underground monitoring of the rescue action or audio transmission from the base to the management on the surface

- Recording the course of rescue action

- Could be adjusted for the use other than recue actions, for example for mining, on client's individual request
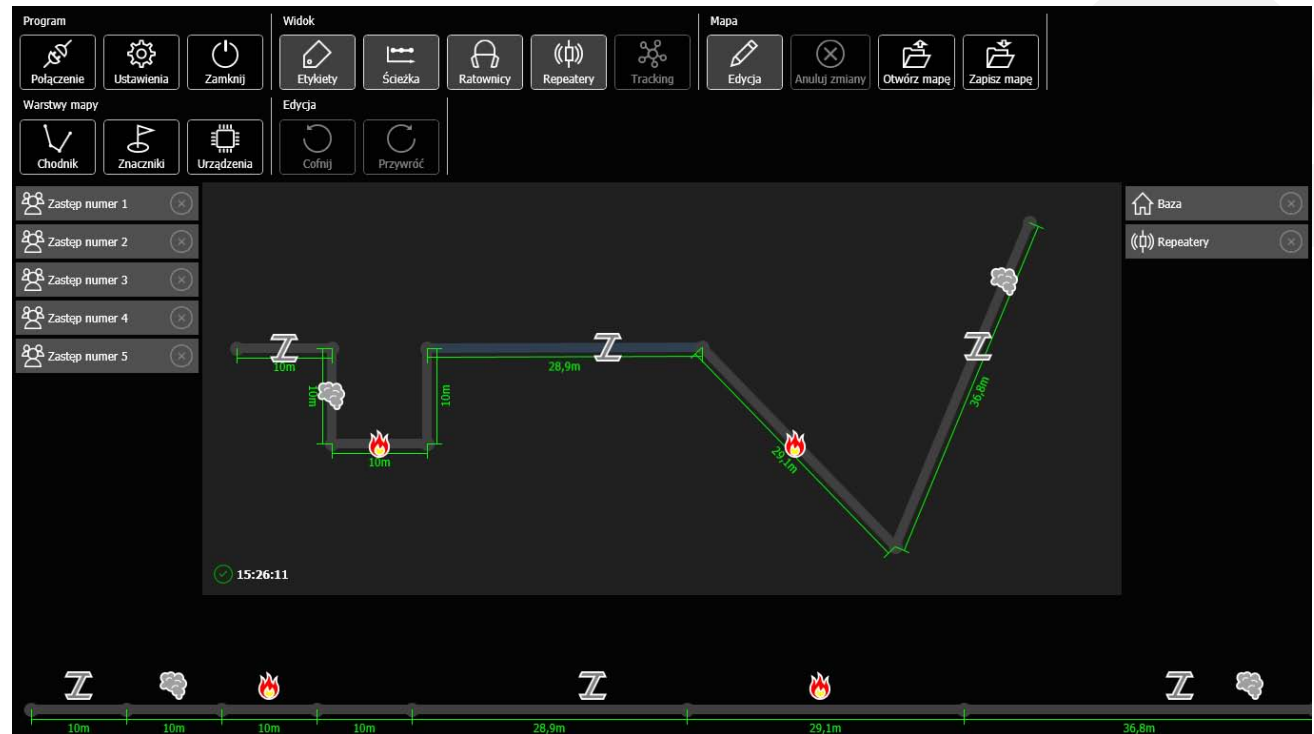
Rescue connection scheme

STAFF

Team 1

Team 2

Team 3

BASE

KAR
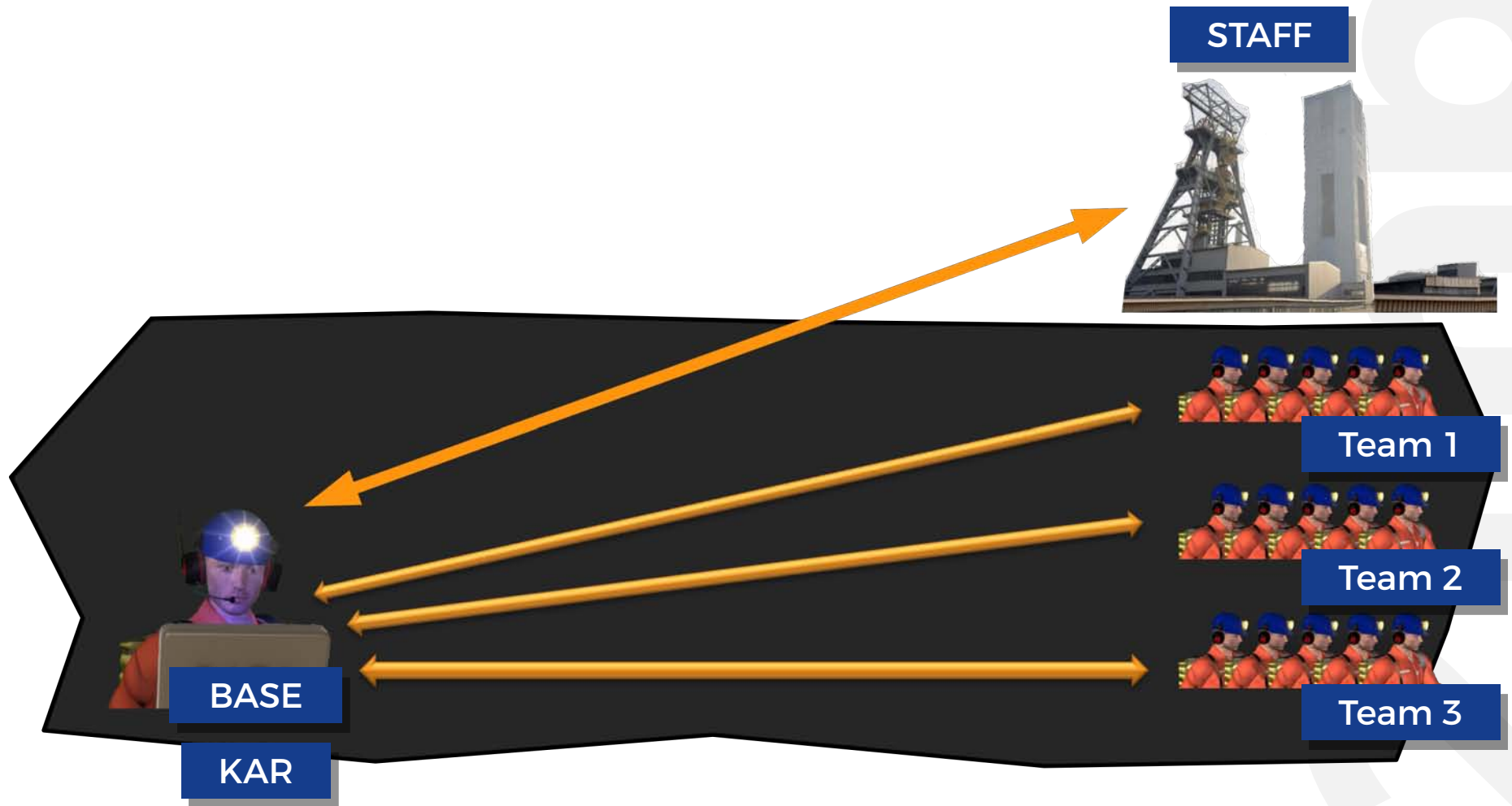
# Rescue connection within a team

Team leader

BAZA

Security features

- Continuous full duplex communication (simultaneous audio signal sending and receiving)

- Housing in the form of a hearing protector – noise reduction (fans, machines) and the ability of ambient listening

- High sound quality and noise reduction systems – speech clarity, easier coordination of an action

- Localization

- Vital signs monitoring (immobility sensor, heart rate sensor)

- Marking the best way of retreat

- Voice SMS – immediate playback of a voice message in all communicators

Example of localization in a drift
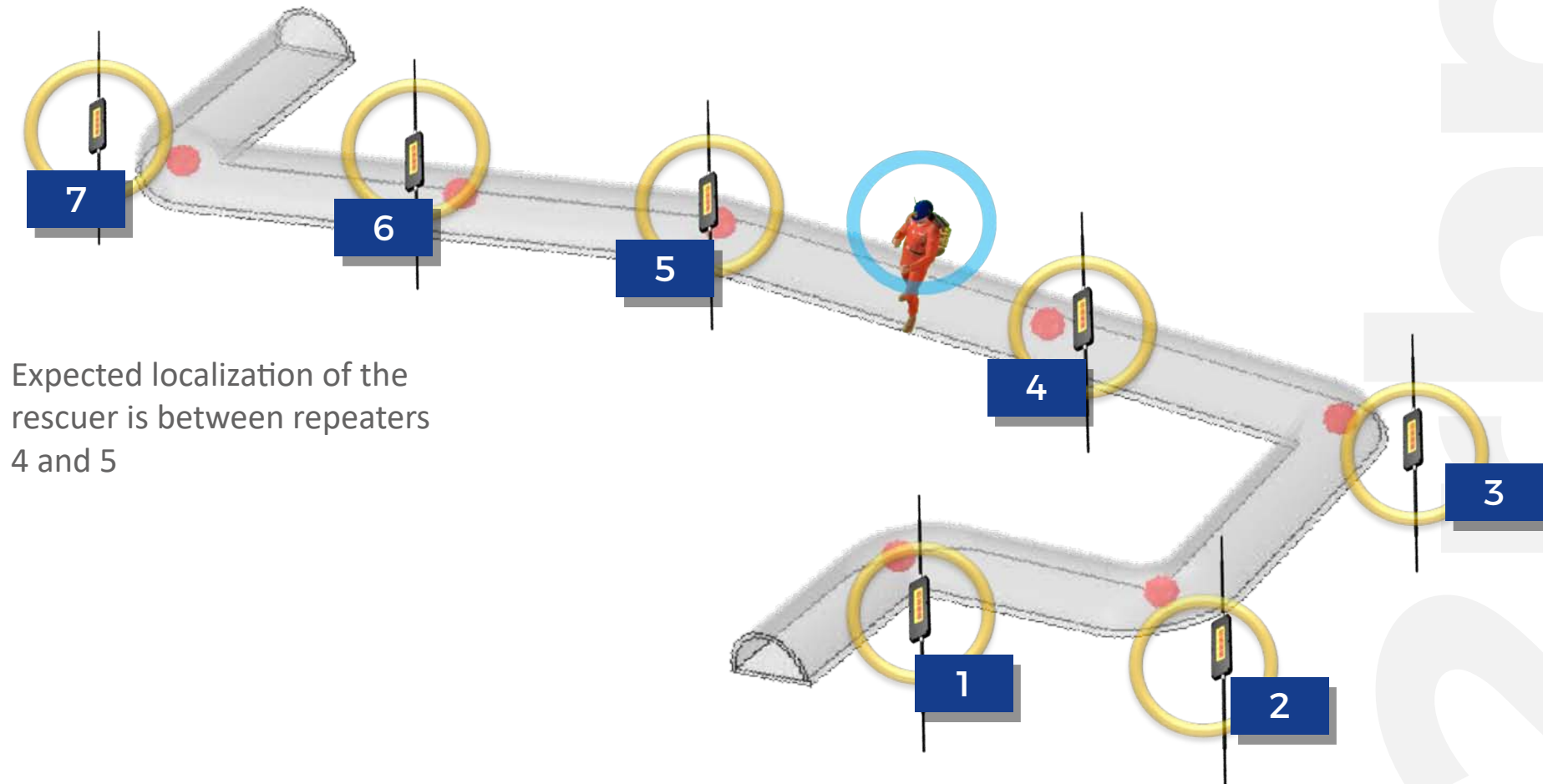
Expected localization of the rescuer is between repeaters 4 and 5

# Using the system for excavation work – coordination of works in noisy environment in M1 hazardous area

The system ensures perfect connection between miners in noisy environments. It increases safety and enables work coordination of miner teams at excavation work.
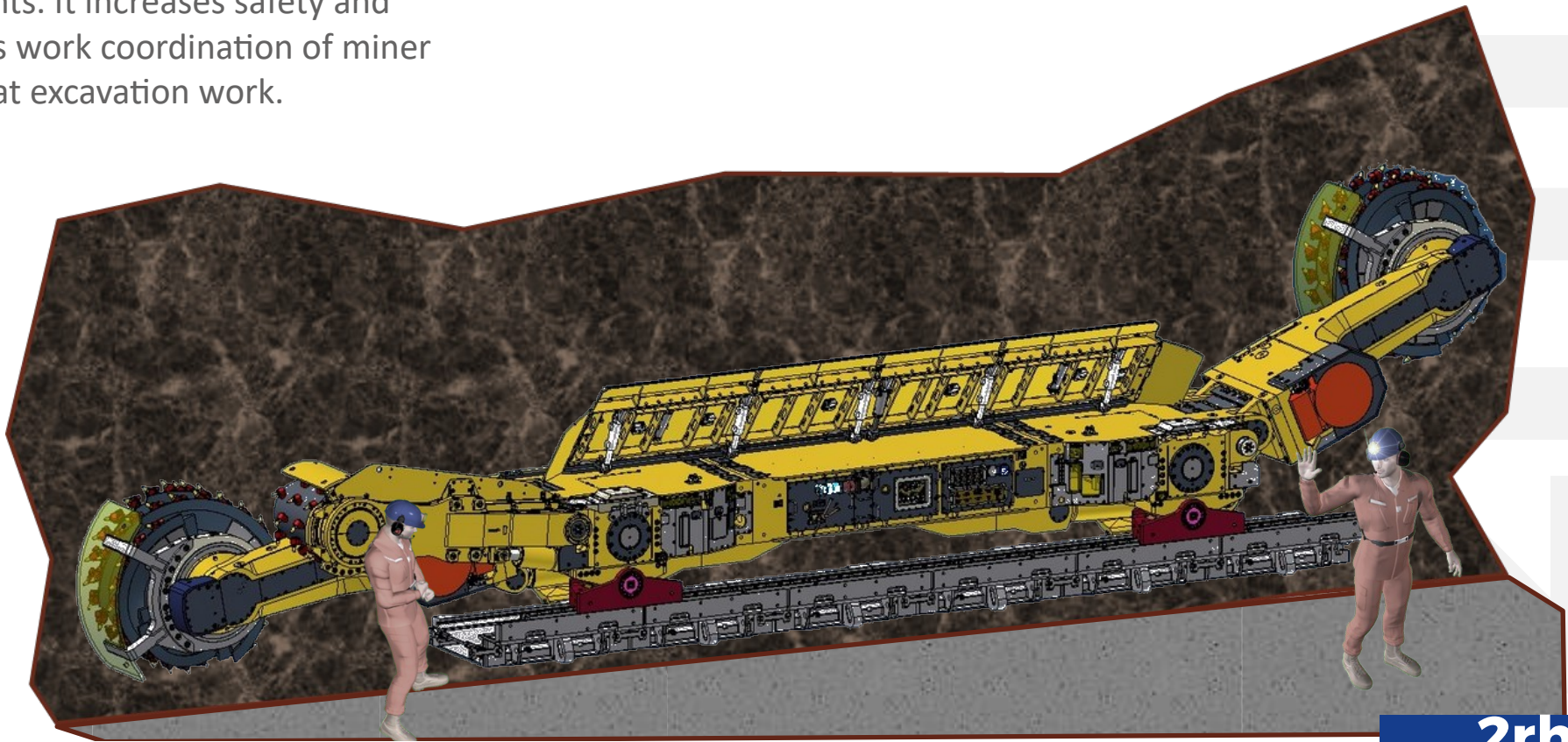
Underground mining communication models

The system gives very wide range of communication models between users. Communication can be immediate between the users of via the backbone network. The immediate communication is available for all the users within the radio range (peer-to-peer) as shown for a 5 member mining team in the drawing no. 1.

Fig. 1. Possibility of voice calls in user group

← - - → Full duplex conection
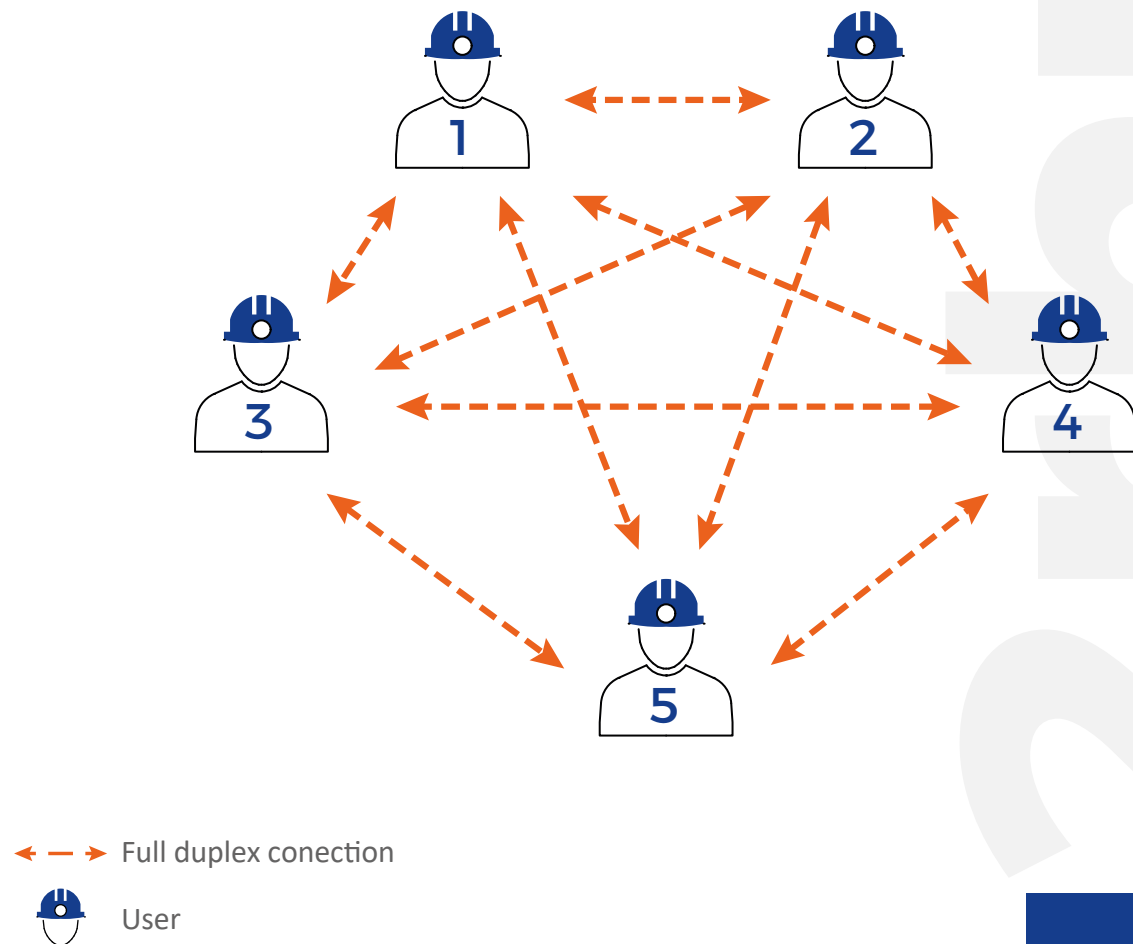
User

Underground mining communication models

Whenever the users are outside immediate radio range, the communication occurs via the backbone network. In the figure no. 2 there is a situation presented in which the distance between Brigade A and Brigade B is bigger than the immediate radio range. There is also a foreman between them, also outside the immediate range of both brigades. Thanks to the network, all members of both brigades can communicate both with the members of the same brigade and the other one. All of them can also contact the foreman, who in turn can contact every member of both brigades.

Fig. 2. View of the drifts from above

Legend:
- 🔴 Repeater
- ⛑ Miner
- ⛑ Foreman
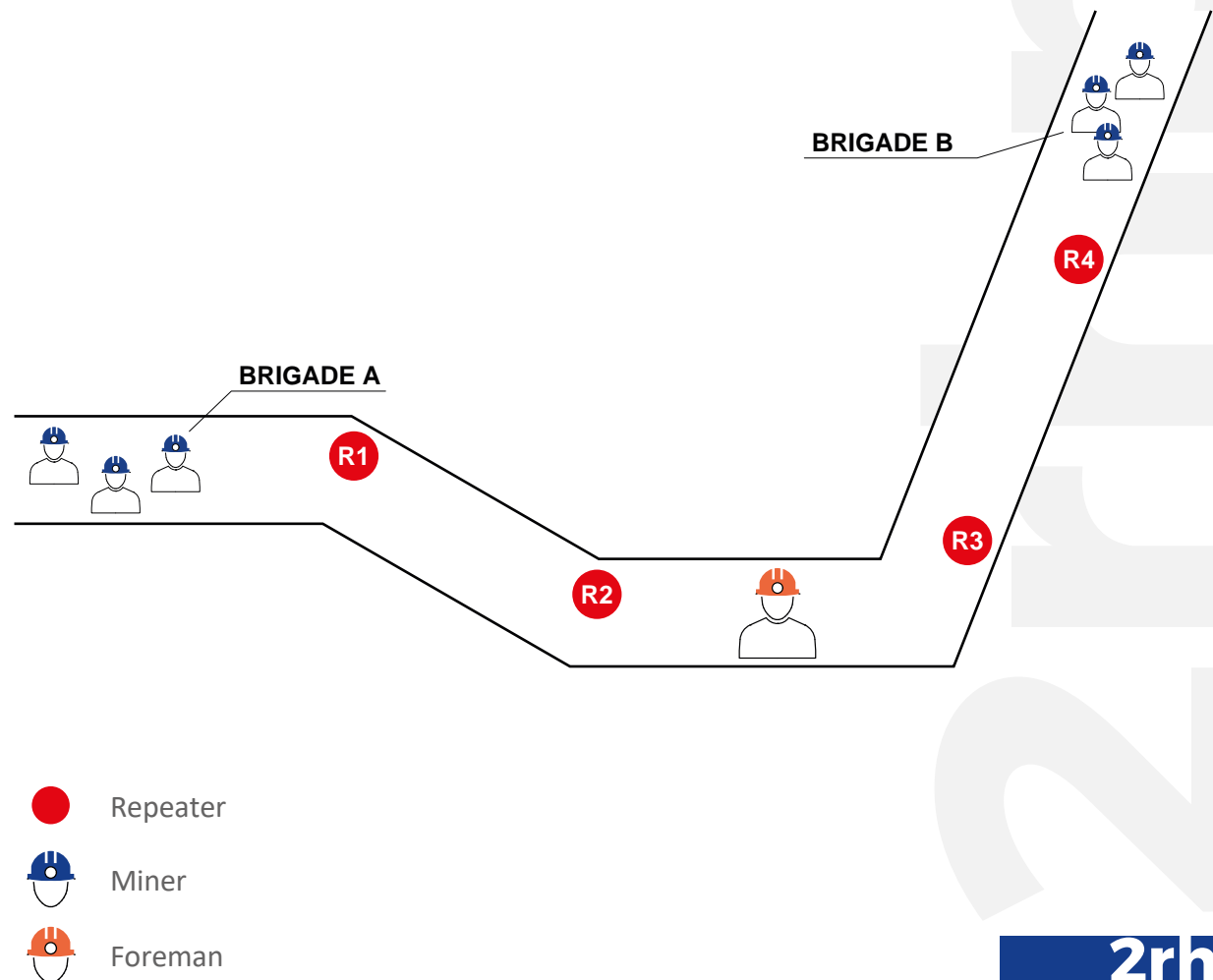
Underground mining communication models

The figure no. 3 shows possible connections of one of the members of Brigade A. It should be emphasized that every member of both brigades and the foreman have the same options. There can be more users along the backbone network and everyone can be connected with.

Communication between the users can be adjusted according to the requirements, e.g. limiting connections between users regarding their importance of the message (information, alarm) and other criteria.

Fig. 3. Voice capabilities for the miner no. 2 from Brigade A through the backbone network

BRIGADE A

BRIGADE B

BACKBONE NETWORK

R   Repeater

◄---►   Duplex radio connection

⛑   Miner

⛑   Foreman
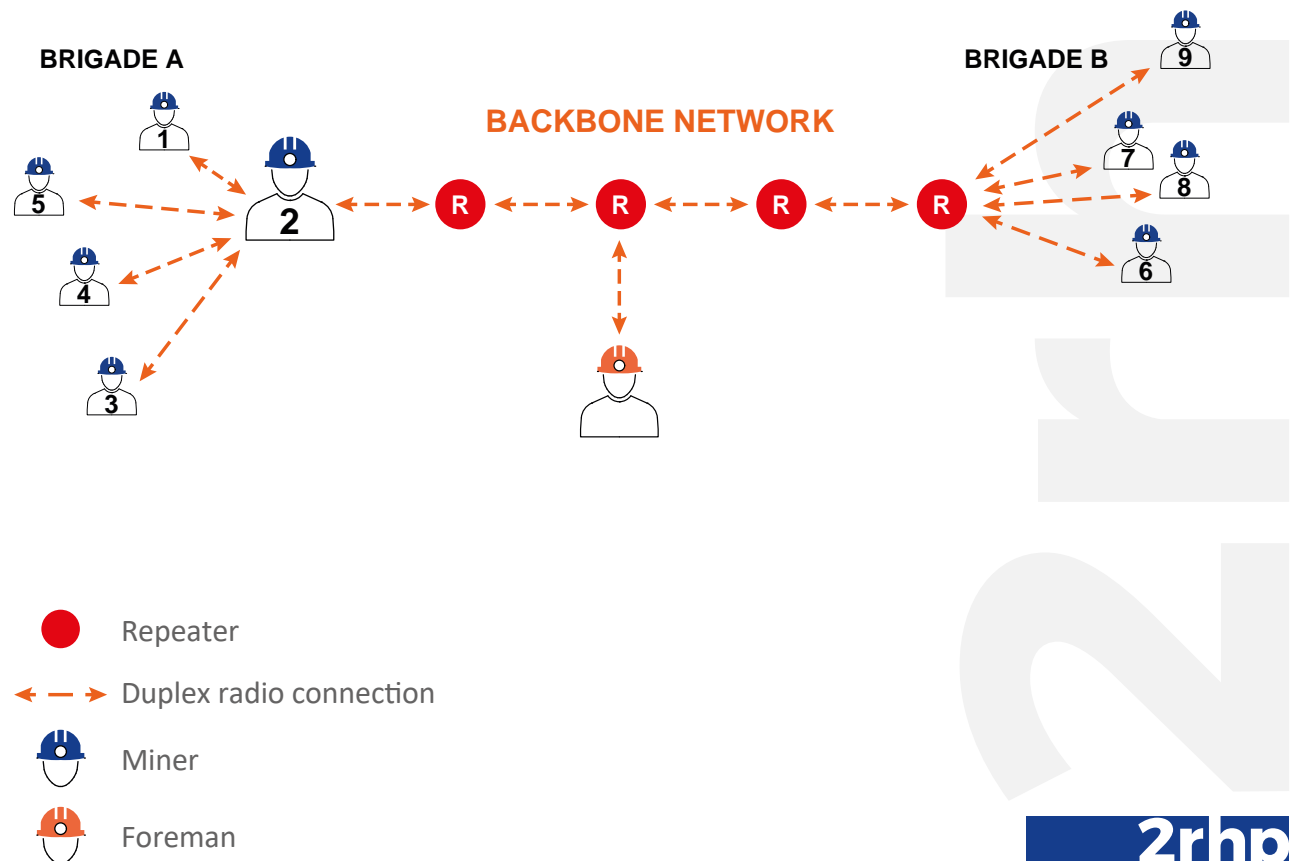
Underground mining communication models

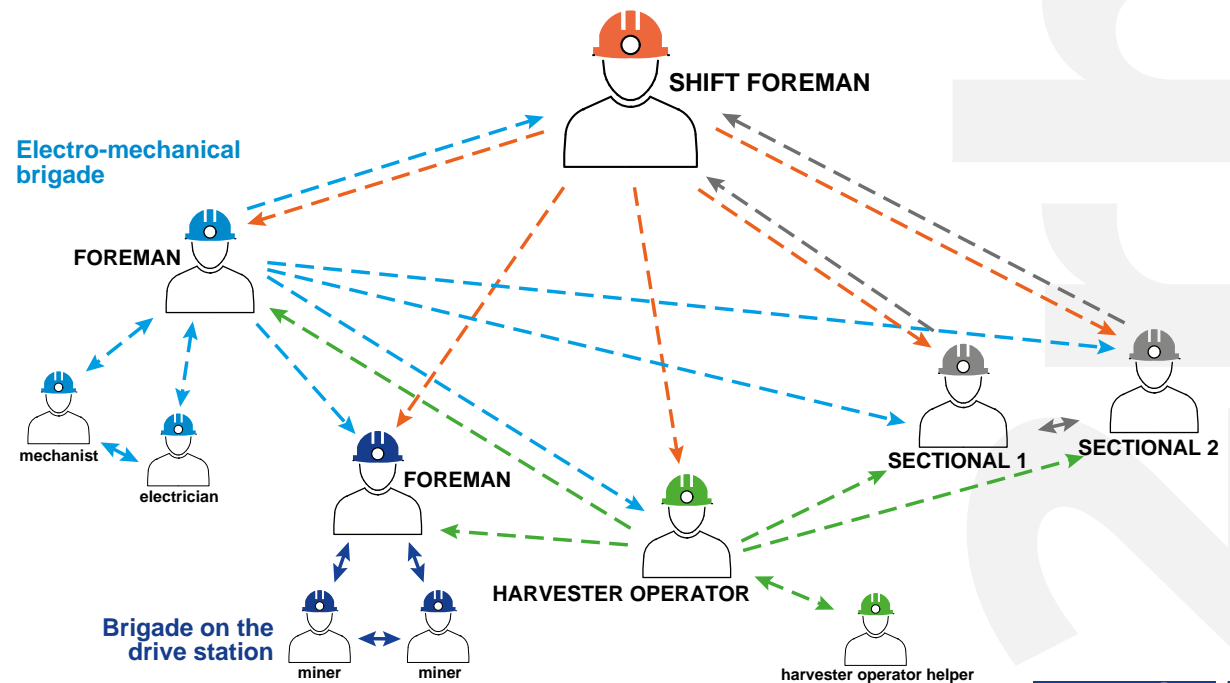Fig. 4. An example of a mine during a exploitation
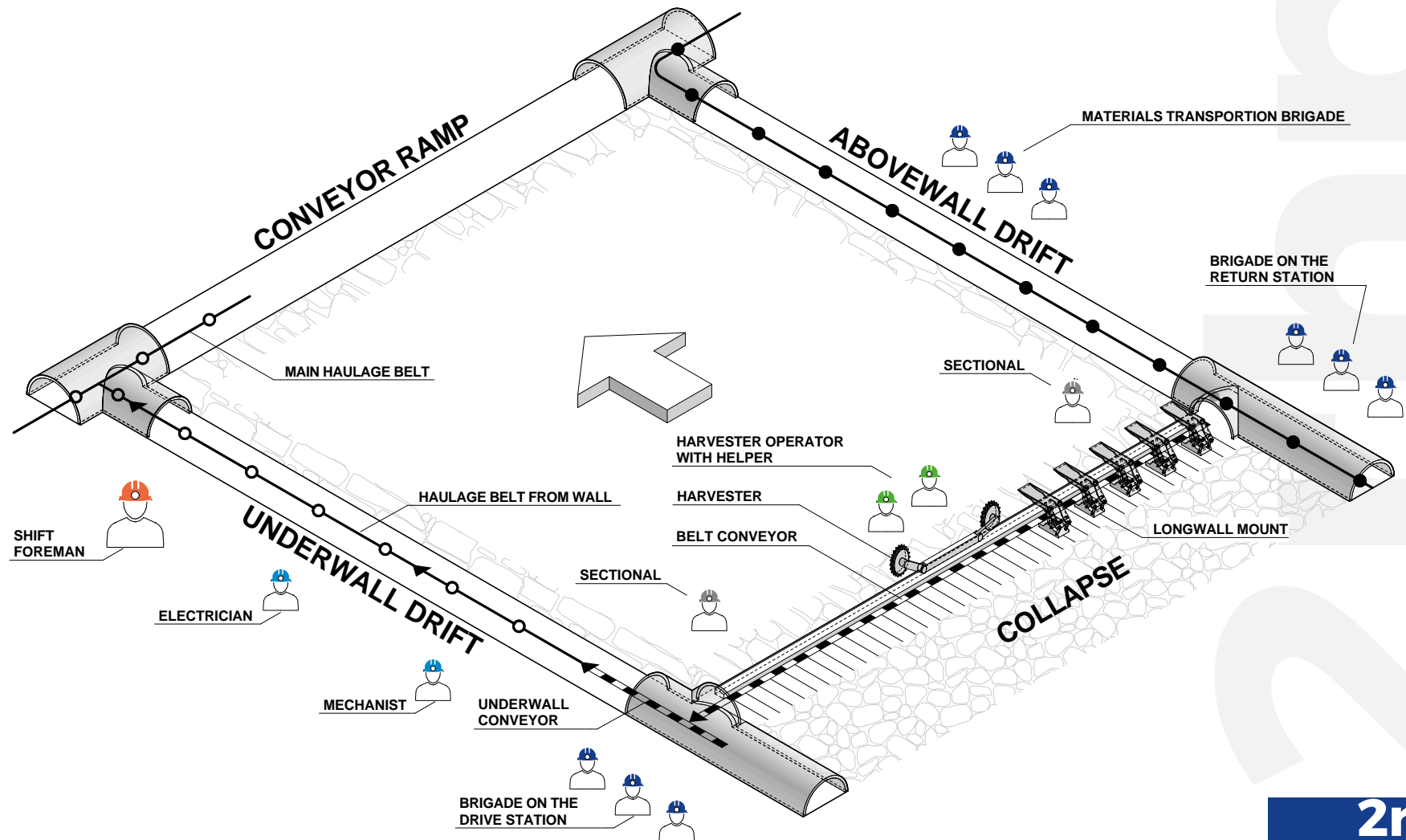
Underground mining communication models

Figure no. 4 shows an example of a part of a coal mine in operation. There are working miners in the drifts, mostly organized in brigades. Communication model can look as shown in fig. no. 5.
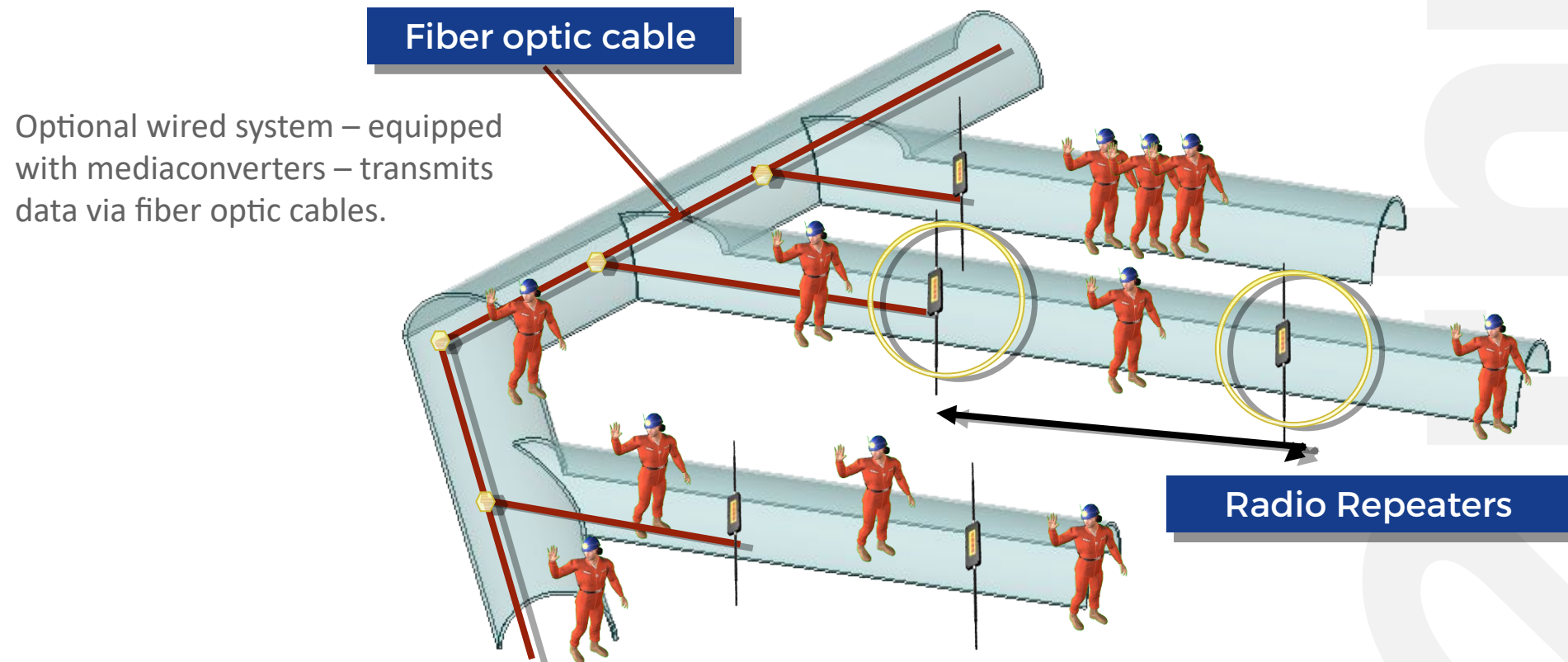
As scheme no. 5 shows, the Shift Foreman can connect with the foremen of all squads, the harvester operator and the powered roof support operators. The foreman of the electro-mechanical squad can connect with the Shift Foreman, foremen of other squads, harvester and powered roof support operators. The members of his squad can connect with each other and the foreman. The harvester operator can connect with Foremen and powered roof support operators. Harvester operator's assistant can connect only with the harvester operator and roof support operators.

Fig. 5. Possibility of network connections for the Shift Foreman, Electro-mechanical Brigade Frontman and Cutter-loaderman

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Example of drift infrastructure using two transmission bands – radio and fiber optic

Optional wired system – equipped with mediaconverters – transmits data via fiber optic cables.

Fiber optic cable

Radio Repeaters

Patent applications

EP16461537.9

„A radio communication repeater, a radio communication system and method", filed July 14th 2016 r.

EP13461534.3

„A method for receiving a signal comprising frames, a signal receiver and a signal comprising frames", filed June 26th 2013 r.

Development of RESYS – Smart Mining

2RHP Sp. z o.o. plans further development of the system aimed at creation of a wireless broadband intrinsically safe mining network serving as communication interface for the Smart Mining idea, enabling data, audio and video real-time transmission.

The company is working on the following devices:

- Communicator in form of a radio-telephone with keyboard, camera and headset

- Modem – device that enables radio connection of other machines/equipment, sensors to the network

- Signal converter – a device that converts other types of signals (e.g. RS485) into a radio signal

- A radio beacon – a device used to localize people, machines/equipment underground, in mine drifts

Thank you for your attention

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