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MINING SECURITY PIPE© (TSM)© WITH UNDERGROUND GPS GLOBAL© (RSPG)© ESCAPE SECURITY DEVICE IN UNDERGROUND MINING

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Abstract:
TSM is escape pipe in case of collapse of terrain. The TSM is a passive security tool placed underground to connect the work area with secure area (mining gallery mainly). TSM is light and hand able pipe made with aramid (Kevlar), carbon fibre, or other kind of new material. The TSM will be placed as a pipe line network with many in/out entrances/exits to rich and connect problem work areas with another parts in a safe mode. Different levels of instrumentation could be added inside such as micro-led escape way suggested, temperature, humidity, level of oxygen, etc.). The open hardware and software like Arduino will be the heart of control and automation system.

Key words: *TSM, Escape pipe anti collapses, Mining Security Pipe, Mining Rescue*

INTRODUCTION

TSM is the Spanish acronyms of Mining Security Pipe and inherent into the name you can discover the final function of this escape pipeline.

DESCRIPTION AND RUNNING

The TS is a passive security pipe for emergency built with many different last generation materials: aramid (kevlar), carbon fibre or glass fibre and polyester fibre. Mainly we are building with new materials with the following properties: Low weight; High resistance and impact absorption; Excellent thermic resistance; Fire resistant, o auto extinguishers; InnocuousBut, such us main problem: the price.

You can use reinforced plastics with carbon fibre. The more similar to this idea could be the Airbus 380 wings and the philosophy is like a rigid emergency pipe with many legs (in/out) like a fire exits. The reinforced plastics with fibres (PRF) (Fig. 1), have been madden with one polymer named "matrix" that next to the charge and additives form the resin, and a kind of fibres.

The mainly performances of this security pipe-line will be light weight in composition [6, 7, 8, 9].

Suppose an easy TS formed by two materials like a sandwich. The thickness will be over 0.5 mm of aramid (kevlar); 0.5 mm of carbon fibre.
The density of aramid fabric is 1440 kg/m^3.
The density of carbon fibre is 1750 kg/m^3.
The density of glass fibre it is in the range of 2550 kg/m^3.
Initially, the volume have been estimated in
Vol = 2πr·thickness·lenght
And weight will be P = m · g = Vol· density · g
In our particular case you can extrapolate the following results of interest:
For one TS, 1 meter length, 80 cm internal diameter (0.4 m of radius).
Carbon fibre (inside). Thickness = 0.0005 m.
Mid radius = 0.4+0.025 = 0.4025 m
External Aramid fabric. Thickness =0.0005 m.
Mid radius = 0.4 +0.05 =0.405 m
Carbon fibre weight:
$P_{fc} = 2 \cdot 0.4025 \cdot 0.0005 \cdot 1 \cdot 1750 \cdot 9.81 = 21.708$ kg

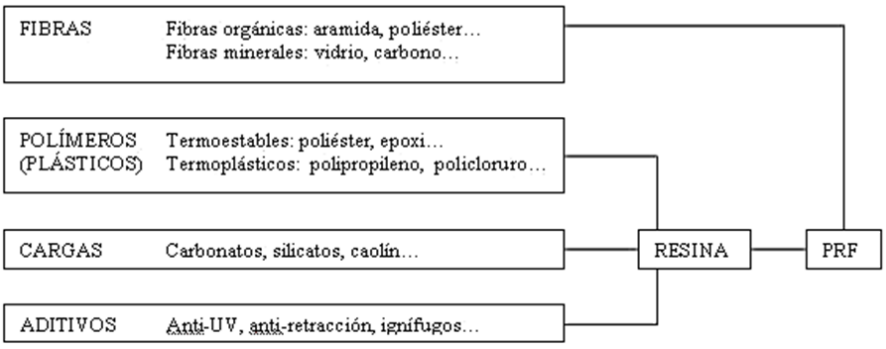

Fig. 1 Fibres and plastic schema

Aramid-kevlar weight:
$P_{kevlar}= 2\pi \cdot 0.405 \cdot 0.0005 \cdot 1\ 1440 \cdot 9.81 = 17.973$ kg

The approximate total weight of TS could be 39.681 kg/m. This is a lot of hand able with shorts segments of 2 meters length (79.362 kg). To this new segment you need to subtract the weight of a transversal circular with similar diameter such as entrance access and/or add ferrule, bridles and ring junction (for this reason and practical effects of this resume you can rounded to 80 kg per segment or 2 meters length of section) (Fig. 2).

Fig. 2 TS carbon fibre

Scalable by modulesyou can continue spread the security pipes along of a mine. Each module not should be exceeded more than 80-100 kg weight to be hand able and easily mount/dismount for two workers. This method involves using a fast bridle assembly system.

Each security pipe segment is joint with another, and must have a transversal entrance/exit (Fig. 3).

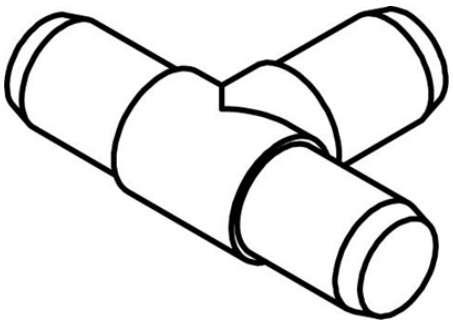

Fig. 3 Connectivity

New segments can be optionally added to configure a mine network. The entrance/exit access not could be reduced in less than one per 10 or 20 meters.

The initial internal diameter should be 80 cm, as well as can be reduced next to 75 cm. Even though dimensions could be change we are using this as start point.
(*) Note: The perfect idea is to develop a very light TS but we need to do many test in order to improved and validate the resistance and calibrate the thickness of different materials. One test could be download raw material in a quarry using a dumper truck since 20 meters high bench.

LENGTH

The length could be variable, and have many legs is advisable but the TS must link the working area with safes areas not disturbed by mining works such as galleries. For safety:
L = max. Length in working area
D_s= length of TS working area to secure area.

The total length of TS must be $2\cdot(L+D_s)$ to rich the connexion with the safe area in spite of secondary collapses rounds the accident.

OPTIONS

The TS could include a wire pipe and different instrumentation devices, sensors and electrical protection and control equipment:

- emergency LED and high performance micro-LED wired line supplies by batteries with very low consume and autonomy over 1500 hours,
- low cost sensor of temperature and humidity (less than 1€/per unit),
- low cost movement sensor,
- mini webcams,
- WIFI points access,
- possibility to use open software/hardware with micro controllers such us Arduino or microcomputers like Raspberry.

In addition methane sensor can be used, controlled and management by independent or autonomous low cost micro controllers and microcomputers based on ARM architecture with a very low electrical power.

JOINTS AND BRIDLES

Joints between pipes are built using a fast assembly system with bridles (Fig. 4) and gussets as you can see describes below.

Fig. 4 Cord rope and bridle

The bridles have been made with high resistance material protected with aramid kevlar or another fibre high temperature resistant. We are talking about a “chain of high resistance rope” The kind of cord rope is like used in climbing with a high guarantee impact over a rock edge using “Hard Choc” technology to obtain best results over sharp slabs and cutting blocks.

The cord rope [10, 11] used like a figure (Fig. 5) it’s just adjust like a chain or zip belt over the bridle and could have many advantages such as:

- reparations without welding (very important in explosive atmospheres),
- low weight,
- high resistance and blow attenuation with flexibility,
- not be rust,
- the synthetic materials are hydro repellent, doing the water one of the most important problems talking about electrical conductivity,
- no make sparks fly in spite of scrape the surface.

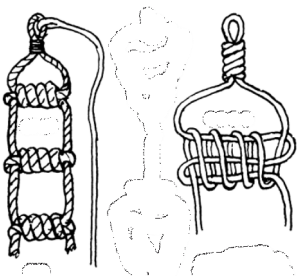

Fig. 5 Scale knot used like joint-straps

INTEGRATION WITH GLOBAL POSITIONING UNDERGROUND NETWORK (RPGS)

The task of this GPS underground network is to use and share your position in tunnels or galleries under the earth surface. Nowadays, any person or vehicle can be situated and placed in a real time.

My first problem about this question was find a new lines of uses, such as GPS geology in mine, secured areas in mine, gas and ventilation GPS map, etc. It was solved in Brasil (2012. MASyS) when y was showing the possibilities putting the geology into a Garmin Montana GPS (Fig. 6).

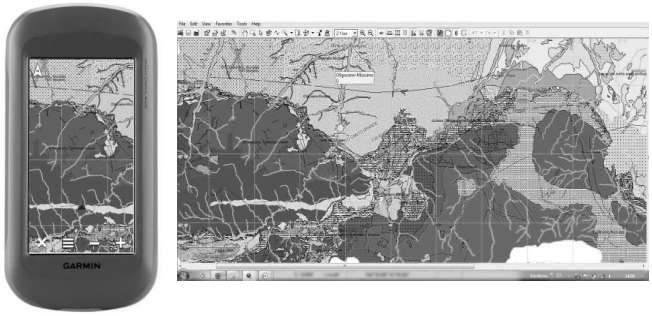

Fig. 6 Geology into a Garmin Montana 650

Requirements of RPGS.This network is based on a very easy system:

1. The external antenna to receipt the satellites (GPS, EGNOS-Galileo, GLONASS). The antenna take the signal. The process unit (external GPS outside with position corrected) give you the antenna position and now we need to apply corrections:
   - change between mine system coordinates and geospatial coordinates. The problem it is not for GPS, is to monitoring in Mining the coordinates of vehicles and human resources,
   - in most of cases I need a translation and rotation to adapt the coordinates. For examples in Polish mines they are using special coordinates and nobody explain to me how this coordinate system works,
   - send to the mine network radiobeacons the external position (well-known coordinates), toestablish dialog and take my underground position. The coordinates will be: external coordinates + mine corrected coordinates,
   - remember that the mine coordinates can be obtained from radiobeacon, RDFI, etc.
2. As you know this is a very easy differential GPS (DGPS) and radiobeacons situated underground communicate like broadcast the position of satellites. The GPS is blind but received signals from the outside coming from beacons.
3. The radio beacons GPS system is a SSGPS (GPS Signal Simulator). Send and received GPS signal emulating to be the available groups of satellites. However, it is a simple device fixed in the upper tunnel surface that sends the satellites constellation and DGPS correction.
4. Into de underground GPS we are using the mining maps by layers. One map one layer (ventilation, geology, methane areas, galleries, electricity, etc.). Later, you should be visible the layers creating the maps with transparent mode to overlap the different map informations.

One of more great advantage of this system give you the position outside because de GPS unit installed received the satellites signal.

The GPS receivers have been reduced a lot and would be used by person, vehicles, etc. Example: SIRF Star IV chip receiver and should be carried by a miner (Fig. 7).

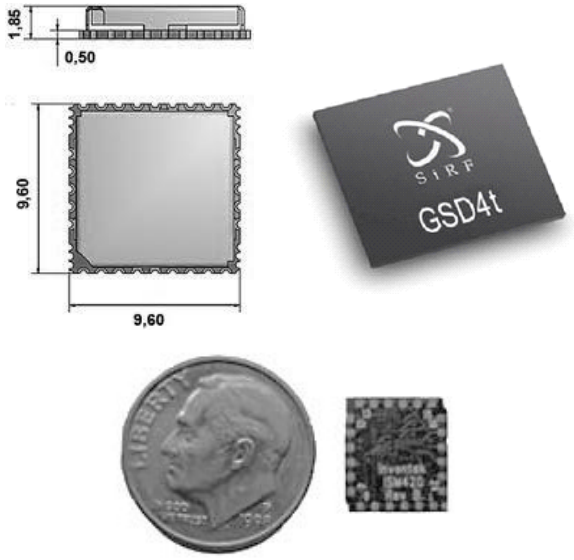

Fig. 7 Real size of SIRF Star IV GPS receiver

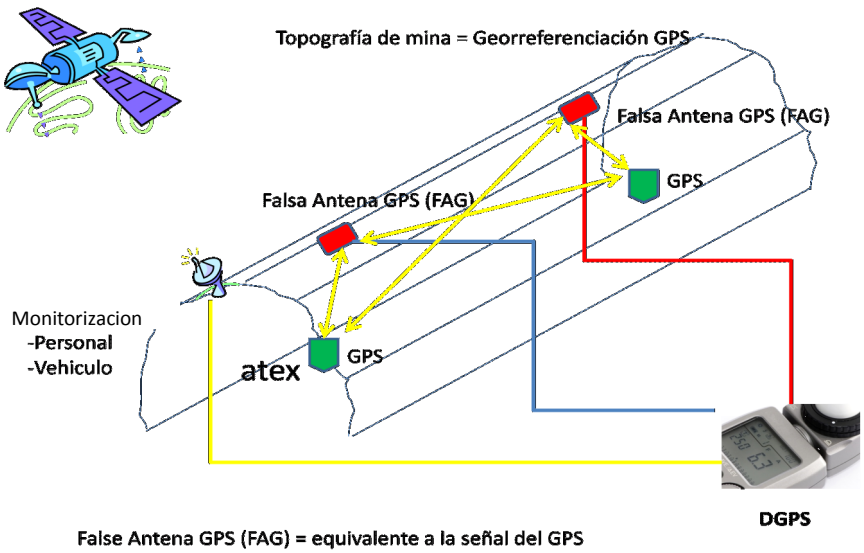

Fig. 8 Jacket with GPS

INTERACTIVE CLOTHES FOR PASSIVE SECURITY

It is very known nowadays the existence of intelligent inks, that change the colour with temperature. The intelligent clothes for fireman that let you the bio-variables for health (Fig. 8, 9, 10) and the geospatial position of fireman.

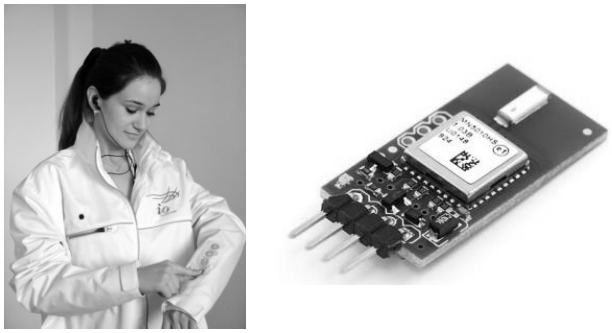

Fig. 9 Arduino micro GPS

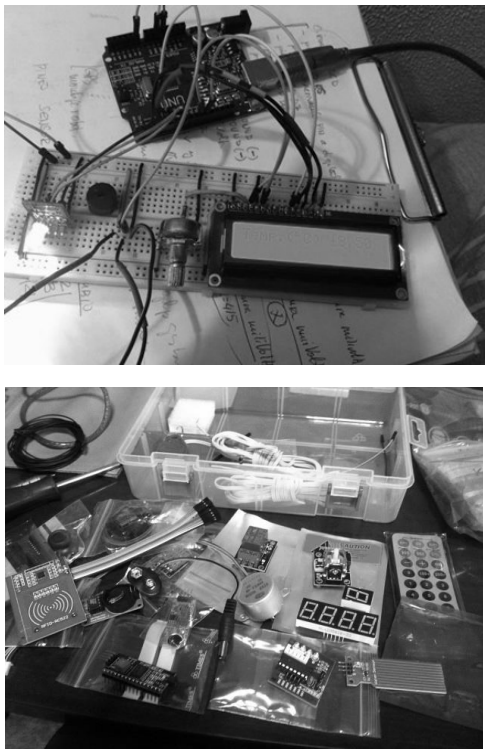

Fig. 10 Arduino UNO breadboard Humidity and Temperature sensors. Kit Arduino (30€)

This kind of technology could be implemented in mining.

This proposal was announced by myself long time ago in 2011 (Quito, Ecuador, MASyS Network), but nobody seems interested to continue the line.

The proposal was to include in mining clothes the following accessories:

- one Micro GPS,
- one methane-meter,
- one WIFI ATEX system,
- one sensor of temperature,
- one pulsometer.

The energy use is very low, and assumable by batteries of individual miner equipment, but a small emergency battery could be added into the jacket to send a periodical signal in rescue situation.

In addition, devices must be incorporate semi-intelligent micro-LEDs (Fig. 11) doing two important tasks when a risk explosives atmosphere is detected:

- to put high the LED pin (red colour danger),
- to send a radio/wifi or other kind of signal to disconnect and switch off all electrical devices or use a flammable or fuel engine (Fig. 12).

Fig. 11 Size of micro ledin comparison human finger

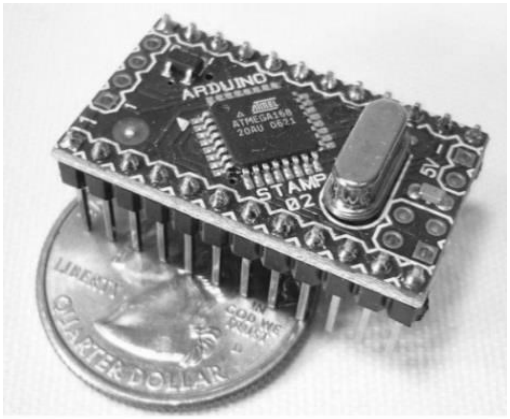

Fig. 12 Open Hardware Micro with a controller based on ATMArduinonano (1.7 €/unit ATMega 328- 5Volt.)

The normal use of the new technologies involve a Wire-Less or wired connections and it is to be able to have an error redundant system in low cost.

It is a spectacular change in mining security that will be active:

- allowing to reports problems,
- allowing to known who is the miner, etc.
- solving risk situations like automata,
- and, very important. The small size let you camouflage it anywhere.

CONCLUSIONS

A very important mismatch exists between the technologies and the "Neanderthal technologies" used in mining operations except in production.

People have abuse of mathematical models instead of live the "real time" and take decisions using nano-controllers (Fig. 12, 13). And models, don't have the possibility to know where the wheelbarrow, wood slab, or raw material will be placed by miner modifying the normal ventilation flow of gas methane and air. Models are useful in a great scale or recovering gas but unknown all around the small space close to the miner.

Fig. 13 My microcomputer open Hardware RaspBerry PI 2b with WIFI micro USB. O.S. Raspbian (Linux Raspberry-Debian)

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REFERENCES

[1] J.M. Ruiz Gutierrez. *Manual de programación de Arduino*. (Transl.: B.W. Evans et al., *Arduino Notebook: A Beginner's Reference*) [Online]. Available: http:// www.arduino.cc
[2] R. Barrionuevo Giménez. *Nuevas tecnologías en Sistemas de calidad aplicados a la Geotécnia: Utilización de la Georrefenciación, mapeado GPS y códigos GeoQR – GeodataMatrix en una red subterránea de posicionamiento global*. Jornada técnico-científica de "Medio Ambiente Subterráneo y Sostenibilidad" – Geotecnia, Ouro Preto, Brasil, 2012.
[3] R.E. Herrador. *Guía de usuario de Arduino*. *I.T.I. Sistemas Universidad de Córdoba. Creative Commons Attribution-Noncommercial-Share Alike 3.0.*[Online]. Available: http://creativecommons.org/licenses/by-nc -sa/3.0/
[4] *Getting Started with Arduino* [Online]. Available: https://www.arduino.cc/en/Guide/HomePage
[5] *Essential C* [Online]. Available: http:// cslibrary.stanford.edu/101/
[6] *Kevlar* [Online]. Available: https://es.wikipedia.org/ wiki/Kevlar
[7] *Aramidas* [Online]. Available: http:// todosobrelasfibrassinteti- cas.blogspot.com.es/2013/04/aramidas-nomex-y- kevlar.html
[8] *Fibra de carbono*[Online]. Available: https:// es.wikipedia.org/wiki/Fibra_de_carbono
[9] *Fibra de carbono* [Online]. Available: http:// tecnologiadelosplasticos.blogspot.com.es/2011/11/ fibra-de-carbono.html
[10] F.G. Polo. *Cómo elegir la adecuada cuerda de escalada* [Online]. Available: http://www.silicia.com/monte/ cuerdas.asp
[11] R. Gasa*. Cuerdas de escalada: Tipos de cuerda y cuidados* [Online]. Available: http:// territoriolimite.com/tendencias-2015/accesorios/ cuerdas-de-escalada