Technical Proposal

ATUT-Location system with VoIP wireless communication
1. Introduction

ATUT-Location System was established primarily with the aim of increasing the safety of persons employed in mine plants. ATUT-Location is dedicated for constant monitoring of workers located underground in different parts of the mine plant. System functionalities are mostly dedicated for:

- mine dispatchers who are about to monitor the mine plant situation prevailing in the corridors of the plant,
- safety related mine departments supervising the safety of the work / service
- ventilation department providing information on the number of employees residing in each of the mine parts, critical from the point of view of the air circulation in monitored zones and mining excavations works.

In addition, this system can be used as a source of information on the currently allocated human resources, the technological work carried out by providing location data along with the identification of the employee who is looked for, in terms of qualifications and / or group / division to which they belong.

The main features of the system include:

- modular design,
- high precision of location, up to 1.5 m. in underground excavations,
- determination of the position of localized man (object) in several dimensions (0D, 1D or 2D),
- sending the text messages (emergency alarms) to selected or a group of selected tags,
- resistance to interference from other radio equipment (eg. Access points WiFi),
- giving the emergency alarm by the supervised persons to the mine dispatcher,
- self-diagnostic system devices and data networks,
- multi-level data archiving,
- balancing the number of employees entering / leaving the monitored zones to ensure the proper migration of humans,
- counting the number of people in these zones
- alarms for employee detour, too long time of remaining in the specified zone, too many people in a given area, etc.,
- intuitive visualization software made in the technology WEB,
- generating reports and statistics based on the data collected,
- ability to search for people within range of the system with their exact location and other collected information (for ex. Division, working time, time of entering the zone, etc.).

Presentation of collected by ATUT-Location system data in an easy to read way, with usage of intuitive visualization software increases monitoring efficiency and safety of the crew working in the mine plant. Visualization software is based on user-supplied maps of the excavation corridors and is accessible through a Web browser. Each of the system user has its own rules and rights given to an ‘user account’ by the system administrator.

ATUT-Location system can be fulfilled by the VoIP communication system. Based on the same network and build into the ATUT-Location system hardware infrastructure Wifi Access points can be interconnected with the Telesis telecommunication central in order to enable establishing calls between handheld VoIP telephone (AT-Tel) and existing telephone cable infrastructure located both on the surface and in the mine underground.
Combining ATUT-Location system with the VoIP communication gives the ability not only to locate persons but also to stay interconnected with those who carry with a tag and VoIP telephone.

2. Technical characteristics

2.1. ATUT-Location system technology

ATUT-Location system is based on the Radio Frequency IDentification (RFID) technology. To locate a person it uses a carried with active tag (AT-LTAG-1) which responds to the ATUT-Location system wireless access gates (AT-LBS modules) with a ‘radio blink’. The time interval between the ‘radio blinks’ can be configured due to the expected location precision and life time of the battery between charges.

The given by tag ‘radio blinks’ are used by the ATUT-Location system wireless access gates (AT-LBS module) to count the time delay between the tag ‘radio blink’ and its arrival to the AT-LBS module. As the AT-LBS module has a fixed coordinates it is able to allocate the tag which it responds to.

![ATUT-Location tag location measurement](image)

ATUT-Location tag location measurement (time of delay).

All the collected data coming from the ATUT-Location system wireless access gates is being transferred to the server database, where it is stored and the location can be calculated and shown by the ATVisio 2 visualization software.

2.2. ATUT-VoIP communication technology

Voice over Internet Protocol, is a method for taking analog audio signals, like the kind you hear when you talk on the phone, and turning them into digital data that can be transmitted over the Internet.

With this technology it is possible to interconnect the handheld telephones (AT-Tel) with any other telephone unit (analog or digital) already connected and existing in the network.
ATUT VoIP system architecture

ATUT-VoIP communication system connection example
2.3. Device characteristics

ATUT-Location and VoIP communication system will be equipped with the devices listed below:

- **Surface:**
  - Telephones (existing equipment)
  - PC work stations (existing equipment)
  - Communication system central – Telesis PX24 (existing equipment)
  - SCADA Server with AT-Visio2 software installed
- **Underground:**
  - AT-LBS – human monitoring local base station module
  - AT-LTAG – location tag for human monitoring system
  - ISPS-2/AP – Wifi access point for VoIP telecommunication
  - AT-TEL – VoIP telephone
  - ANTI-2G4 – ISM band antenna
  - KM – media converters (fiber <> cooper)
  - ISE – Ethernet switch
  - Rechargable battery unit for ex. IZ-CX
  - ZIM-BX intrinsically safe power supply

### 2.3.1.1. AT-LBS-1 module

ATUT-LOCATION System Base Station is a reference point to determinate the position of AT-LTAG radio tags in zones endangered with explosion. The module can be equipped with one of two available interfaces: RS422 or Ethernet. The interface selection is done at the stage of device ordering. Electrical equipment is made as intrinsically safe, what allows it to be used in mining plants in chambers with danger of methane and / or coal dust explosion. AT-LBS-1 Base Station should be placed in the casing of localization gateway providing at least IP54 protection degree.
2.3.1.2. AT-LTAG-1/LCD

AT-LTAG-1/LCD is an active radio tag operating in the 2.4 GHz ISM band. The device in association with the infrastructure of the ATUT-Location system allows the location of object in move with accuracy of 1.5 m. The device is equipped with a rechargeable battery which allows continuous operation for a period of 4 weeks between charges. However, tag can be equipped with a bigger battery (1200 mAh) which enlarges the time between charges to approx. 5 months. Device configuration is done through radio transmission path. Moreover, the device is equipped with a button allowing configuration to interact with the system (pressed in case of emergency can send an alarm to the dispatcher). For the optional AT-LTAG-1/LCD can be equipped with accelerometer motion sensor which allows, passing tag to sleep when not moving (energy saving mode) or to send an alarm. Charging AT-LTAG-1/LCD can be done by USB.

2.3.1.3. ISPS-2/AP

Intrinsically safe serial ports server ISPS-2 provides data transfer between ATUT-NET system devices or other working in RS-422 or RS-485 standard and intrinsically safe 10/100Base-TX Ethernet network or wireless Wi-Fi network. The device can work as a converter between intrinsically safe 10/100Base-TX Ethernet network and wireless Wi-Fi network (Access Point mode), as wireless network client (client mode) or in a mode with both functionalities. The device is equipped with LEDs signaling settings and work parameters.
2.3.1.4. AT-TEL

AT-Tel was designed to enable establishing calls between the telephone network subscribers both located underground or/and on surface. AT-Tel uses VoIP technology to provide the communication with other handheld telephones like AT-Tel or/and with the existing infrastructure of analog telephones located in mine plant. Equipped with color LCD display telephone provides its user with basic information about its condition – battery status, signal strength, etc. It is possible to receive and send messages within AT-Tel alfanumeric keyboard. When telephone is out of Wifi Access Point range it is possible to communicate with another AT-Tel device, when distance between AT-Tel devices is not bigger than 100 meters.

2.3.1.5. ANTI 2G4

ANTI-2G4 intrinsically safe antenna is used to transfer data in radio channels in ISM 2.4 GHz range. The antenna is mechanically adapted to build in any location. There are two different construction versions: RP-SMA (when the antenna is a part of another intrinsically safe device), N (when the antenna is installed separately - the N type connector is more resistant to damages). The antenna is made as intrinsically safe, what allows it to be used in mining plants in chambers with danger of methane and / or coal dust explosion. The casing provides IP65 protection degree.
2.3.1.6. Media converter type KM-i

KM-i media converter is a device used to convert signals between intrinsically safe 10/100Base-TX cable networks and 100Base-FX fiber optic networks. The device is equipped with one intrinsically safe Ethernet 10/100Base-TX port intended to connect cable lines with UTP cable ended with RJ-45 connector and second fiber optic transmission port with SC optical connector. KMi-1 converter depending on its type can use for data transmission two fibers (TX, RX) or single fiber using Wavelength Division Multiplexing technology. Thanks to this solution only one fiber is needed to create single transmission channel (broadcasting and receiving are on different wave lengths of one fiber). KMi-1 converters are working only in single-mode networks.

2.3.1.7. ISE module

ISE-1 device is working as an Ethernet switch. It is equipped with 5 intrinsically safe 10/100Base-TX ports that automatically detect connection speed and provide half/full duplex mode. Switches can be cascaded connected, what allows to easily expand the network as needed. Connected media converter KMi-1 gives an optical output to connect with fiber optic networks. Electrical equipment is made as intrinsically safe, what allows it to be used in mining plants in chambers with danger of methane and / or coal dust explosion. Ethernet switch ISE-1 sould be placed in casing providing at least IP54 protection degree.
2.3.1.8. Rechargable battery type IZ-CX-9,5

Intrinsically safe battery source can be used as backup power source for control devices with voltage up to 15 VDC, installed in mining chambers with „a”, „b” or „c” degree of danger of methane explosion and in chambers with „A” and „B” degree of danger of coal dust explosion. The device is equipped with connector to join intrinsically safe devices with „ia” category and to connect intrinsically safe cells charging voltage. LEDs placed next to the connector are indented to signal operation status of the bus (TX, RX) and to signal charging status.

2.3.1.9. MoBI

Intrinsically Safe Barrier Module MoBI can be used as „ib” power inputs into „ia” output switch in electrical devices in chambers with danger of methane and coal dust explosion. The module has independent certificate from certification body, that confirms meeting the requirements of ATEX Directive, what allows it to be used in any hardware configuration. The construction of module meets the requirements of IEC61131 norm in terms of functional and operational features and programming process.
2.3.1.10. ZIM-BX power supply

Intrinsically safe power supply type ZIM-BX is designed to supply electrical and electronic installations, especially the intrinsically safe control and signaling systems. Stabilized output voltage allows the use of power supply to power the microprocessor controllers. It is characterized by high stability of the output voltages at the volatile input voltage, which changes may take place in the range from 36V to 75V (for power supply in “L”) with DC current or from 35V to 54V with AC current and from 80V to 250V (for power supplies as “H”) when powered by AC voltage. Connecting the power supply is done by output junction chamber equipped with two conduits. Power supply type ZIM-BX can be supported by two independent outputs with different values of current and voltage according to the customer needs. It is equipped both with an LCD display, giving the ability to monitor voltage and current values of output and with RS-485 port for remote reading made for monitoring purposes on the surface of the mine. Power supply type ZIM-BX/A is equipped with two signal LEDs, but does not have LCD display and RS-485 communication protocol.

2.4. AT-NODE/CL

On the figure below a general concept of the AT-NODE/CL device is being drawn. Such a devices can be plugged into the existing ATUT-MFE network – please see the map attached.
2.5. Network

Network topology: Bus
Cables: fiber optic armoured prepared to be used in mining with the proprietor certificates. Number of cores can vary depending on customer needs. We propose to use 24J (core) cable as the main system bus.
Connectors: cables are equipped with the ZAT-S connectors for making the system assembly fast and easy. Connector can be fitted with one or two fibers. Special protection mechanism made for fiber-optics ferrules prevents them from contamination, keeping them clean during transportation or reconnection of network.
Data transmission: full-duplex
Network reconfiguration time: ~50 ms
Transfer rate: 100 Mb/s

All of the fiber optic devices use WDM technology (Wavelength Division Multiplexing), which can reduce by half the number of fibers used for data transmission. Due to the fact that the ATUT-Location system network is based on TCP/IP protocol it is possible to implement a full-duplex data transmission with usage of just one fiber.
3. Cables & connectors

For Adularya project we propose usage of fiber optic cable type:

- CDAD 24J – 24 core cable used to build the main bus which shall be also suitable to be expanded in the future.

For the fiber cable interconnections with devices like AT-HLBS/… we propose usage of connectors type ZAT/S. Connectors can be equipped with up to four ferulas attachment.

For powering the active devices we use 4 wire cable as shown on the figure below. Power cables are also coming with connectors for easy and fast assembly.
All of supplied by ATUT cables are suitable to be used in mine plants and have all the necessary certification done.

All of the connectors provides IP 67 degree of protection without using for assembly any tools beside bare hands.

4. AT-Visio 2 software

ATVisio2 system software platform was developed by ATUT to provide system user with a flexible tool supporting machinery, equipment and crew supervision. ATVisio 2 is designed to smoothly guide user in the areas of information provided by a variety of devices and subsystems, with particular emphasis on handling tailor made hardware solutions.

Using individual modules ATVisio2 platform can provide:

- supervision of the ongoing work of machines and equipment from any place in the network,
- analyze the work of machines, including for ex. the degree of their use and failure,
- browse historical data associated with machines usage, monitored objects movement,
- generate reports based on the collected data
- send commands to devices,
- monitor the location of the crew, machines and transported material,
- receive up to date statistical information, for example. on the current production capacity,
- receive information about the warning and alarm conditions occurring in the observed processes
- view images from cameras located in the factory,
- manage documents (including technical documentation, manuals, protocols, service) in electronic format,
- text message sending to the ATUT-Location device tags.

Example of a 2D visualization of the ATUT Location system done in ATVisio 2.
5. General concept

As the fiber optic network will be done over the H and E block by ATUT it is highly recommended to plug the ATUT-Location and ATUT-VoIP system into the main fiber optic Ethernet network type ATUT-MFE.

Such a solution will be much more cost effective as the great part of the costs was already spent on developing the network within the ATUT-MFE system.

Also from the technical point of view ATUT-Location and ATUT-VoIP will be able to use the resources of ATUT-MFE system which are left and can be used for the data transmission from mentioned systems.
From the point of view of the ATUT-VoIP system it is important to underline that main fiber Ethernet network, which is at the moment underconstruction, already became a part of the mine wide VoIP network system. This can be now fullfilled with the handheld devices (such as AT-Tel) which in order to communicate with any other device in network will use the ISPS-2/AP access point device. Wifi wireless communication between handheld telephones and the fiber optic network will be able to run efficiently due to the fiber network high rate performance.

ATUT-Location system can as shown in the AT-NODE/CL device is becoming a second independent part of the whole systems infrastructure. In is very important to underline that all of the devices of ATUT-Location are done as separated units, due to stay not influenced by any other system (systems) units malfunctions. As for the safety reasons ATUT decided to separate both by hardware and software devices associated with safety from all the other devices not-safety related. This is also why the main backbone of the ATUT-Location system should stay interconnected by fiber optic network while the branches can be interconnected wirelessly.

The reason not to make the system fully wireless over the main galleries is because of the number of the system users which might be working in or migrating over those corridoors. It is possible to imagine that with a great number of users running over the main galleries carring and speaking on the phones will make the system data transmission stucked. This is why ATUT recommends to make the main branch (backbone) of the human monitoring system to use the fiber optic communication which can be also separated from any other type of communication (voice, data from PLC, CCTV cameras, etc.). Such a solution will provide the highest level of safe data transmission.

The less occupied (with limited number of persons having access to) branches of the mine wide human monitoring system network where geological changes are taking place such as longwalls, headers can have a network done over the wireless communication (the same access point which is also used for the voice communication from the handheld telephones). This solution will definitely help to rescale or reconfigure the devices network as will not require to redone the cabling.

Due to the safety improving reasons ATUT-Location system tag is equipped with a bright contrast LCD display which enables text messaging between the Dispatcher located in Control Room and the tag carrying employee or group of employees. By the buttons located on the tag user can confirm receiving the message, or by pressing the buttons in the proper combination can also give a emergency alarm to the Dispatcher. Receiving a message on tag is being indicated by a beep sound. Tag can also be equipped with the acceleration sensor which indicates the user movements (G forces). When the tag will stood (meaning someone lost conscious) for a longer (setted) time an alarm at Dispatchers Control Room may arrise.

All the required informations about the tags are being shown by the visualization tool – ATVisio 2. Its data presentation can be done on 2D or 3D maps depending on customers needs. Moreover the visualization can provide usefull informations about the number of workers in given range (zone), time of their preesence in particular place. All of those informations can be automatically converteyed into report which allows to be transferred into Excel datasheet or printed (saved) in pdf format.

Beside the current location on map (maps) ATVisio 2 software can also provide it user with the informations associated with the current status of the devices running in system such as for example ‘heartbeats’ of the AT-LBS modules. ATVisio 2 can also become a source of the tag condition information – such as for example tag battery voltage (charged or discharged status).

On the attached corridors plan with the violet color the possition and possibility of plugging the ATUT-Location and ATU-VoIP systems to the fiber optic network is shown.
General concept of the ATUT-VoIP and ATUT-Location system for Park Termik

6. Future expansion

System can be easily expanded both on hardware and software side due to the arising needs because of its modular built. All of the devices can be easily installed and maintained by the trained mine personnel.

In the future both ATUT-Location and ATUT-VoIP system can be extended on different mine zones providing different functionalities for example associated with material transportation supervision. Tags can be than installed on the machines, trolleys, suspended monorails in order to give their position but also to transmit the machine operating data, such as for example oil temperature.
7. Safety

All of the proposed devices are suitable to be used in mining environment. Electrical equipments have an appropriate ATEX certificate I M1 or I M2 that confirms to be operated in underground coal galleries.

8. Appendices

- Map