Enabling Mine Automation through the Application of Neptec's OPAL and 3DRi Technology

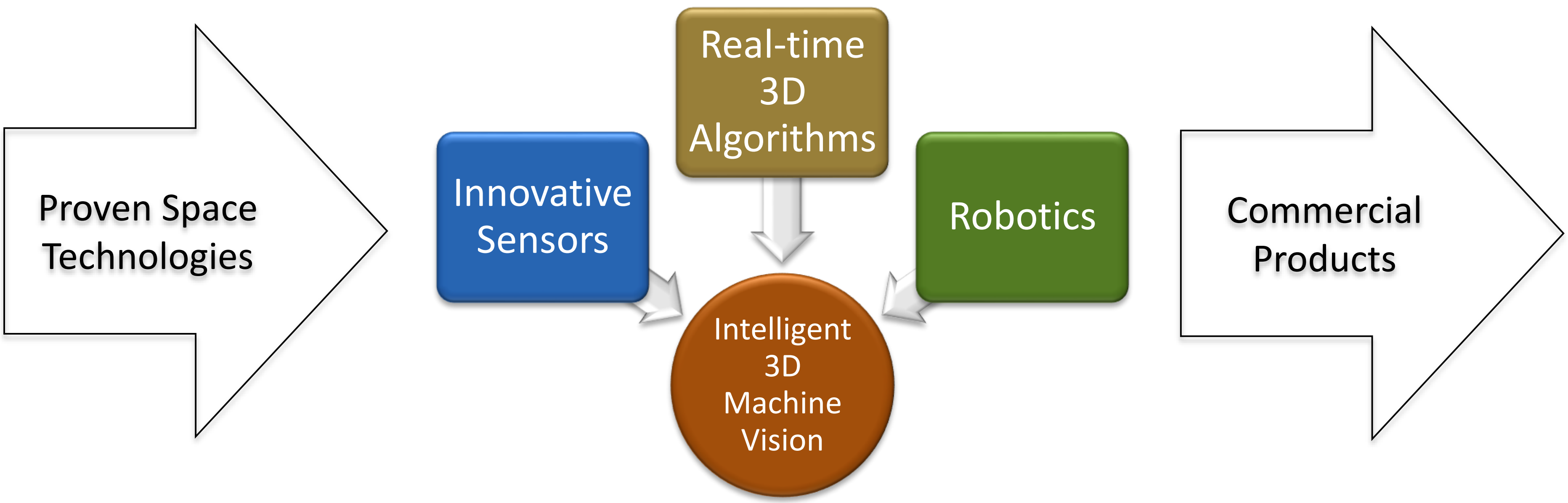
Evan Trickey, Dan Lucifora, Peter Wan, Andrew Scott

Haulage and Loading Conference 2013

Copyright 2013 © Neptec Technologies Corp. All rights reserved.

What Neptec does….

- We develop innovative 3D machine vision products for machine automation and robotics applications in harsh environments
- Spin-out of an award-winning technology innovation company and NASA Prime Contractor



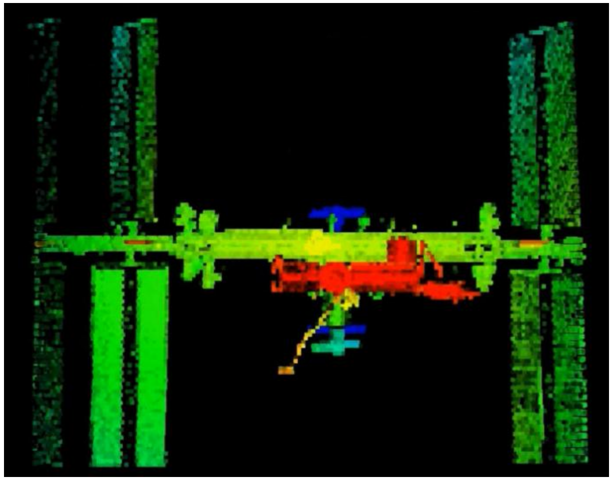
Machine Automation

Copyright 2013 © Neptec Technologies Corp. All rights reserved.

Our history

- Founded as Neptec Design Group Ltd. in Ottawa, Ontario in 1990
- Industry leader in developing innovative 3D sensor, software and robotics technologies for the Space market
- Systems developed by NDG have flown on 40 Space Shuttle mission and the Space Station
- Only non-US recipient of NASA's George M. Low award for quality and performance
- Started exploring opportunities in terrestrial markets in 2009.
- Spin out of Neptec Technologies Corp. in 2011 as a separate company focused on commercialization and product development.

3D laser sensor to inspect the heat shield on the Space Shuttle



TriDAR Laser Sensor: automated docking system for the Space Station
(3D scan of the International Space Station shown)

Copyright 2013 © Neptec Technologies Corp. All rights reserved.

OPAL-360 for harsh environments

- Up to 360° x 60° FOV
- Up to 200kHz data acquisition
- Penetrates obscurants
- Real-time applications
- Survey-grade performance
- 400m to 2.7km range options
- Harsh environment ready!
  (IP67, no fans, tolerates vibrations)

Copyright 2013 © Neptec Technologies Corp. All rights reserved.

OPAL LiDAR Sensor Evolution

Prototype

OPAL-360 Prototype

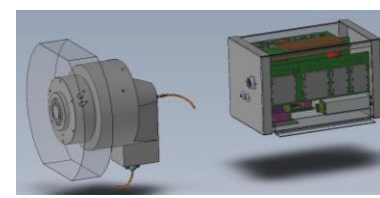
OPAL-360 Rel 1.0 (Q1/2013)

– Time-to-market release

OPAL-360 Rel 1.1 (2014)

– Size/Cost reduction release

OPAL-120 Rel 1.0 (2013)



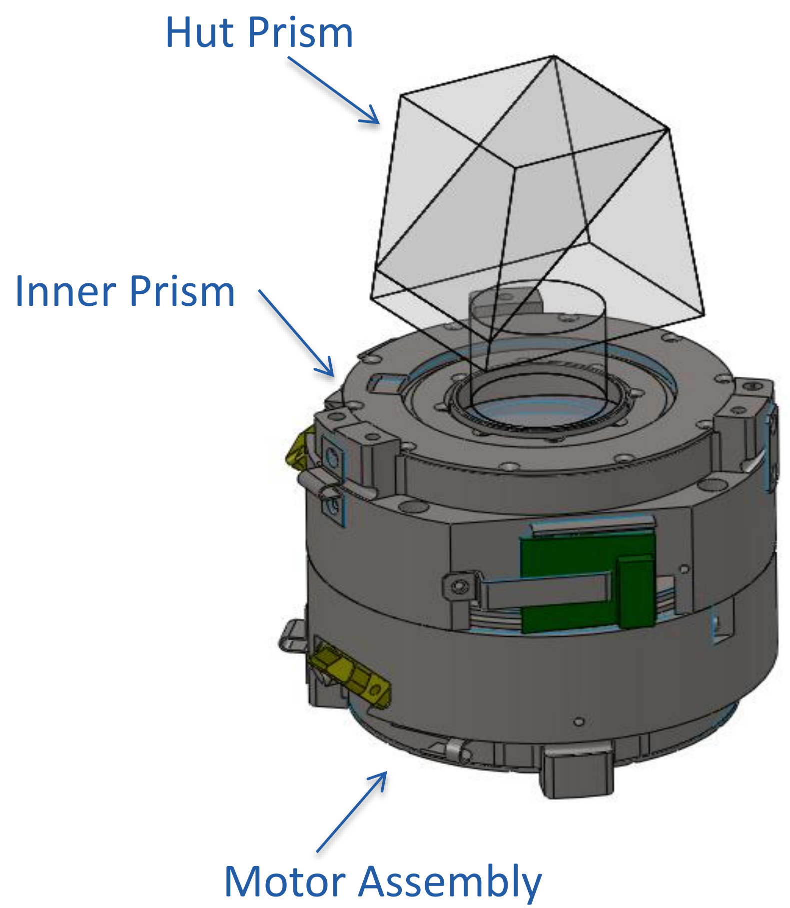
Other variants by request

- Aerial mapping/UAV
- Mobile mapping
- Defence applications

Copyright 2013 © Neptec Technologies Corp. All rights reserved.

Novel sensor concept

- Independently rotating prisms
- Inner prism creates a circular pattern
- “Hut prism” folds and rotates the circular pattern over 360^{o}
- Prism speeds define unique non-overlapping scan pattern



Copyright 2013 © Neptec Technologies Corp. All rights reserved.

Unique scan pattern

Elapsed Time

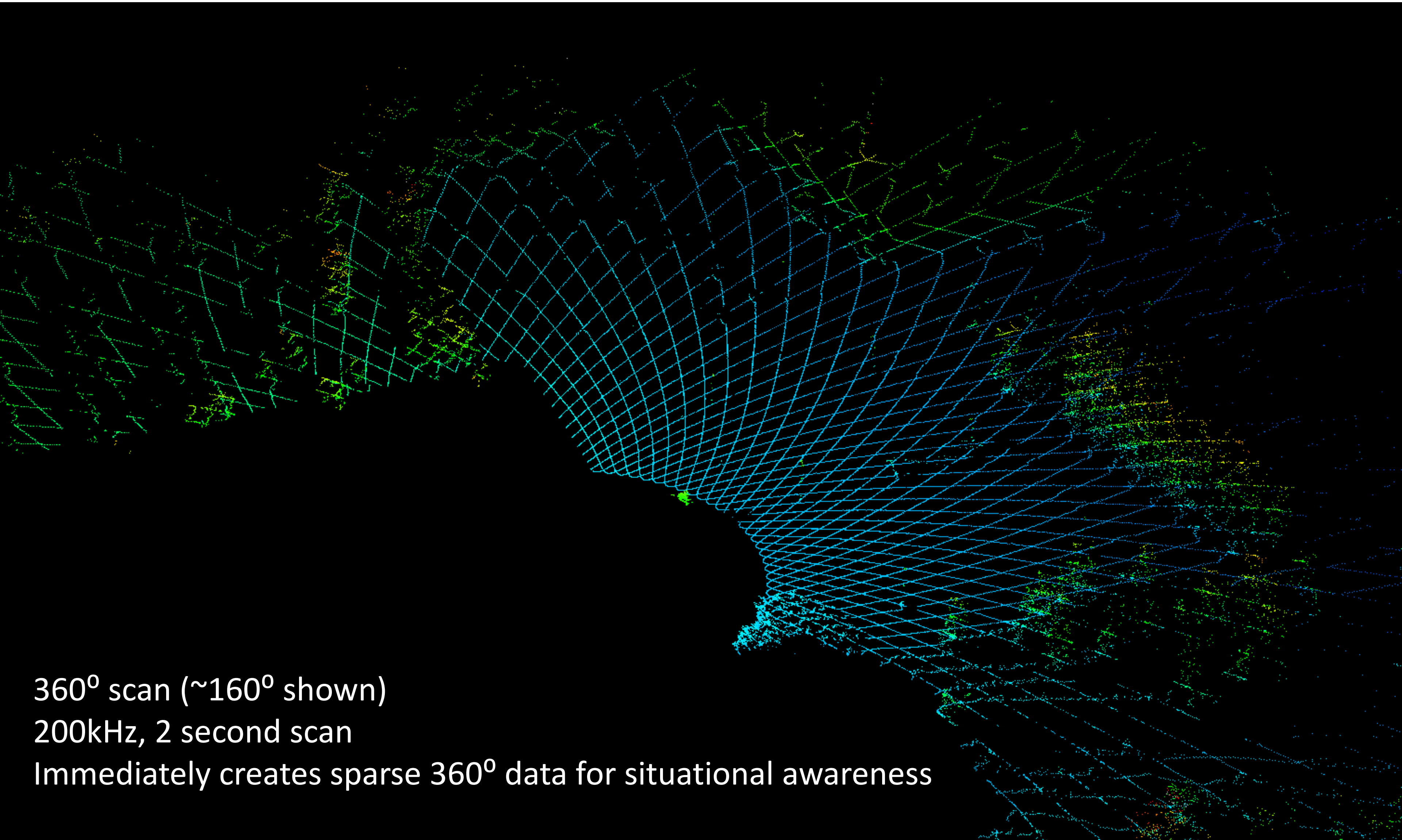
- Very fast 360º scanning (30 revolutions per sec)
- No data gaps when stationary
- “Smart scanning”
  - seamlessly switch from sparse to dense scanning

Copyright 2013 © Neptec Technologies Corp. All rights reserved.

Sample OPAL-360 scans

Copyright 2013 © Neptec Technologies Corp. All rights reserved.

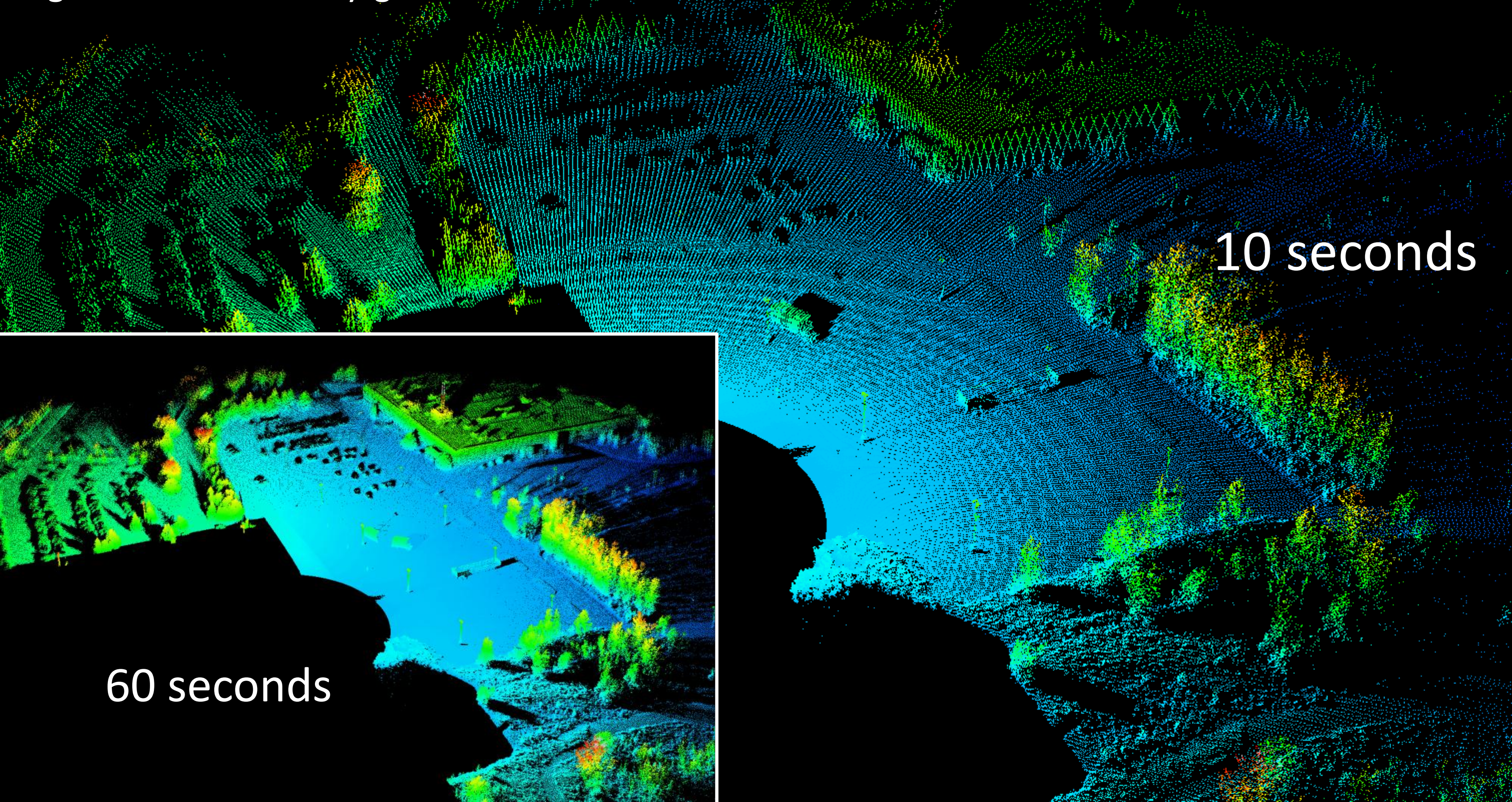
OPAL-360: 2 second scan



360⁰ scan (~160⁰ shown)
200kHz, 2 second scan
Immediately creates sparse 360⁰ data for situational awareness

OPAL-360: 10 second scan

Non-overlapping scan pattern rapidly fills in data gaps (even when stationary)
High-resolution survey-grade 3D data in seconds



Can LiDAR penetrate obscurants?

In real-time (no post processing)

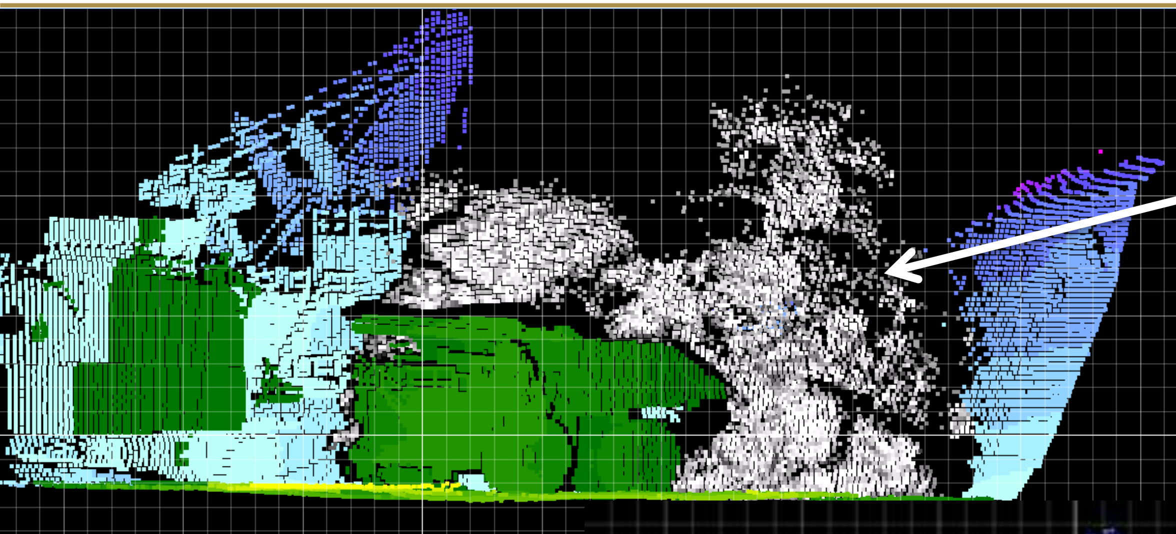
OPAL Technology

neptec
Technologies Corp

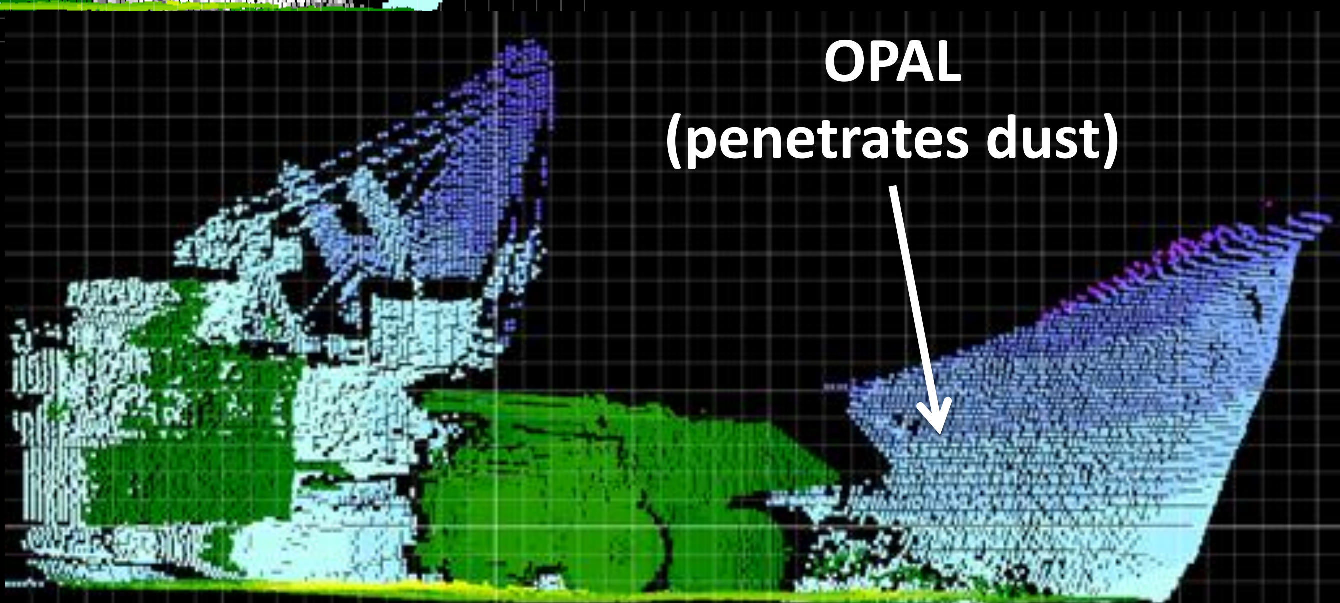
Dust in an Open-Pit Mine

Copyright 2013 © Neptec Technologies Corp. All rights reserved.

OPAL in an Open Pit Mine



Conventional LiDAR (sees dust)



OPAL (penetrates dust)

Copyright 2013 © Neptec Technologies Corp. All rights reserved.

3DRi Technology

Technology

- Proprietary, highly efficient algorithms and software for real-time intelligent processing of 3D point clouds
  - From mobile platforms
  - In real-time
  - Extract actionable information
  - Runs on a standard PC

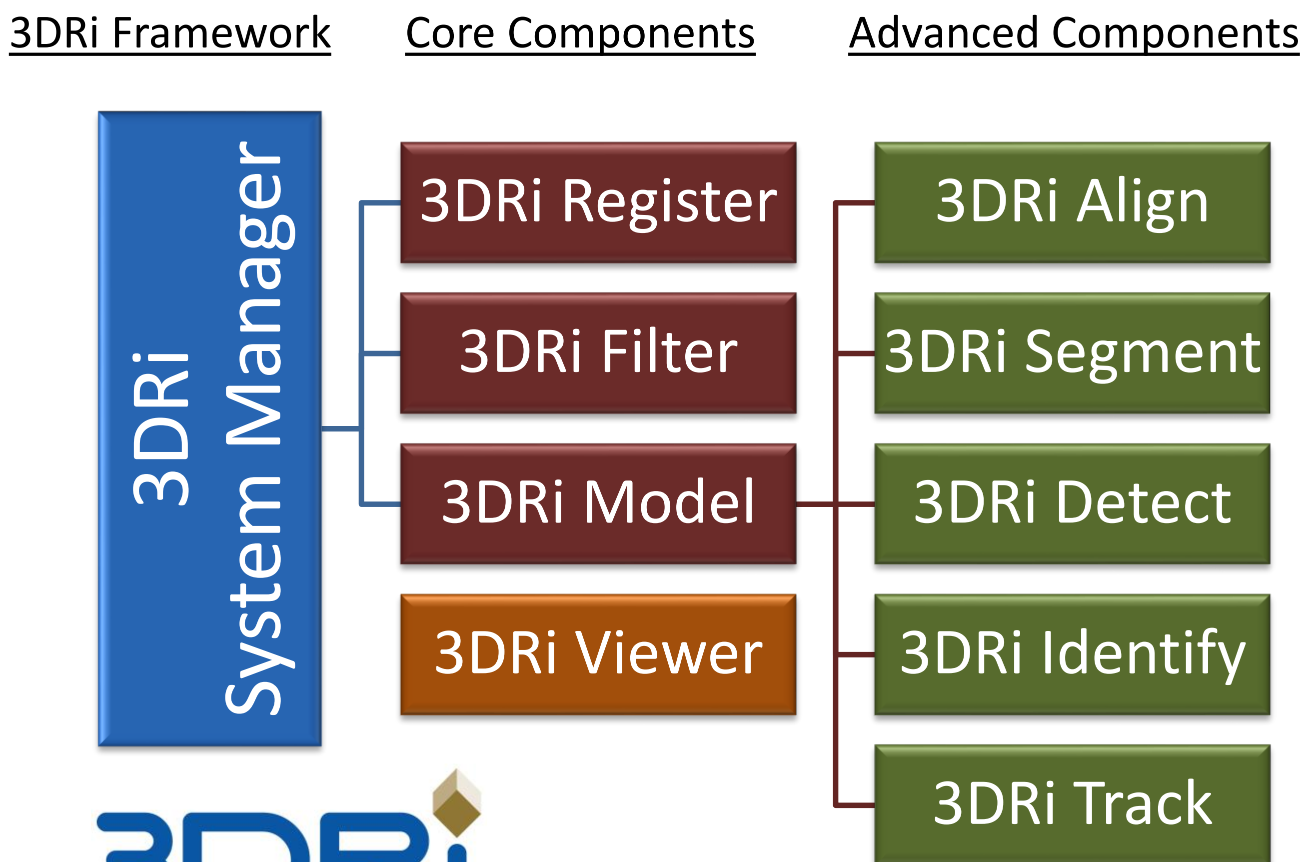
Real-time Features

- Automatic scan alignment (without reference markers)
- Automatic Change Detection
- Automatic Feature Extraction
- Automatic Object recognition
- Automatic Object tracking
- Automatic Image Analysis

More Information, Less Data!

Copyright 2013 © Neptec Technologies Corp. All rights reserved.

3DRi Software Development Toolkit



Copyright 2013 © Neptec Technologies Corp. All rights reserved.

3DRi Architecture

3DRi

Up to 4
OPAL 2.0 scanners

System Manager

API

External Application

- Setup Scans
- Initiate Scans
- "Housekeeping"

- Save point clouds in standard formats e.g. (x, y, z, Intensity)

3DRi Viewer

Easy to integrate OPAL scanners

Copyright 2013 © Neptec Technologies Corp. All rights reserved.

Core 3DRi Plug-ins

3DRi Register

- Geo-reference 3D data to external GPS/IMU data

3DRi Filter

- Advanced filtering functions to remove noise
- Performs segmentation (ground vs. above ground objects)

3DRi Obscurants

- Identify presence of obscurants in 3D data
- Manage OPAL clear vs. obscurant detection modes
- Remove obscurant returns from 3D data

3DRi Model

- Combines multiple scans into a coherent geo-referenced 3D model (database)
- System Manager supports up to 4 OPAL scanners

Copyright 2013 © Neptec Technologies Corp. All rights reserved.

Advanced 3DRi Plug-ins

3DRi Align	• Automatic scan alignment (without reference markets)
3DRi Segment	• Advanced segmentation (segments moving from stationary above ground objects)
3DRi Detect	• Automatic Change detection (in real-time)
3DRi Identify	• Object recognition (against a database of known objects)
3DRi Track	• Object tracking

Copyright 2013 © Neptec Technologies Corp. All rights reserved.

Mining Applications

Copyright 2013 © Neptec Technologies Corp. All rights reserved.

Motivation

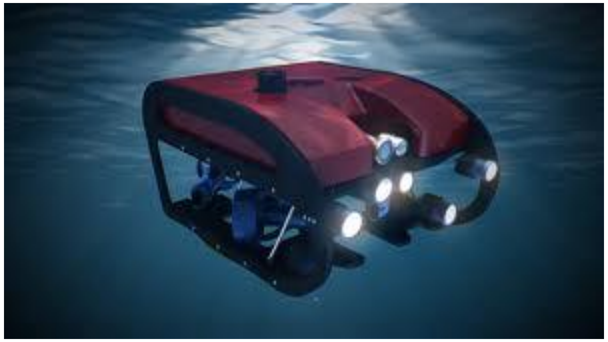
- The mining industry is constantly pushing to increase safety and productivity in open pit mines
- Automation is seen as key to supporting this goal, but for automation to work a viable machine vision solution is required

Copyright 2013 © Neptec Technologies Corp. All rights reserved.

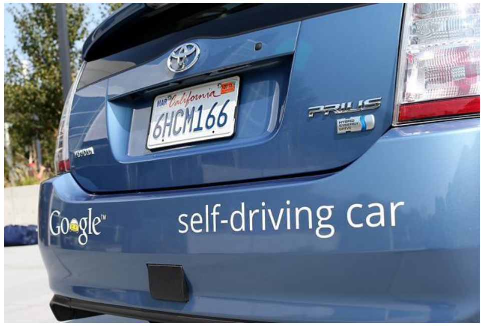
Real-time 3D "robot" vision

To take on greater autonomy, machines need:

1. Sensors that can give them an accurate view of their surroundings
2. Intelligence to interpret that input and react appropriately to the situation.



And it all has to work in real-time, while moving, at night and in bad weather, in harsh environments and unpredictable dynamic situations



Copyright 2013 © Neptec Technologies Corp. All rights reserved.

Applications of Interest

- Working with Teck Resources Ltd., Barrick Gold Corp., and Peck Tech Consulting a number of mining application priorities were defined:
  - Truck Spotting
  - Volume Measurements
  - Obstacle Detection
  - Road Profile monitoring
  - Fragmentation Analysis

Copyright 2013 © Neptec Technologies Corp. All rights reserved.

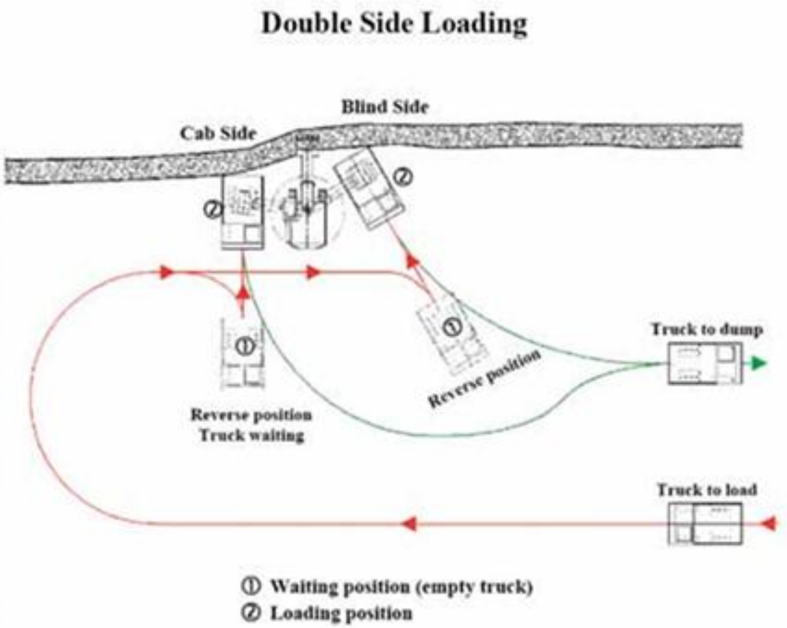
Challenges

- Dust
- Remoteness
- Weather
- Operator error
- Hazardous environment

Zaldivar Mine, near Antofagasta, Chile

© 2013 Neptec Technologies Corp. All rights reserved.

Truck Spotting



Source: Steve Fiscor, "Productivity Considerations for Shovels and Excavators"

- Truck backing up beside shovel for loading
- Safety
- Productivity

© 2013 Neptec Technologies Corp. All rights reserved.

Spot Assist—Motivations

- **Improve shovel efficiency**
  - Minimize re-spots
  - Reduce shovel swing time
  - Improve loading process
- **Reduce incident costs and related maintenance**
  - Truck collisions with shovel
  - Shovel bucket hitting truck
- **Reduce clean-up requirements and related maintenance**
  - Truck is evenly loaded
  - Less truck maintenance (tire wear)
  - Less clean-up around shovel
- **Reduce training requirements**
  - Driver training
  - Skilled labour shortage
- **Others…**

Cowal Mine, New South Wales, AUS

© 2013 Neptec Technologies Corp. All rights reserved.

Spot Assist—Motivations

Spot Assist ROI

↑ double side loading
↓ bucket swing time
↓ occurrences of truck re-spots
↓ truck/shovel collisions & related maintenance
↓ truck operator training requirements

ROI <12 months

depending on specific mine characteristics

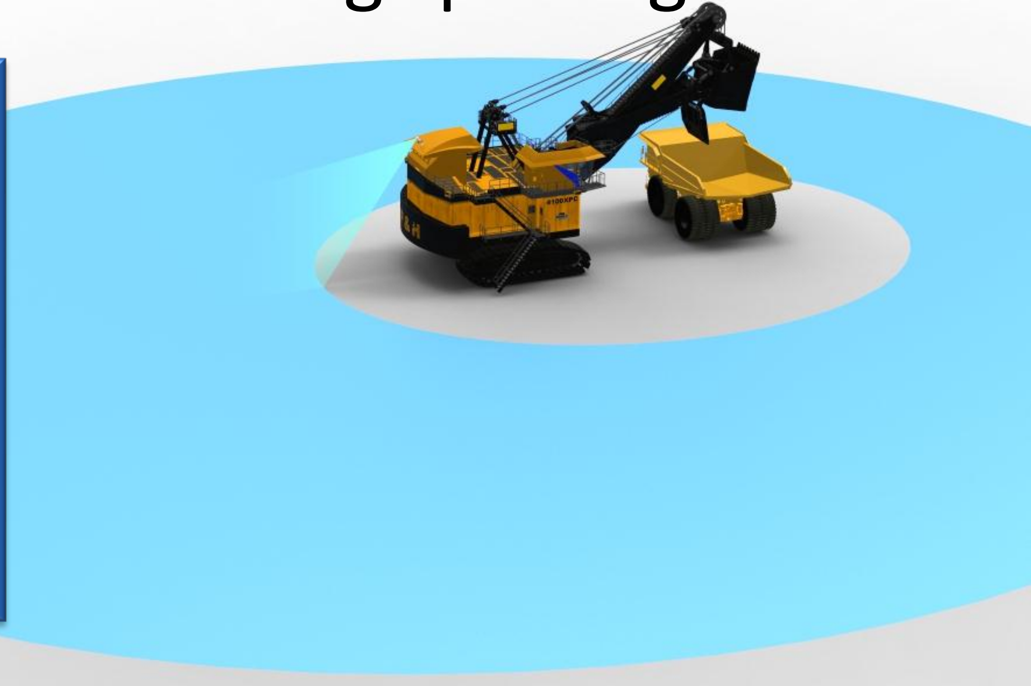
© 2013 Neptec Technologies Corp. All rights reserved.

Spot Assist - Concept

- LiDAR on the shovel
- Real-time relative truck/shovel position
- Feedback to truck driver during spotting

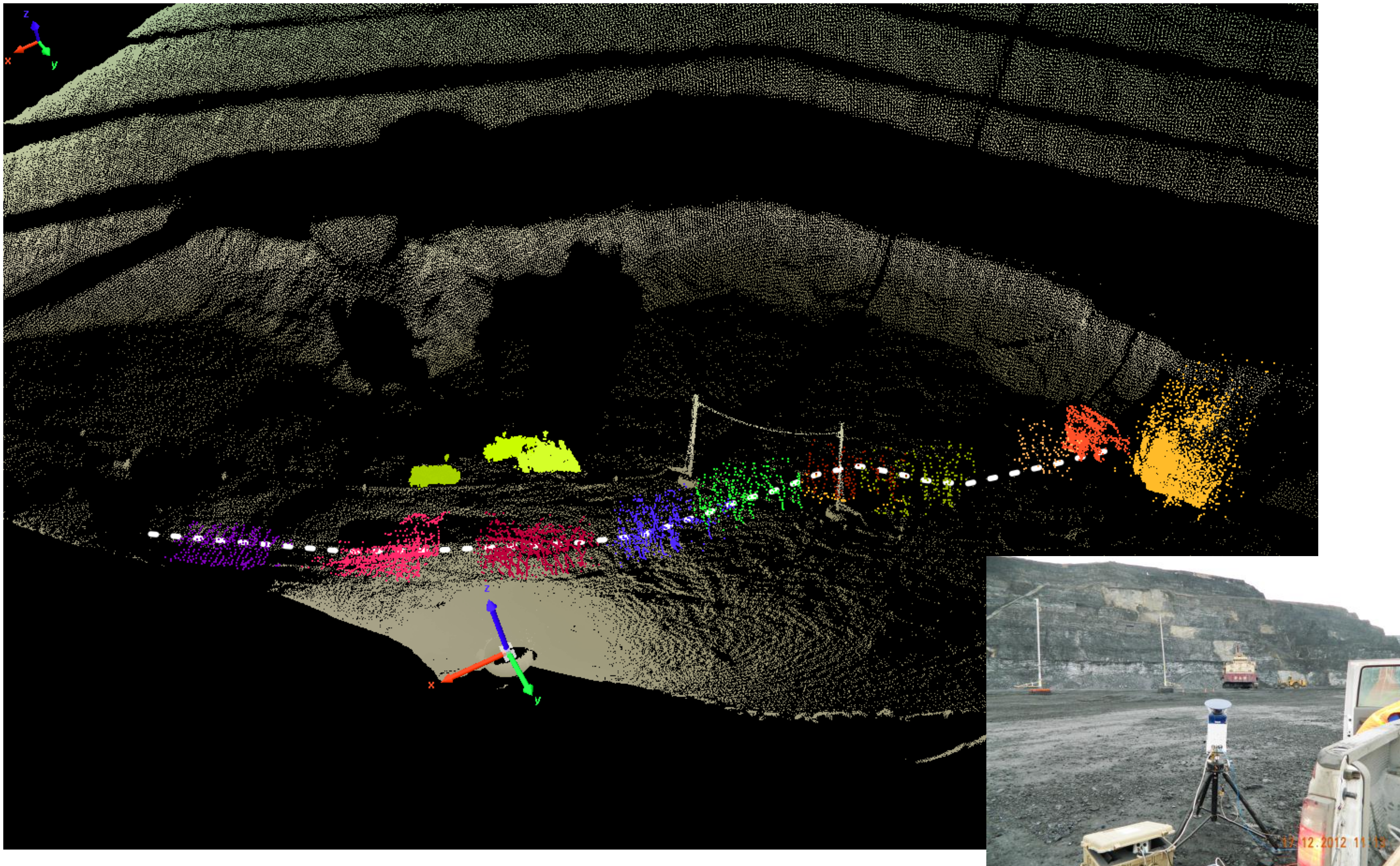
<u>Requirements</u>

Rugged(!)
Reliable
Accurate
Self-contained
Cost effective



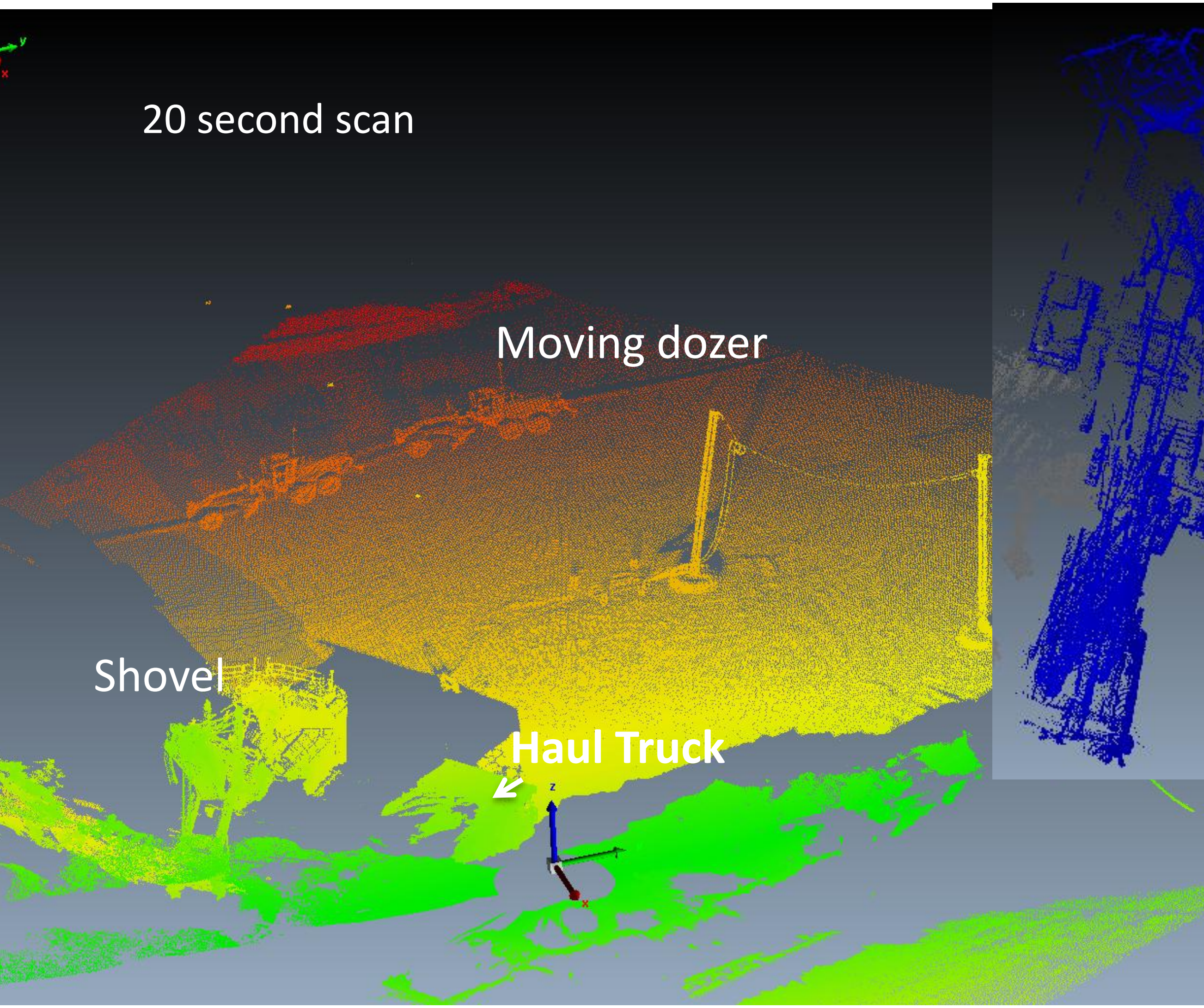
© 2013 Neptec Technologies Corp. All rights reserved.

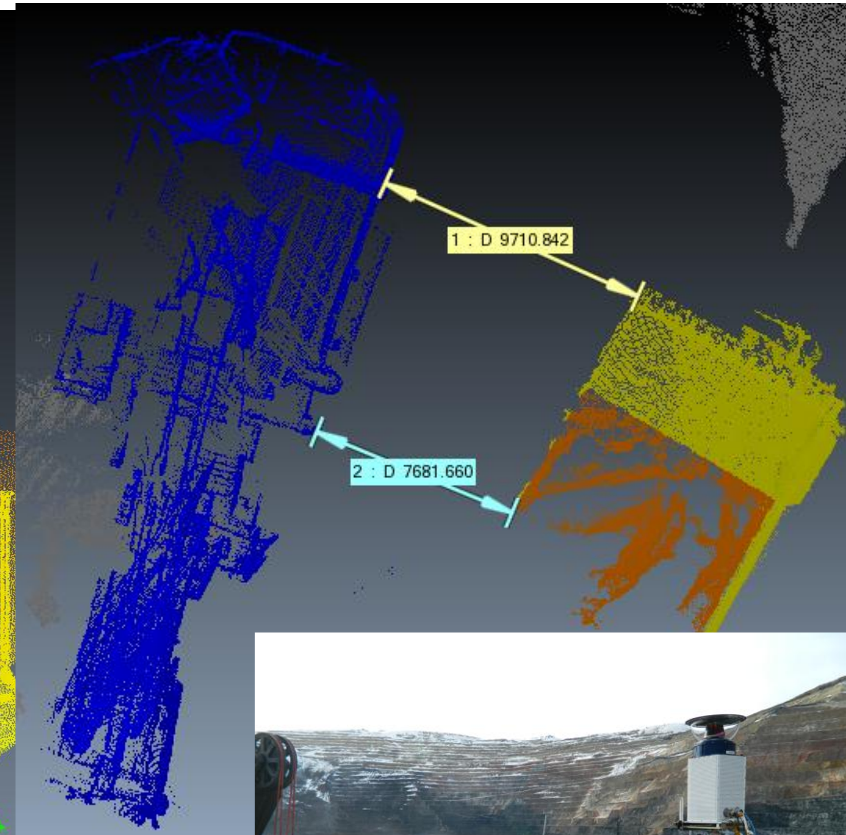
Truck Leaving Scan Mosaic



Copyright 2013 © Neptec Technologies Corp. All rights reserved.

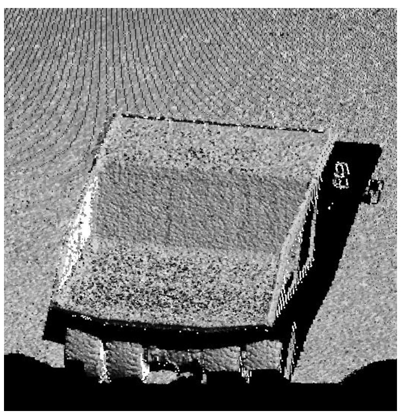
Application: Spot Assist

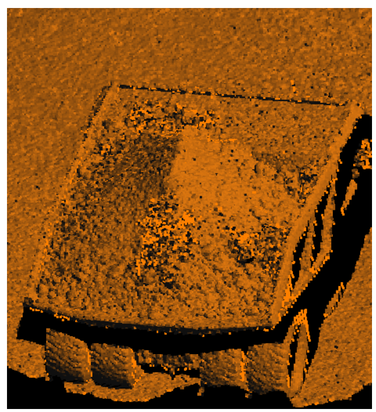


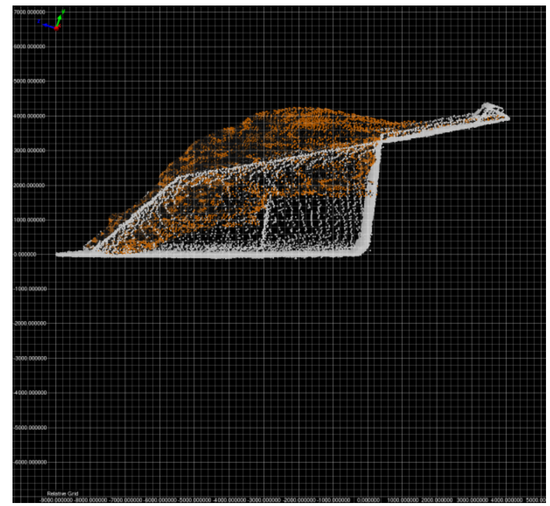


Copyright 2013 © Neptec Technologies Corp. All rights reserved.

Haul Truck Bin Volume





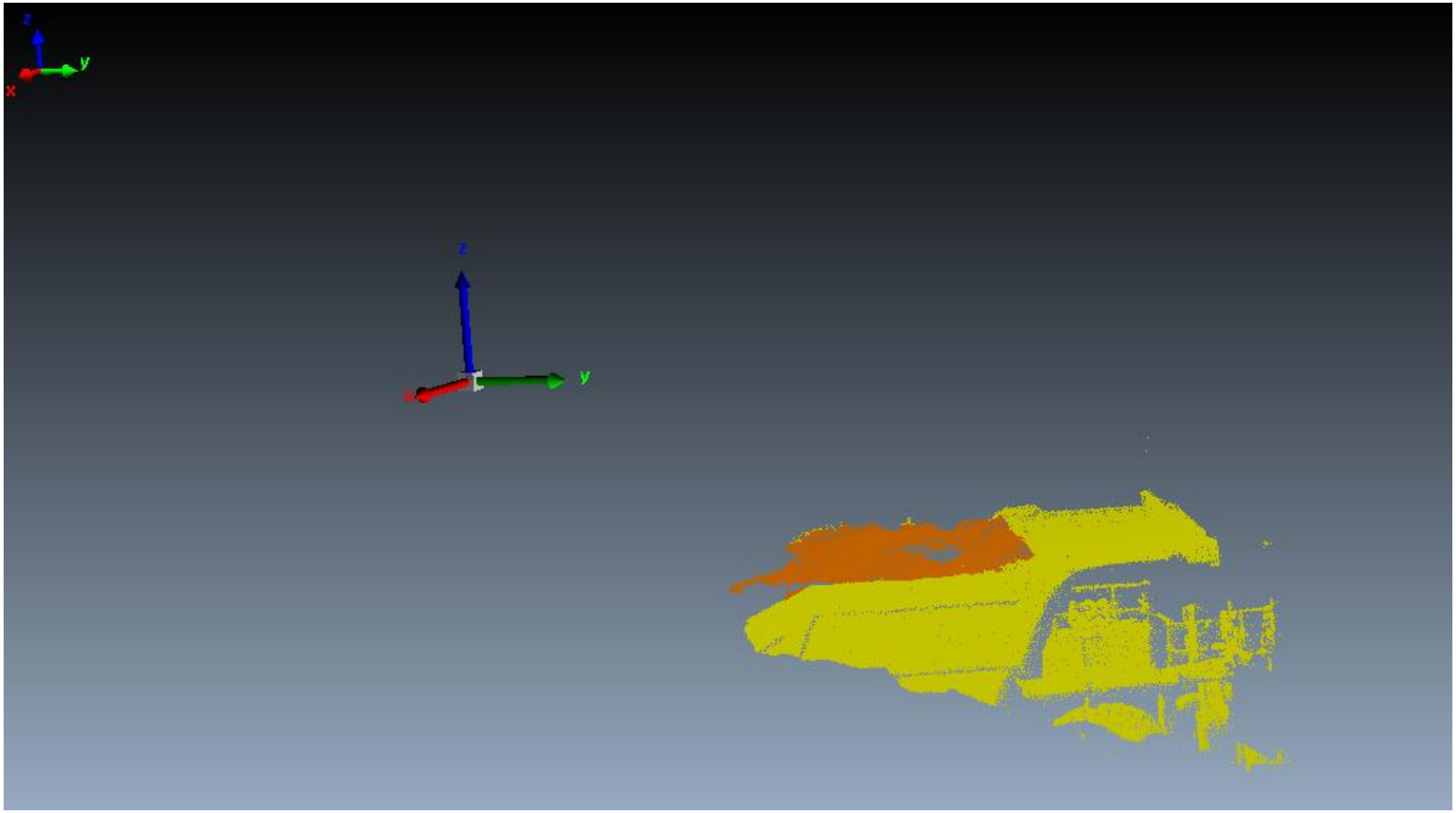


The volume of material in the bin was calculated to be ~149.7 m^3

Acquire → Re-orient → Segment → Measure

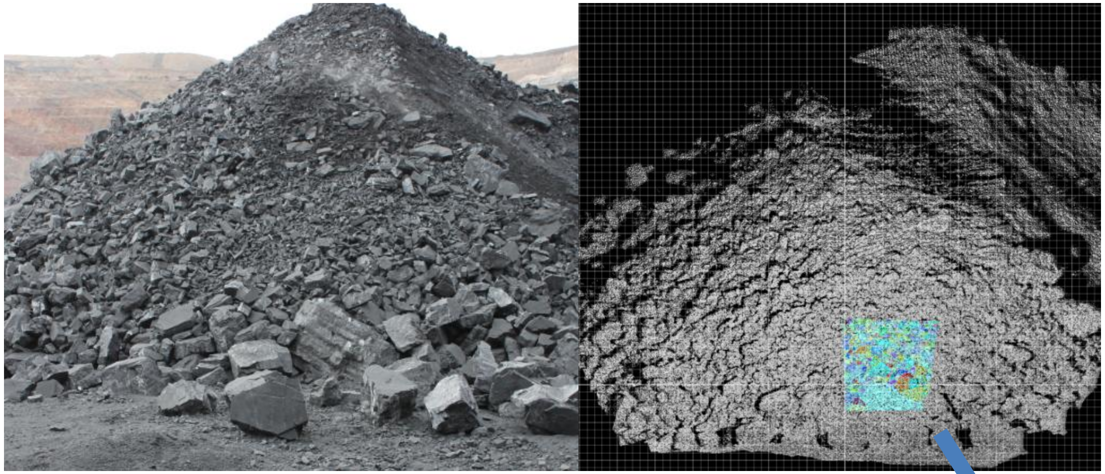
Copyright 2013 © Neptec Technologies Corp. All rights reserved.

Truck with Bin Contents Highlighted



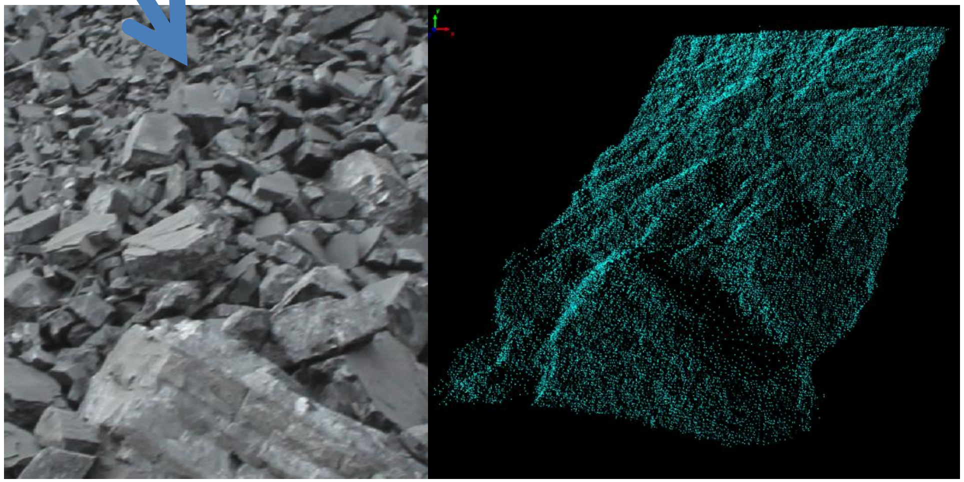
Copyright 2013 © Neptec Technologies Corp. All rights reserved.

Fragmentation Analysis



Demonstrate the use of 3D OPAL data for fragmentation analysis using a 3D algorithm developed by Neptec

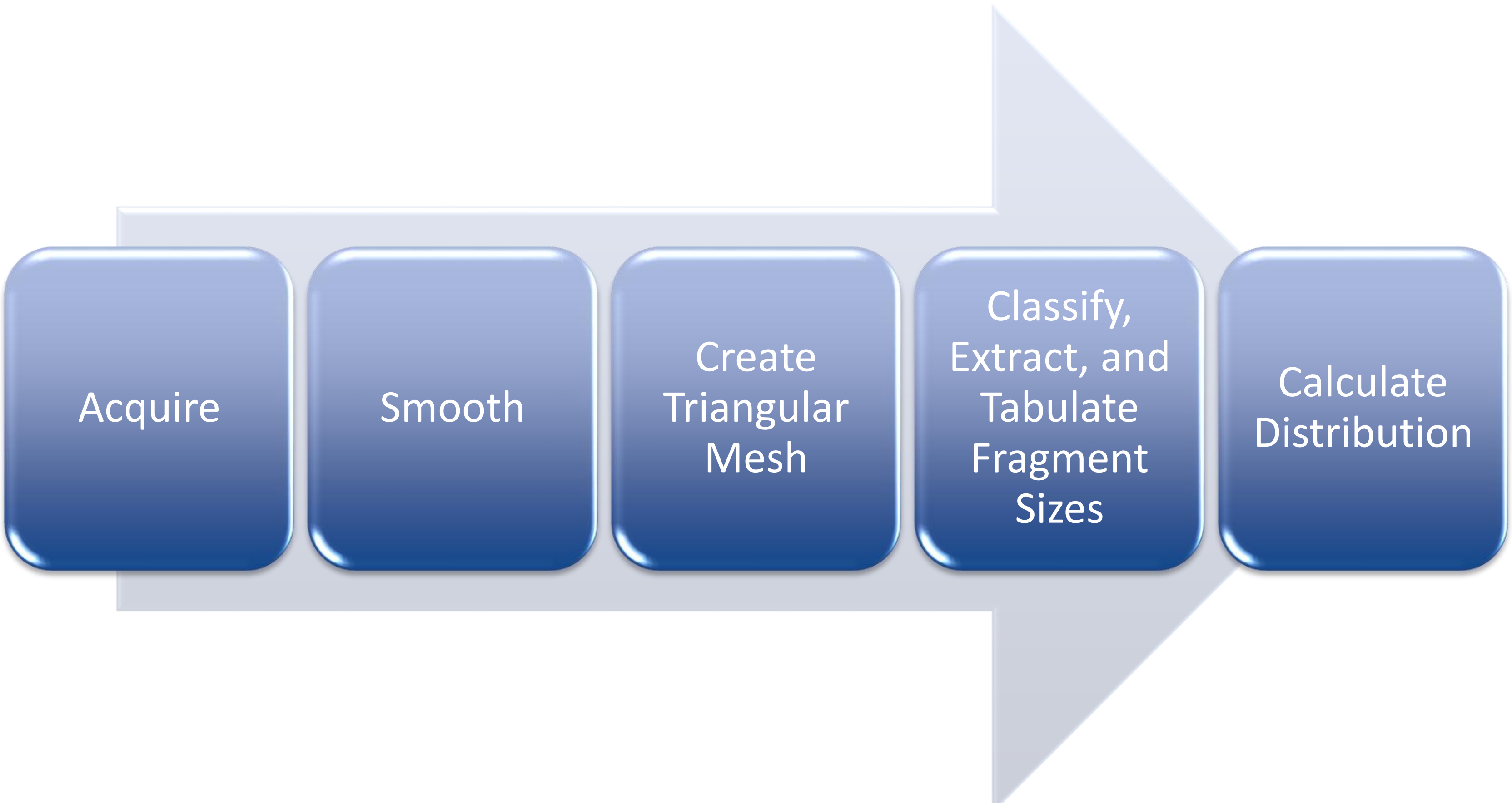
A subset of the data was used to develop the algorithm for practicality reasons, but algorithm can easily be applied to the full muck pile



Photograph and Raw Scan Data (rotated for perspective view)of Area Used for Analysis

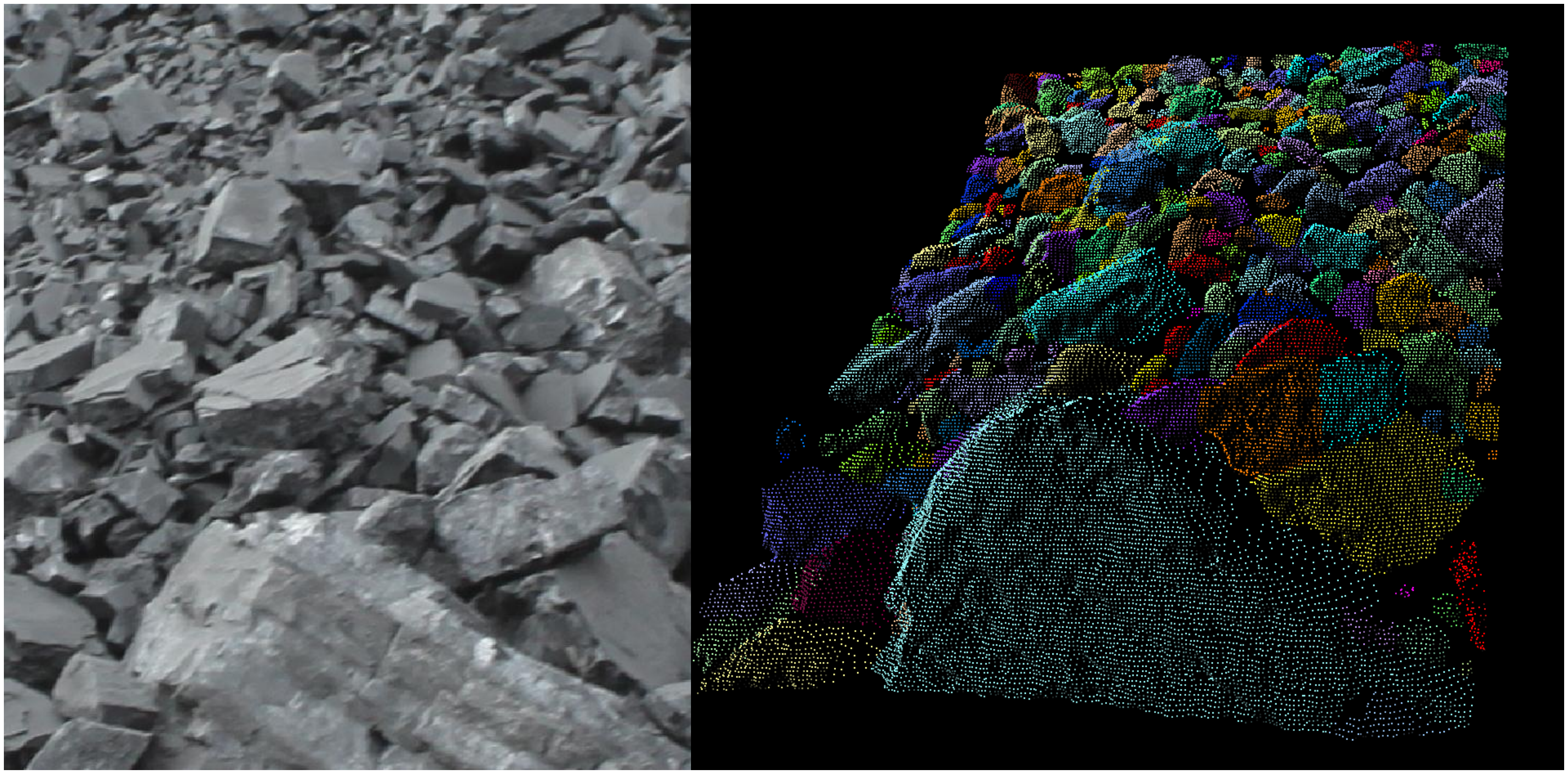
Copyright 2013 © Neptec Technologies Corp. All rights reserved.

Processing Steps



Copyright 2013 © Neptec Technologies Corp. All rights reserved.

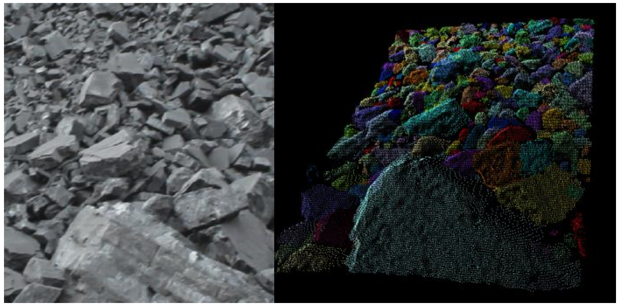
OPAL 3D Fragmentation Analysis



Photograph and Colourized Fragmentation Analysis Result

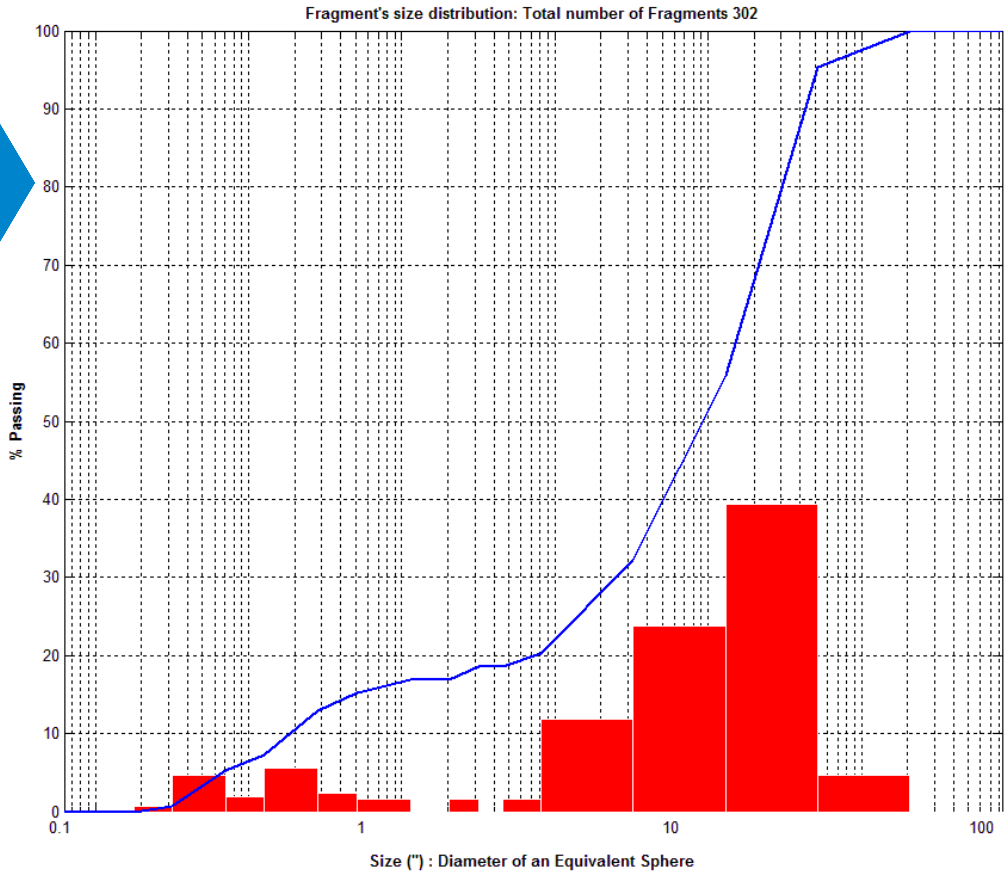
Copyright 2013 © Neptec Technologies Corp. All rights reserved.

OPAL 3D Fragmentation Analysis



This kind of fragment analysis processing could be applied to scan data obtained from the active face, the bin of a haul truck or the dipper of a shovel.

OPAL enables data collection and analysis to be completed “in-process” despite dusty conditions originating from working mine equipment.



Fragment size distribution that was calculated and output by the algorithm.

Copyright 2013 © Neptec Technologies Corp. All rights reserved.

Summary

- OPAL and 3DRi are the sensor and intelligence that can provide true 3D robotic machine vision for harsh environments

- OPAL and 3DRi have the potential to deliver mission-critical 3D machine vision for mine automation
  - Improved Safety
  - Process Monitoring
  - Process Optimization

- OPAL & 3DRi is future-proof
  - Same OPAL hardware supports multiple applications
  - Improve Customer Return on Investment (ROI) by adding new applications via software upgrades

Copyright 2013 © Neptec Technologies Corp. All rights reserved.

Evan Trickey
Product Development Lead
etrickey@neptec.com

www.neptec.com

More information, less data!

Thank you

Copyright 2013 © Neptec Technologies Corp. All rights reserved.