pempek
mining automation

Pempek Shuttle Car Advanced Assist System Collision Avoidance & Autonomous Navigation

ADAS

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Introduction

Autonomous tunneling operations in hazardous areas have been successfully developed and deployed by Pempek for more than 5 years.

An example of this technology is described in the Pempek Underground Miner Laser Guidance and Remote Control System. See further details here
This technology is ideal for slow moving application such as those used to excavate tunnels
(such as Bolter Miners and Road Headers).

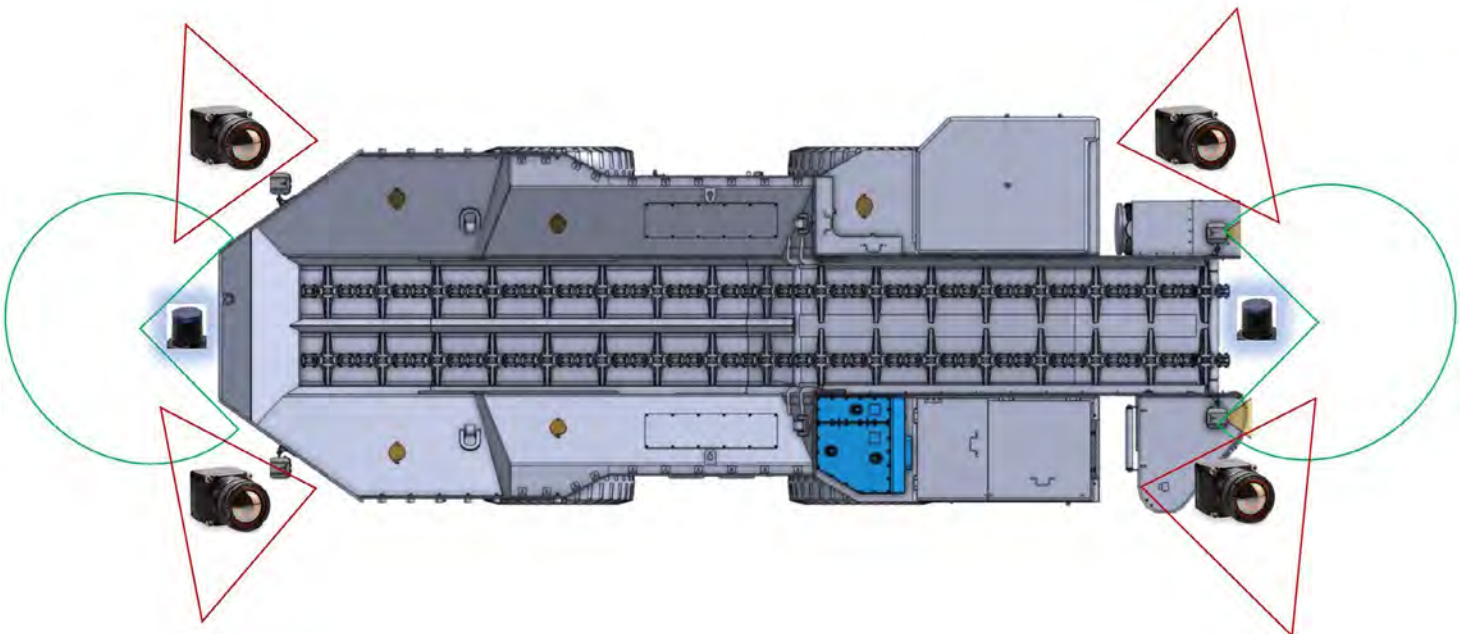
Pempek now introduces a companion technology that provide collision avoidance and even autonomous navigation of shuttle cars – allowing improved safety and higher productivity.

Pempek's ADAS (Advanced-Driver Assist System) supports both collision mitigation functions to assist an on-board vehicle driver as well as fully autonomous navigation.

Using a multi-layered mapping and sensing array package - the system provides shuttle car platforms with three levels of autonomous operation:

1. Driver Assistance (advanced warning of possible collisions)
2. Collision Avoidance Intervention (automatic slow down and braking)
3. Fully Autonomous Operation

A typical installation that integrates directly with Pempek's ObelixPLUS Control System.
(1 Camera one on each corner and one lidar one on each end)



Key System Components

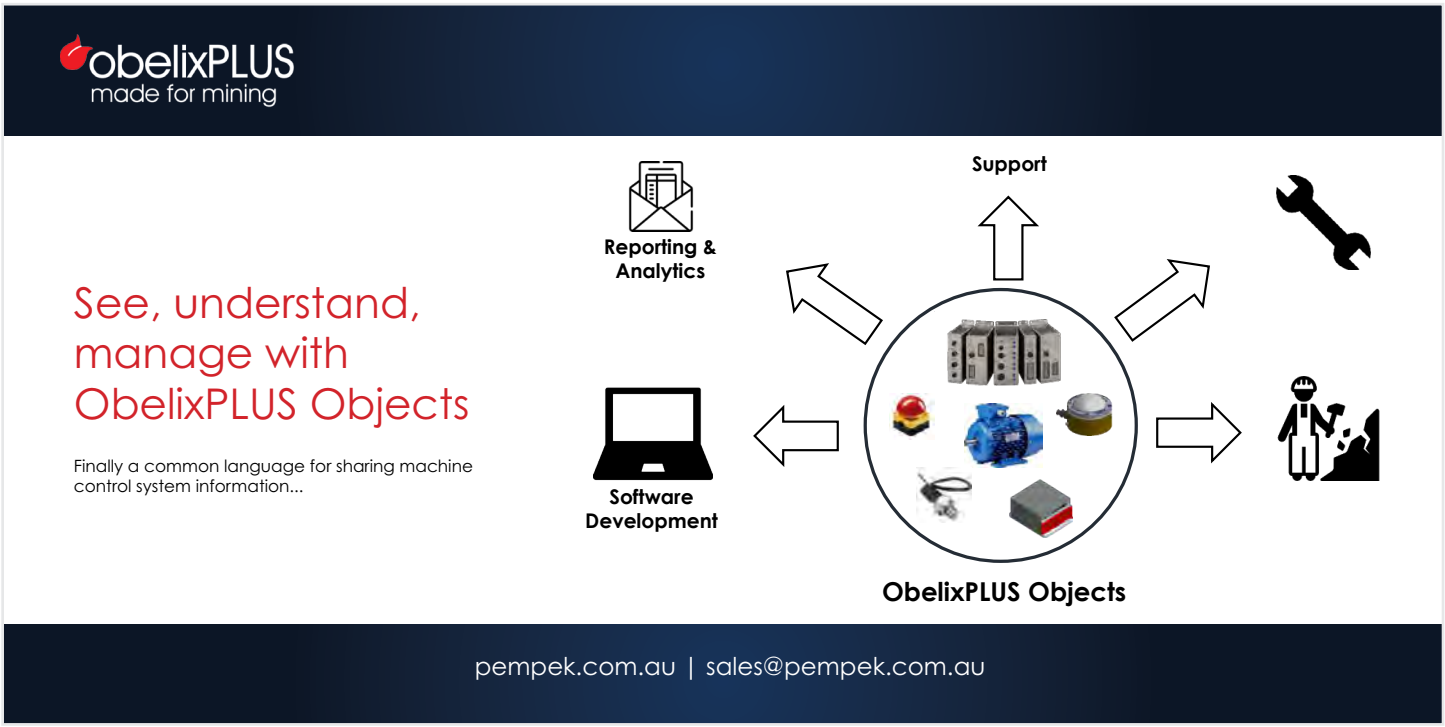
Pempek's Shuttle Car ADAS is composed of the following sub-components

1. Traditional Pempek "ObelixPLUS" Shuttle Car Control System
2. Pempek Electric Traction Motor Controllers (AD or DC)
3. Lighting and Visual Cameras
4. LIDAR Sensors (Real-time distance ranging and object detection)
5. Thermal Imaging Cameras
6. Off-board Telemetry (via power line modem)

Pempek ObelixPLUS Advanced Control System

Pempek's ObellxPLUS is a state-of-the-art, fully-programmable control system platform for safe and reliable control of mining vehicles.

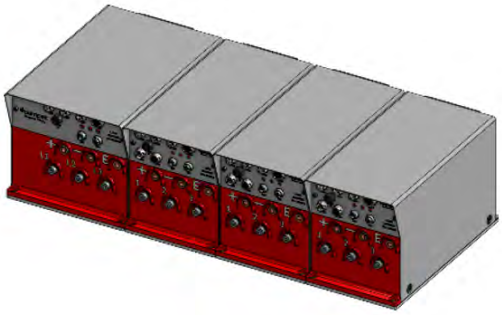
Several configurations of the control system are available to support a wide range of standard shuttle car vehicles. PLC programming languages support the customization of features or the rapid development of new systems to suit new vehicles.



Pempek Electric Traction Motor Controllers (AD or DC)

Smooth, reliable, and safe traction motor control is essential for any effective autonomous vehicle application.

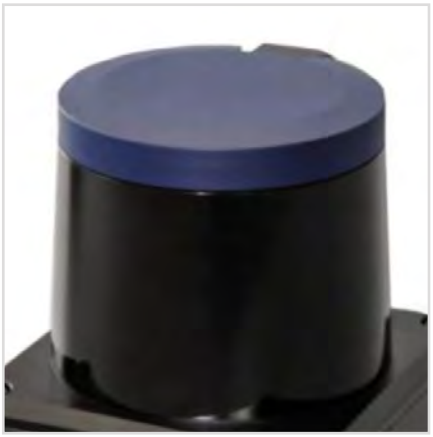
Pempek has 20 years of experience in the design and manufacture of variable speed motor controllers for mobile mining vehicles. Various, proven models are available for both DC and AC motor applications.

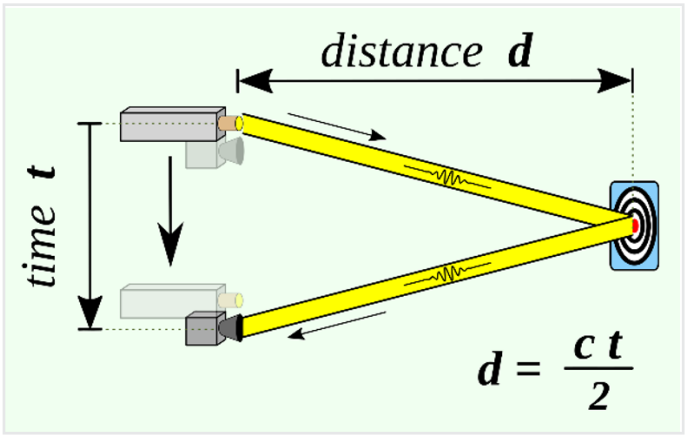


Lighting and Visual Cameras

Visual monitoring of the shuttle car from the surface is supported by a purpose-designed lighting and visual camera package.

Lidar (3D Laser scanning, detection and ranging)



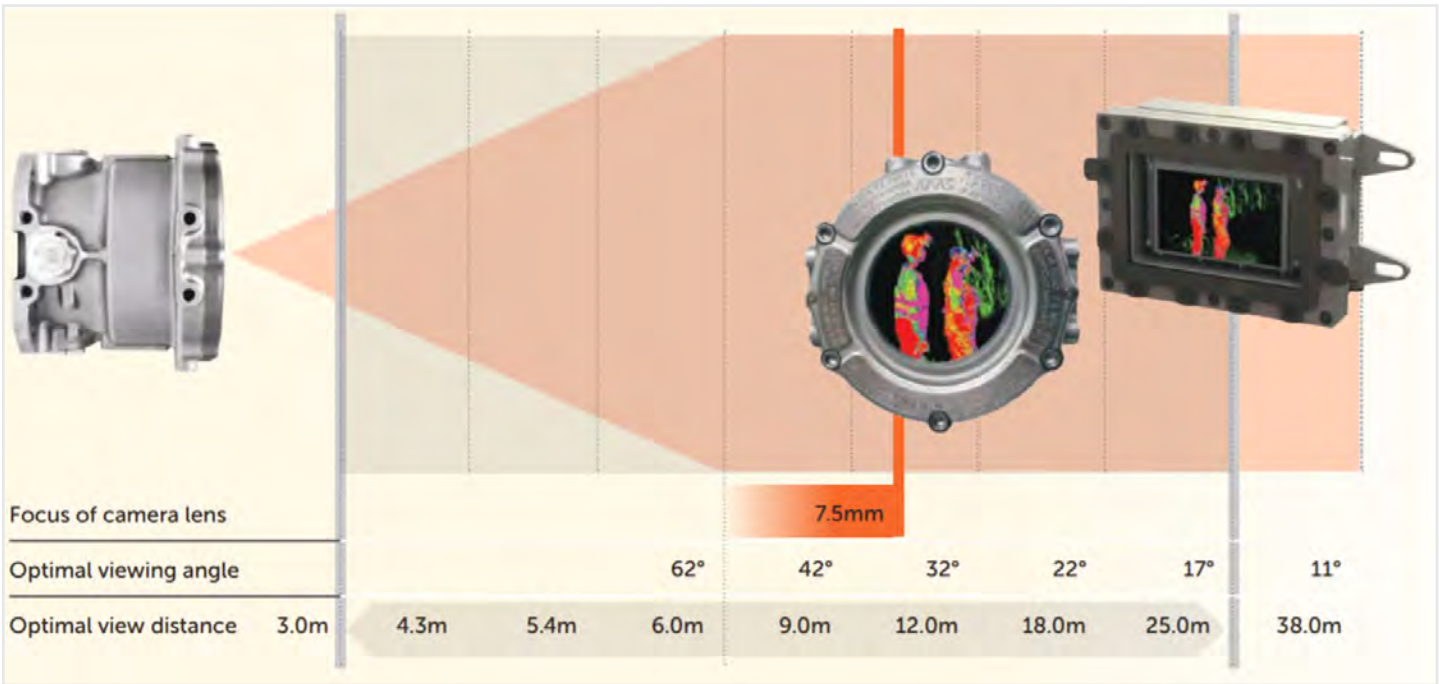


The Pempek Lidar is multi-line laser using time of flight to accurately map the local terrain.

The Lidars are the eyes of the guidance and anti-collision system and operate through a dedicated image processor. Control and navigation coordination with the ObelixPLUS control system is achieved with the ROS (robot operating system) bridge module.

Thermal Camera system

A further backup to the obstacle detection system afforded by the Pempek Lidar's are the thermal camera which are effective at adding another layer of safety in detecting people.

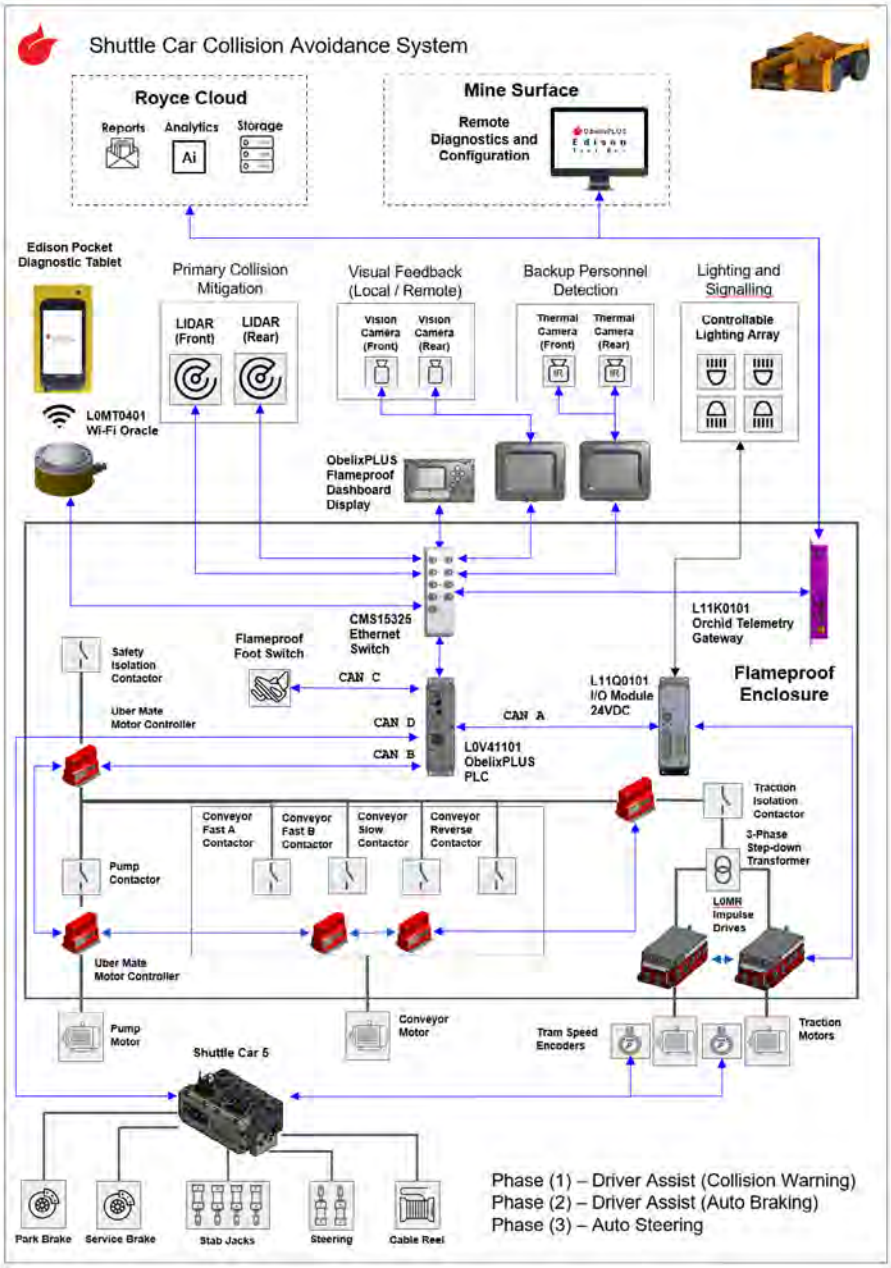


Telemetry

The collection of machine operational data (Telemetry) is an essential part of the mining process. Data collection and analysis provides significant benefits and improves production and maintenance activities. The Pempek control system (ObelixPLUS) integrates directly with the Pempek ROYCE telemetry system.
See further detail here

Pempek recommends power-line modem technology from its partner to provide reliable, low-maintenance network connectivity to support telemetry and remote visual monitoring.

Telemetry

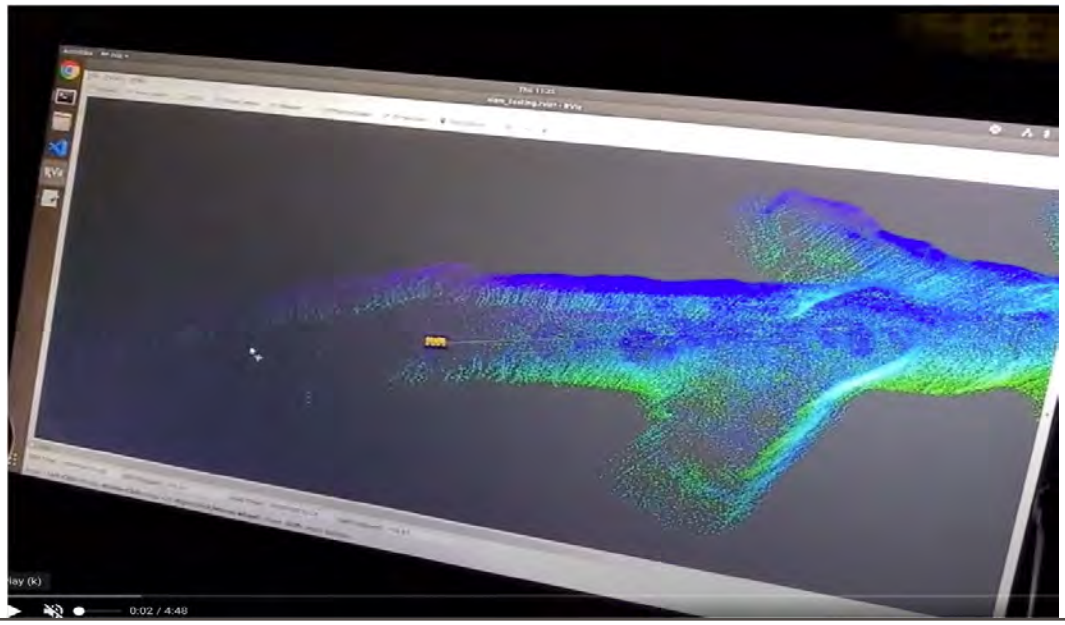


Step (1) – Gathering Point Cloud Data

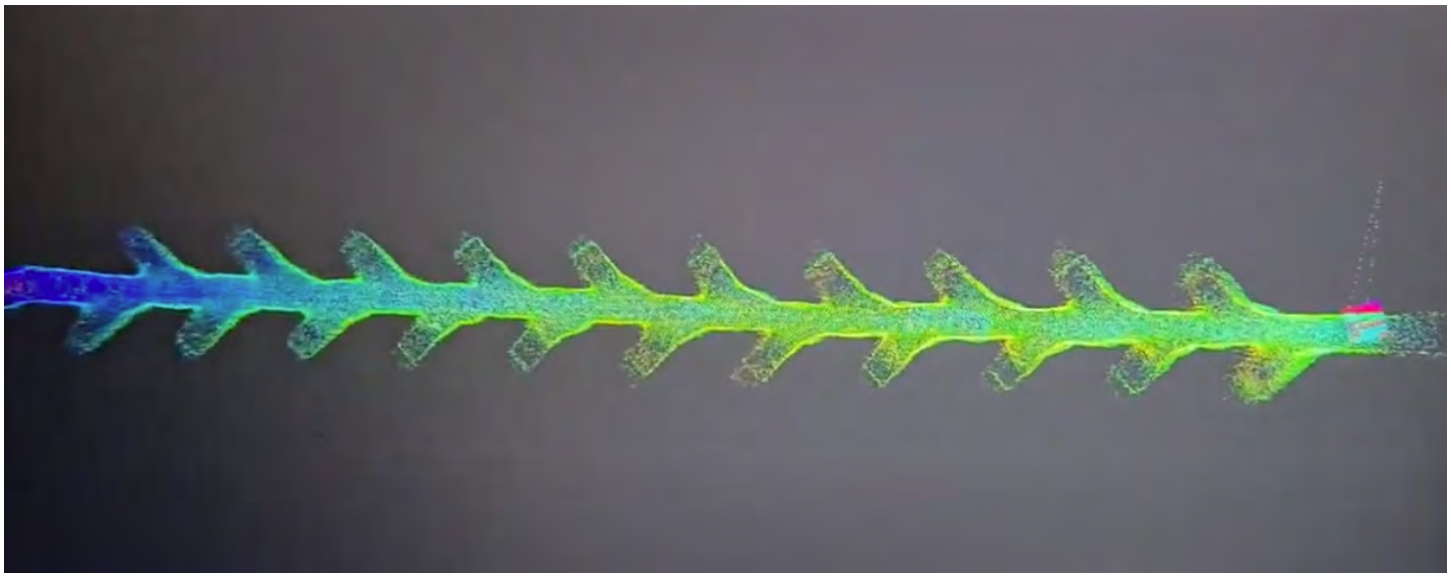
When the vehicle is first introduced into the mining environment – some training of the system is required so that it can map a point-cloud representation of its environment.

This mapping requires the shuttle car (or a stand-alone mapping rover) be driven between the conveyor discharge point and the cutting face. While it travels the system scans the environment to build up a point cloud map.

The operator must drive all of the terrain that is to be the operating space of the subject Shuttle robot. The output of the drive through is a point cloud that consists of millions of coordinate vectors.



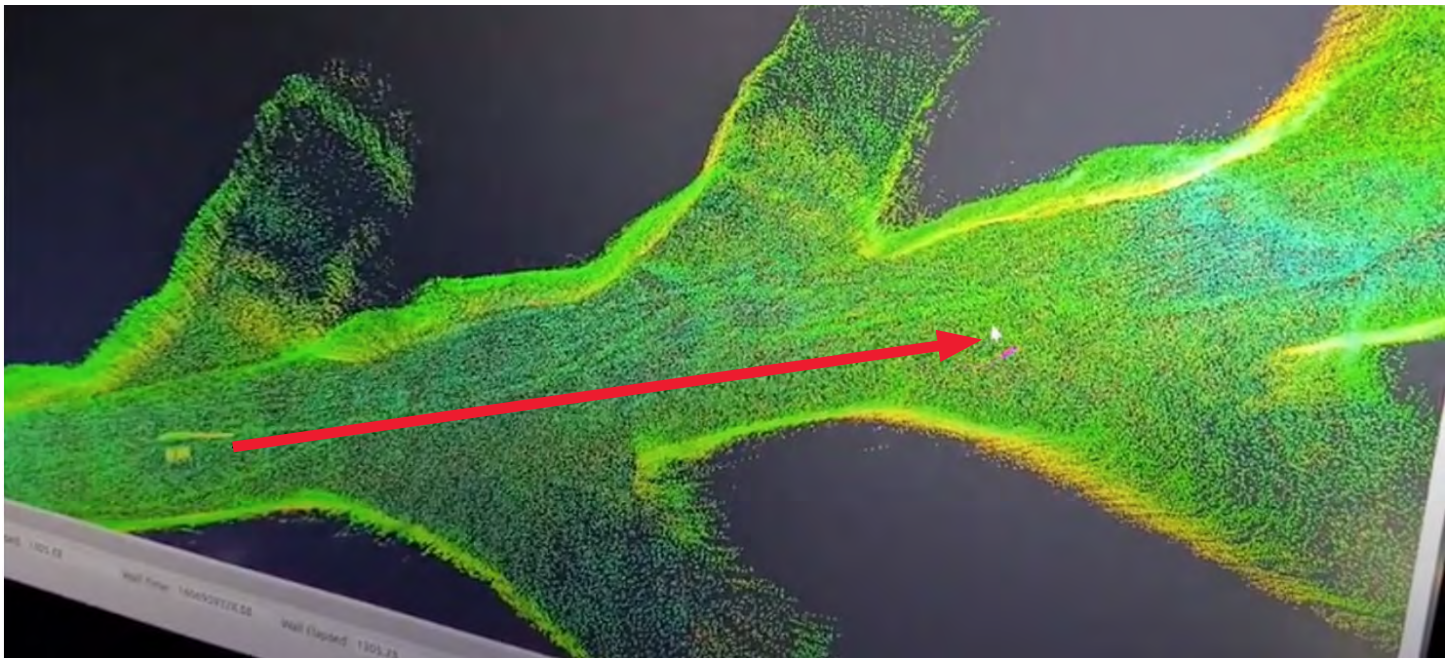
Step (2) - Use the global map software to converge the map.



The millions of data points are processed in a number of ways and by proprietary software into a functional GLOBAL MAP.

Later extensions of the global map are performed by the shuttle robot in operation as the drive is extended by the miner leading to the LOCAL MAP map extending beyond the boundaries of the GLOBAL MAP. If the shuttle robot is in extension mode than the GLOBAL MAP is extended by the addition of the new LOCAL MAP.

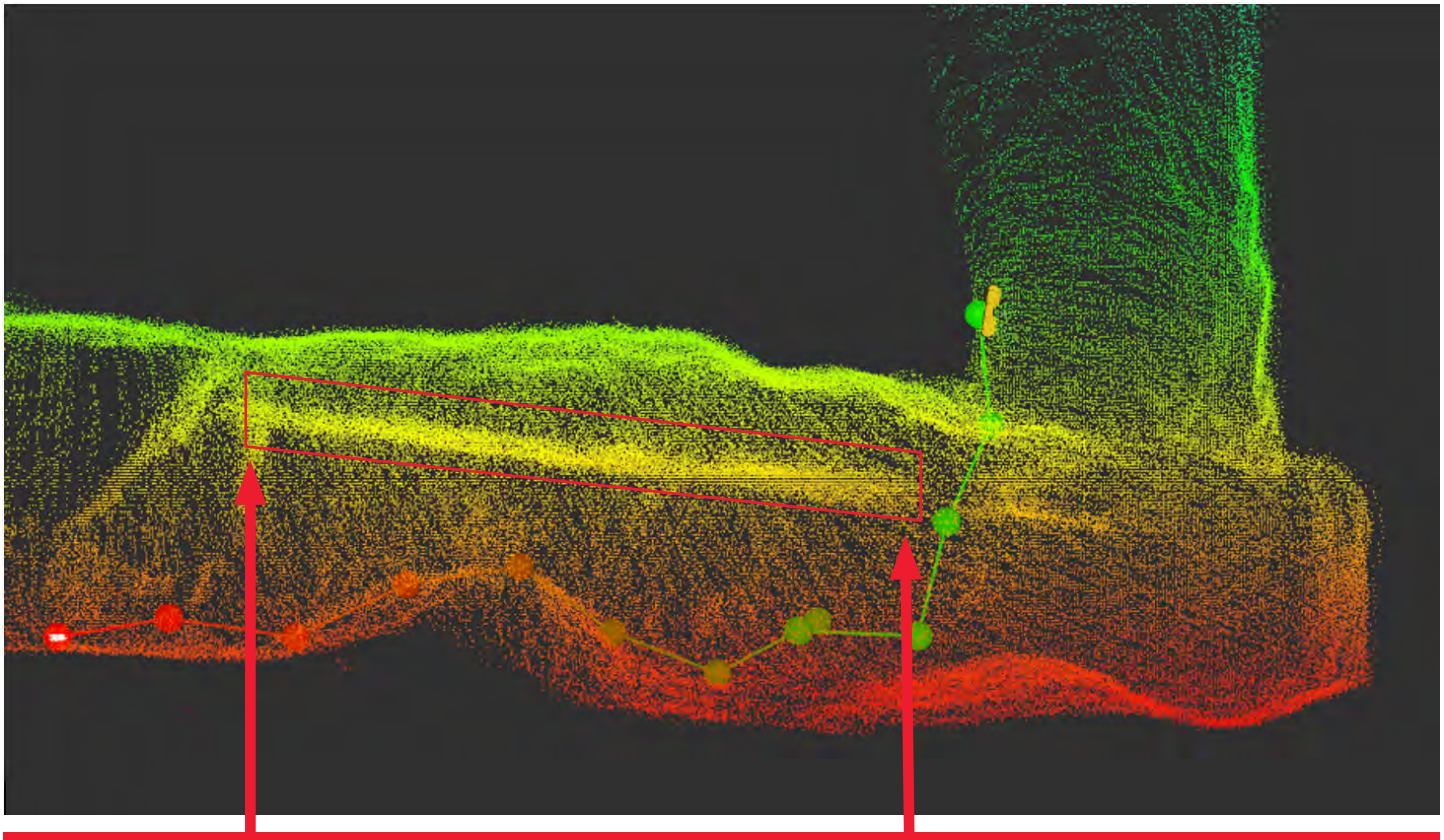
Step (3) - Download GLOBAL MAP to the Navigation stack on board the Shuttle Robot.



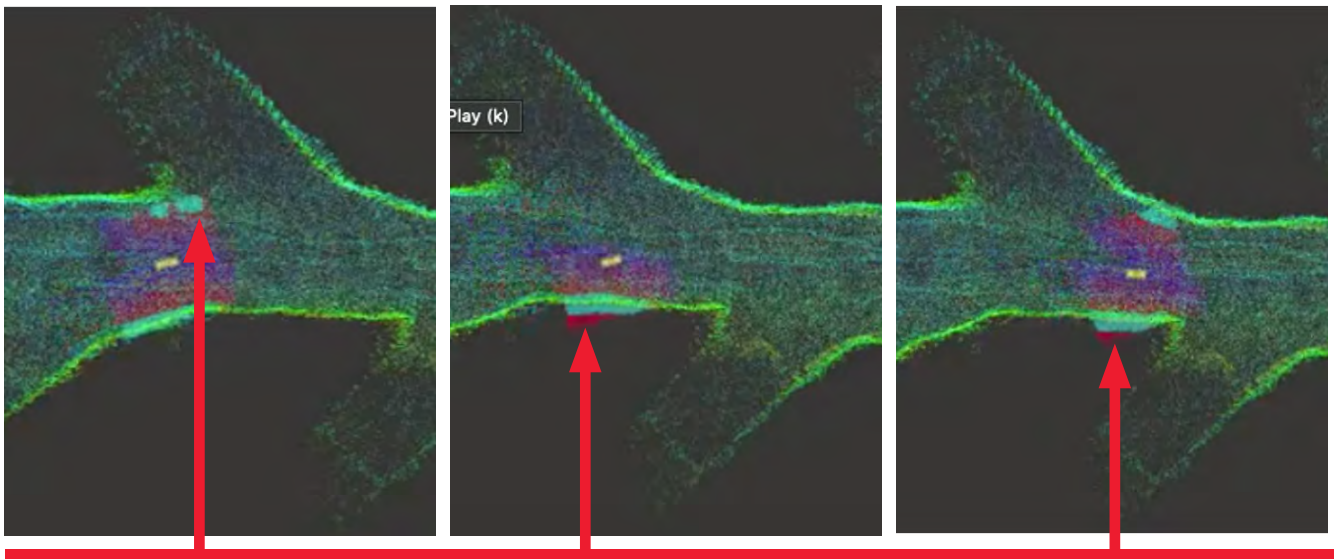
Shuttle can now navigate itself to a given target.

Operator can than indicate a TARGET POSITION on the map which is translated to a coordinate position and the robot can then use SLAM (Simultaneous Localisation And Mapping) to move from current position to the TARGET POSITION.

The Shuttle robot is continuously scanning the local environment and matching that local mapping to the global map to both confirm its current position and navigate towards the TARGET POSITION.



The Shuttle robot is able to navigate around declared no drive zones and navigate around corners.

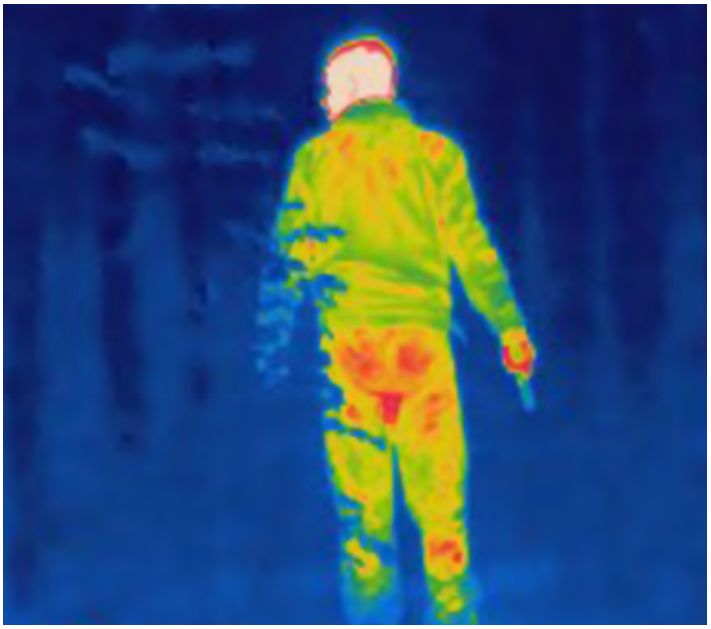


LOCAL COST mapping algorithms keep the shuttle away from obstacles.

A COST MAP is a local navigation map produced by the scanner in real time where obstacles are given a high cost and to be avoided. The Robot Shuttle tries to lower the cost by going around the obstacle.

Certain obstacles such as another moving object that could be equipment or a PERSON are TOO HIGH COST and the shuttle robot will stop until the obstacle in clear of the LOCAL MAP and then the shuttle robot will proceed.

A second layer of protection is afforded by the thermal cameras which are tuned to recognise people.



Slow down ramps and speed up ramps and emergency braking are all controlled by ObelixPLUS.

~~Shuttle can now navigate itself to a given target.~~

Other obstacles regularly detectable include:

Detect a Chain and Sign

The shuttle robot scanner can identify a change and hanging object in its LOCAL MAP and halt or treat the chained off roadway as a temporary no go and find another way to the TARGET POSITION

Detect a reflective sign hanging from ceiling

The shuttle robot can respond to a general position and a particular sign such as ALL ROBOTS TURN RIGHT =>>

Navigation Strategies

The combination of GLOBAL MAP, SLAM and LOCAL MAP EXTENSION provide the required, real-time positional awareness to the shuttle robot.

Remote control room can identify the target position as the tail end of the miner and the feeder breaker.

The shuttle robot is able to navigate between the two points using a range of strategies, allowing for real world practicalities such as temporary changes to the road way network, occasional obstacle while provide a 2 layer safety system to avoid people (obstacle, moving obstacle and thermal detection).

The sophisticated mapping and navigation system augmented by thermal cameras provide an effective alarm and auto braking system to defeat collisions with a wide range of stationary or moving objects.
This is supported in both manual driving (on-board operator) and autonomous modes.

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made for mining

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