

Autonomous Vehicles in Mining Surface and Underground















Autopilot ? 100% Automated Operation!



Autonomous Loader Tactical Screen unique to each operating loader.



Autonomous System Components

- **Two Independent Systems Support The Autonomous Operation**

- **Area Isolation System**: Monitors the safety aspects of the operating area and the communication link to the operating loader.

- **Automation System**: Loader operating system supporting the remote operation of the machines movements.

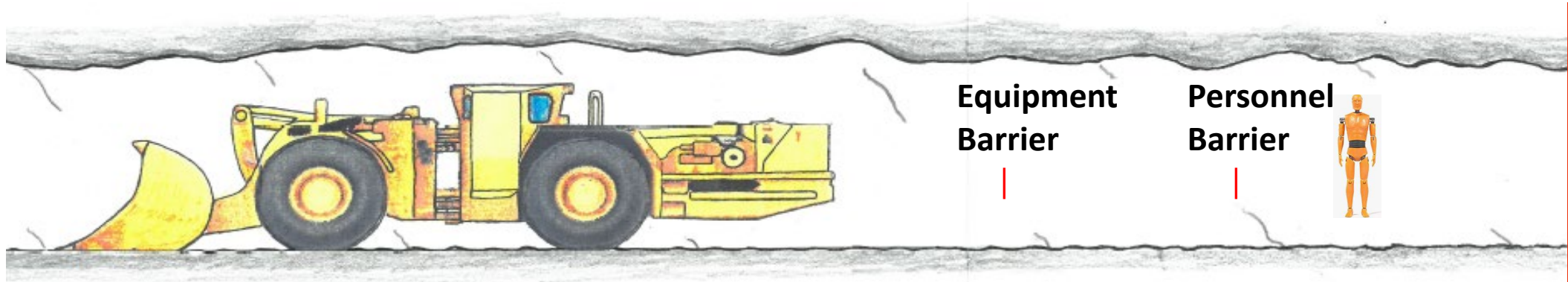
- The two systems operate independently but are linked together.

- **If safe operating conditions are not maintained,**

- **the Area Isolation System shuts down the Automation System.**

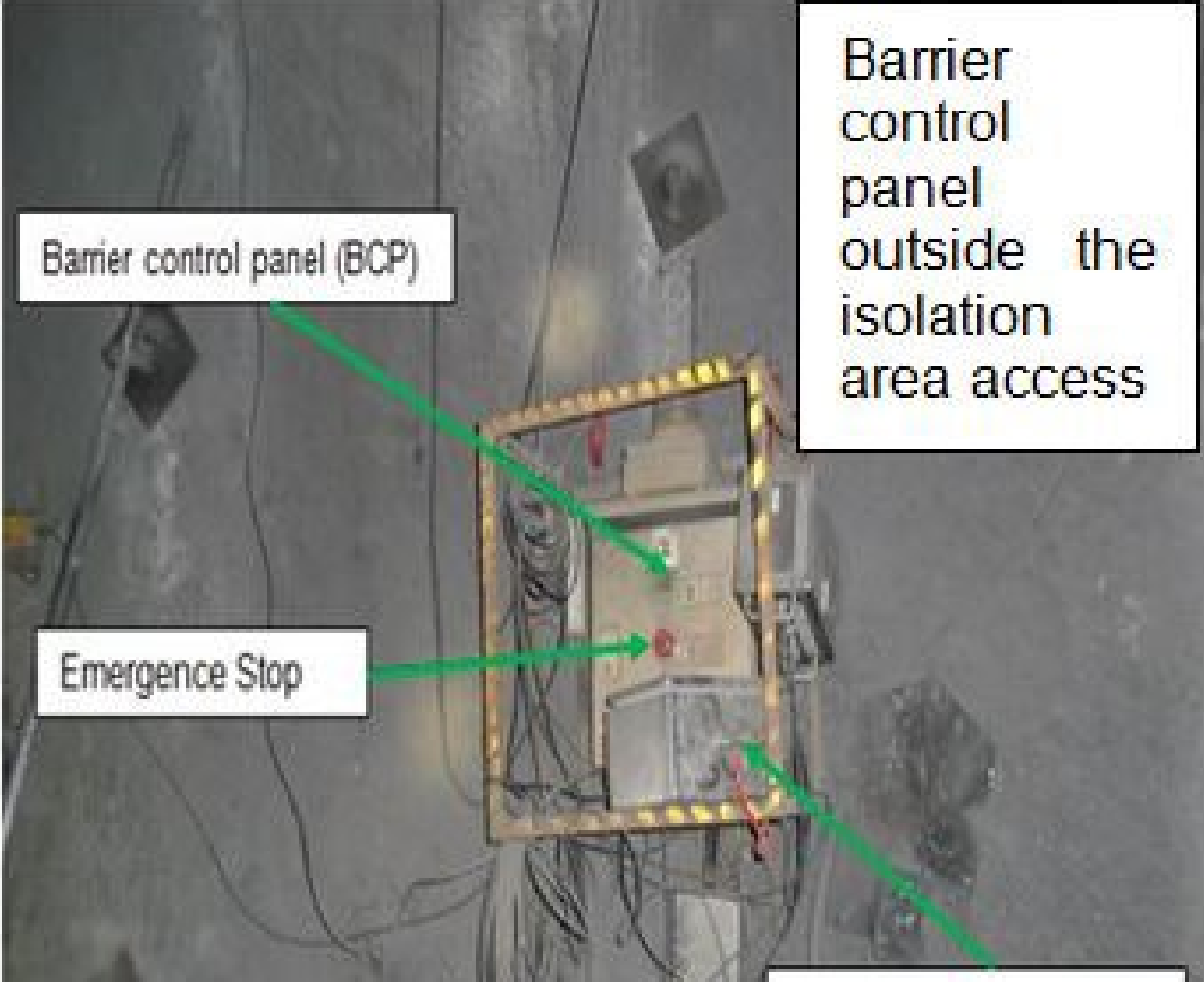
Autonomous Barrier Arrangement

Area isolation barriers are installed in pairs, one for the equipment, one for personnel.



Each access point into the autonomous operating area has this barrier arrangement.

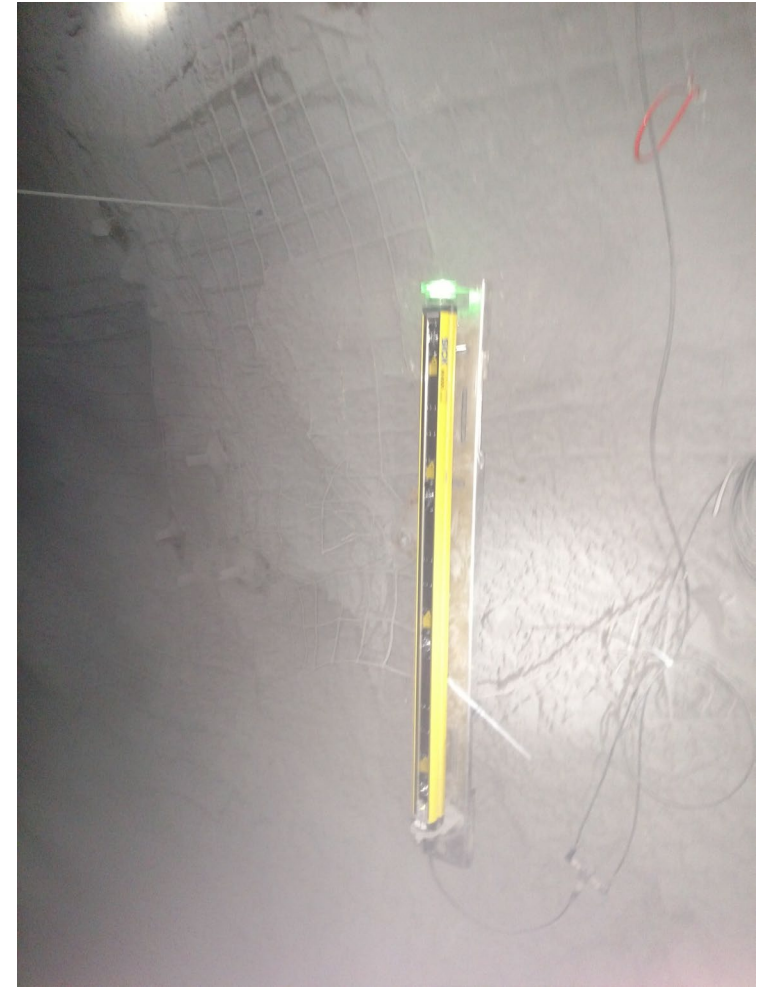
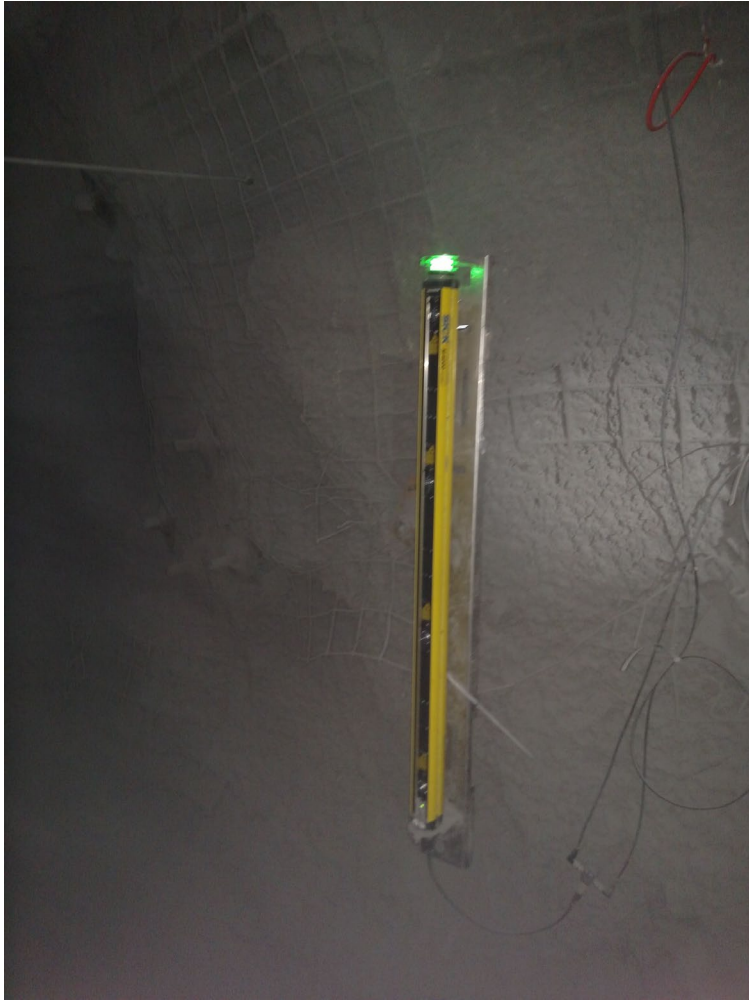
Barrier control panels



Barrier Types: (Note in an emergency situation persons are expected to break the connections on these electronic barriers. Any broken /disconnected electronic barrier will shut down the loader allowing a person to safely travel through an isolated area. Pressing the emergency stop on the barrier control panel would also shut down the loader.



Light curtain: Light curtains are a set of bars bolted on opposite sides of the drift. They send a signal from one bar to the other. When the signal is broken by walking in between the light bars the loader would be shut down immediately.



Gate: This is a hinged gate attached to the drift rib. When closed to the other rib they would make a connection to the barrier control panel. When opened the connection would be broken and shut down the loader immediately

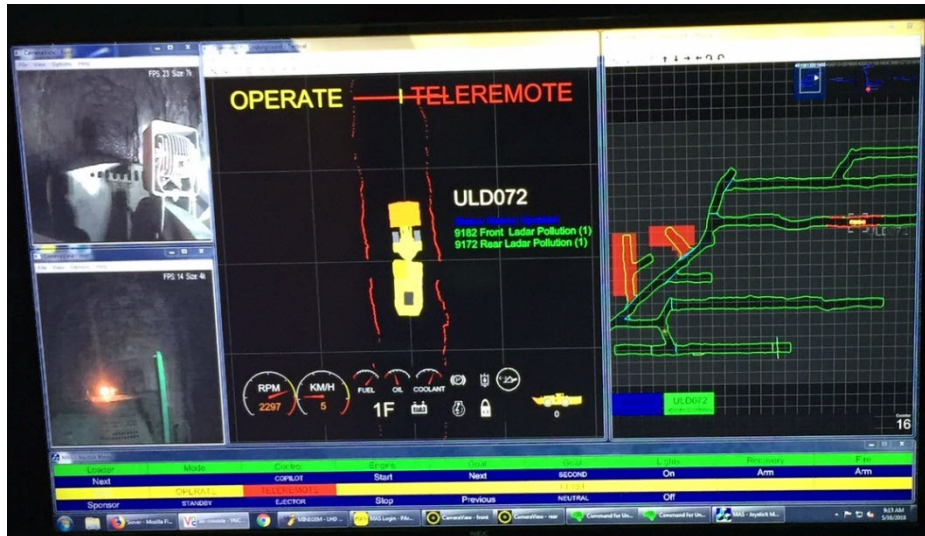


Autonomous System Shutdown Conditions

- **Area Isolation System Shutdown**

- **An equipment or personnel barrier has been breached.**
- **A electrical power bump or failure has occurred at a barrier location or within the area isolation system.**
- **The communication link monitored by the area isolation system between the machine shutdown module (Lunch Box) and loader is lost or lagging.**
- **An autonomous operator emergency stop condition.**

Autonomous Operating Modes

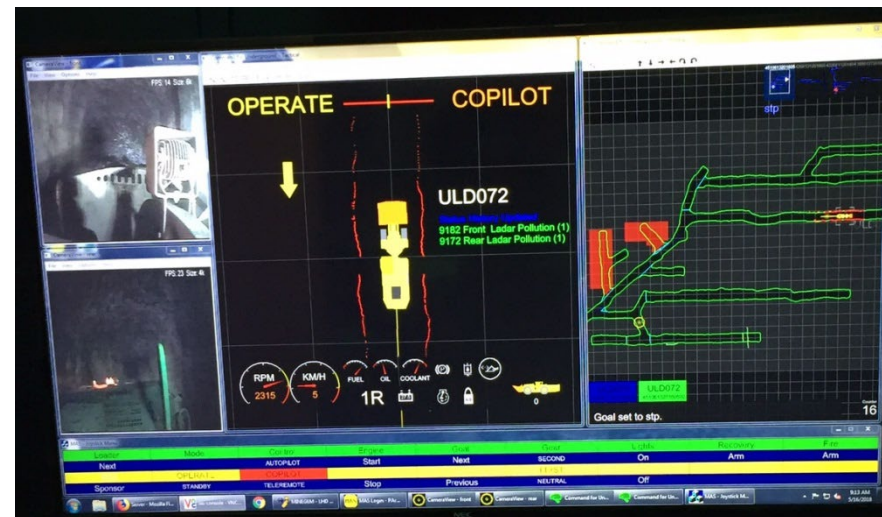


Autonomous Loader Tactical Screen
unique to each operating loader.

Telemote - The autonomous operator is
in 100% control of machine functions.

Copilot - The autonomous loader is operating
self guided with minimal autonomous operator
inputs. The operator can apply directional and
steering inputs.

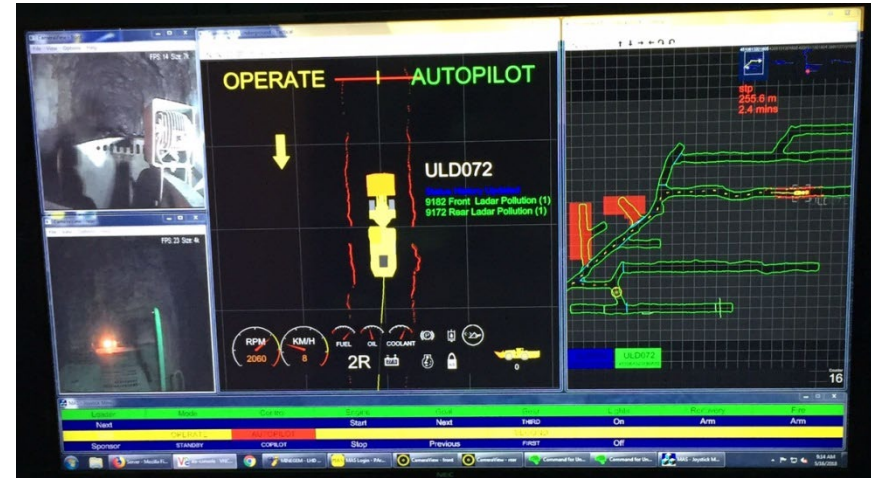
The loader is equipped with LADAR which is a
laser assisted guidance system and reference
map for self guided operation.



Autonomous Operating Modes

Autopilot

100% Automated Operation!



In autopilot, the loader is self guided using a reference map, programmed reference points and the LADAR guidance system.

The autonomous operator may be running more than one loader from a single operating station and may not even be looking at the tactical screen of the unit in autopilot.

Visibility and LADAR Elevations:

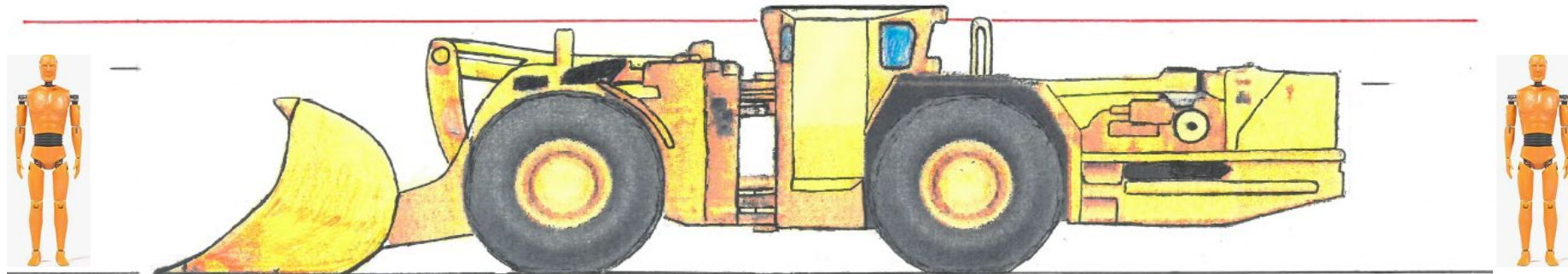


In tele remote and copilot, the autonomous operator has limited visibility.



Front
Camera
View

Rear
Camera
View



I Can't See You In Autopilot !

Autonomous Personal Safety:

- **Active Autonomous Operating Areas**
 - **Do Not Enter An Active Autonomous Operating Area.**
 - **The Autonomous Operator Is In Control Of The Active Area.**
 - If Entry Is Required Into The Area,
 - The Autonomous Operator Is The Communication Point Of Contact.
 - Entry Will Be Coordinated With The Assistance Of Trained Autonomous Personnel.
 - **Only Autonomously Trained Personnel Will Operate The System And Controls.**
 - (Area Isolation System Components and Loaders).
 - **Look At And Become Familiar With The Barriers In Idle Conditions.**
 - **Know How To Breach A Barrier In An Emergency!**

Thank you.

Any Questions ?