FTI project: Underground Mineral Exploration using Cosmic Rays Muons

Background:

Lingacom Ltd., is a strong R&D oriented SME located in Israel and a market-leading technology provider of an innovative Cosmic Ray Muons Detection Technologies. Lingacom has built a highly skilled and experienced team that has developed and demonstrated successfully key muon detection capabilities including building over the last 4 years**,** muon detectors, and cost-effective small scaled proof of concept prototype.
The company offers its cutting edge eco-green and passive detection technology and expertise tailored for variety of muon imaging solutions (1) Shipping containers and vehicles (2) Underground mining exploration (e.g. minerals) (3) Large geological or civil objects.
Lingacom has formed a strategic collaboration with 1st Tier US inspection equipment provider for the home land security product.
Lingacom awarded by end of 2015 a security project at SME instrument phase 2 of the H2020 program.

Introduction

Lingacom "Underground Mineral Exploration using Cosmic Rays muons" target is to perform mapping of underground soil densities using muons. The maps can then be used to extract information on the depths of the geological layers and the ore deposits above the sensors. This will enable the mineral exploration companies to estimate the economic value of the mineral block. The concept relies on high-energy cosmic ray muons, penetrating the earth and collected by dedicated muons boreholes sensors. The data collected from each detector is used to map the weight of the ground above the detector in several directions. Cosmic ray muons are part of the naturally occurring cosmic radiation. Cosmic rays muons are the most-penetrating charged particles on earth. The muons arrive at the earth's surface with energies ranging from less than a GeV to thousands of GeVs. The muons lose energy as they travel through matter, with the energy loss proportional to the transversed mass. The denser rocks result in larger energy loss and in fewer muons that penetrate through these rocks. Thus a map of the rates of muons arriving at an underground sensor provides a map of the weight above the sensor. This basic correspondence has been used successfully in archeology and in mapping volcanos.

Lingacom borehole sensors:

Lingacom cylindrically-shaped imaging sensor with high spatial resolution that fit in a PQ-sized borehole as shown in Figure 1 **Error! Reference source not found.**. The idea is to measure the positions that each muons hit the 2x2 detectors plates and accordingly the arrival direction of each muon.

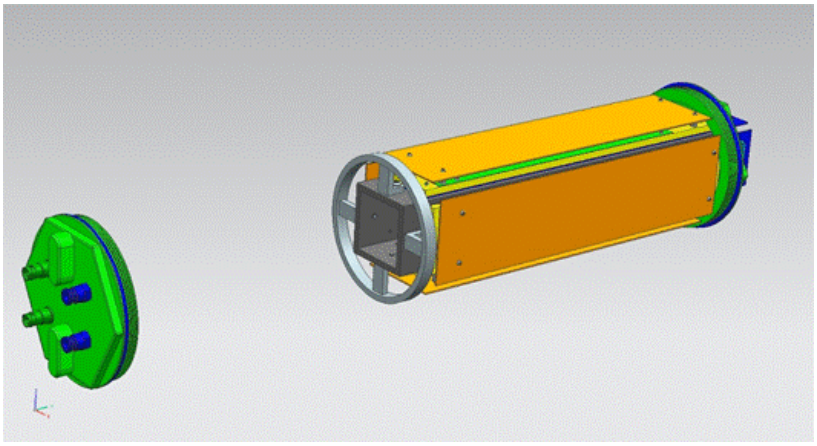

Figure 1 : cylindrically-shaped muon sensor

Lingacom cylindrically-muon sensor prototype as shown Figure2 built and tested successfully.

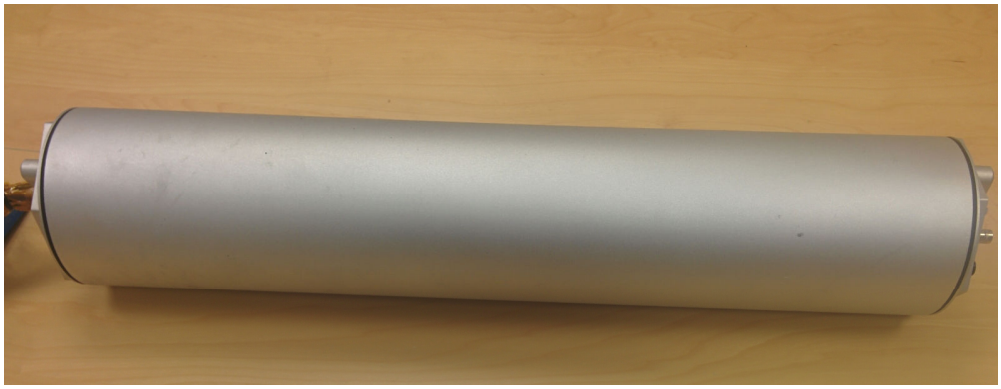

Figure2 : Lingacom cylindrically muon sensor prototple

Proposed project

We propose to form a project under the Fast Track to Innovation (FTI) Pilot under the H2020 program:
http://ec.europa.eu/research/participants/data/ref/h2020/wp/2016_2017/main/h2020-wp1617-fast-track_en.pdf
The target of the project is to demonstrate a pilot of muon detectors to be operated within the boreholes in various depths collecting data that shall be combined with additional boreholes sensors for enhanced mineral mapping exploration.

The Solution:

Using muon sensor collected data, we propose the following capabilities:

(1) **Measure undersground soil densities**

Measure and map the underground soil densities over a time scale of days and/or weeks as shown in Figure3 . For example, given a density difference of 0.2 g/cm^3 between layers, the muon flux at a depth of 100m will vary by ~1% for every 10m change in the boundary between the layers. This will enable the optimization the exploration phase and plan the next drillings accordingly.

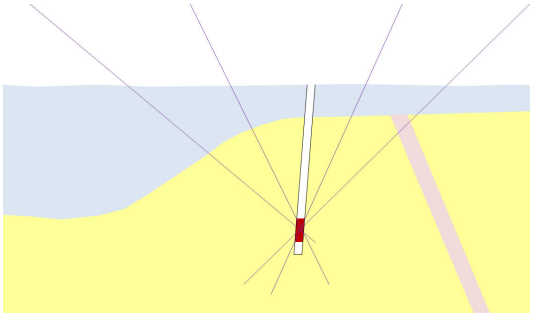

Figure3 : measure underdgound soil densities

(2) **Combined data from muon sensors in verios depths**

Combine the measurements from several sensors to form 3D images as shown in Figure 4 . This can be done after the initial project as it requires higher spatial resolutions leading to (a) different tradeoffs in the design, and (b) longer exposure times.

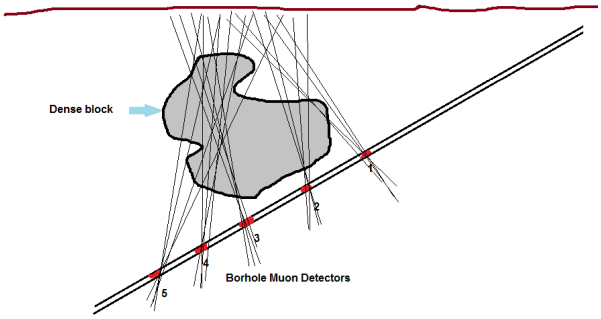

Figure 4 : Combined data from muon sensosrs in variuos depths

(3) Enhanced 3D density mapping using multiple sensors

Build a quantitative model of various sensors. The concept is to reconstruct enhanced 3D images of ground Densities from the measurements using regularized unfolding techniques.
For example the gravimetric sensors generally consist on measurements of the vertical component of the local gravity field. The muon tomography provides information on the density structure of the Earth's at deeper levels of the ground. Both methods are linearly linked to density, but their spatial sensitivity is different. The enhanced 3D density algorithm combines the two or more sensors measurements into a 3D image by optimizing both the functional shape and overall strength of regularization to the specific use case.

Benefits:

(1) Enable to estimate the economical value of potential mineral object.

(2) Reduce the number of drillings.

(3) Provide directions for next drillings during the exploration phase.

(4) Save time and cost.

Expected Partners of the Project:

- Lingacom commercial and technology provider also acting as project Coordinator
- End User – Mineral exploration company to support in finally defining project's attributes and acting as Beta Site
- Commercial and technology provider - for integration of Lingacom's technologies with other sensors.

Submission due: March.15, 2016