



Real Applications of Remote Technology in Mine Rescue and Emergency Response

Today and Tomorrow

Introduction

My Background



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Glencore and Kidd Operations

- Mining Engineer (prev. Engineering Manager at Kidd Mine)
 - 6 years site Incident Command
 - Emergency Response Risk Owner
 - 3rd party Incident Investigations in Emergency Responses
 - Extensive Technology initiatives (Drones, AI/ML, RTLS etc)
- Currently global Business Planning for Glencore Nickel-Zinc



Ontario Mine Rescue

- 10 years active Mine Rescue
- 4 years in Competition
- Chair of provincial Mine Rescue Advisory Committee
- Participation in International body (IMRB and IMRC)

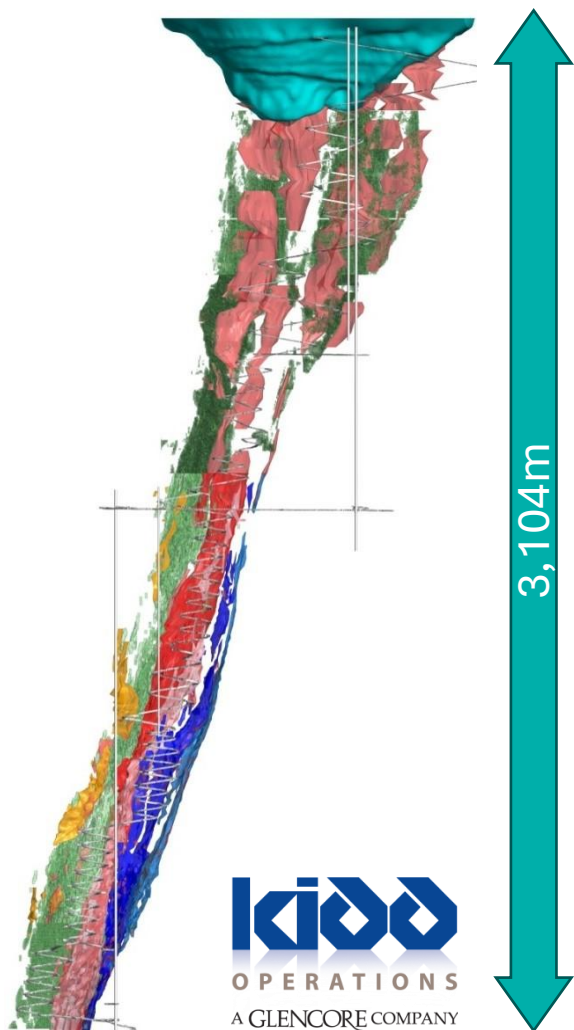


Wilderness Search and Rescue

- 12 years active Search and Rescue unit
- Deputy Area Search Manager
- Equipment Manager and Chair

Background – Why Remote?

Ultra-Deep High-Stress Mining at Kidd Mine



Initial Investment in Remote Technology comes from a background in Ultra-Deep High-Stress Mining!

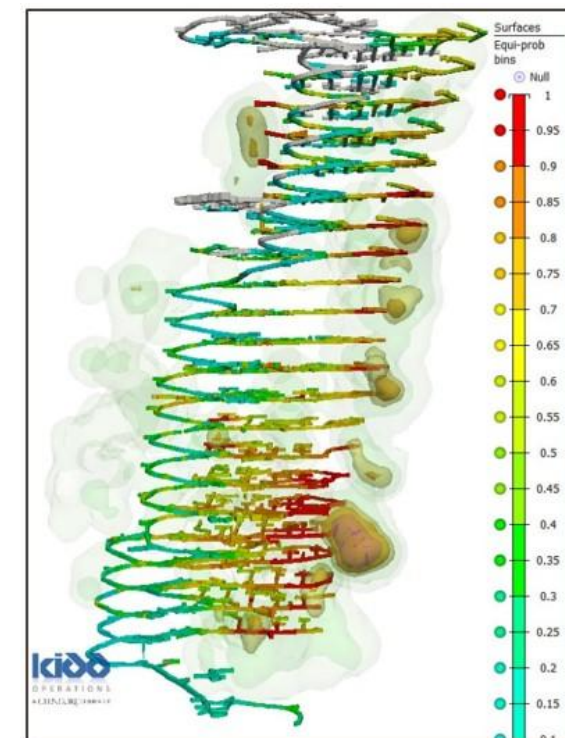
The Environment: **Kidd Mine** (Ontario, Canada)

- Ultra-Deep (over 3km – deepest base-metal mine)
- High-Stress (ground stresses > rock strength)
- High-Seismicity (seismicity > Mn3 **expected**)

Damaging seismicity is experienced regularly – up to historical max of Mn3.9 (with extensive damage)

Challenges of this environment:

- Extensive **Area Isolation** is used to manage exposure of personnel to High-Hazard areas

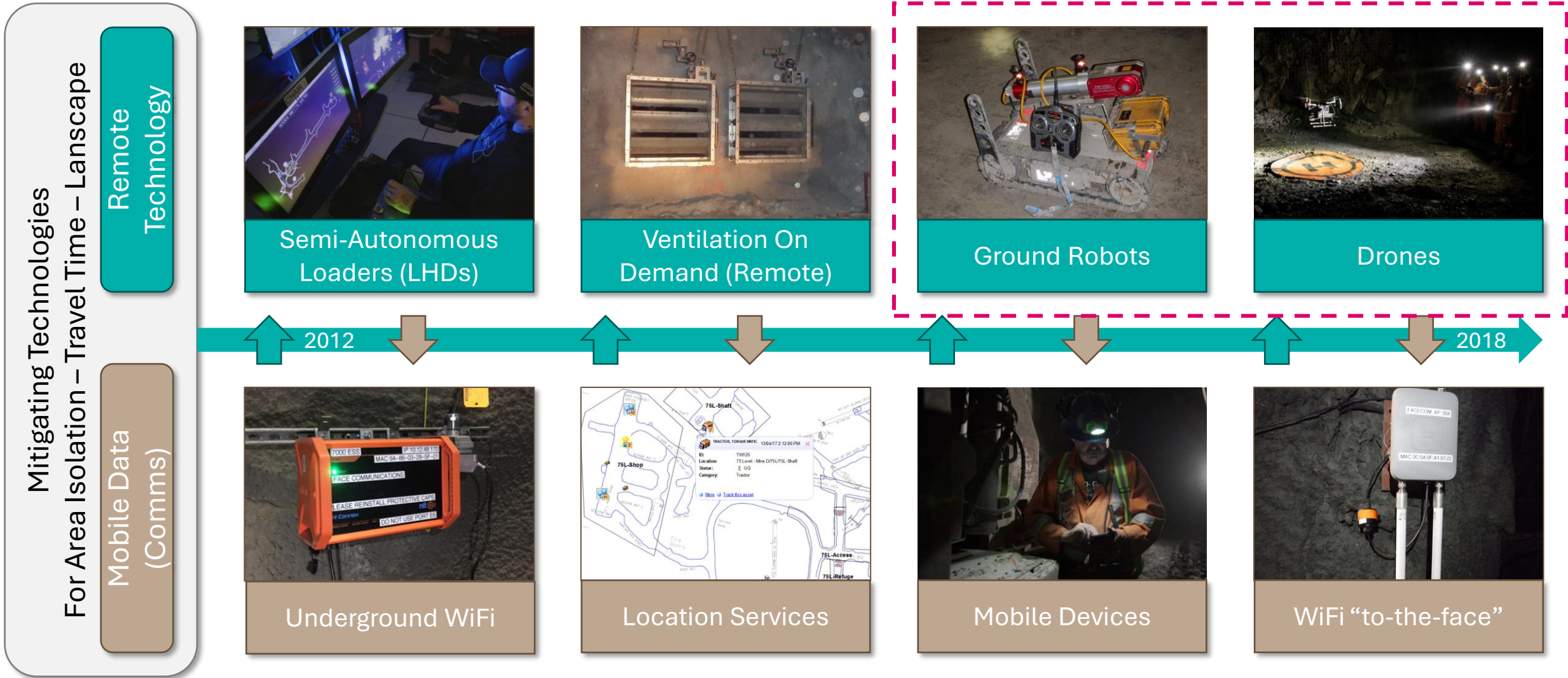


Seismic Hazard Map indicating areas of high probability of seismicity (Red = 100% > Mn1.5)



Background – Why Remote?

Mitigating Technologies from Ultra-Deep High-Stress Mining

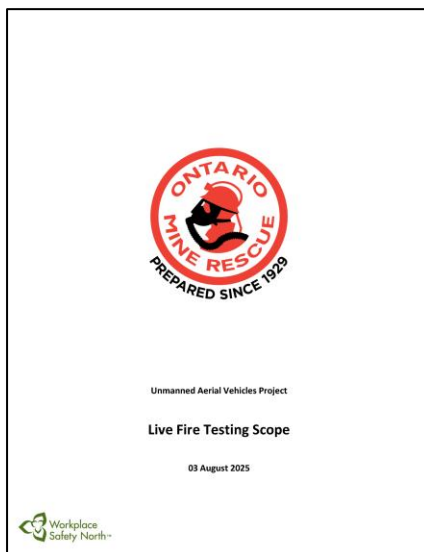


Adoption in Ontario Mine Rescue

2022 OMR Live Fire Test

OMR Established Live Fire Testing Scope

- Objective to test performance of several technical systems in a controlled underground Live Fire, including:
 - UAVs and Ground Vehicles (Robots)
 - Mobile Tablets / Captain's Tablet
 - WiFi Signal, Radios and Thermal Imaging



Live Fire Underground at Maclean Test Site

Class A fire set for testing purposes (Objective to access chamber beyond fire)



State of Technology

Current Systems and Capabilities

State of Technology

System Overview (Remote Technology) – Elios

System	
Type	Aerial Drone (UAV)
Make-Model	Flyability / Elios
Sensors	Video – Thermal – LIDAR
Key Features	Collision-Tolerant LIDAR Stabilized Return-To-Home (Semi-Autonomy)
Availability	Available End-User-Operable
Service Record	Flown in Contamination (near Fire) Deployed in Non-Fire Emergencies <ul style="list-style-type: none"> Falls of Ground Equipment lost in Stopes Extensive non-emergency use in active mining and other industries



- Can be operated successfully by pilots with relatively limited training
- Complete system is compact and easily transportable
- System is crash-tolerant, allowing it to fit through very small openings
- Considerably safer to personnel in the vicinity (protected propellers)
- Immediate Visual, Thermal and 3D LIDAR results on-screen to the user

State of Technology

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State of Technology

System Overview (Remote Technology) – Hovermap

System	
Type	Aerial Drone (UAV)
Make-Model	Emesent / Hovermap (Tested) Safesight, Exyn (Similar systems)
Sensors	Visual – LIDAR
Key Features	LIDAR Stabilized Semi-Autonomous (assisted flight) Fully-Autonomous waypoint and exploration modes
Availability	Available End-User-Operable
Service Record	Deployed in Non-Fire Emergencies <ul style="list-style-type: none"> Falls of Ground Abandoned Workings / Re-entry Extensive non-emergency use in active underground mining and other industries



- Autonomous Exploration: Can operate beyond Control Link range using full autonomy modes (autonomous exploration)
- Autonomous and Waypoint modes cover ground very quickly (generally faster than what a manual pilot can safely execute)
- LIDAR scans at survey-grade accuracy suited for geotechnical analysis supporting assessment for safe re-entry following ground movements

State of Technology



System Overview (Remote Technology) – Hovermap

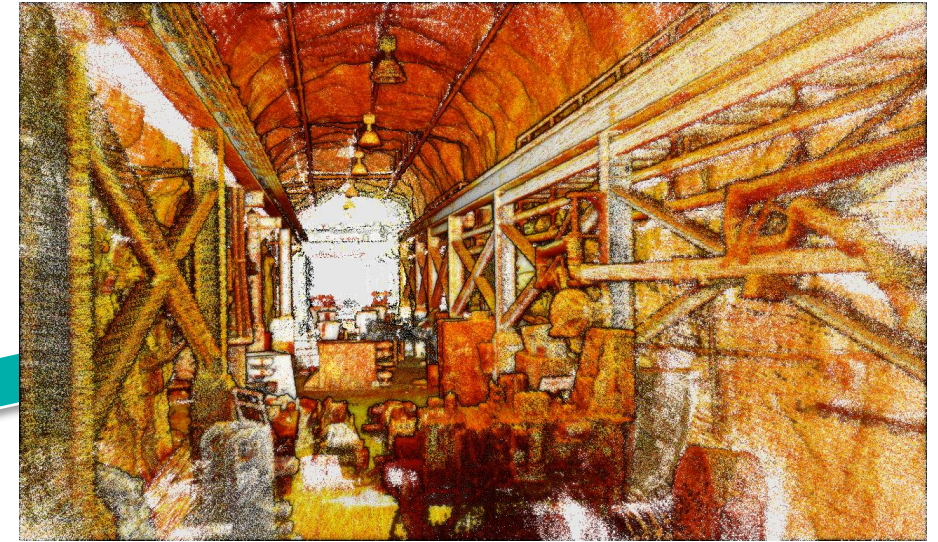
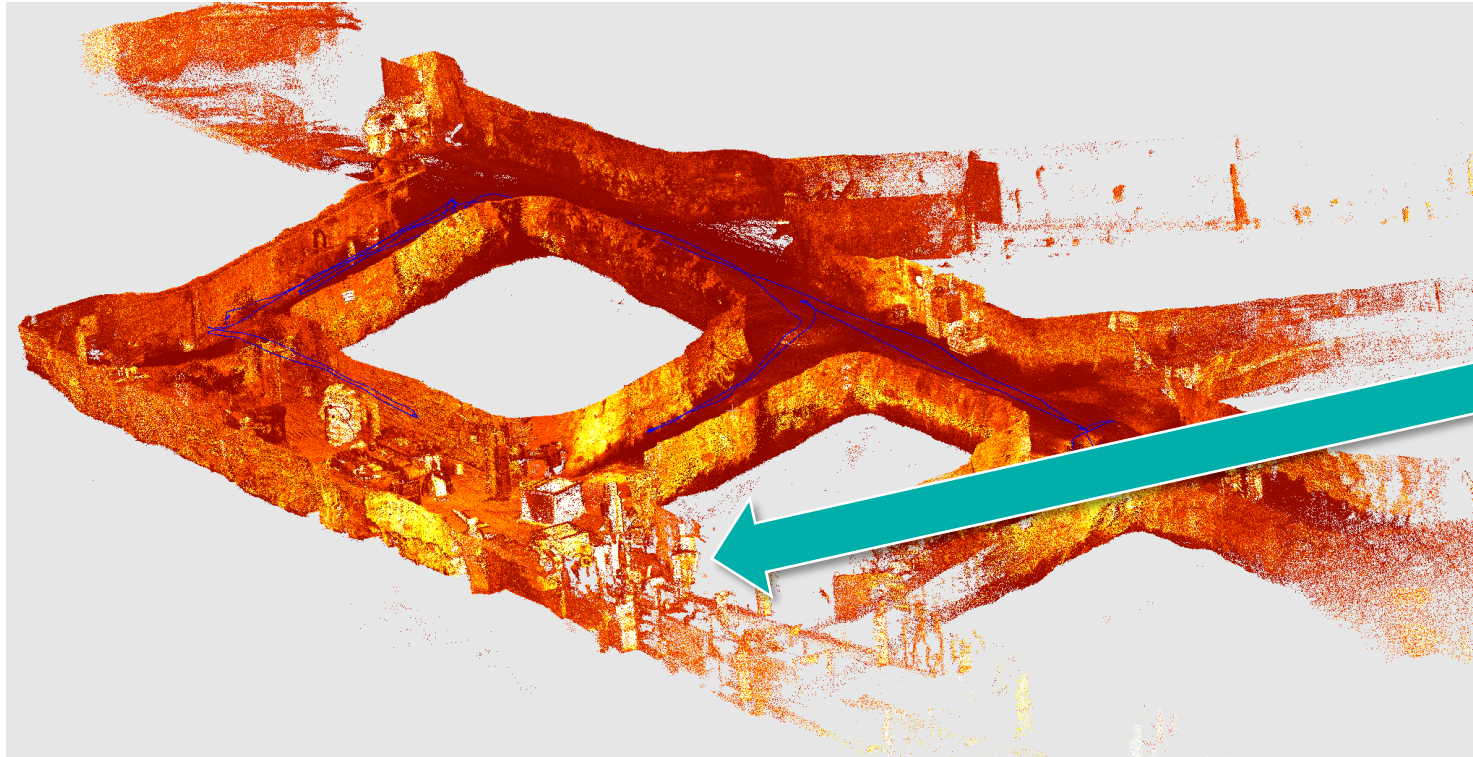
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State of Technology



System Overview (Remote Technology) – Hovermap

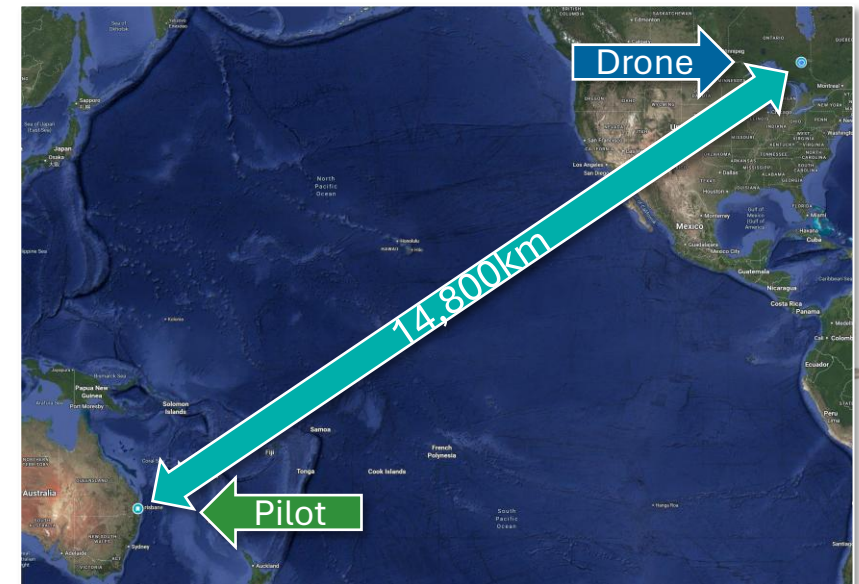


Unique Capability: Full Autonomy

- Allows operation with Long-Range, High Latency (Slow) Control Links
 - Extreme tests have proven the potential to operate over WiFi and Internet
- Pilot does not need to directly control or react to avoid obstacles or hazards

This type of operation provides a **different kind of information**:

- High resolution and detail of the environment – but **requires post-processing**





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Application Scenarios

Actual Emergencies Suited to Remote Technology

Application Scenarios

Impassable Hazards – Incident Example (Seismicity / Fall of Ground)

Application Scenario 1: Impassable hazard (Fall of Ground)

Incident Details

- Large Seismic Events (M_n 3.9, 3.8, 3.1)
- Magnitude and Location not accurately predicted by Seismic Hazard Modelling (occurred outside of exclusion zones)
- Occurred Mid-Shift (workers underground)
- Large Landscape (damage over many levels)

Unique Hazards

- Unsupported / Compromised Ground
- Aftershocks / Loss of Support Capacity
- Difficult or Impassable Terrain
- Destruction of Communications and Location Systems
- Large Affected Landscape



Seismic Damage in a Workplace from M_n 3.8 Seismic Event

Application Scenarios

Impassable Hazards – Incident Example (Seismicity / Fall of Ground)

Application Scenario 1: Impassable hazard (Fall of Ground)



Main footwall drift (prior to Seismic Damage)

Note catastrophic damage even with Dynamic Support in-place.



Main (footwall) drift damage from M_n3.8 Seismic Event

Application Scenarios

Impassable Hazards – Incident Example (Seismicity / Fall of Ground)

Application Scenario 1:
Impassable hazard (Fall of Ground)



Note continuation of main drifts beyond seismic damage; areas may need to be searched for unaccounted personnel.

Main (footwall) drift damage from $M_n 3.8$ Seismic Event

Application Scenarios

Impassable Hazards – System Capability Example (Seismicity / Fall of Ground)

Application Scenario 1: Impassable hazard (Fall of Ground)

Solution: All UAVs (Drones)

Capability: Mine Rescue Team Member

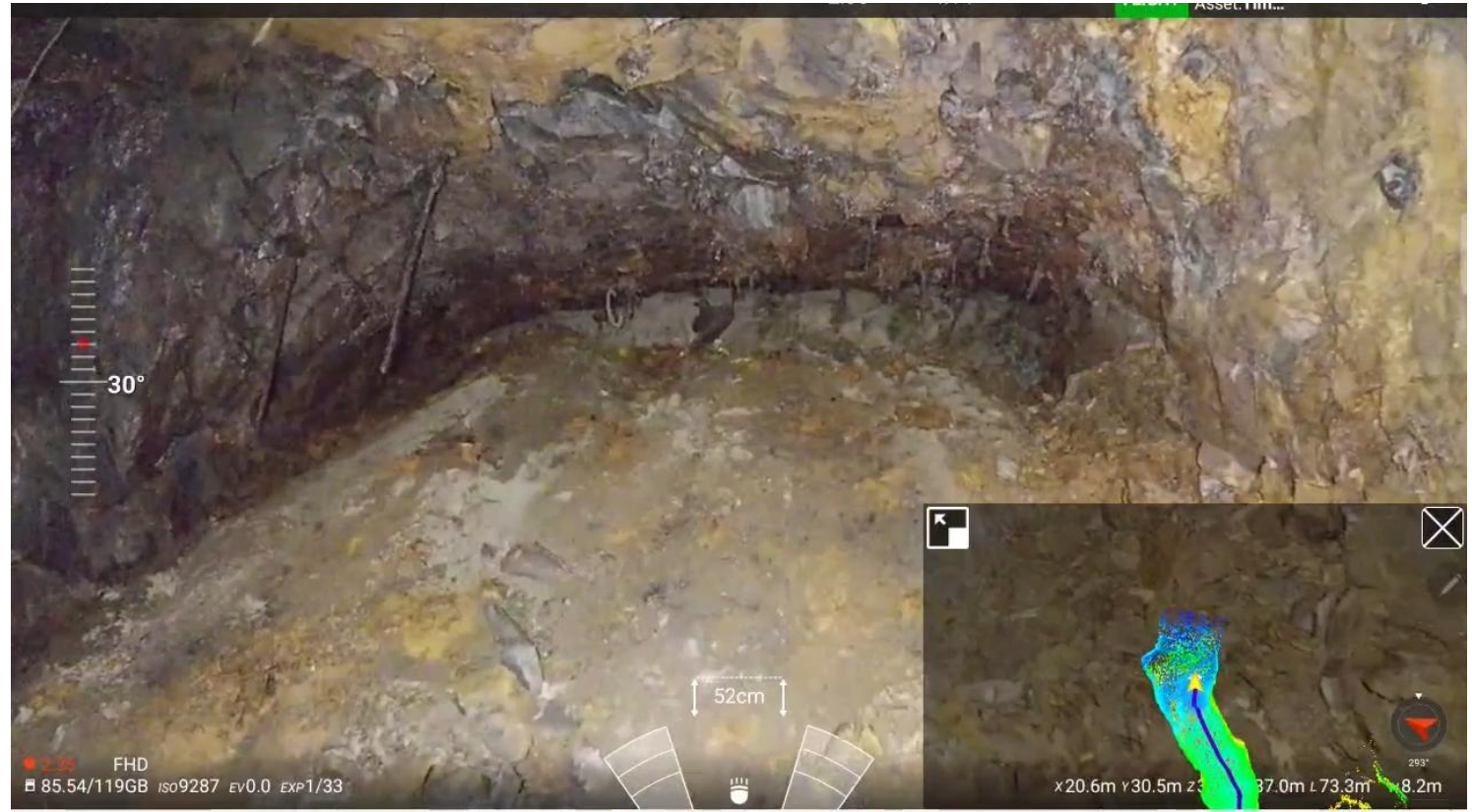
Availability: Current!

Application Details

- Search for persons stranded or injured beyond an impassable hazard area
- Determine priority for re-entry and rescue
- Triage response in large-scale incidents

System Recommendation: Elios

- Pass through tight/small openings
- Negotiate hanging debris
- Can be used directly by Mine Rescue Teams on first response (immediately)
- Rapid information for Incident Command for decision-making and prioritization



Video: Elios 3 Flight through Seismicity-Damaged Ground

- Unique ability to navigate through past obstacles and damaged support
- Considerably safer to attempt by a regular Mine Rescue Team Member

Application Scenarios

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Video: Elios 3 Flight up Raise to Inaccessible Level

- Used to fly up a ventilation raise to inspect a damaged level / stranded area
- Considerably safer to attempt by a regular Mine Rescue Team Member

Application Scenarios

Impassable Hazards – Incident Example (No-Go Zone)

Application Scenario 2: Impassable Hazard (No-Go Zone)

Incident Details

- LHD was operated inside Open Stope (operator did not use Remote)
- Large piece of oversize fell and pinned the operator in the cab
- Required removal of pinning rock and extrication of the operator with the entire scene ~10m beyond the open stope brow

Unique Hazards

- No direct access to pinned operator without entering into open stope
- Operator beyond line-of-sight (could not see to plan safe extrication)
- Extreme stress / pressure due to operator actively communicating
- Video phone taped to poles used to gain intel



Incident Scene - LHD inside Open Stope

Application Scenarios

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Incident Scene - LHD inside Open Stope



Application Scenarios

Impassable Hazards – System Capability Example (No-Go Zone)

Application Scenario 2: Impassable Hazard (No-Go Zone)

Solution: Collision-Tolerant (Elios)

Capability: Mine Rescue Team Member

Availability: Current!

Application Details

- Provide immediate, high-quality information to form extrication plan
- Provide monitoring of the casualty

System Recommendation: Elios

- Quickly deployable by the Mine Rescue Team
- Immediate Visuals and Lighting
- Inspection from all angles
- Inspection at very close range
- Ability to inspect above stope brow (hazards above the extrication operation)



Video: Elios 3 Inspecting a Buried LHD

- Unique ability to navigate very close to the object being inspected

Application Scenarios

Extensive Impassable Hazards – Incident Example (Large / Unknown Landscape)

Application Scenario 3: Extensive Re-entry Landscape

Incident Details

- Incident in extensive non-entry area
- Requires gaining information from beyond line-of-sight in unknown conditions
- Operator requiring information to plan monitoring and/or re-entry or recovery plan

Unique Hazards

- Significant Landscape requiring coverage
- Unknown potential for further damage
- No control link / communications
- Hazard of the Unknown!



Landscape from Entry to Area of Interest (two incidents pictured)

Application Scenarios

Extensive Impassable Hazards – System Capability Example (Large / Unknown Landscape)

Application Scenario 3: Extensive Re-entry Landscape

Solution: Autonomous Exploration

Capability: Trained System Operator

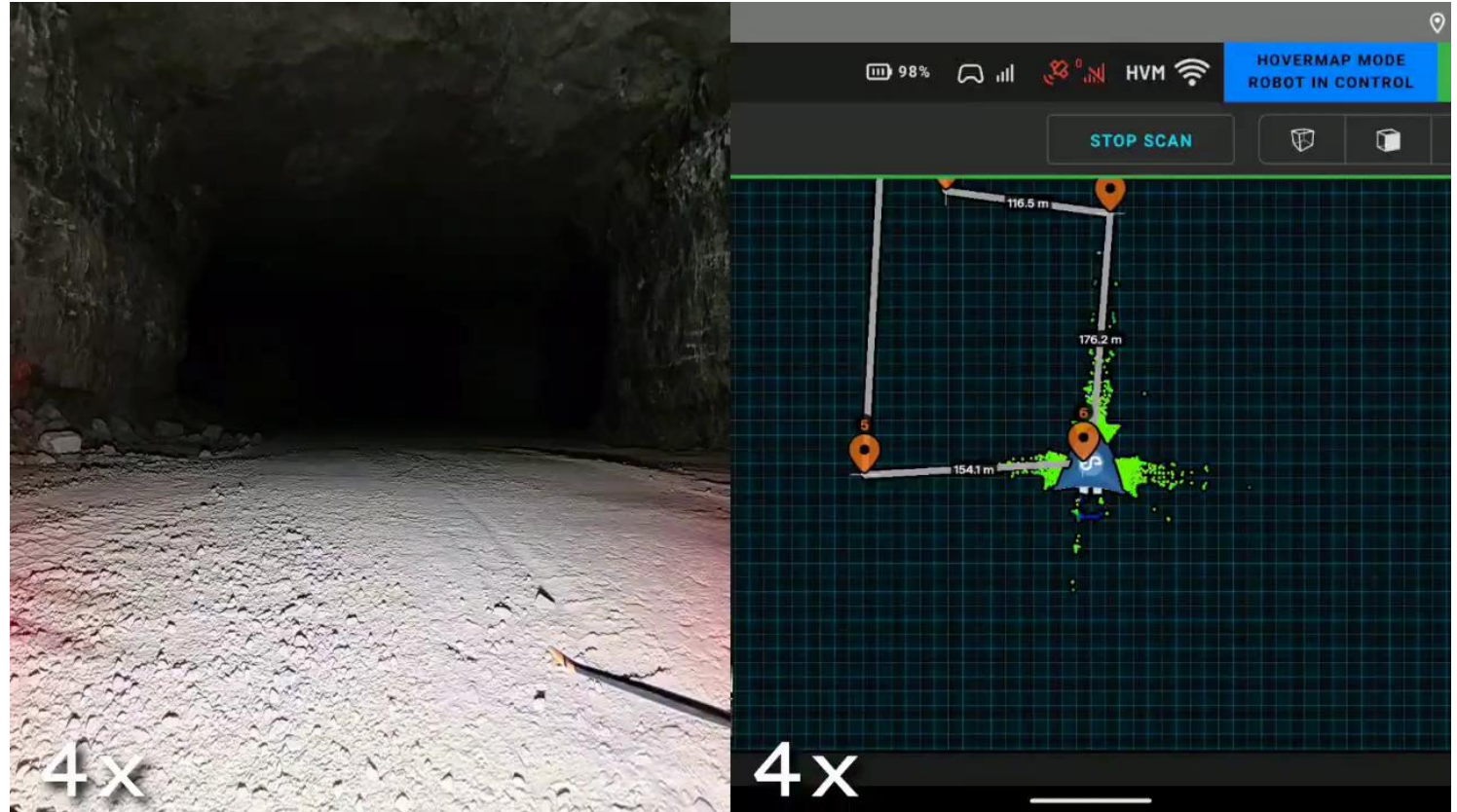
Availability: Current!

Application Details

- Gain detailed, high-resolution data on the current state of conditions within the area to guide entry planning
- Gain sufficient resolution to analyse support condition and capacity

System Recommendation: Hovermap

- Capability of exploring beyond line-of-sight and communications / control link in autonomous exploration mode
- Return survey-quality data on the environment for analysis



Video: Hovermap Autonomous Exploration Fly-Through

- Unique ability to explore well beyond control link connectivity
- Multiple missions can be flown to progressively build the environment

**Sample courtesy of Unmanned Aerial Services*

Application Scenarios

Extensive Impassable Hazards – System Capability Example (Large / Unknown Landscape)

Application Scenario 3: Extensive Re-entry Landscape

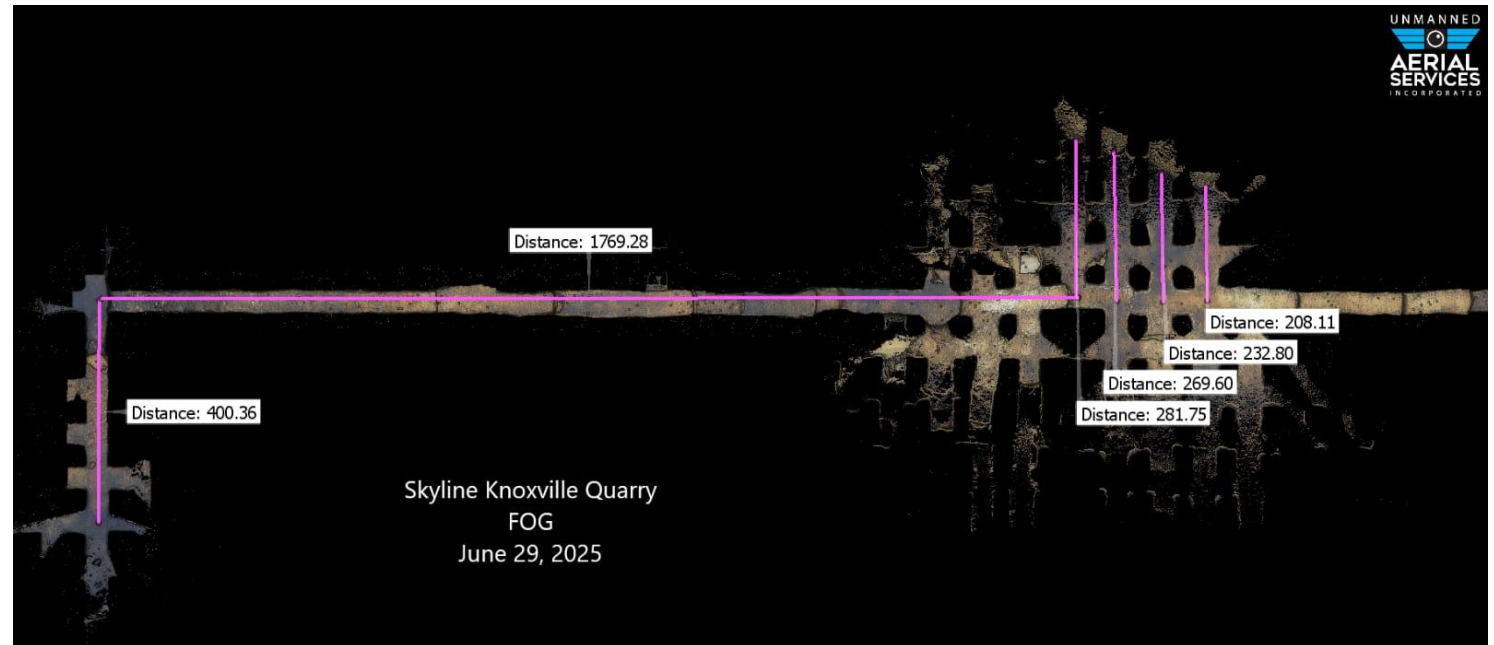
Solution: Autonomous Exploration
Capability: Trained System Operator
Availability: Current!

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Video: Hovermap Detail from LIDAR Scan

- Significant details can be collected from beyond line-of-sight
- Survey-grade data can be used generate re-entry and recovery plans

**Samples courtesy of Unmanned Aerial Services*

Application Scenarios

Extensive Impassable Hazards – System Capability Example (Large / Unknown Landscape)

Application Scenario 3: Extensive Re-entry Landscape

Solution: Autonomous Exploration

Capability: Trained System Operator

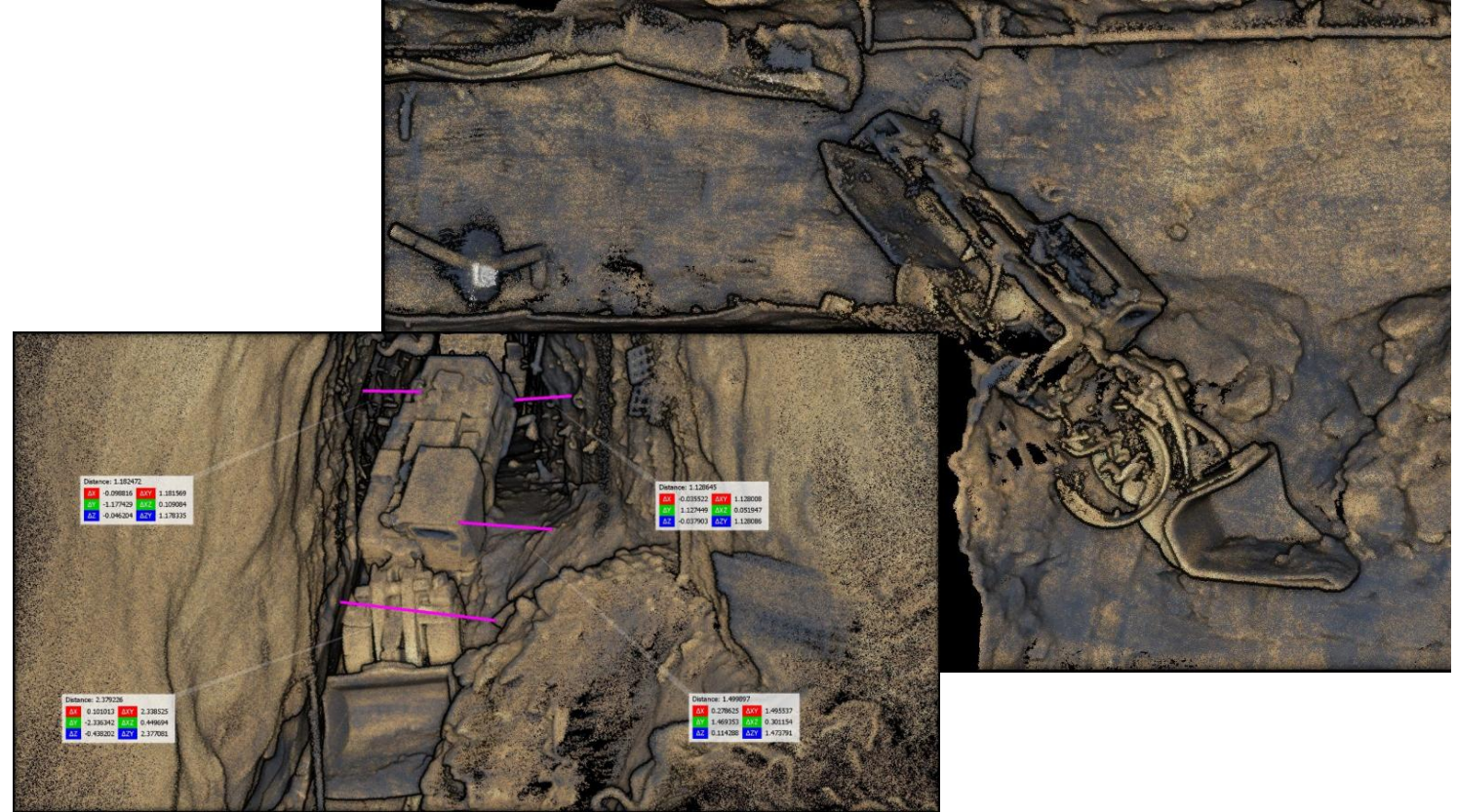
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Thank You!

Link to Full Presentation:



Thank You!



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Further Information – Links for Remote Technology



“Drone inspects the deepest mine in the world at Glencore Kidd Operations. Discover mining drones”
Flyability / Elios 3



“Improving ground support at Glencore’s Kidd Operations”
Emesent / Hovermap



“Underground Mining Drones? Glencore Kidd Operations share their experience on drones underground”
Flyability / Elios 3



“Remote capture of geotechnical data”
Emesent / Hovermap



“Mine Mapping with Drones! Elaborating the underground mine data collected by a mapping drone”
Flyability / Elios 3



“Glencore Kidd Operations | Mine productivity and Safety”
Emesent / Hovermap STx



“Spot at Kidd Creek Mine”
Boston Dynamics / Spot



“Next-Generation Mines with Pointr”
Pointr