In Cycle Laser Scanning Implementation for Rapid Underground Development

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In Cycle Laser Scanning

• **Goals**
  
  • High resolution as built model of open ground before ground support installation, such as shotcrete lining
  
  • Minimal cycle time impact
  
  • Fast turn around time of deliverables
  
  • Provide benefits to multiple groups, clear improvements
  
  • Gain experience for company on many uses of underground laser scanning

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In Cycle Laser Scanning

• Why?
  • Accurate as builds of open ground profile before support installations

• Challenges and Considerations
  • Rapid development- 100-200’/week in 1 to 3 faces
  • Limited survey support for reference control points
  • In cycle shotcrete lining application on all rounds
  • Cycle impact- equipment in face and time requirements
  • New technologies and methods
  • Clear outcomes and benefit to project
In Cycle Laser Scanning - How

- Equipment for typical scan setup
  - Small, phased base laser scanner
  - Tripod stand
  - Black & white control targets (optional)
In Cycle Laser Scanning - How

- Arrive with shotcrete equipment to face, let them setup
- During sprayer setup time, perform laser scan of face
- Scan time ~3-5 minutes
- Sprayer can be positioned at face, drop sprayer boom to bench
- Does not require survey control points near face
- Scanner settings: 3x repeat, 44 million points, 10240 pt/360°
In Cycle Laser Scanning - How

- Cross section of single face scan
- Scanner does full 360° scan, sees open ground and previous rounds
### In Cycle Laser Scanning - Registration

- Laser scans require registration to bring into mine coordinate space
- Many options exist depending on scanner type, software
- Two types of registration are used

<table>
<thead>
<tr>
<th>Survey Control</th>
<th>Round by round</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial registration</td>
<td>Leapfrog transit from Survey</td>
</tr>
<tr>
<td>Uses survey’s control points</td>
<td>Does not use control points</td>
</tr>
<tr>
<td></td>
<td>Overlapping scans</td>
</tr>
</tbody>
</table>
In Cycle Laser Scanning - Registration

• Initial survey control point registration
  • Survey adds three control points near face
  • Use of phase based black and white circular targets
  • Scanner software auto picks center point
  • Offset between survey prisms and targets are the same
  • Use 3 point registration tool in software to translate scan to mine coordinates

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In Cycle Laser Scanning - Registration

- Round by round “leap frog” transit using global registration
  - After using survey control target points
  - Overlapping scan points between scans used to match common points to register new scans
  - No survey support required, no control points required
  - 200’ between known control scans, 15-20 rounds before new control is brought in
  - Acceptable RMS errors of < 6” between control scans
  - Global registration also known as cloud to cloud, point to point by different vendors
In Cycle Laser Scanning - Registration

- Round by Round after initial survey control

Step 1: Initial Survey Control (grey)
Step 2: 1st round, global reg (red)
Step 3: 2nd round, global reg (white)
Step 4: 3rd round, global reg (blue)
• Round by Round after initial survey control – 1 round in
In Cycle Laser Scanning - Registration

- Round by Round after initial survey control – 2 rounds in

Step 1: Initial Survey Control (grey)
Step 2: 1st round, global reg (red)
Step 3: 2nd round, global reg (white)
Step 4: 3rd round, global reg (blue)

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In Cycle Laser Scanning - Registration

- Round by Round after initial survey control – 3 rounds in

Step 1: Initial Survey Control (grey)
Step 2: 1st round, global reg (red)
Step 3: 2nd round, global reg (white)
Step 4: 3rd round, global reg (blue)

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In Cycle Laser Scanning - Registration

• Cross section
In Cycle Laser Scanning - Deliverables

• Round Scan Reports
  • Compare against design, overbreak % and yards
  • Cross section showing profile (color schemes +0.5’ overbreak, -0.5’ under)
  • Rib line asbuilt
  • 3D pdf of round surface showing over and underbreak
  • Sent out within hours of mapping
  • Ability to show actual drill pattern

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In Cycle Laser Scanning - Deliverables

Location:

<table>
<thead>
<tr>
<th></th>
<th>Asbuilt</th>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max height (ft)</td>
<td>21.8</td>
<td>19.5</td>
</tr>
<tr>
<td>Max width (ft)</td>
<td>22.4</td>
<td>19</td>
</tr>
<tr>
<td>Round length (ft)</td>
<td>14.0</td>
<td>14</td>
</tr>
<tr>
<td>Overbreak volume (yd$^3$)</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Overbreak (%)</td>
<td></td>
<td>0.0</td>
</tr>
<tr>
<td>Floor type</td>
<td>Muck</td>
<td></td>
</tr>
<tr>
<td>Half-barrels</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Drillholes Navigated</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

Geology Notes

Mapped By: Ben Beard
Scan Report By: Ben Beard

Design profile is shown above along with asbuild profile from center of rod. Cross-hairs show location of drill hole. Overbreak is shown in red, to design is green, underbreak (-0.5ft) is shown in blue. Next page contains 3D object click to activate and manipulate it.
In Cycle Laser Scanning - Deliverables

- Round report - rib line asbuilt
In Cycle Laser Scanning - Deliverables

- Round Report: 3D PDF
In Cycle Laser Scanning – Geology Mapping

- Scans can be used with or without photos for geology mapping
  - Accurate orientation for discontinuities

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In Cycle Laser Scanning – QC

• Scans are used for ground support quality control checks
  • Low bolts, low wire coverage
  • Mesh overlap
  • Bolt spacing
  • Bolt coverage to face
  • Shotcrete thickness

• Improvements over previous means
  • Less exposure at face during QC check, no cycle impact
  • Accurate measurements
  • No drilling for shotcrete thickness
  • Historical records available showing installed support
• Shotcrete thickness between two scans
In Cycle Laser Scanning – QC and Records

- Scan models show installed support, which is sometimes later covered by utilities such as vent ducts and piping
- Models can be subsequently reviewed in a post incident situation showing original ground conditions, installed support
- Scanner can also be used for incidents such as ground support failures or others to capture an accurate model before remediation
- Better planning for rehabilitation because original state can be assessed
In Cycle Laser Scanning – Asbuilts

• Traditional total station survey asbuilts have known issues
  • Face availability, equipment obstructions
  • Survey resources, frequency
  • Line of sight, irregularity of profile, distances
  • Setup locations
  • Ground support “thickness”
  • Quantity of points

• Scanner advantages (round by round)
  • More points, better surface generation options
  • More setups, less line of sight problems
  • No cycle time impact
  • More
In Cycle Laser Scanning – Asbuilts

- Grey outline shows laser scan profile
- Red outline is survey (total station) profile

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In Cycle Laser Scanning – Asbuilts

- Grey outline shows laser scan profile
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In Cycle Laser Scanning – Asbuilts

- Grey outline shows laser scan profile
- Red outline is survey (total station) profile
• A more accurate point cloud can have large impact
  • Overbreak and underbreak are capture and not “smoothed” out
  • Drill plan designs
  • Payments to contractors
  • Cycle time impacts
In Cycle Laser Scanning – Special Circumstances

- For rapid development, a situation such as extreme overbreak (fallout) can more rapid be addressed, allowing continuation of development
- Difficult to measure and assess open ground profile, no access
- Wide overbreak due to lithologic contact, stable with shotcrete
  - Scanned at 3:30 PM after muck out, before shotcrete
  - Model assessed, new support design at 4:30 PM
  - Bolting began at same shift

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In Cycle Laser Scanning - Quality

- Scanners can take pictures, either drape picture or color points.
- Point intensity - reflective strength of point, can be turned on to view reflective properties (water, geology, shotcrete, metal, spray paint).

View down drift, not a picture, grey scale point cloud.
In Cycle Laser Scanning - Capabilities

- Laser scanners do not replace a need for a surveyor
  - They do not mark up control, points
  - Typically not as accurate as traditional survey methods
  - Require some advanced skills to understand registration and control

- Scanner relationship with surveyors
  - They do replace a tedious task for surveyors, asbuilts
  - Ability to quickly shoot many points instead of using total station
  - More points offer better surface generation options
• Geology and Geotechnical team collects data, then used by
  • Survey
  • Mine Design and Planning
  • Blast Design
  • Contractor Management
  • Health and Safety
  • Development Team
In Cycle Laser Scanning – Going Forward

- Improved ability to bring in actual drill hole patterns
- Wireless drop of data while underground
- Improve shotcrete training through visualization of thickness, fallout
- Auto recognition of bolts, auto measurement of spacing
- More geological mapping
- Deformation monitoring

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In Cycle Laser Scanning – Questions

- Ben Beard

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