

Wrap-up

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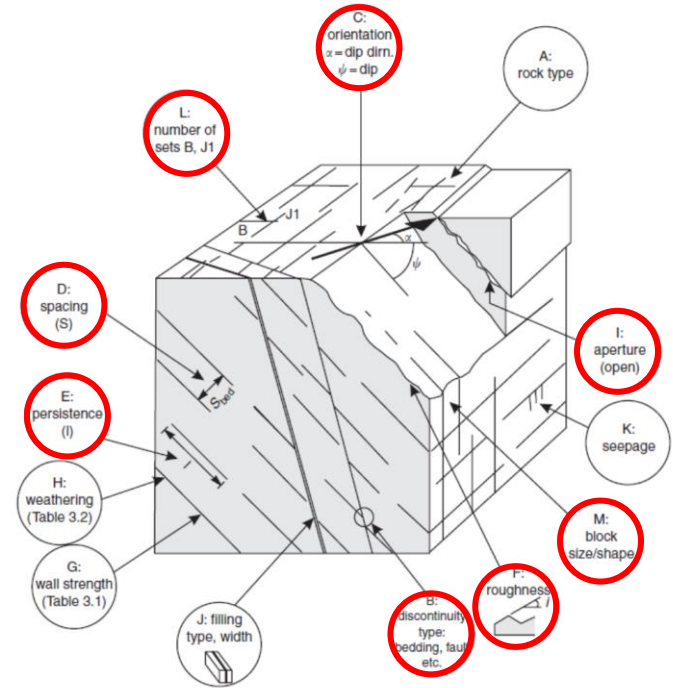
TERRA
Remote rock mass characterization

Wrap-up

- SfM photogrammetry produces high-quality 3D models of rock mass surface
 - Requirements: 1:1 scale, oriented, high resolution, georeferenced
 - Resolution
 - fracture orientation: cm, depends on fracture size and spacing
 - roughness: mm,
- 3D models enable remote mapping
 - discontinuities: no. of sets, orientation, spacing, persistence, roughness
 - computer-assisted manual mapping or semi-automatic mapping

Remote rock mass characterization

- remote sensing technologies: **LiDAR** and **photogrammetry**
- high-resolution, accurate **3D models of rock mass surfaces**
- enable **detailed analysis of discontinuities** -> orientation and other geometrical properties
- analyze rock mass features over **large areas**
- **statistical distribution** of parameters
- provides **unbiased data** from **inaccessible or dangerous locations**



3D model of a rock mass surface

Reconstruct a **3D digital model of a rock mass surface**

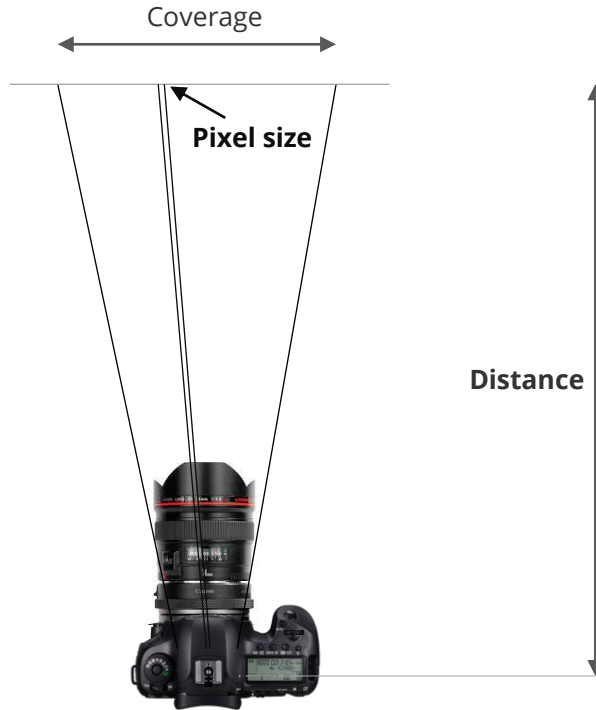
- ✓ **sufficient point density => GSD**
- ✓ **1:1 scale => accuracy**
- ✓ oriented (N, horizontal plane)
- ✓ (georeferenced)
- ✓ (correct color)

What are the requirements
for rock mass 3D models?

Good input data is key

- ✓ high quality scans/image sequences
- ✓ high overlap
- ✓ capturing from various angles

Ground pixel size (= Ground Sampling Distance GSD)

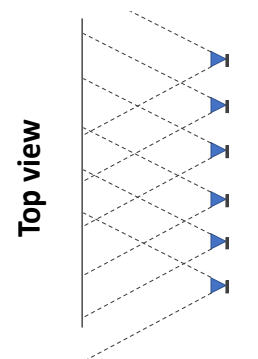
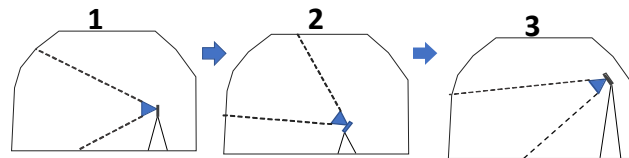


determine the approximate coverage (field of view) and the 'ground' pixel size of a particular lens and camera at a given distance

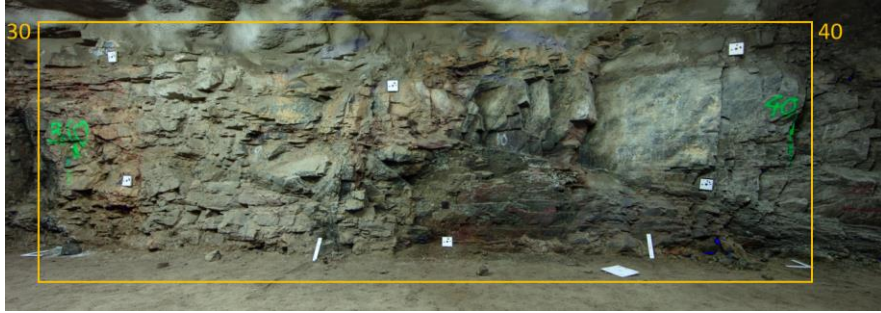
1. Focal length ⓘ	<input type="text" value="14"/>	mm	1. Input focal length
2. Format size ⓘ	Width <input type="text" value="36"/>	mm	2. Input sensor format
	Height <input type="text" value="24"/>		
2b. Format size preset ⓘ	<input type="text" value="Full frame 35mm"/>		
3. Distance of camera to object ⓘ	<input type="text" value="10"/>	meters ▾	5. Set a distance
4. Allowable coverage ⓘ	<input type="text" value="80%"/>		3. Set coverage to 80%
5. Resolution (optional) ⓘ	<input type="text" value="50.6"/>	mega-pixels	4. Input camera resolution
Computed coverage ⓘ	Width <input type="text" value="20.57"/>	meters ▾	
	Height <input type="text" value="13.71"/>		
Computed pixel size ⓘ	<input type="text" value="2.952"/>	millimeters ▾	6. Check if the computed pixel size is less than required GSD and modify the distance if needed
manual marking=2x ⓘ	<input type="text" value="5.903"/>		
subpixel=1/20th ⓘ	<input type="text" value="0.148"/>		
dot-size=8x ⓘ	<input type="text" value="23.613"/>		

High overlap and imaging from various angles are key for correct reconstruction

- several rounds of overlapping image sequences to provide sufficient coverage
 - each point should be visible on at least 3 photos
 - viewing angle is adjusted by varying height and camera tilt
 - in the 1st round keep the camera parallel to the tunnel wall
- start so that 1/3 of the object is visible
- take a photo at every translated distance along the tunnel wall until the section is covered



Scale, orientation, position - accuracy



How to orient and scale the model?



Orientation board



Scale bar

Relative accuracy



Ground Control Points

Absolute accuracy

Tunnel visit



data collection for
photogrammetry



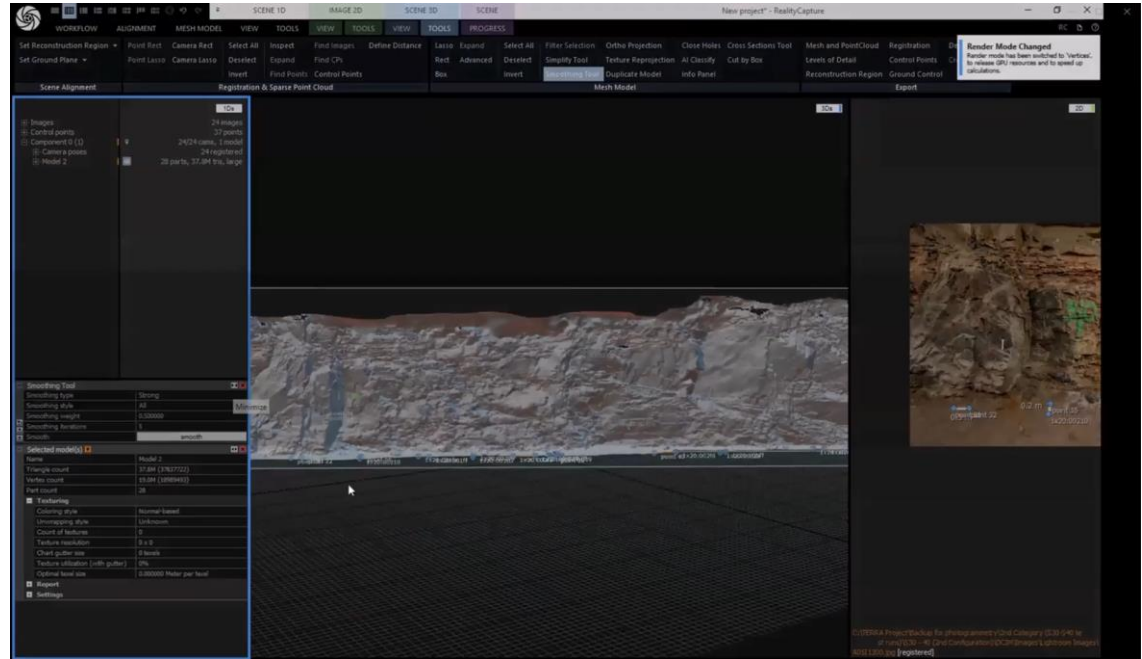
manual compass
measurements



TLS and handheld
lidar demo

3D model processing workflow

- RealityCapture software
- 24 images
- processing time
- 37 million triangles



Remote fracture measurements

- point cloud of the tunnel wall + simplified textured mesh for visualization
- computer-assisted – compass plugin in CloudCompare
- semi-automatic – Discontinuity Set Extractor DSE
- roughness 2D profiles – JRC and Z_2