

[geospatial.trimble.com](https://geospatial.trimble.com)

# Mine Survey & Monitoring

Enhancing Surveying Efficiency for Mines

# Trimble Overview



## Group



NASDAQ:  
**TRMB (S&P500)**



**\$3.6B**  
In Revenue



**39%+**  
Building &  
Infrastructure



## Innovation



**2,000**  
Patents



**360** Construction Workflow  
& Technology Patents



**\$450M+ (~15%)**  
R&D Re-invested



## Resources



**12,000+** Employees  
in 35 Countries



**1000+** Construction  
Professionals



Global Customers  
in **150** countries



# Trimble Sectors

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Natural  
Resources



Geospatial



Construction



Transportation



Autonomy



Corporate  
Accounts



# Additional industries we serve

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Rail



Environmental & Waste



Water Utilities



Electric Utilities



Mining



Forestry



Field Service

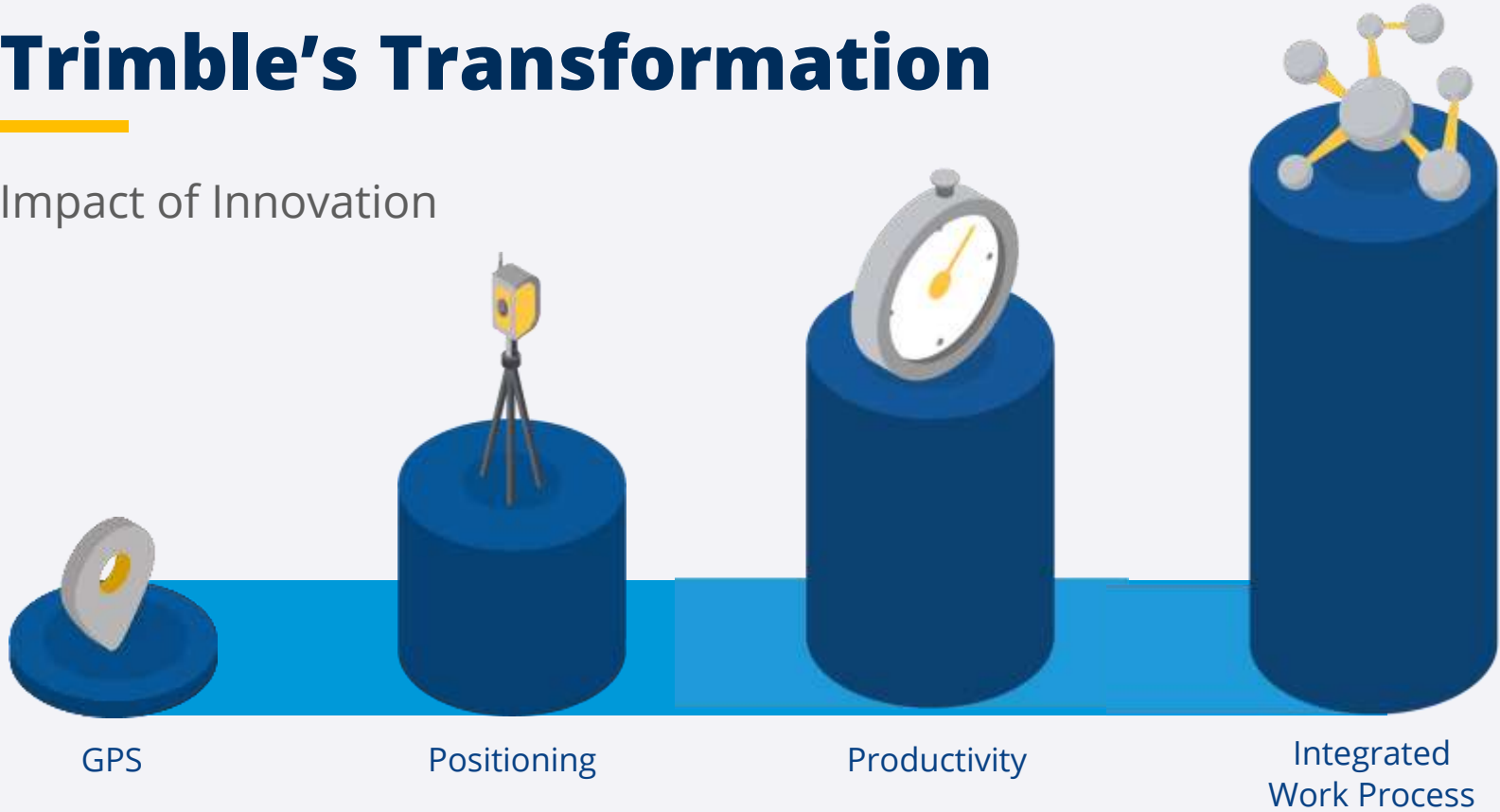


Oil, Gas, & Chemical



# Trimble's Transformation

Impact of Innovation



# Trimble Surveying & Mapping connects the physical earth with the digital world enabling professionals in a wide variety of industries to transform the way they work



# The Trimble Geospatial Story

- **Premium** brand in the survey and mapping industry
- Leader in **GNSS, Optical** and **Imaging** technology
- Diverse portfolio of data collection **hardware and software** solutions
- **Vertical market solutions** to address different market segments and their unique needs
- Leverage **global distribution network** for localized expertise, service, support and delivery

<p>Geospatial</p> 	<ul style="list-style-type: none"><li>• <b>&gt;70%</b> of POB<sup>1</sup> top 100 geospatial companies use Trimble</li><li>• <b>&gt;10,000</b> surveyor and mapping firms in N.America are Trimble customers</li><li>• Joint venture with Nikon</li></ul>
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# 01

## Mining Life Cycle

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Breaking down each stage of  
the mining process





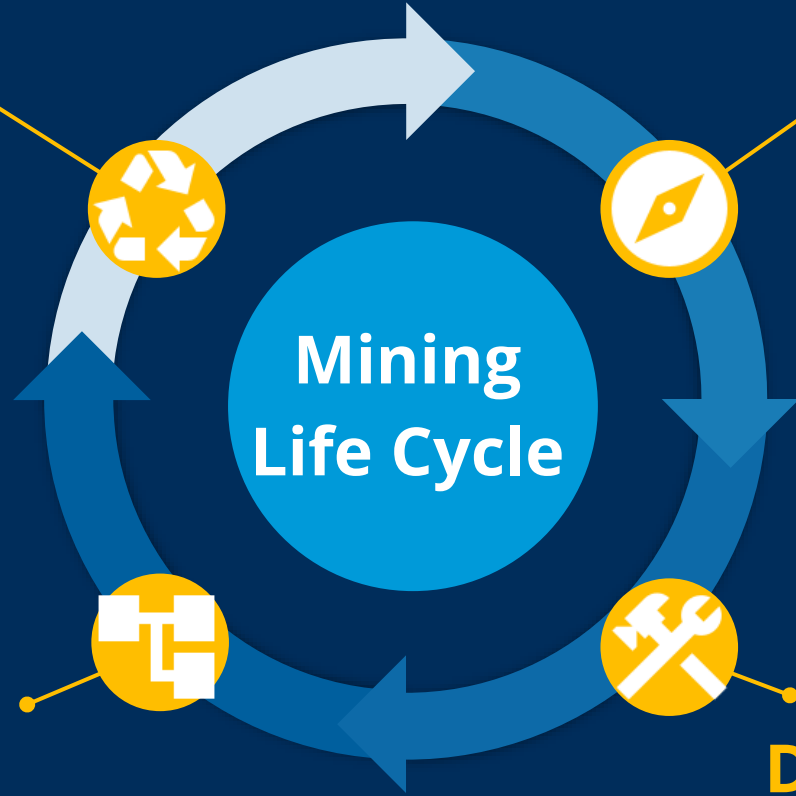
**Remediation**

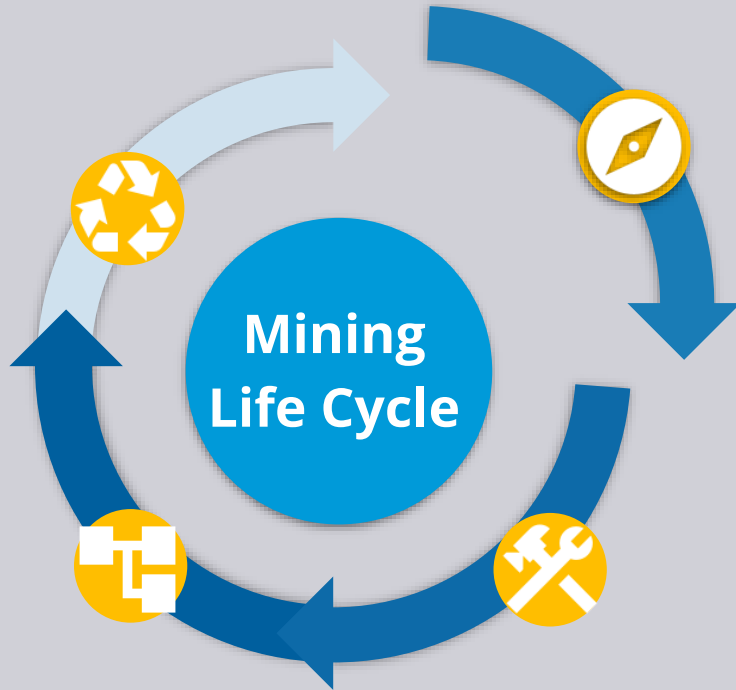
**Exploration**

**Mining  
Life Cycle**

**Operations  
& Processing**

**Design &  
Development**





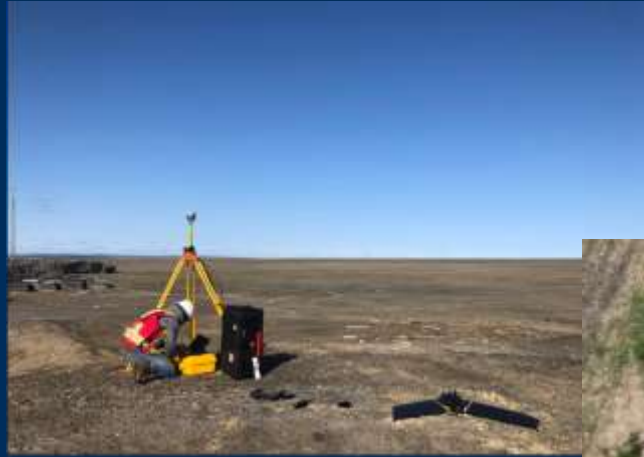
## Exploration

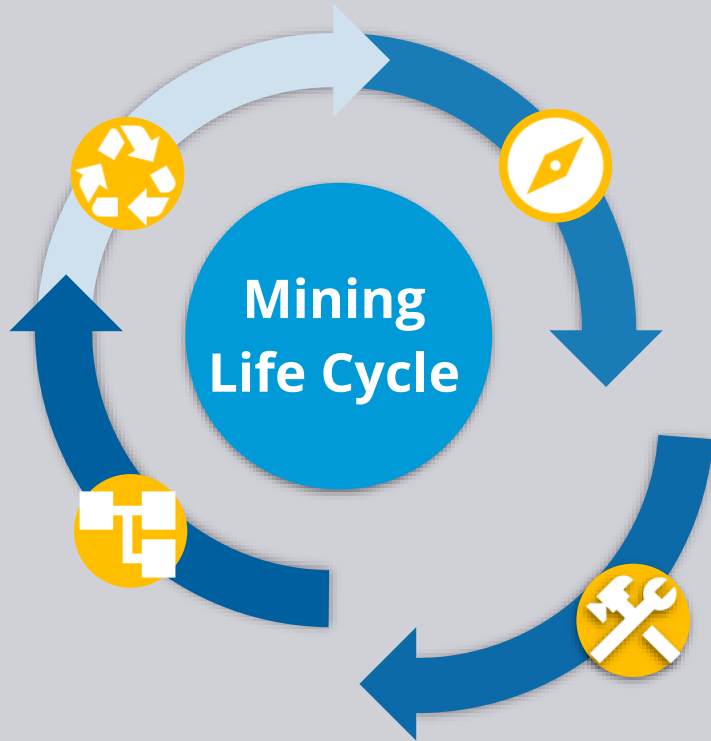
- Searching for DEPOSITS OF MINERALS and NATURAL RESOURCES – Legal Boundary
- Geological sampling and seismic investigation
- **Estimating mineralisation for commercial extraction**



# Topographic Survey

- R12i is the perfect GNSS solution for mapping; quick measurements, **no levelling required** with TIP technology
- Use R12i to **set out ground control** for UAV surveys or pair with echosounders for hydrographic surveys





## Design & Development

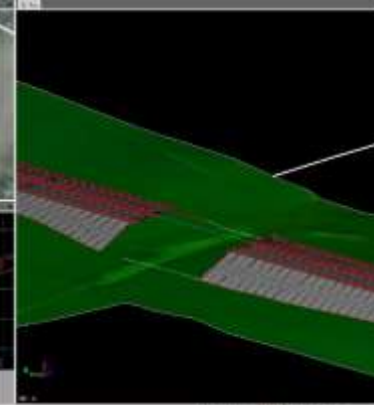
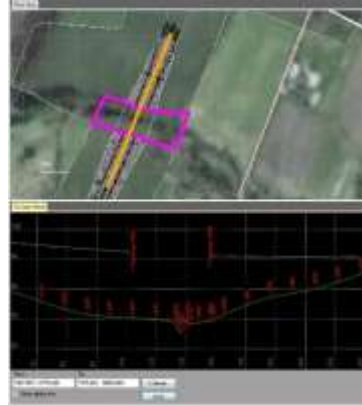
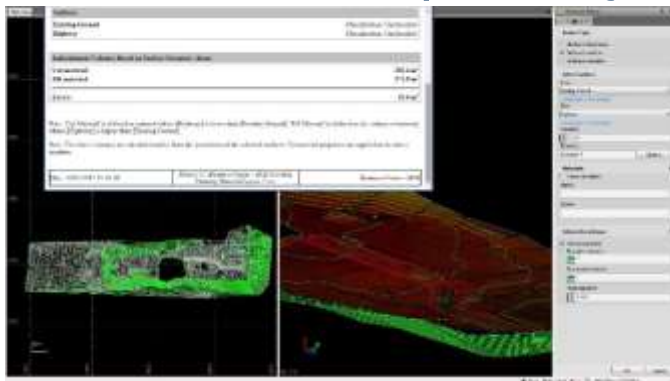
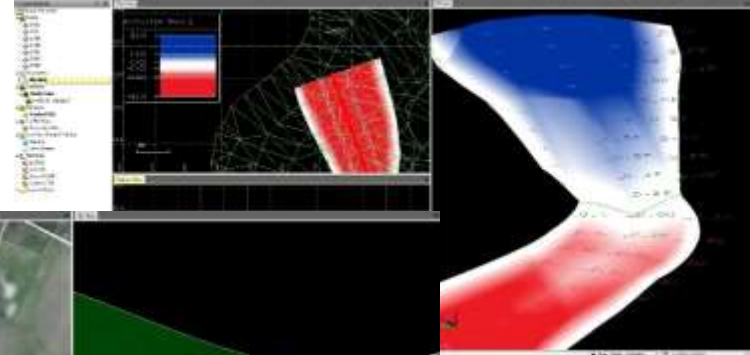
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- Designing and building the mine's infrastructure
- Clearing the local area to prepare for mining activities; earthworks, road installation, etc.
- Establishing refineries, tailings dams, dykes, offices, camp, etc.



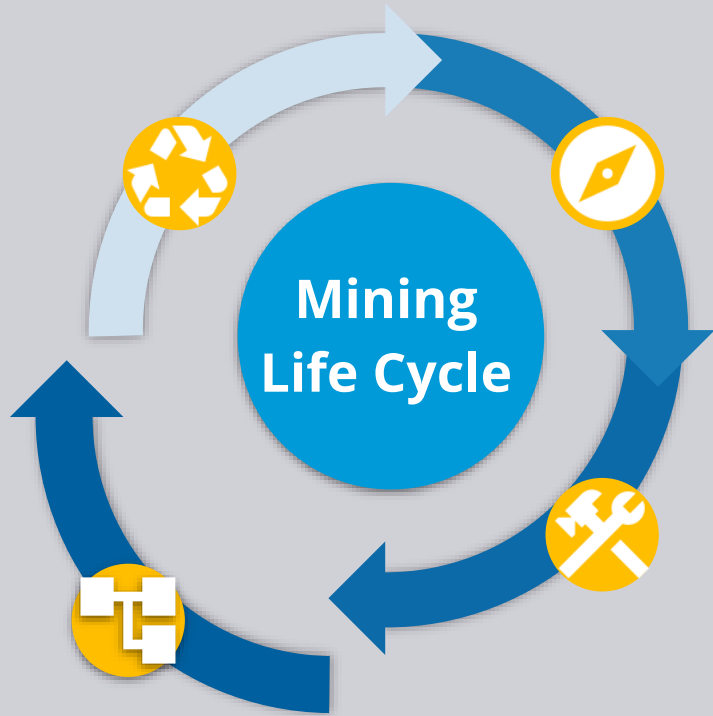
# Site Preparation

- Surface Generation
- Contour Maps
- Boundaries and Breaklines
- Volume computation
- Cut/Fill Map Analysis



# Surface and Volume Analysis





## Operations & Processing

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- Extracting discovered resources from the Earth
- Processing of the extracted materials into a usable state for commoditization and further application
- Ongoing development of the mine site



# Mapping

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- Mine sites have vast resources and infrastructure that must be maintained and accounted for
- Surveyors must as-built site infrastructure for verification and ongoing construction / maintenance
- Laser Scanning, GNSS, Total Station, UAV can all be used for these purposes





# Mapping

- **Fast, efficient** collection and scanning workflows
- **Interoperability** of data from GNSS, TS, and Scanner **into one job** (TA)
- Single source of truth = **less confusion** and **more confidence**



# Monitoring

- Monitoring is **critical** for **detecting any deformation** of key infrastructure on site; including open pit slopes, production facilities, and underground caverns
- **High risk** to **safety, production** and **human life**
- **Structural, surface and ground monitoring** can be carried out via Total Station, GNSS, Geotechnical sensors, or a combination thereof



# Monitoring

- Trimble enables **automated movement detection with confidence**
- **Automate** the monitoring process with **T4D, S-Series total stations, GNSS receivers, and wireless geotechnical sensors**
- T4D provides **real-time analysis, visualization, and alarming**; configured with unique warning conditions such as **inverse velocity**



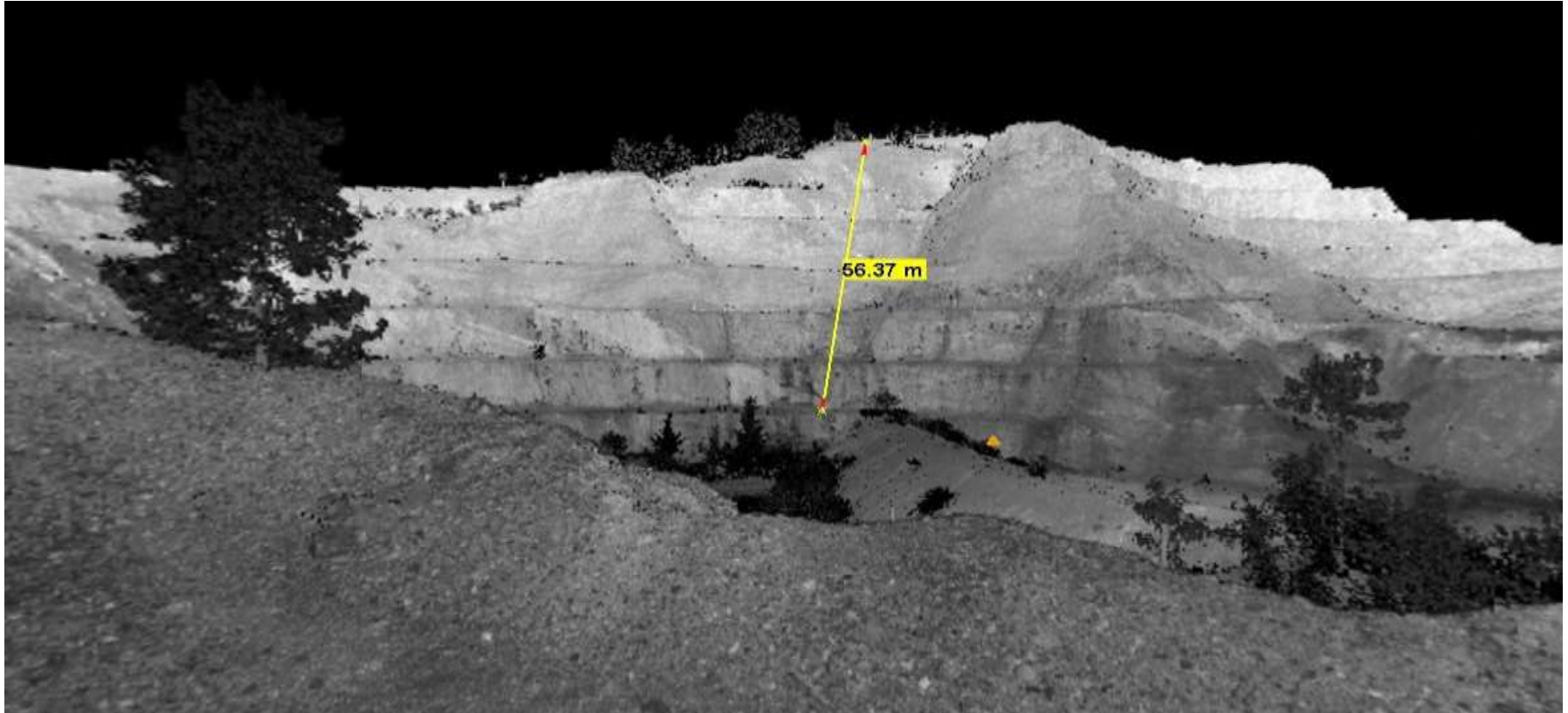
# Periodic Volume Reporting

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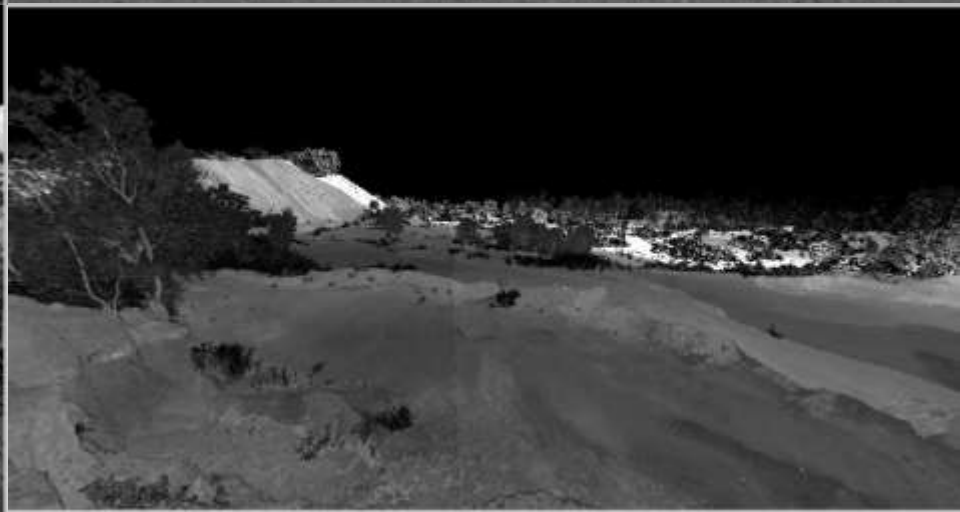
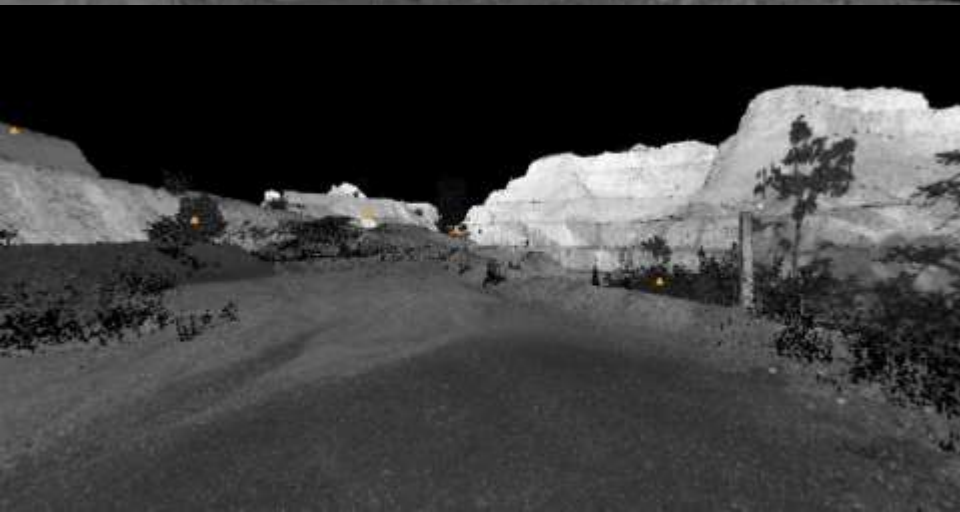
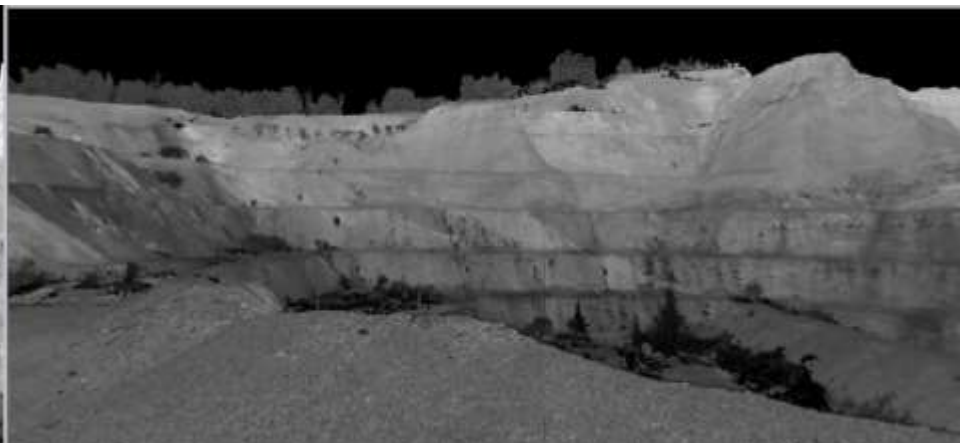
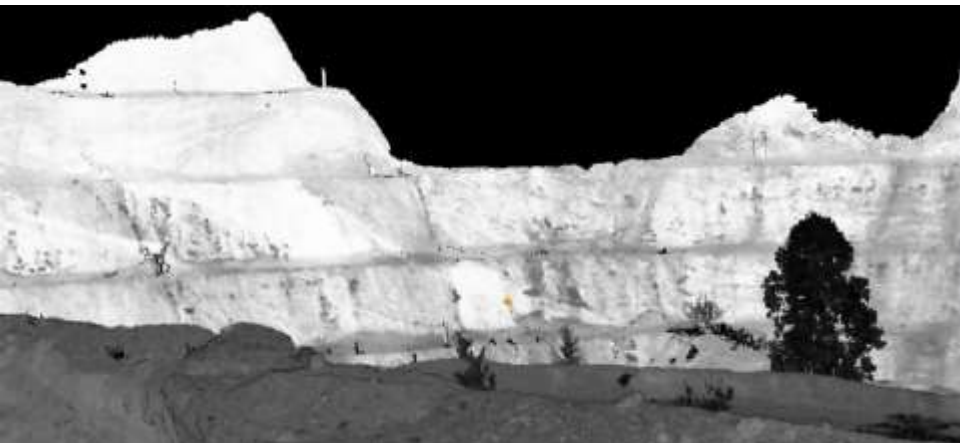
- **SX12 & X7** provide **fast and comprehensive** point clouds; **easy setup** and **no post-processing** to extract volume
- **R12i** can be leveraged for rough **manual pickups** or for setting out **ground control** for UAV collection
- **One tool**, whether SX12 or R12i, can be **used for multiple workflows**

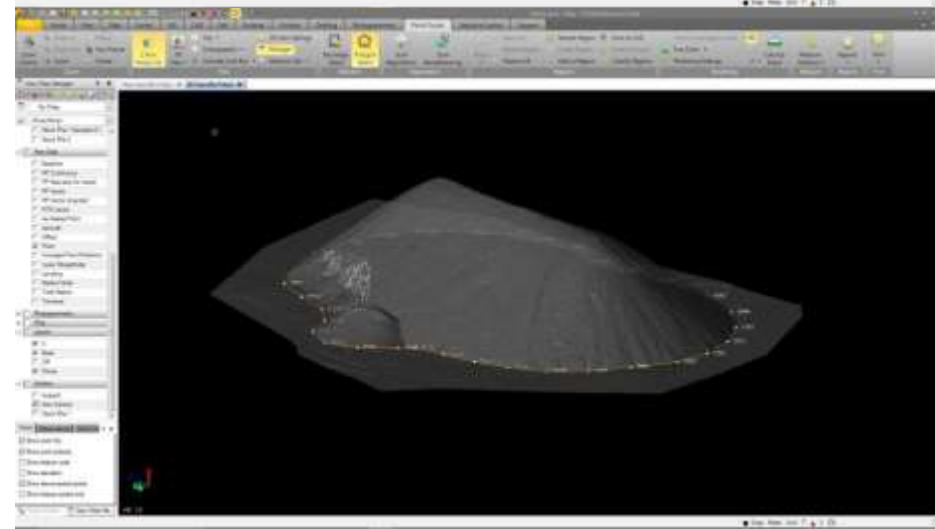
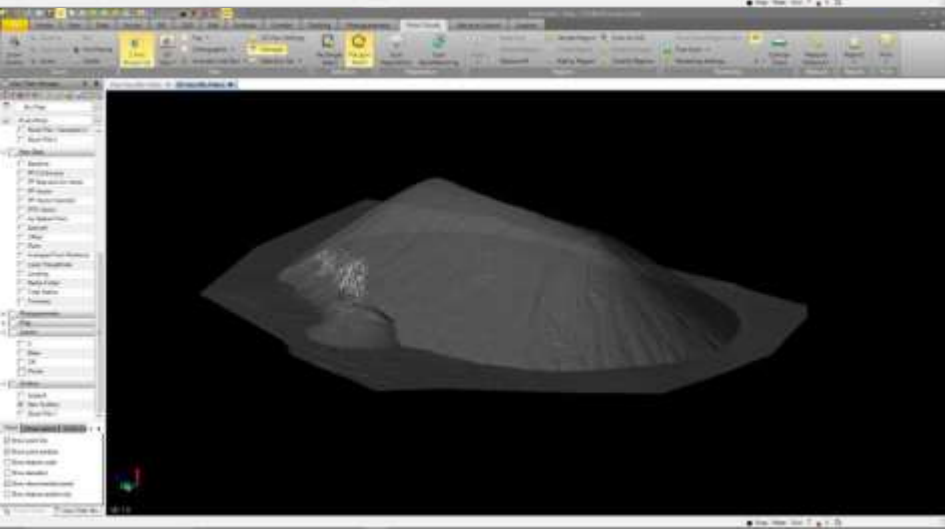
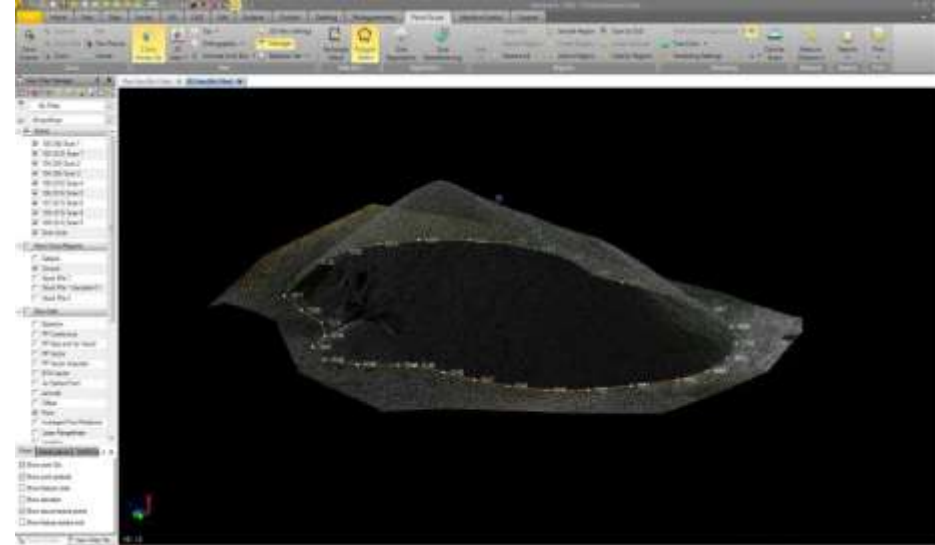
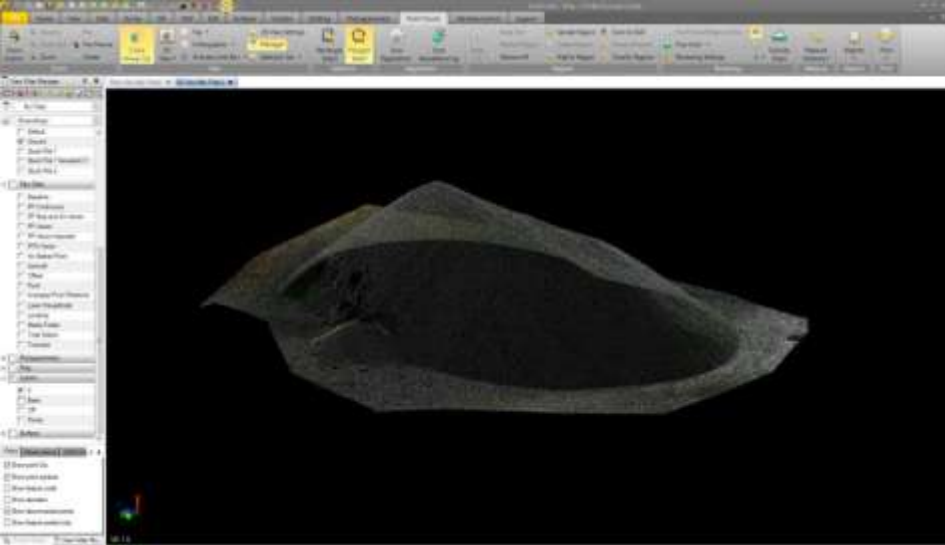


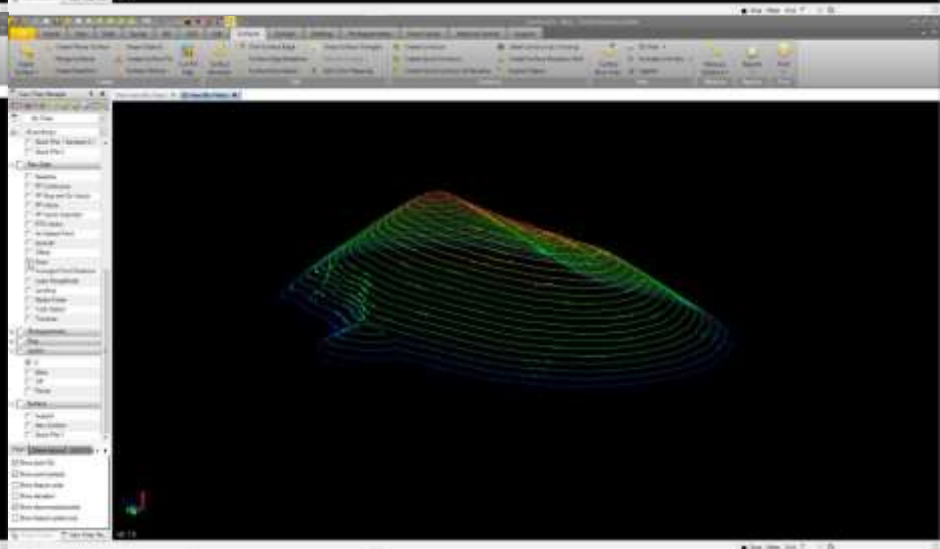
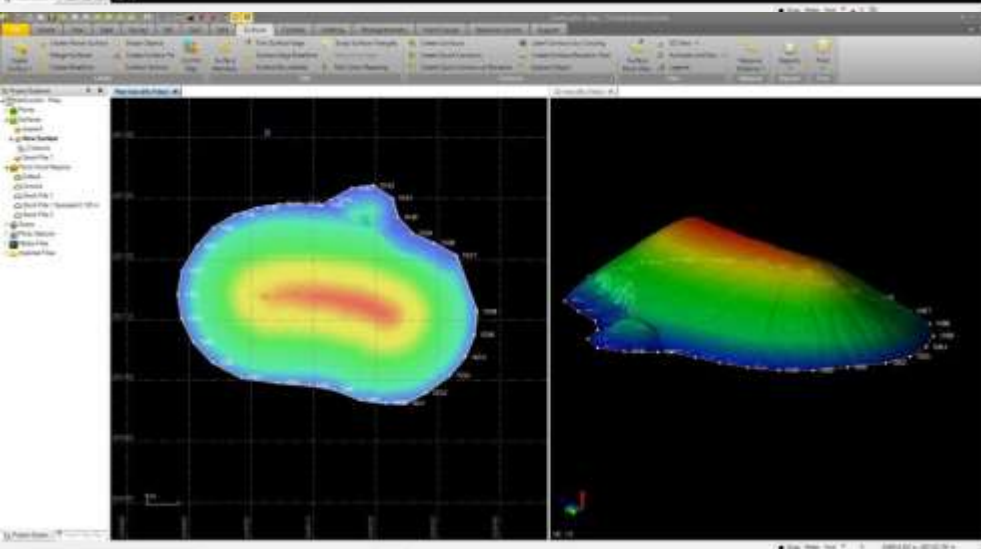
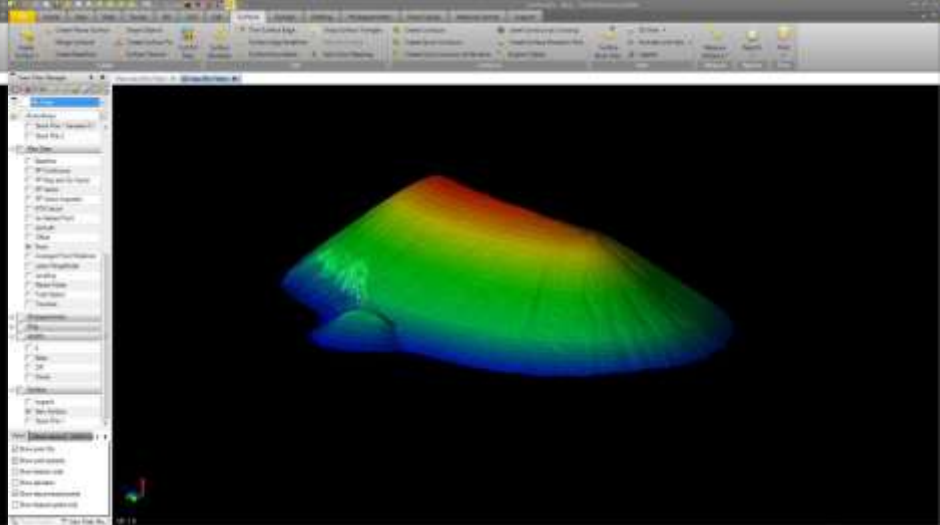
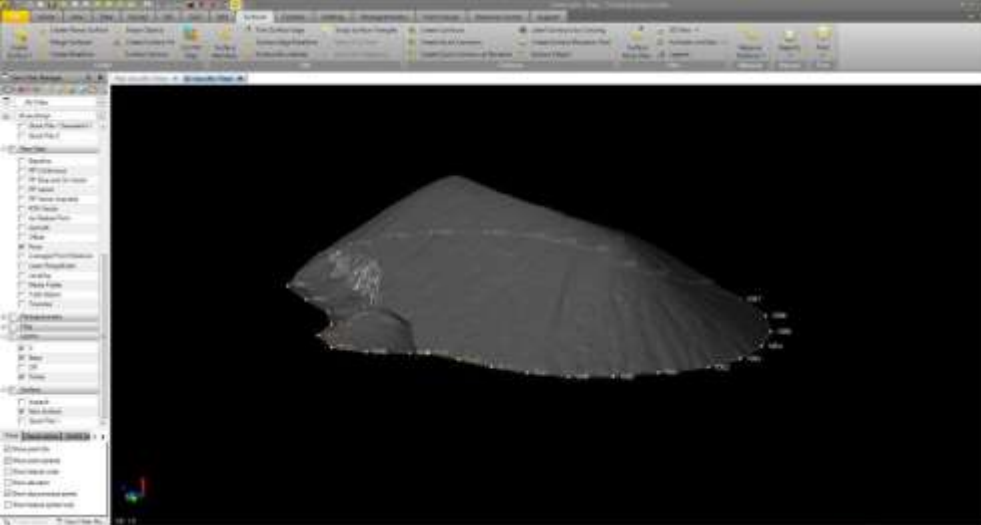
# BASIC FUNCTIONS ON SITE MEASUREMENT AT THE SAME TIME



# PREVIEW RESULTS ON SITE









# BACKOFFICE PROCESSING

The image shows the Trimble RealWorks software interface. The main workspace displays a 3D point cloud of a terrain, color-coded by elevation. A vertical color scale on the left indicates elevations from 983.61 m (purple) to 1023.61 m (red). The word "CONTOURING" is overlaid on the point cloud. A scale bar below the point cloud shows 20.00 m. The software's ribbon menu includes tabs for File, Home, Edit, View, Drawing, Surfaces, Imaging, Model, Inspection, Storage Tank, Media, and Support. The Drawing tab is active, showing various tool icons. The workspace panel on the left contains a "Tools" section with a "CONTOURING" tool. The tool settings include: TO: 1044.79 m, Interval: 0.20 m, Number of Contours: 201, Step 2 - Calculate Contours (Tolerance: 0.01 m, Display Cloud checked), Step 3 - Principal Contours (Define Principal Contours unchecked), First: 1, Skip: 1. The List panel shows a table of objects:

Name	Type
Project Cloud	Project Cloud
OBJECT1	3D Point
OBJECT2	3D Point
OBJECT3	3D Point
OBJECT4	3D Point
OBJECT5	3D Point

The Properties panel at the bottom shows the selected object's details:

Properties	
General	
Type	Cloud
Name	OBJECT11

# BACKOFFICE PROCESSING

**CONTOURING**

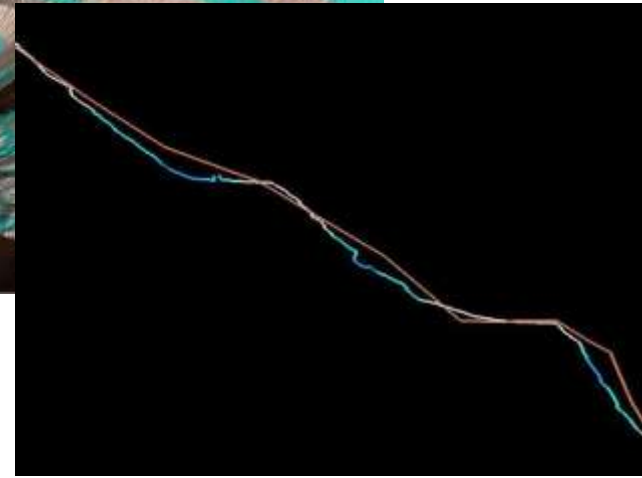
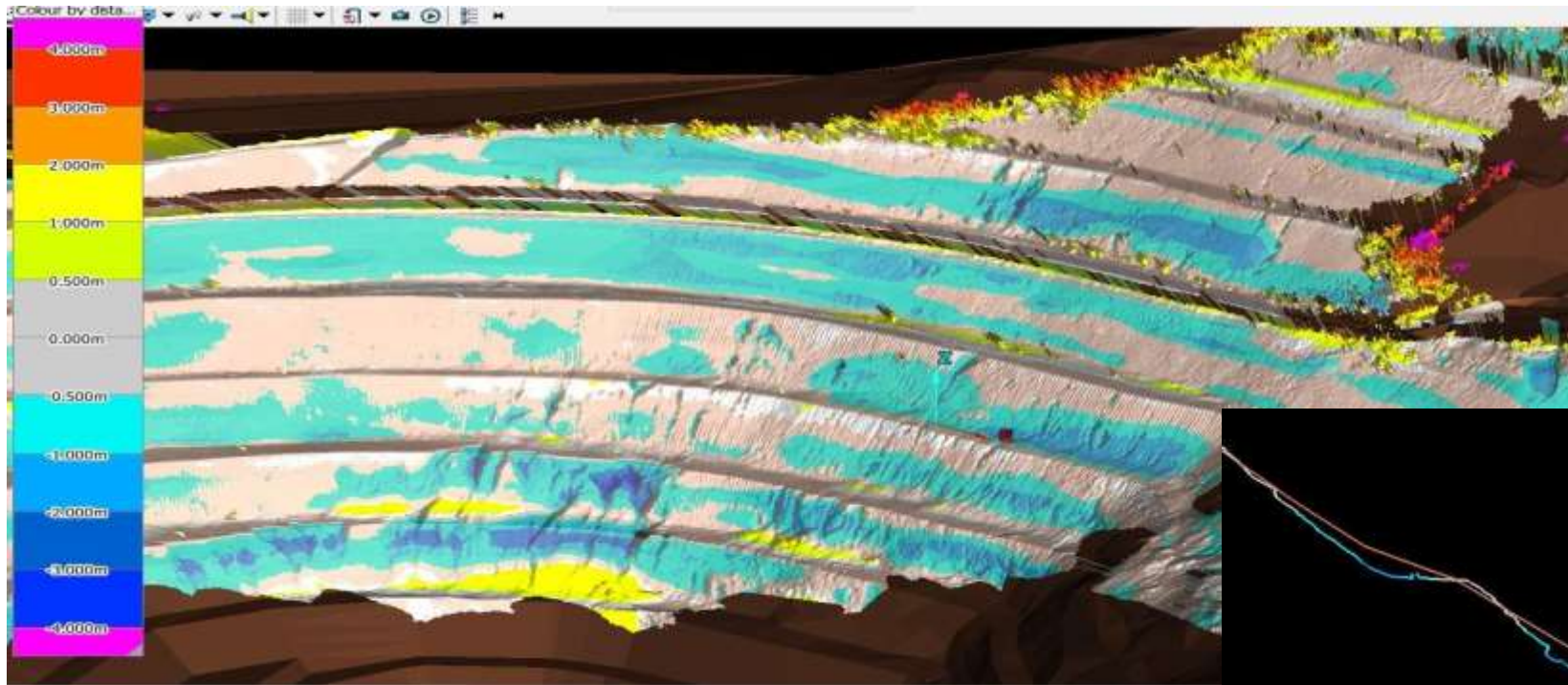
Cross-Map022:Alt 1006.41 m  
Polyline - Fitted

20.00 m

**Properties**

General	
Type	Cloud
Name	OBJECT11

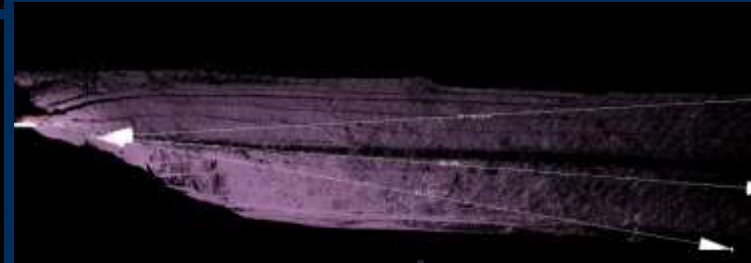
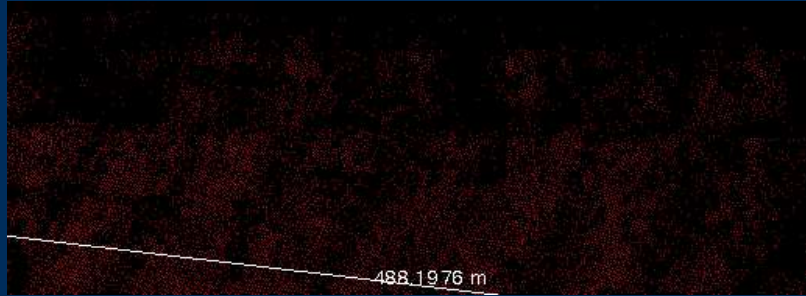
# Sectioning



# REALTIME MEASUREMENTS ONSITE



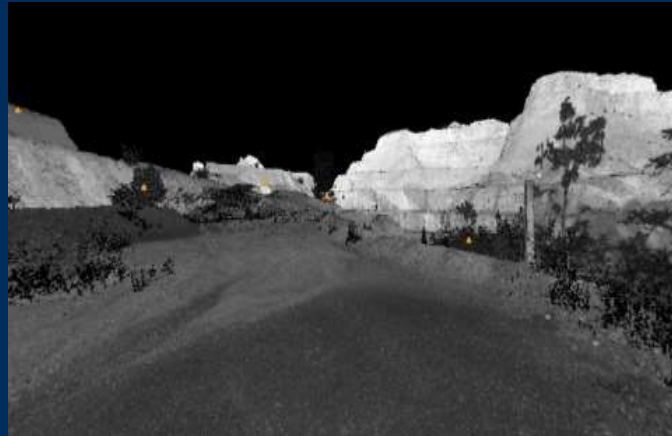
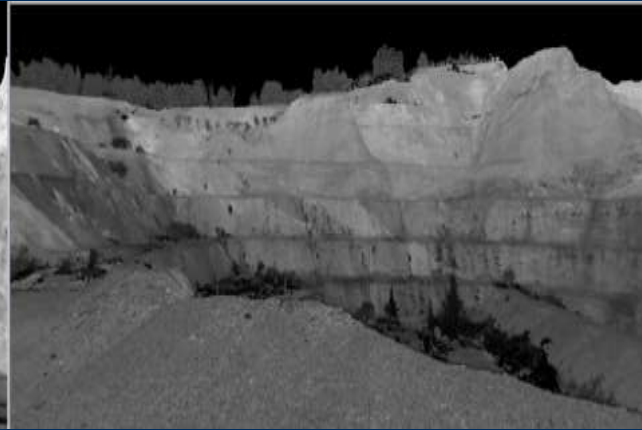
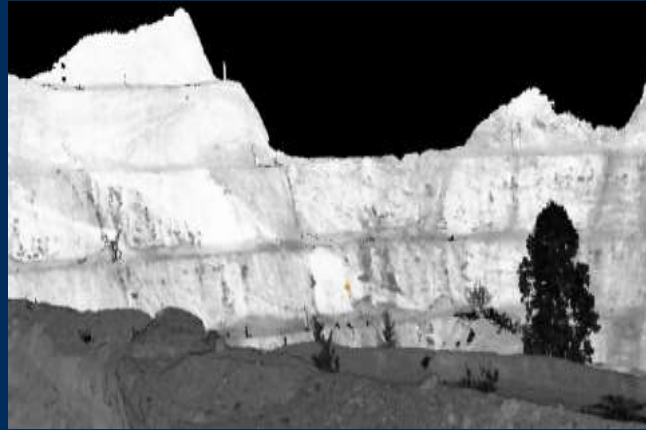
# RANGE TEST AT 18% REFLECTIVITY



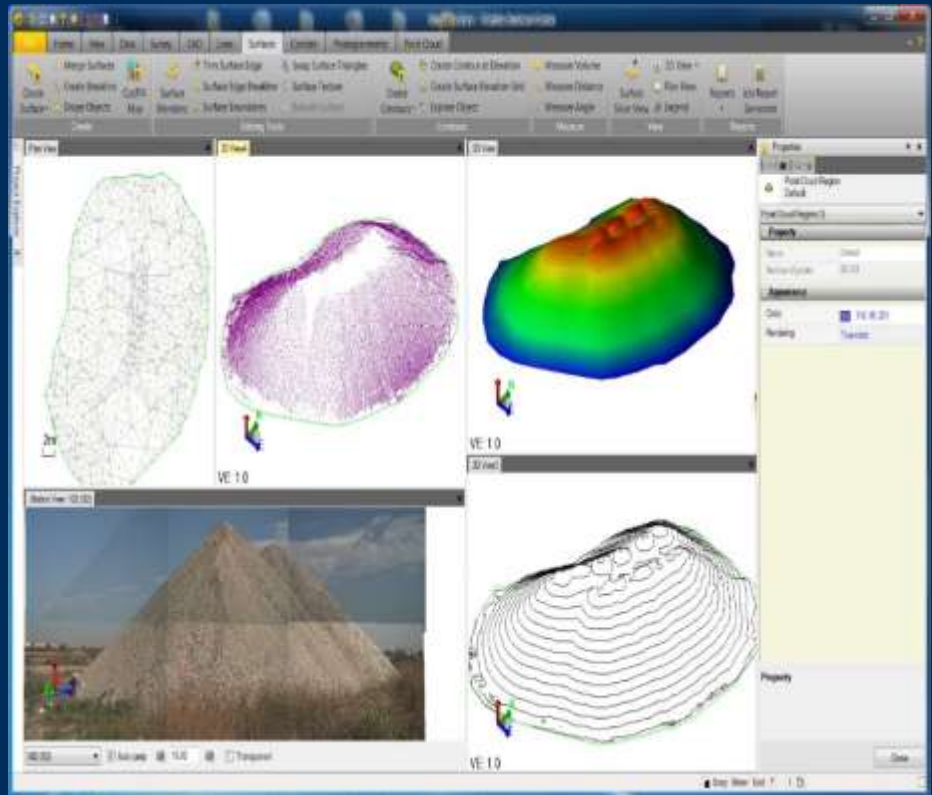
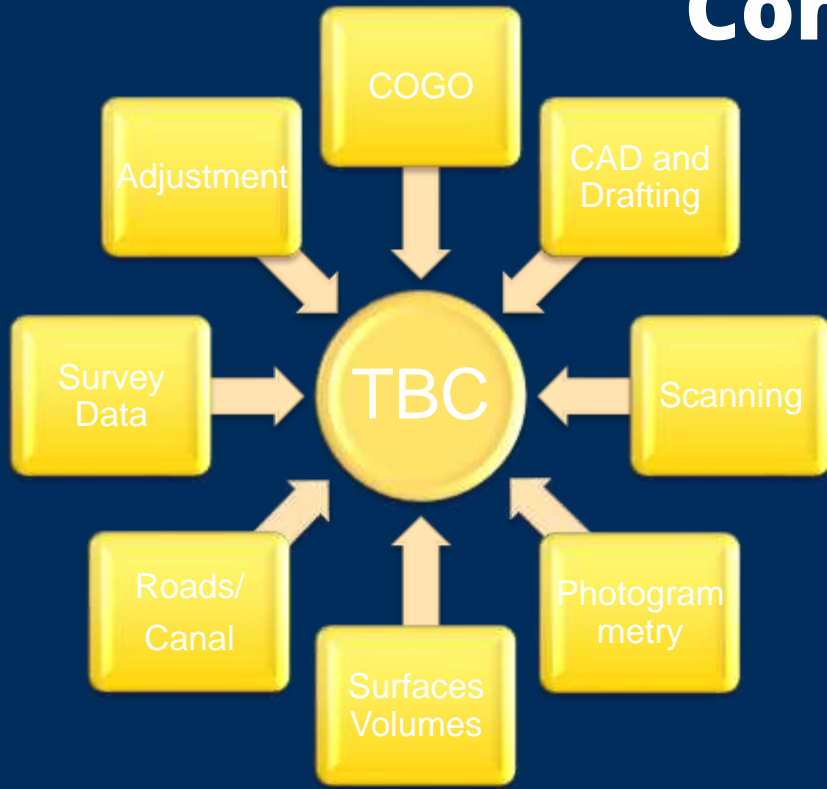
# Point Cloud Overlaid on the Image in Real Time



# MEASUREMENTS ON SITE



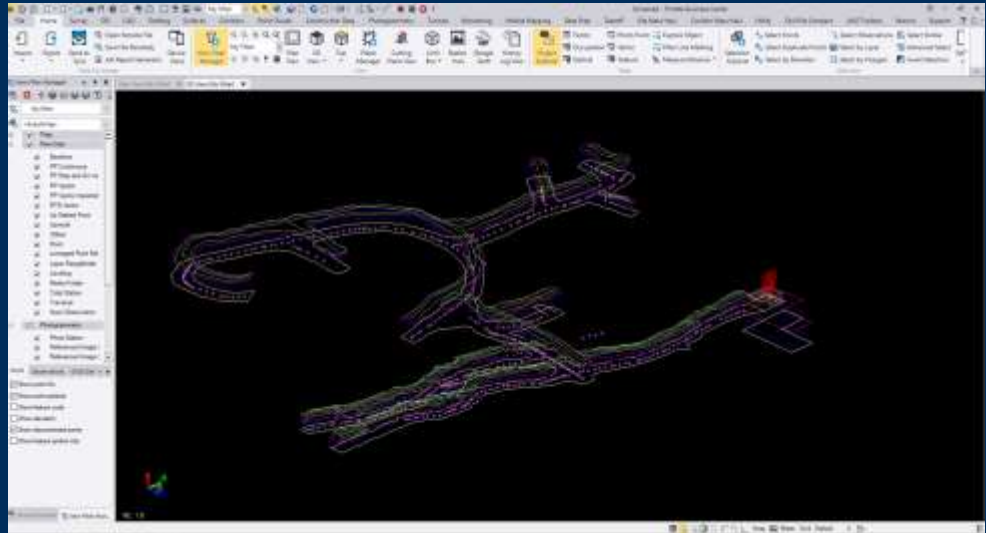
# TBC- Field to Finish Workflows with Confidence





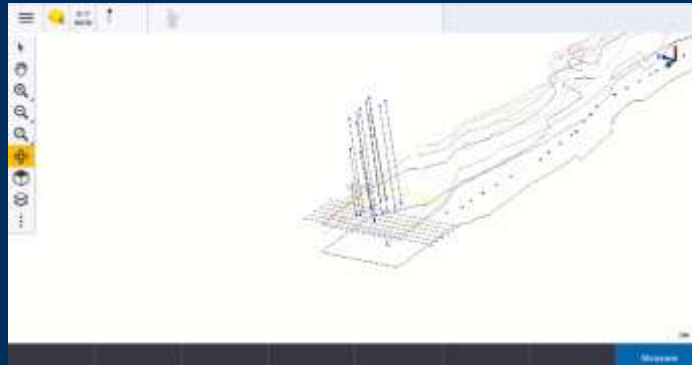
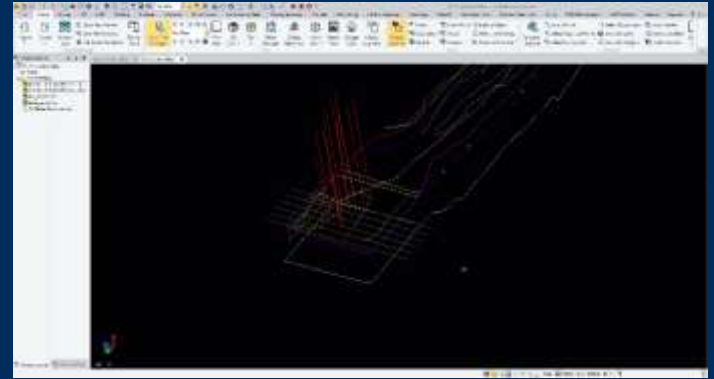
# Data Delivery

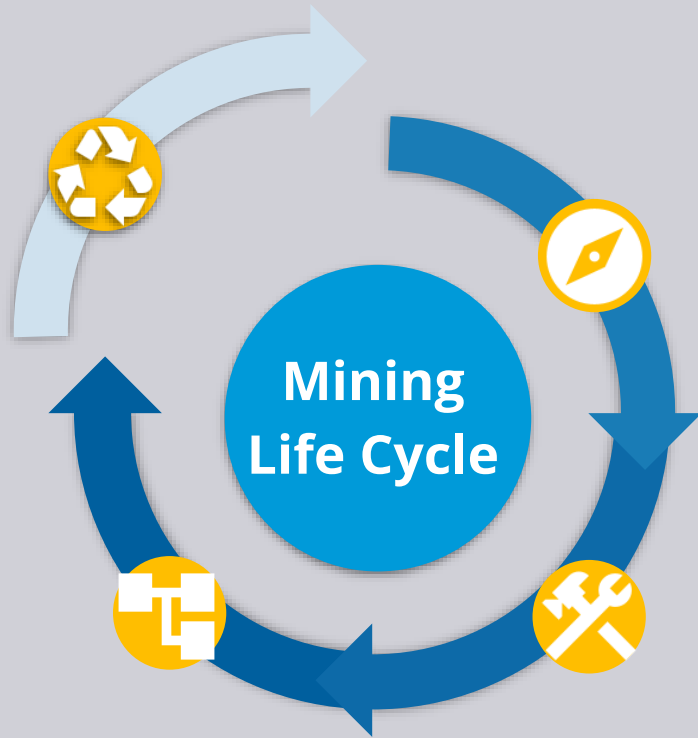
- Geospatial data is collected through various sources; GNSS, total station, Scanner, LiDAR, etc.
- Needs to be centralized and refined before being delivered to the client
- Need comprehensive reporting for volumes, as-builts, and inspections



# Data Delivery

- **Single source of truth** for all geospatial data
- **One software to learn** for all analytics / sharing
- **Seamless integration** with field software, Trimble Access, and with mine planning and design software





## Remediation

- The resource has been exhausted so the area must be returned to its natural state
- Continued deformation monitoring of site infrastructure; tailings dams, dykes, slopes, etc.
- Heavily regulated procedure with comprehensive reporting requirements
- Deconstruction of site infrastructure; safe decommissioning of mining activities



# Construction

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- Tailings dams are built to store byproducts of mining operations; liquids, solids, and slurry
- Tailings dams are built at a base level and then gradually raised over time as it fills with further tailings and water
- **Survey is required** for every step of the way; **staking grades** for initial construction; **as-built** for further design; continuous **set out and pickups** over time



# Construction

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- Trimble Access meets all the needs of the construction surveyor for tailings dams
- Leverage **R12i GNSS** for **topo**, **set out**, and **pickups**
- Where **SX12** and **S-Series TS** can be used for **high precision** set outs and comprehensive **as-builts through scanning**



# Monitoring

- Monitoring is **critical** for **detecting any deformation** of key infrastructure on site; including open pit slopes, tailings dam integrity, production facilities, and underground caverns
- **High risk** to **safety, production** and **human life**
- **Structural, surface and ground monitoring** can be carried out via Total Station, GNSS, Geotechnical sensors, or a combination thereof



# Monitoring

- Trimble enables **automated movement detection with confidence**
- **Automate** the monitoring process with **T4D, S-Series total stations, GNSS receivers, and wireless geotechnical sensors**
- T4D provides **real-time analysis, visualization, and alarming**; configured with unique warning conditions such as **inverse velocity**



# Mapping

- Mapping of Tailings ponds and dams is critical for reporting and continuous design over time
- **3D modelling** of Tailings Ponds and Dams is **becoming increasingly popular**; for large ponds, **hydrographic surveys** are required
- These as-built / mapping surveys are completed with a **combination of UAV and ground data**





# Common Request For Monitoring



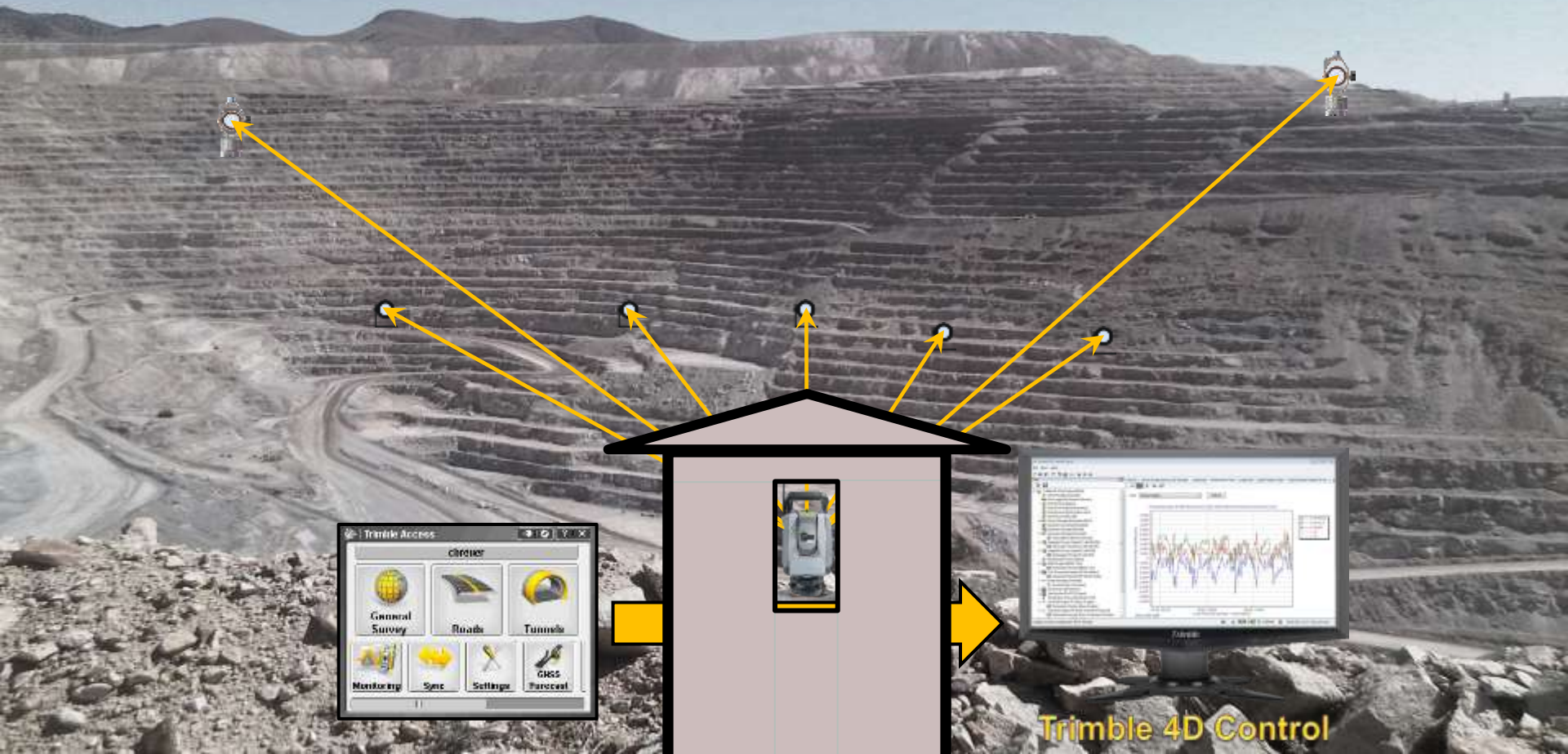
Information

+ Time

Trend

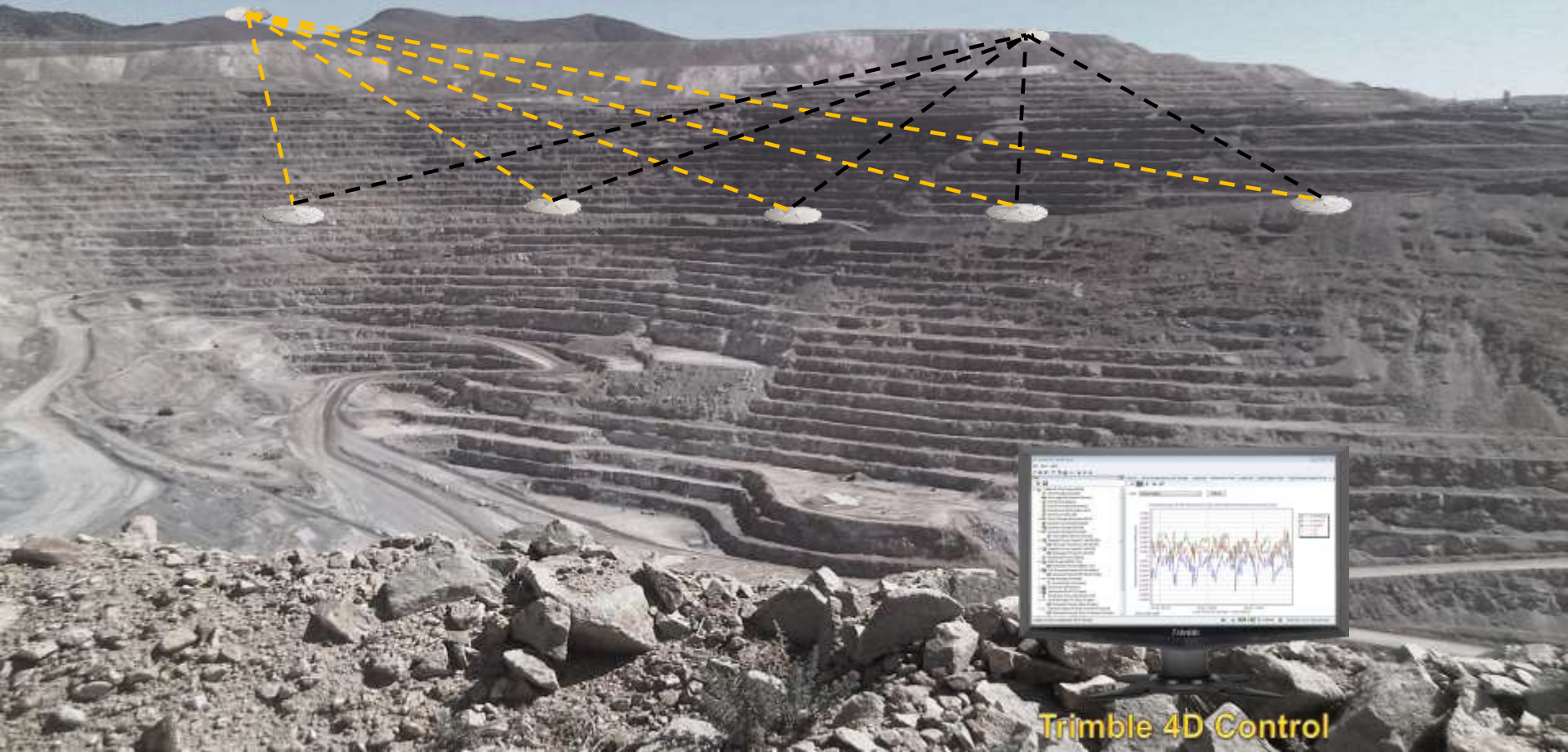


# Total Station



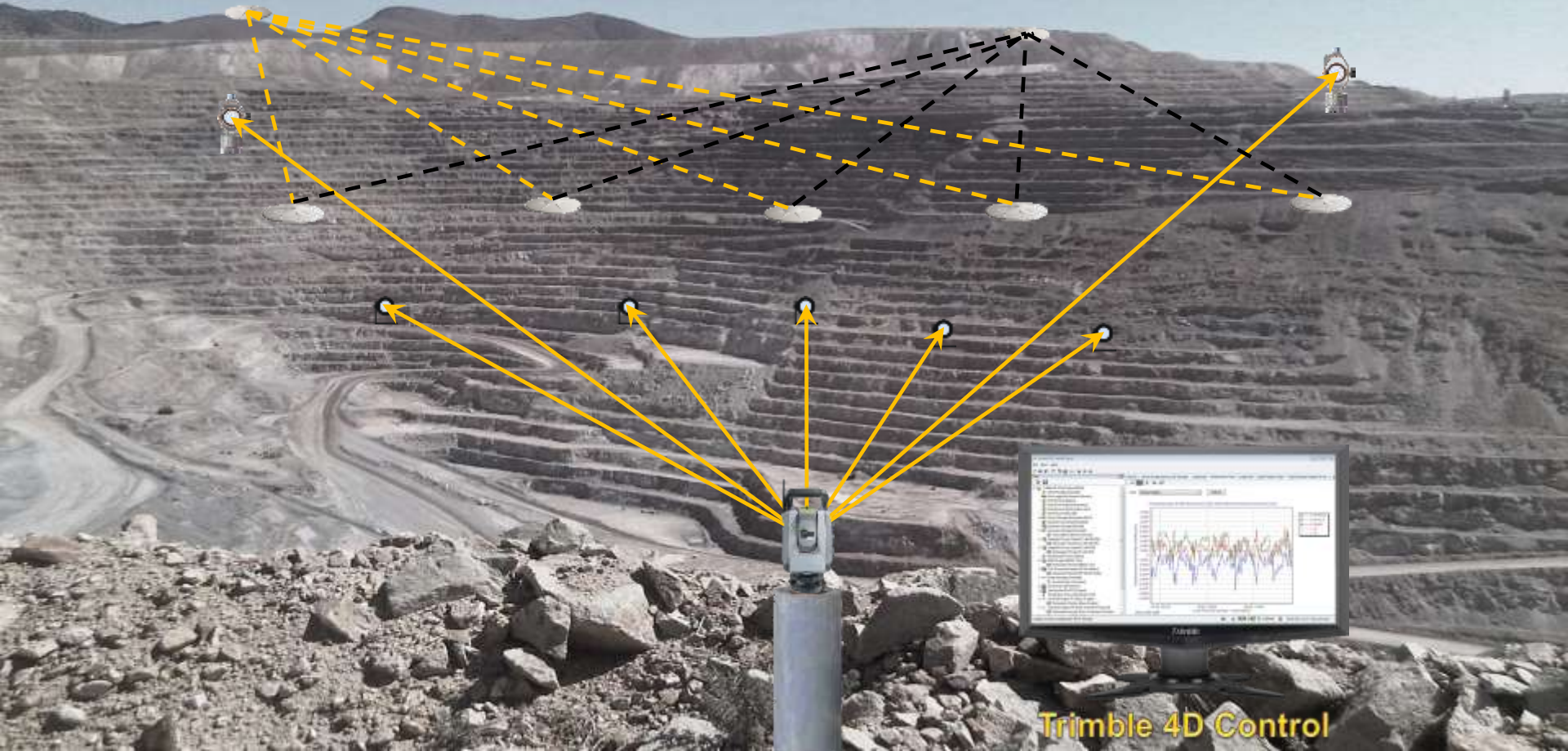
Trimble 4D Control

# GNSS



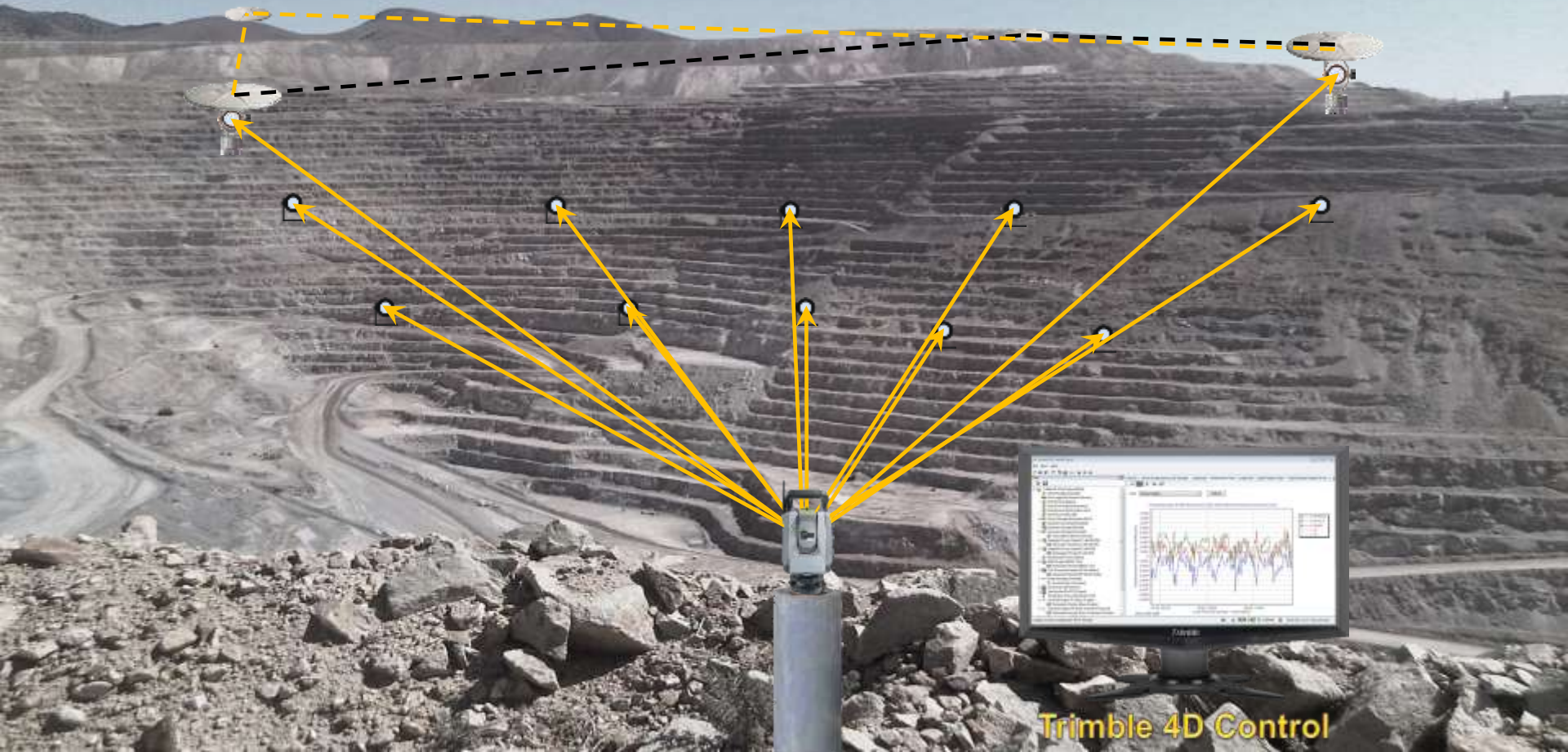
Trimble 4D Control

# Combined System



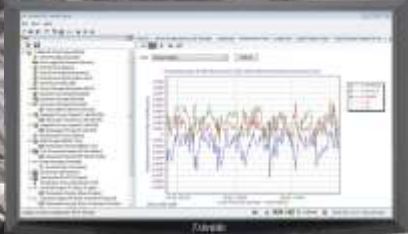
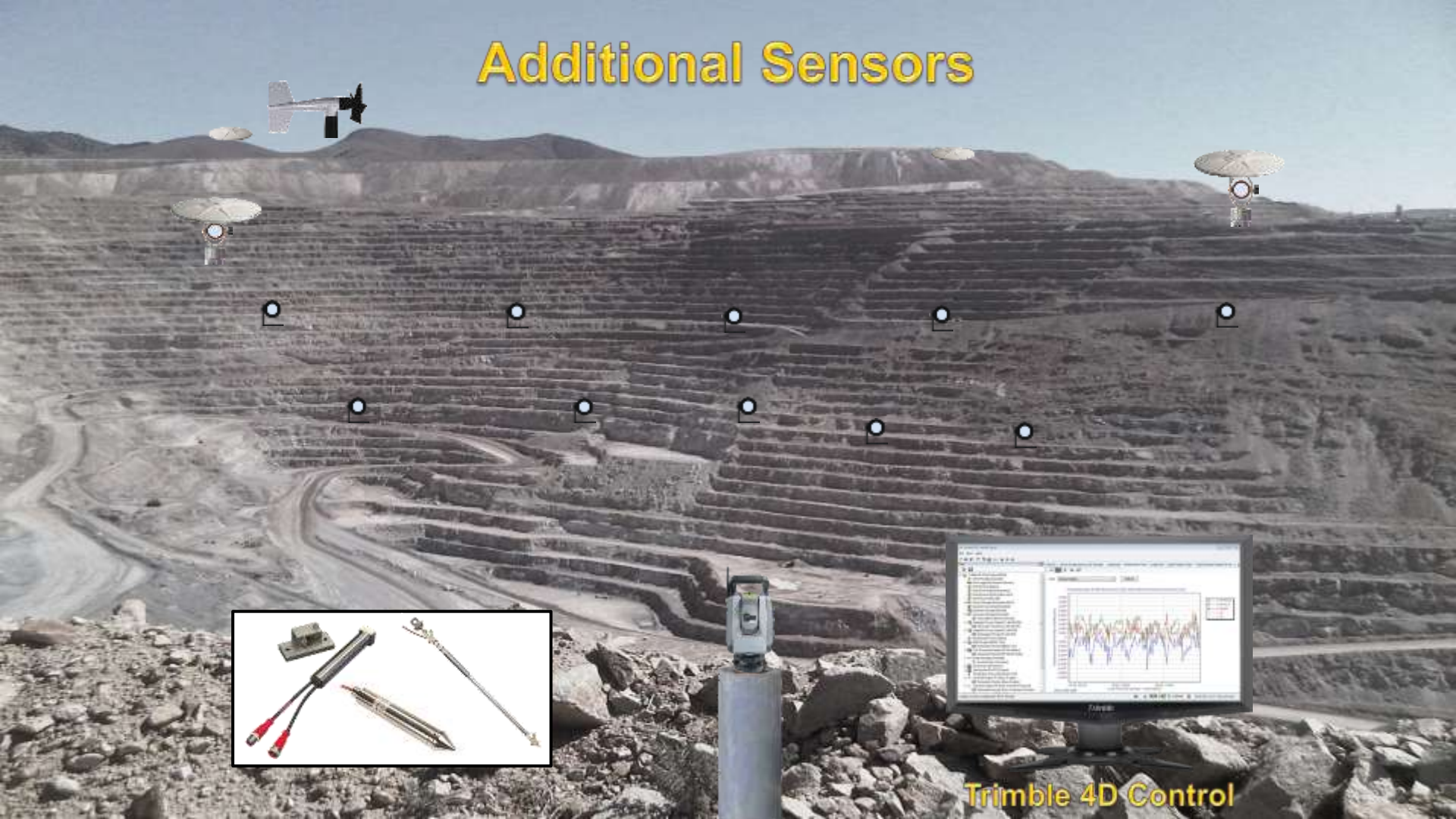
Trimble 4D Control

# Integrated System



Trimble 4D Control

# Additional Sensors



Trimble 4D Control

# Lomas Bayas Copper Mine, Chile

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# Phalaborwa Copper Mine, South Africa





# Round Mountain Gold Mine, U.S.A.

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# El Romeral Iron Ore Mine, Chile

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# Copper Mine, Thailand



# Copper Mine in Etropole, Bulgaria



# Thank You

For Questions or Feedback please contact:  
[Pranay\\_Johri@trimble.com](mailto:Pranay_Johri@trimble.com)

THANK YOU

GRAZIE  
VINAKA  
ERIMA  
KASIH  
TAKK  
merci

감사합니다  
다

謝謝  
謝謝

ありがとう