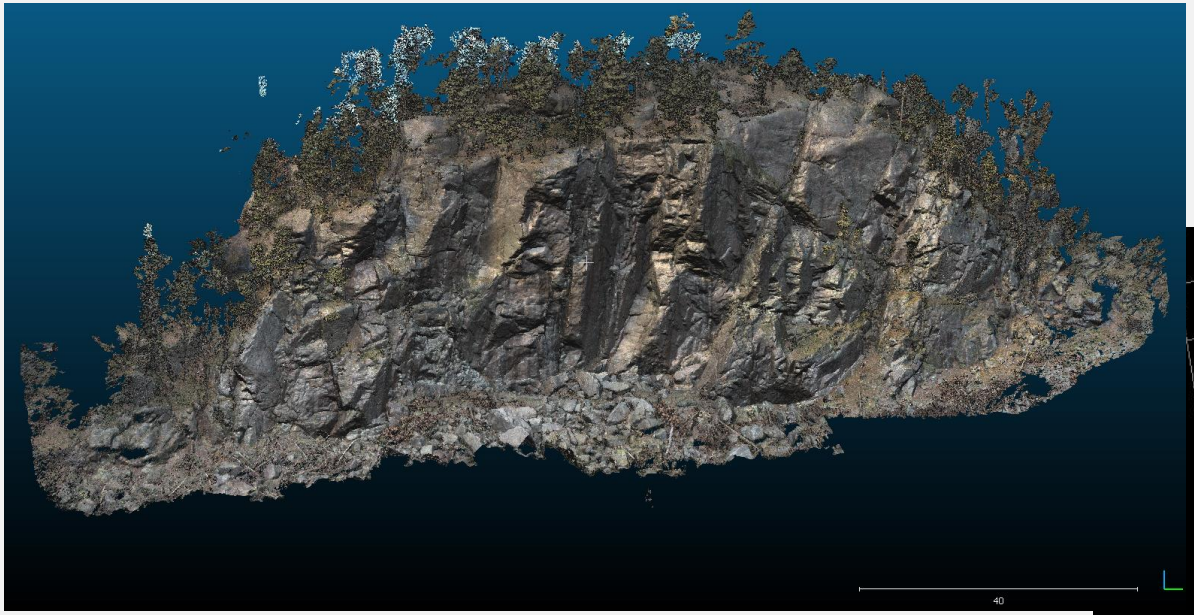
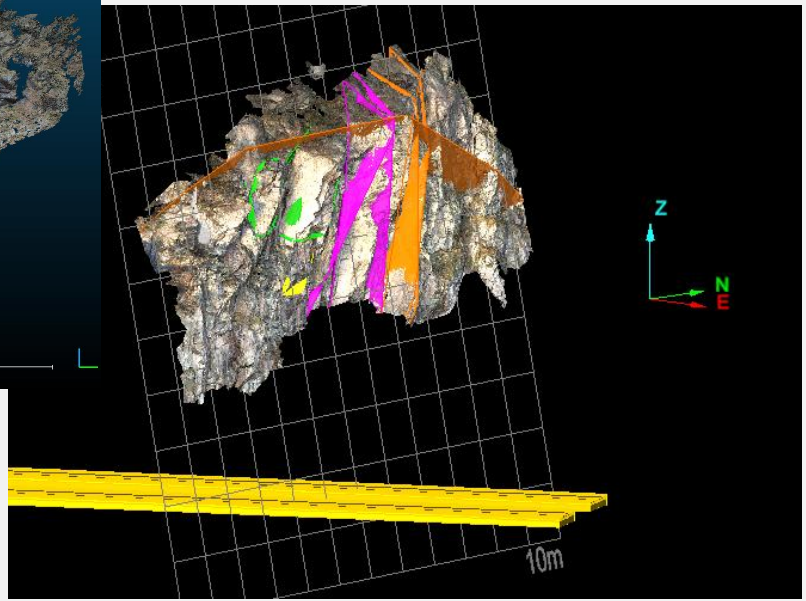
Stability analysis of photogrammetry models - Case studies

Jessica Ka Yi Chiu

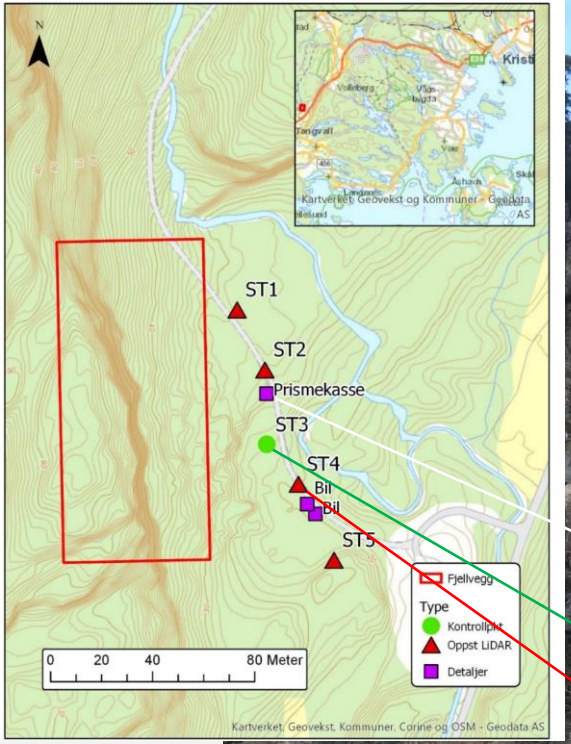
2020-03-05 NBG Vårsleppet

E39 Rock Cliff above Eastern Portal for Søgne Tunnel






LiDAR X Photogrammetry



Leica P40

Control and scanning points are surveyed by CPOS → cm accuracy


DJI Phantom 4 Pro drone


DJI Phantom 4 Pro drone

LiDAR X Photogrammetry

ST1 ST2 ST4 ST5

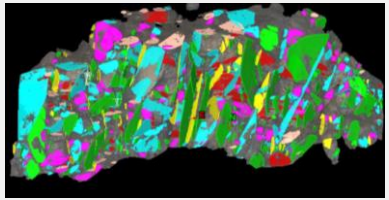
Cloud to Cloud registration
(error: 2-4 mm)
DGNSS (error 3-9 mm)

LiDAR model

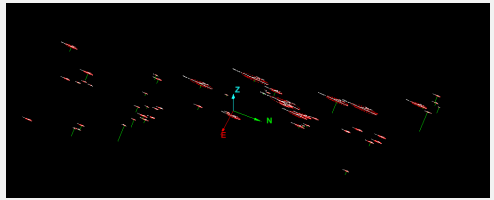
Georeferencing:
Agisoft Metashape

Photogrammetry model
(<5 cm accuracy)

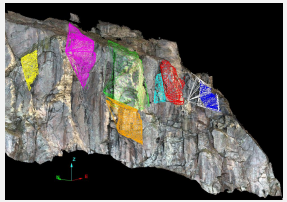
Meshing, joint mapping, volume estimation:
Maptek Point Studio



Joint orientation



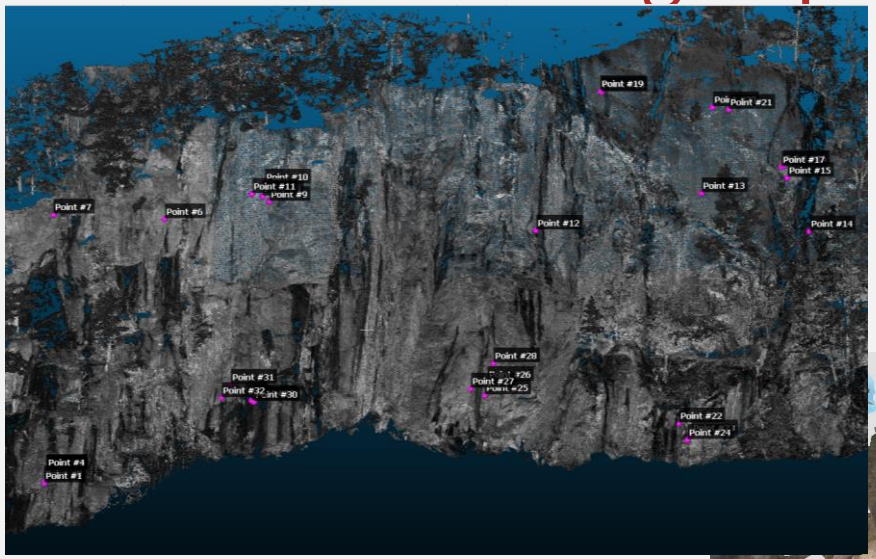
Joint spacing



Volume

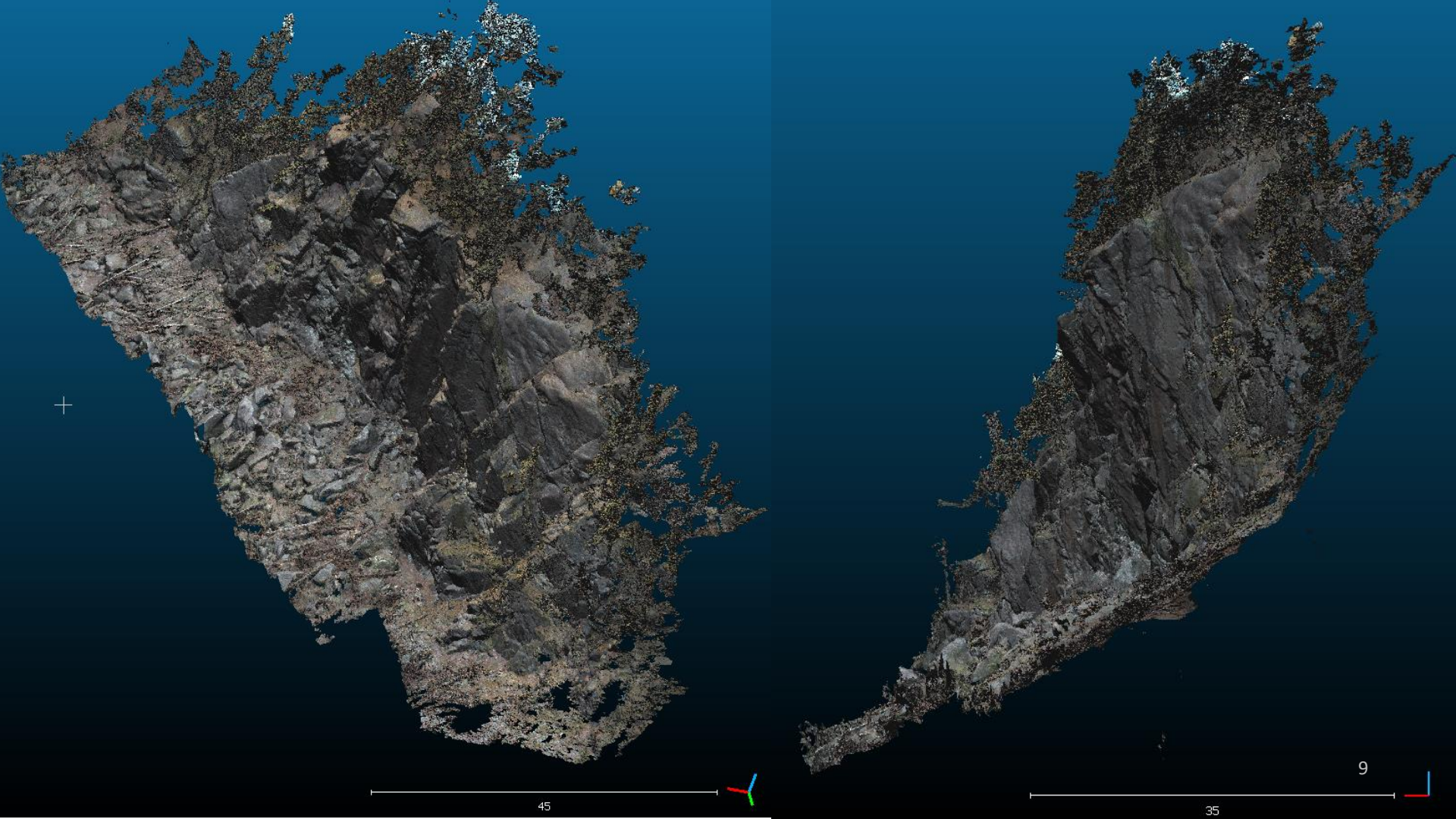
NGI

Georeferencing of photogrammetry model

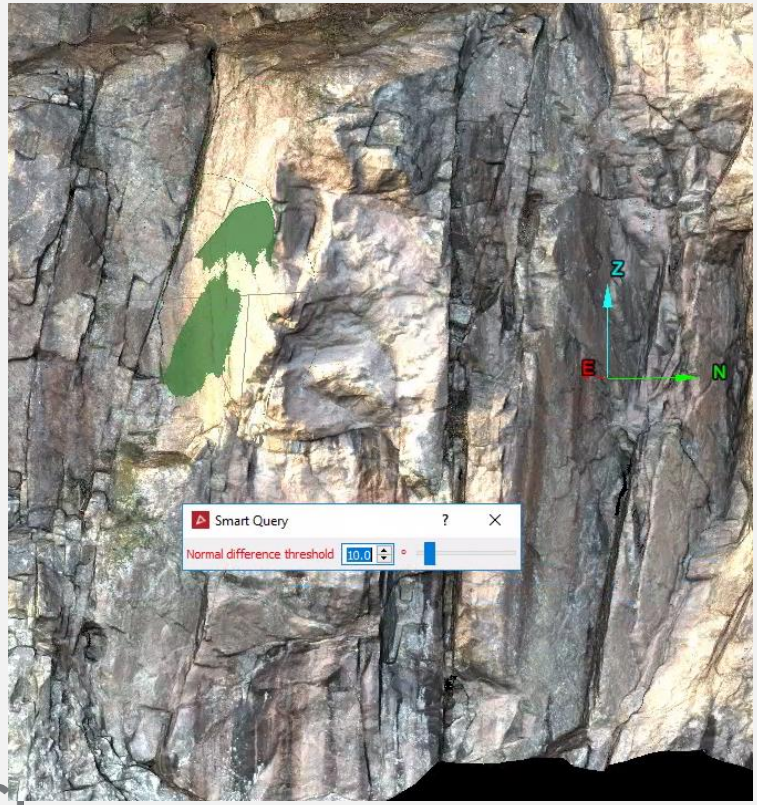


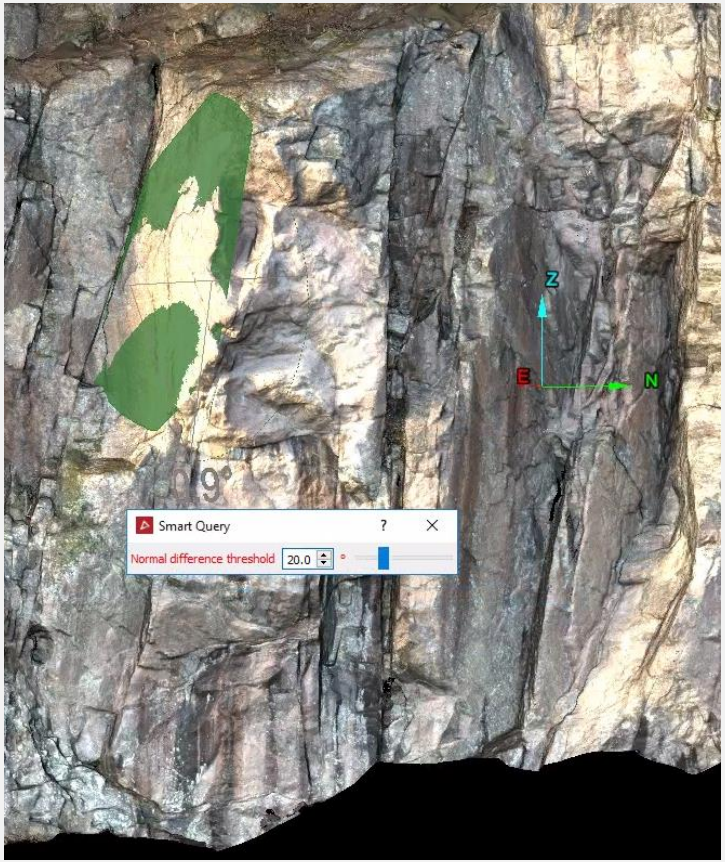
Picking 28 fixed points + 8 controlled points using ***CloudCompare***

Error ~ 3-3.3 cm

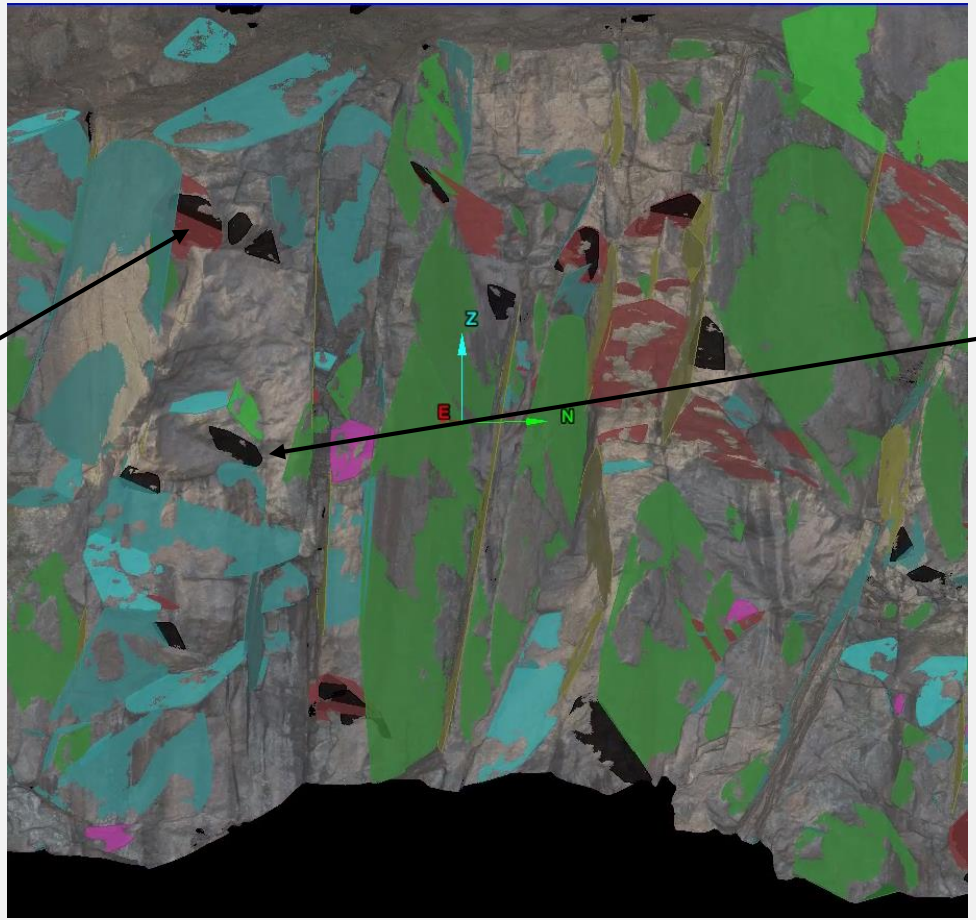

45
9
35

‘Smart query’


Z
E
N
Smart Query
?
Normal difference threshold
10.0
°


Z
E
N
9°
Smart Query
?
Normal difference threshold
20.0
°

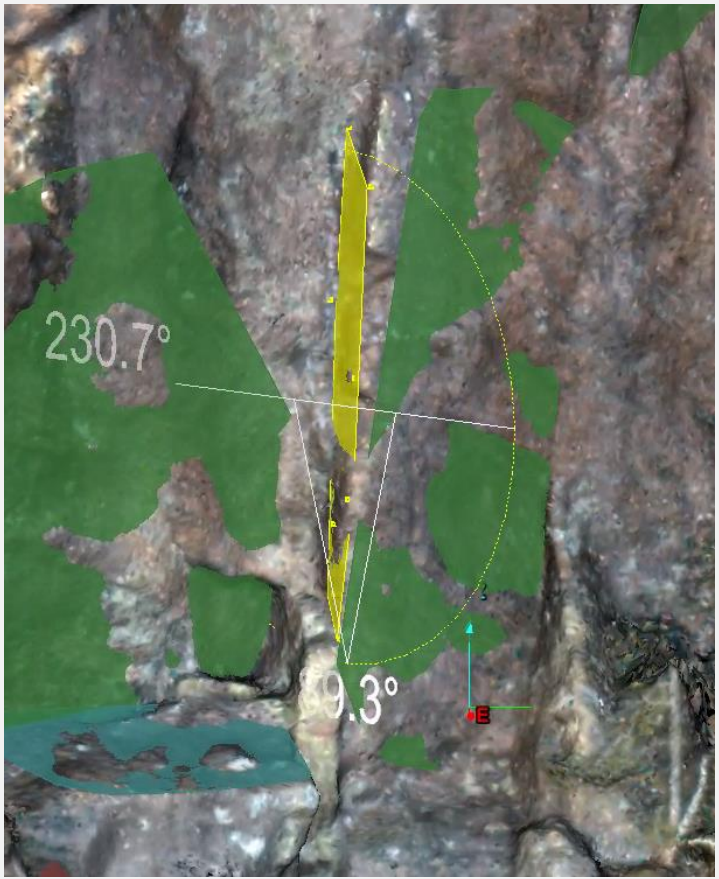
‘Extract’

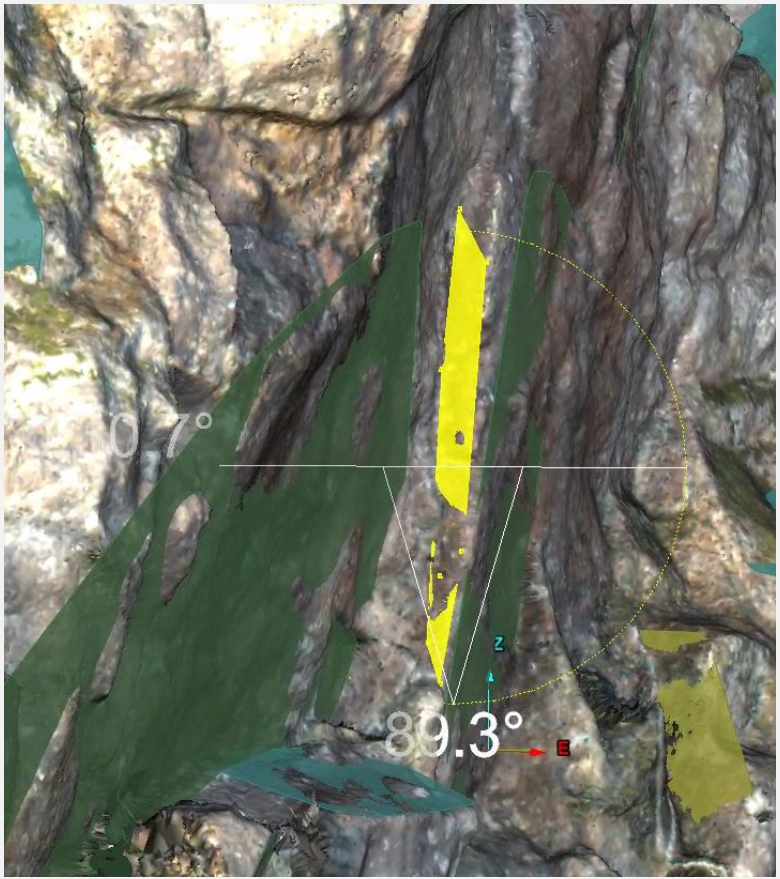


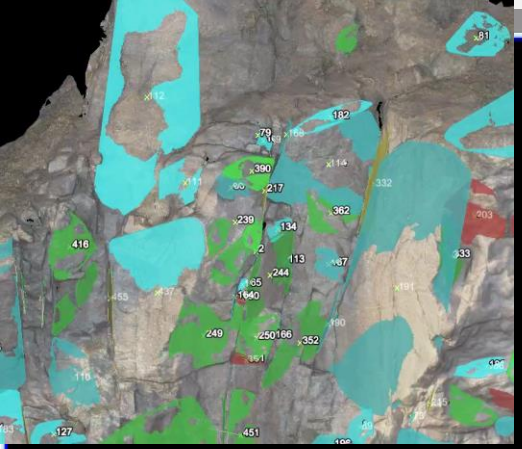
Red+Black: mapped both manually and automatically

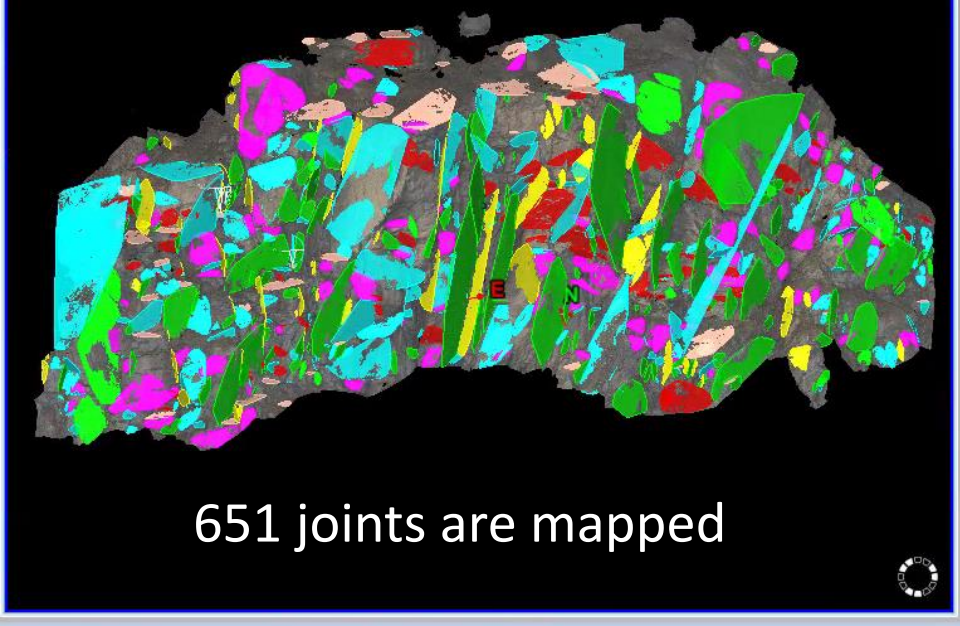
Black: overlooked by manual mapping

‘Query’ – manual trace mapping



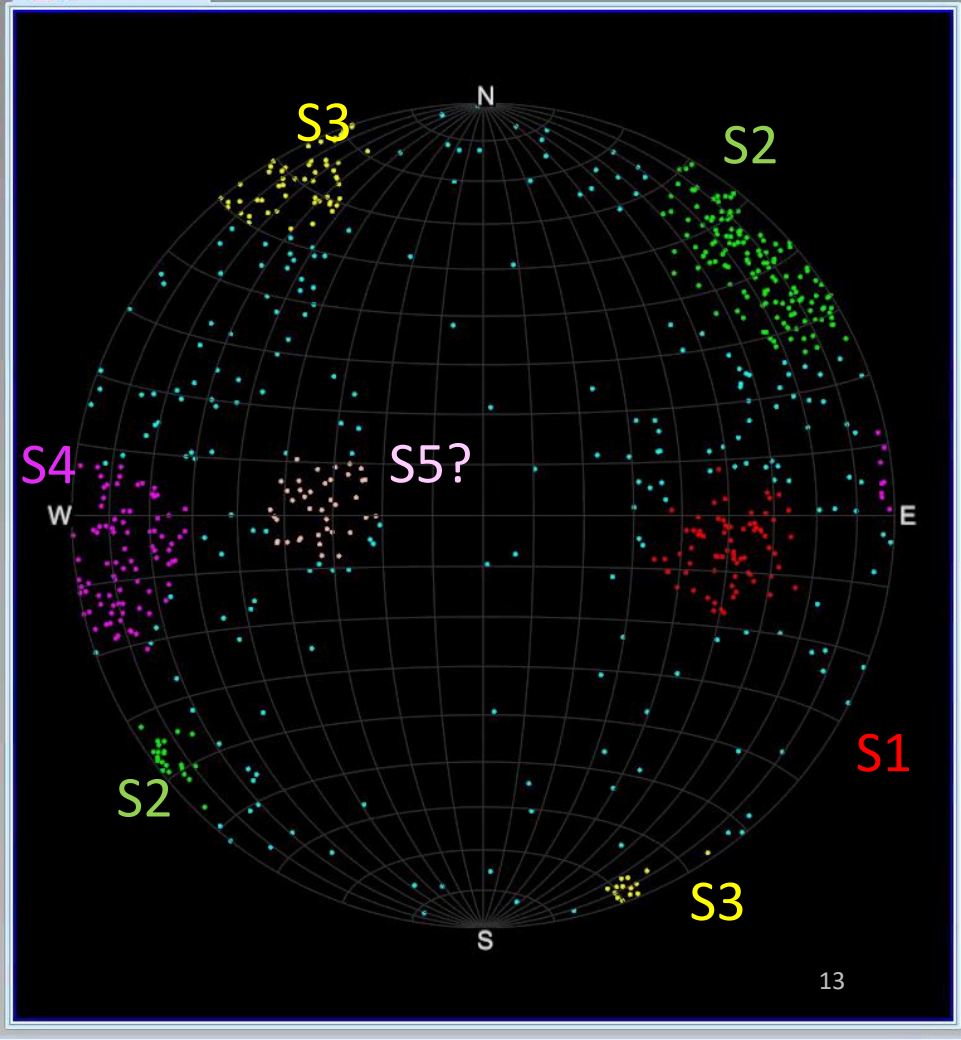






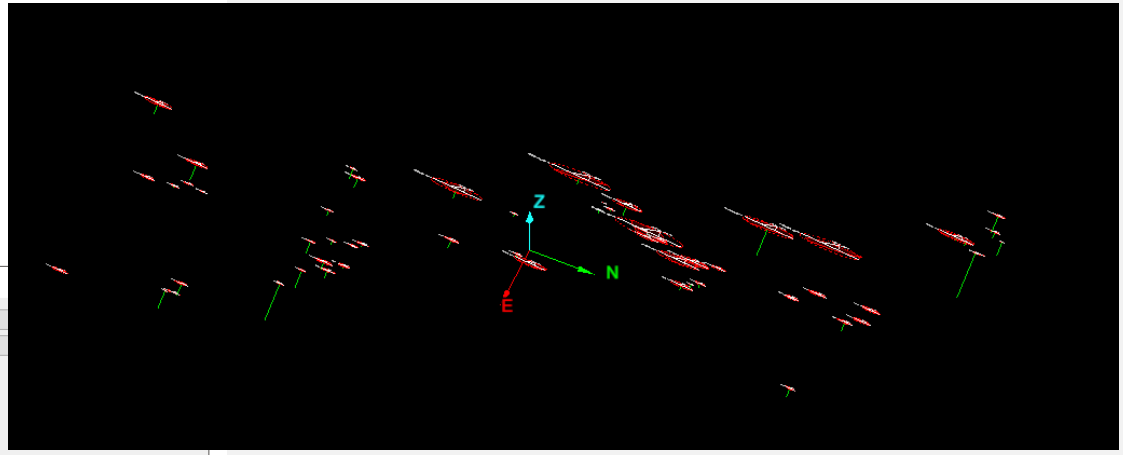
651 joints are mapped

/geotechnical.....



Joint Spacing for each joint set

- discontinuity spacing of discontinuity set
  - Discontinuities
  - Measurement lines
    - discontinuity 5 to discontinuity 10
    - discontinuity 10 to discontinuity 7
    - discontinuity 7 to discontinuity 6
    - discontinuity 6 to discontinuity 8
    - discontinuity 8 to discontinuity 9
    - discontinuity 9 to discontinuity 2
    - discontinuity 2 to discontinuity 4
    - discontinuity 4 to discontinuity 1
    - discontinuity 1 to discontinuity 3



Export custom ASCII format

ASCII format: New format...

Export data as: Edge properties

Column separator: Comma

Add whitespace to ensure column alignment

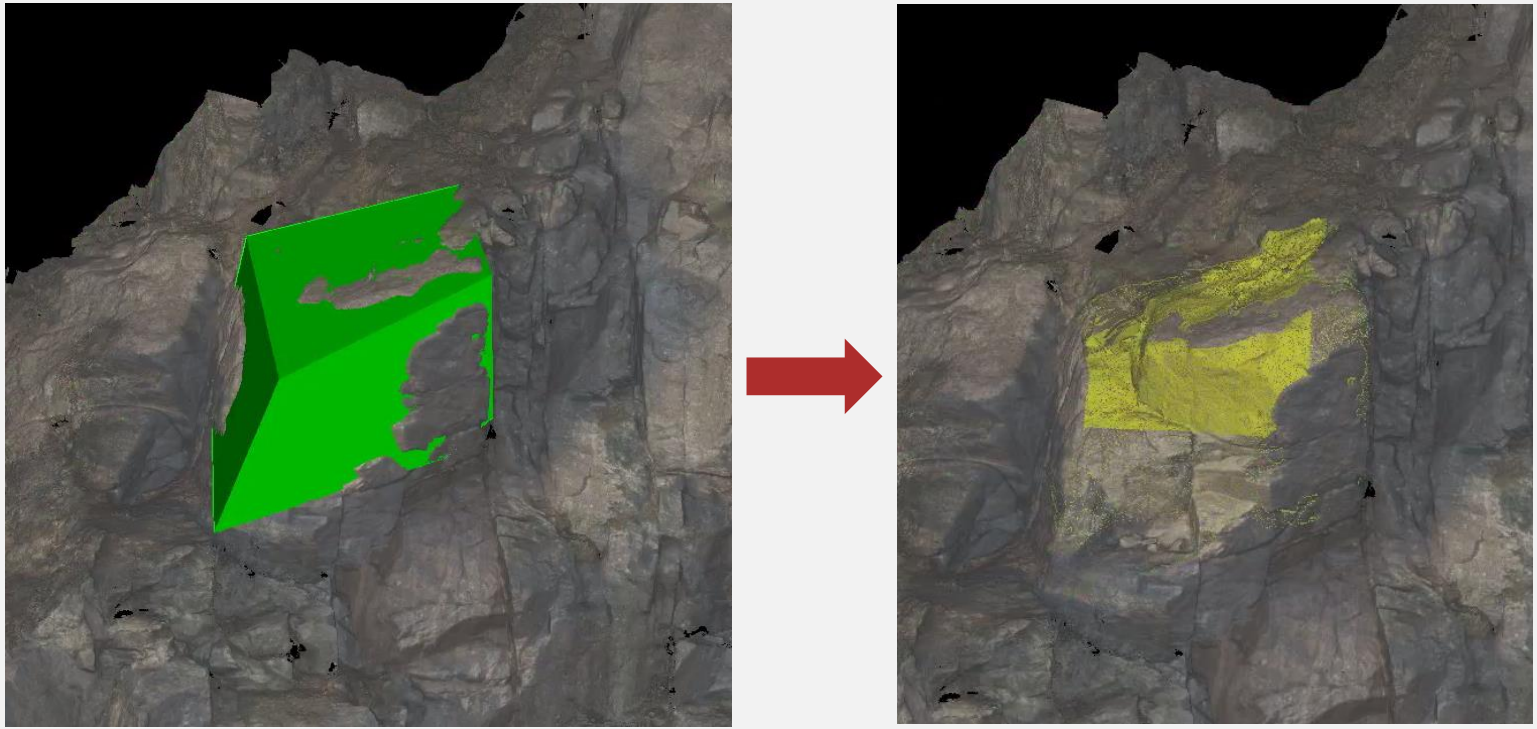
Comment character: #

Output format

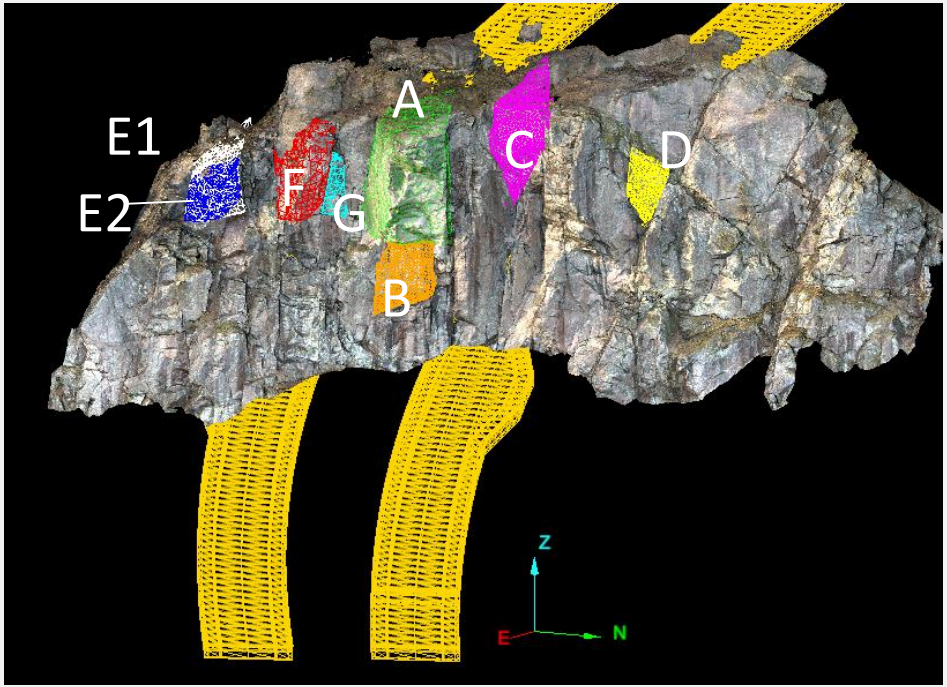
	Name	Length (m)	Centroid X Coordinate (m)	Centroid Y Coordinate (m)	Centroid Z Coordinate (m)
1	discontinuity to discontinuity3	3.313	426,112.554	6,784,724.137	1,441.204
2	discontinuity to discontinuity3 2	3.313	426,112.554	6,784,724.137	1,441.204
3	discontinuity to discontinuity3 3	3.313	426,112.554	6,784,724.137	1,441.204
4	discontinuity to discontinuity3 4	3.313	426,112.554	6,784,724.137	1,441.204
5	discontinuity to discontinuity3 5	3.313	426,112.554	6,784,724.137	1,441.204
6	discontinuity to discontinuity3 6	3.313	426,112.554	6,784,724.137	1,441.204
7	discontinuity4 to discontinuity3	2.329	426,111.903	6,784,732.793	1,443.080
8	discontinuity4 to discontinuity3 2	2.329	426,111.903	6,784,732.793	1,443.080
9	discontinuity4 to discontinuity3 3	2.329	426,111.903	6,784,732.793	1,443.080
10	discontinuity4 to discontinuity3 4	2.329	426,111.903	6,784,732.793	1,443.080

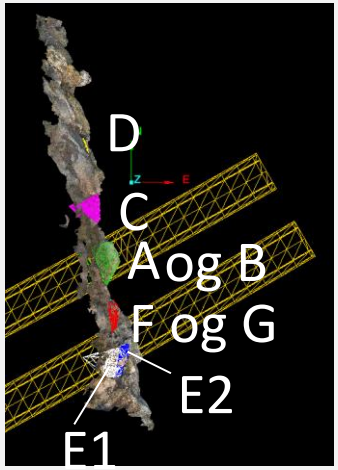
OK Cancel

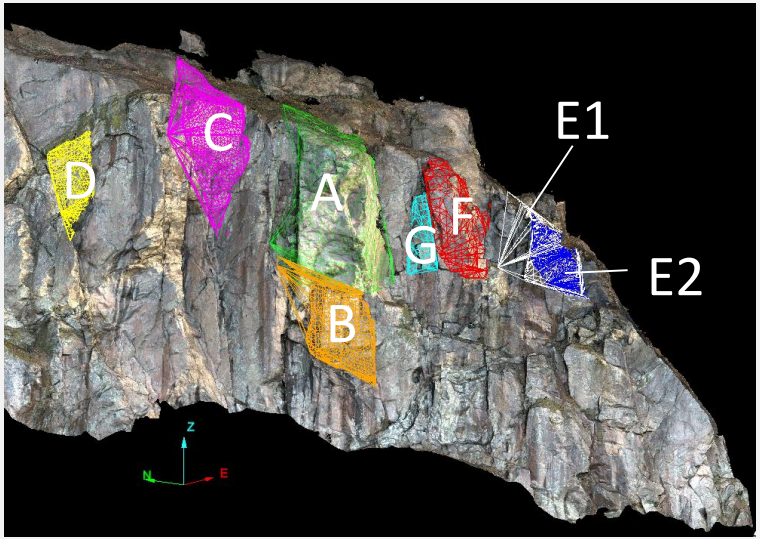
Volume estimation



Volume estimation – agreed with client







E18 Larvik Rock cut failure investigation

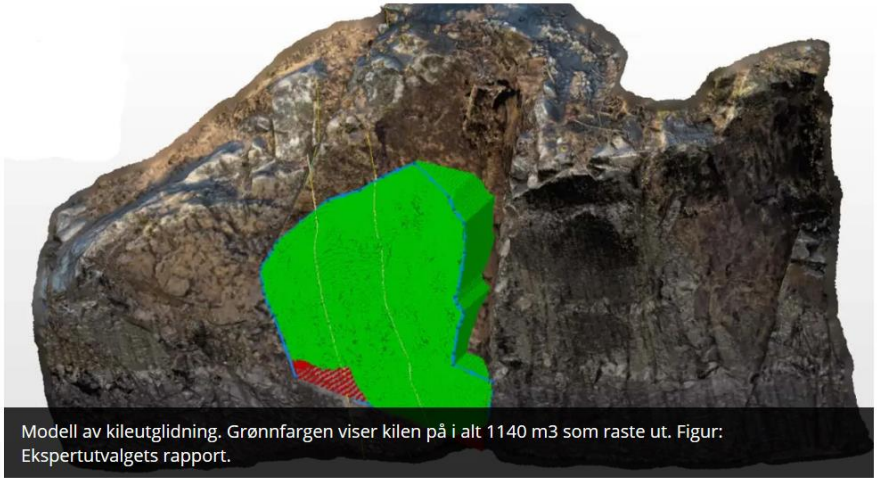
https://www.bygg.no/article/1425649

Byggeindustrien
bygg.no

Les Byggeindustrien digitalt Tips oss Hva

Ekspertrapport om E18-raset: - Boltesikringen vurderes som svært mangelfull

https://geo365.no/ingeniorgeologi/knusende-rapport-klar-etter-e18-skredet-ved-larvik/



Modell av kileutglidning. Grønnfargen viser kilen på i alt 1140 m3 som raste ut. Figur: Ekspertutvalgets rapport.

Home › Ingeniørgeologi

Knusende rapport klar etter E18-skredet ved Larvik

Problemet med den 30 meter høye bergskjæringen ble påpekt allerede i prosjekteringen av motorveien. Hovedkonklusjonen på kileutglidningen langs markerte sprekkeplan er at bergsikringen har vært for dårlig.

Before failture

Google Maps Platform > Documentation

Google Maps Platform Terms of Service

Last modified: November 21, 2019 | Previous Versions

3.2.4 Restrictions Against Misusing the Services.

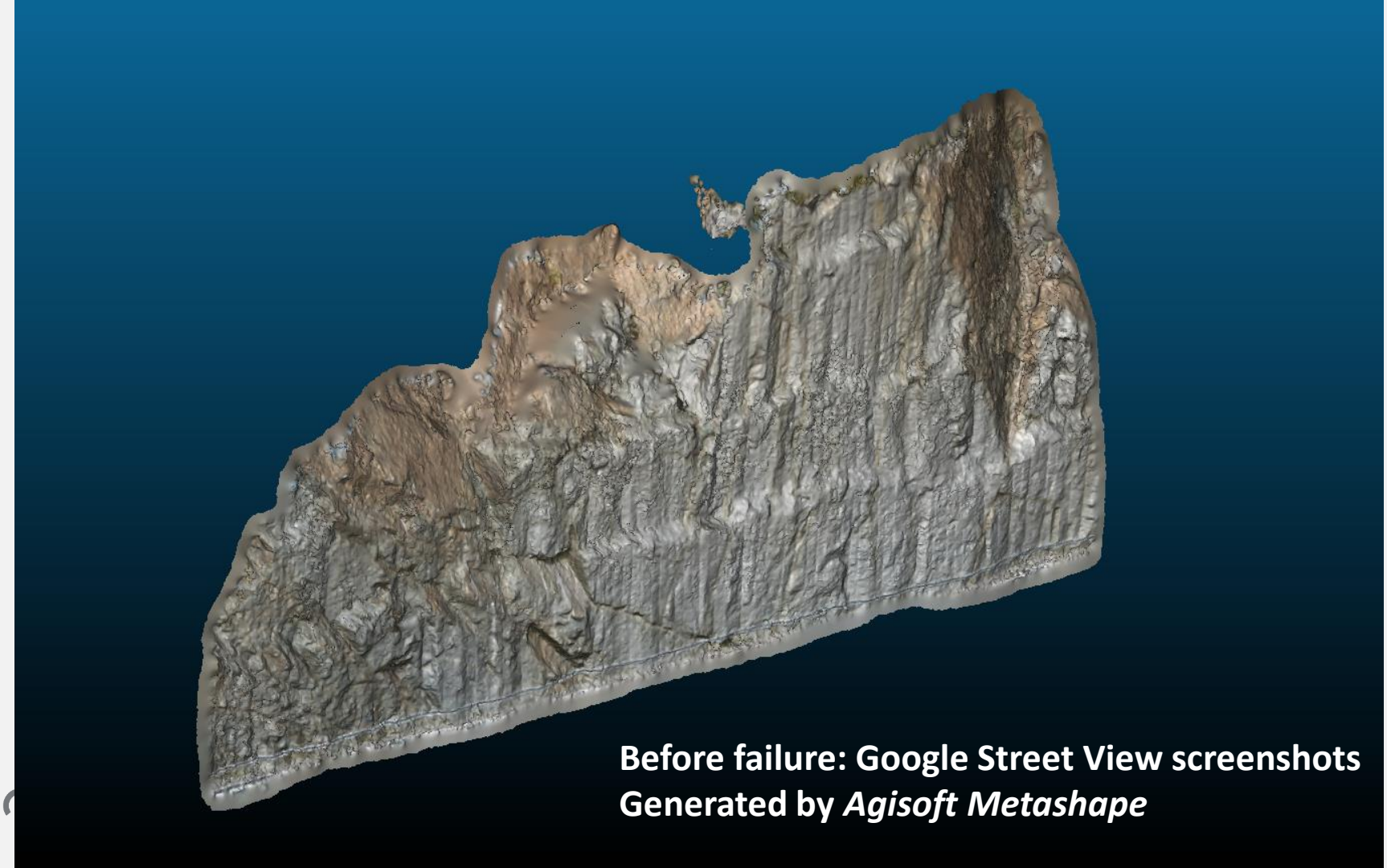
(a) No Scraping. Customer will not extract, export, or otherwise scrape Google Maps Content for use outside the Services. For example, Customer will not: (i) pre-fetch, index, store, reshare, or rehost Google Maps Content outside the services; (ii) bulk download Google Maps tiles, Street View images, geocodes, directions, distance matrix results, roads information, places information, elevation values, and time zone details; (iii) copy and save business names, addresses, or user reviews; or (iv) use Google Maps Content with text-to-speech services.

(b) No Caching. Customer will not cache Google Maps Content except as expressly permitted under the Maps Service Specific Terms.

(c) No Creating Content From Google Maps Content. Customer will not create content based on Google Maps Content. For example, Customer will not: (i) trace or digitize roadways, building outlines, utility posts, or electrical lines from the Maps JavaScript API Satellite base map type; (ii) create 3D building models from 45° Imagery from Maps JavaScript API; (iii) build terrain models based on elevation values from the Elevation API; (iv) use latitude/longitude values from the Places API as an input for point-in-polygon analysis; (v) construct an index of tree locations within a city from Street View imagery; or (vi) convert text-based driving times into synthesized speech results.

(d) No Re-Creating Google Products or Features. Customer will not use the Services to create a product or service with features that are substantially similar to or that re-create the features of another Google product or service. Customer's product or service must contain substantial, independent value and features beyond the Google products or services. For

https://cloud.google.com/maps-platform/terms/#3.-license-.

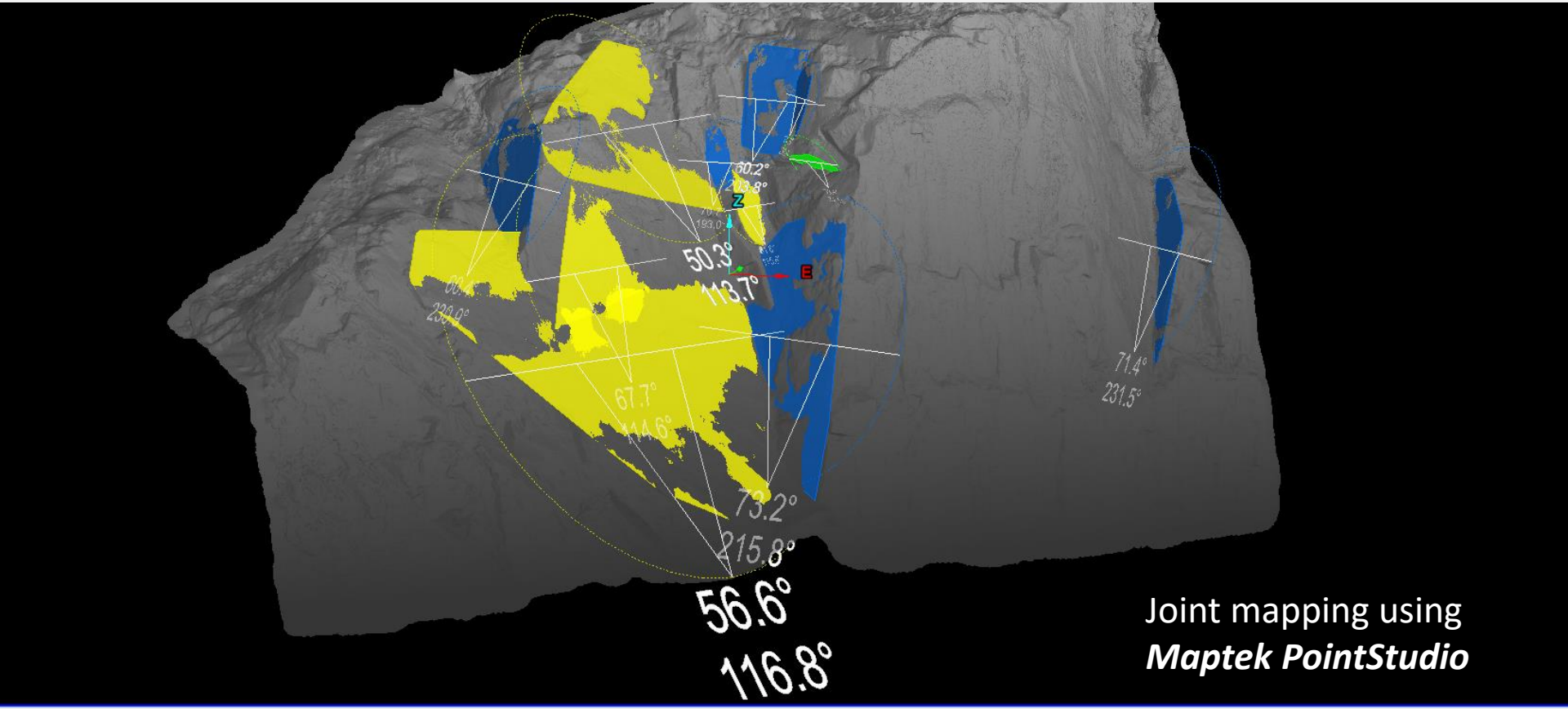


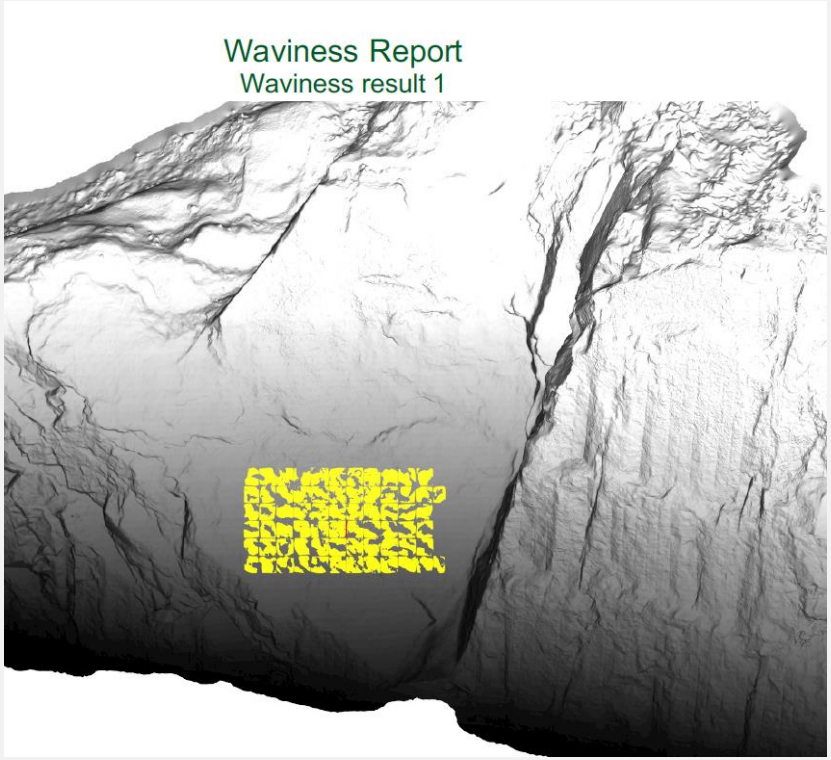
Before failure: Google Street View screenshots
Generated by *Agisoft Metashape*

After failure: Drone + camera pictures
Generated by *Agisoft Metashape*

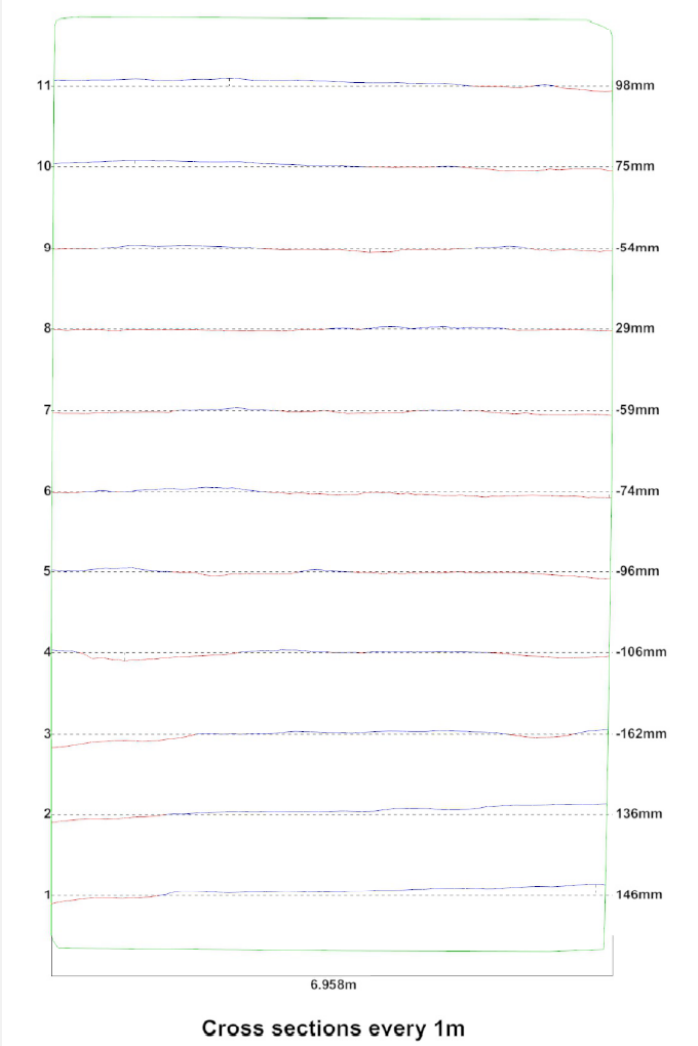

Before and after failure

Georeferencing of models by using Ground Control Points surveyed by DGNSS. Accuracy better than 5 cm


Z
E
50.3°
113.7°
67.7°
73.2°
215.8°
56.6°
116.8°
71.4°
231.5°
Joint mapping using
Maptek PointStudio

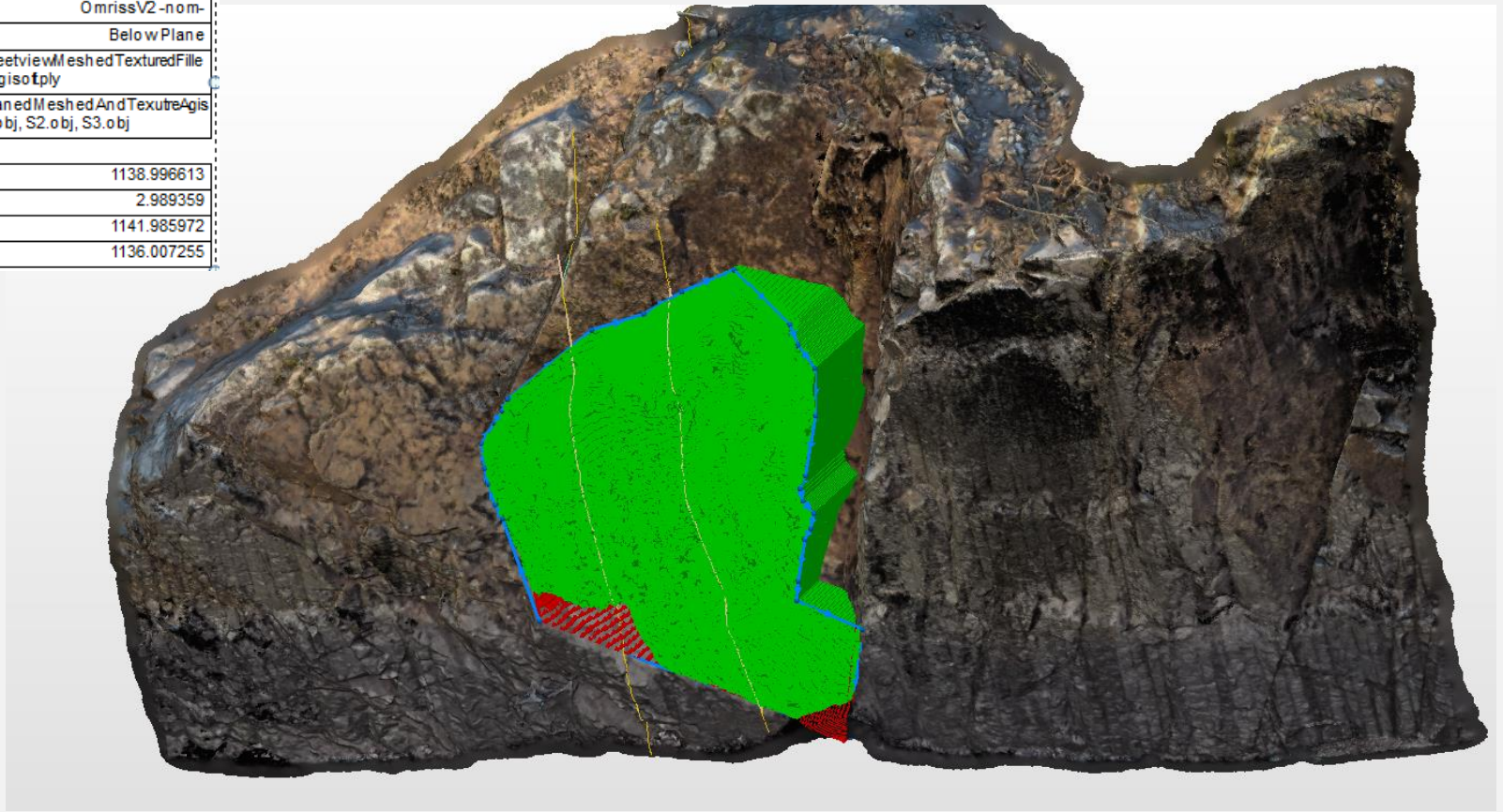


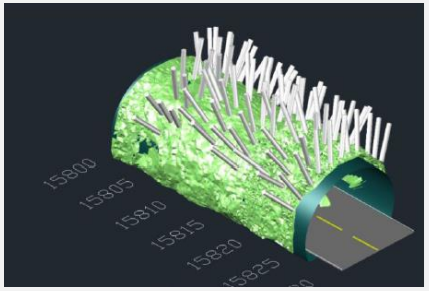
Joint roughness estimation using
Maptek PointStudio

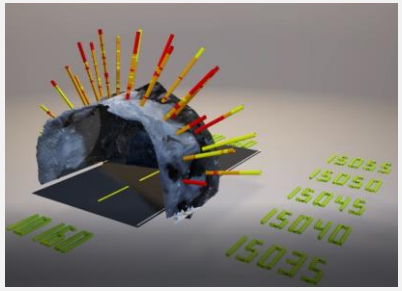


Volume and distance measurement using ***PolyWorks***

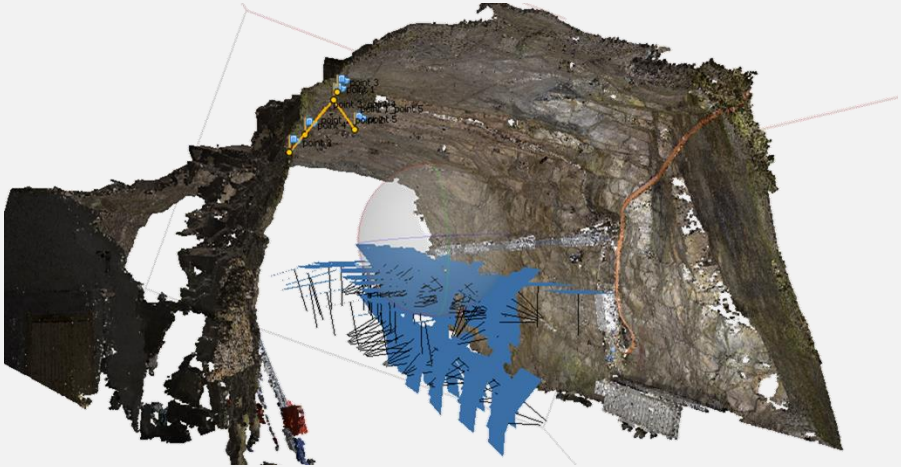
Table Type	Volume
Units	Meters
Method	Data to Data
Reference Plane	plane 4 -nom-
Contour	OmrissV2 -nom-
Direction	Below Plane
Ref Data	GoogleStreetviewMeshedTexturedFilledHolesInAgisoft.ply
Meas Data	SurveyCleanedMeshedAndTexutreAgisoft.ply, S1.obj, S2.obj, S3.obj
Positive Volume	1138.996613
Negative Volume	2.989359
Total Volume	1141.985972
Signed Volume	1136.007255





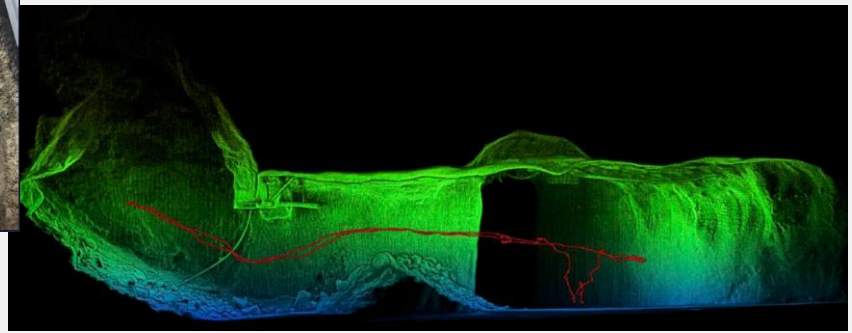


(Source: Bever Control)



Underground?

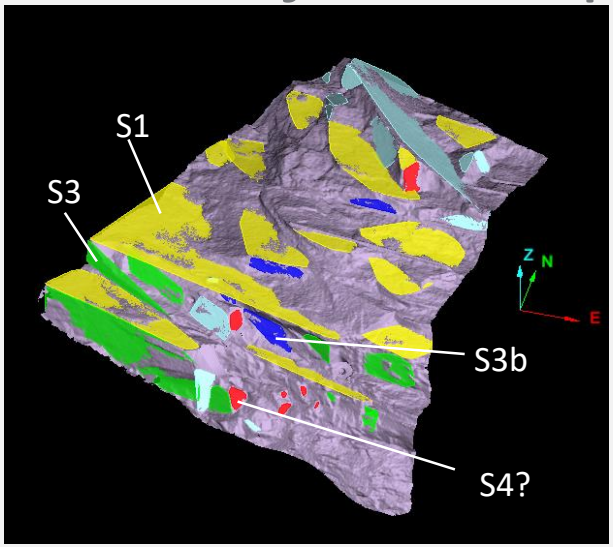
Hoverings Solutions drone

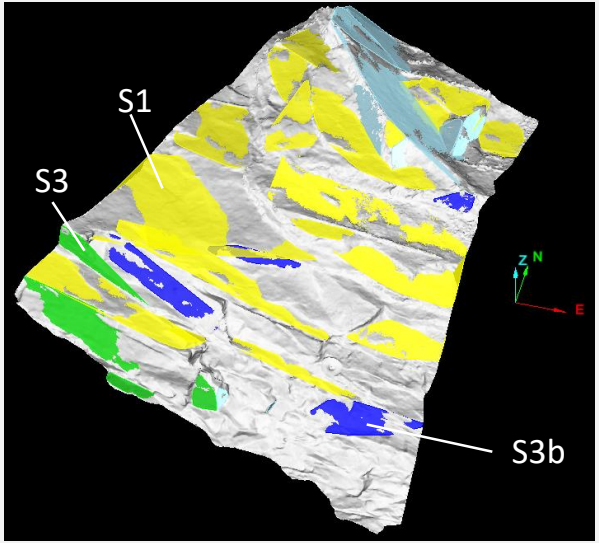


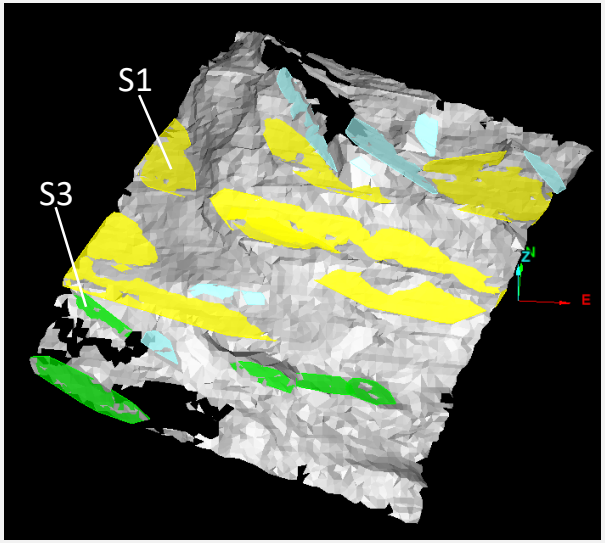
Autonomous flight beyond line-of-sight (source: Emesent)

NGI

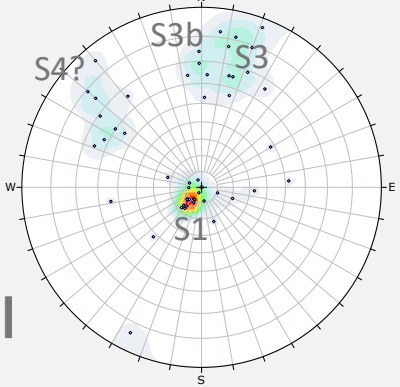
Rock joint mapping in tunnel (Båndkall)



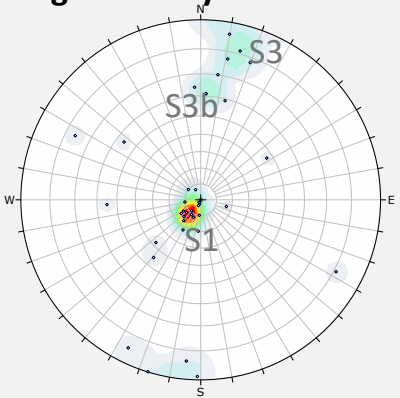




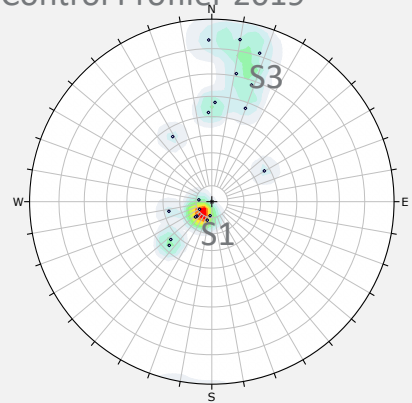
Maptek Laser skanner 2018



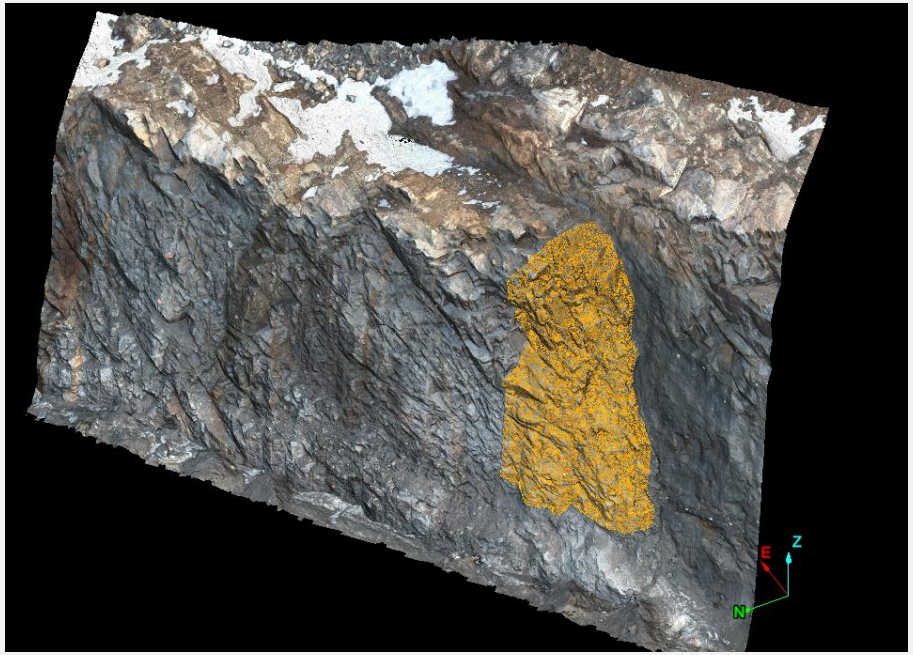
NGI Photogrammetry 2017

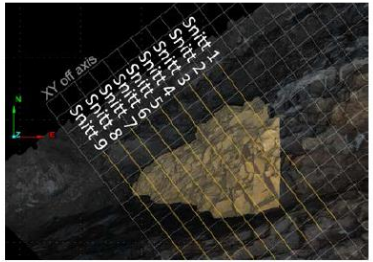


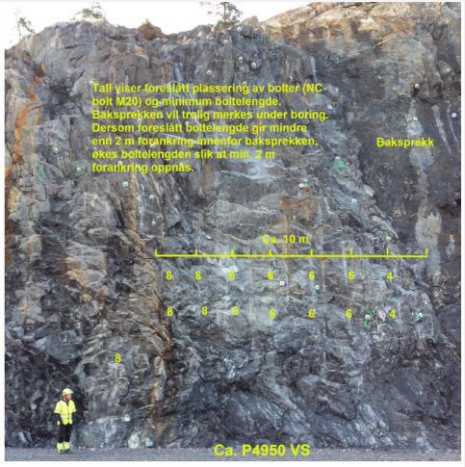
Bever Control Profiler 2019



Further applications of 3D models:

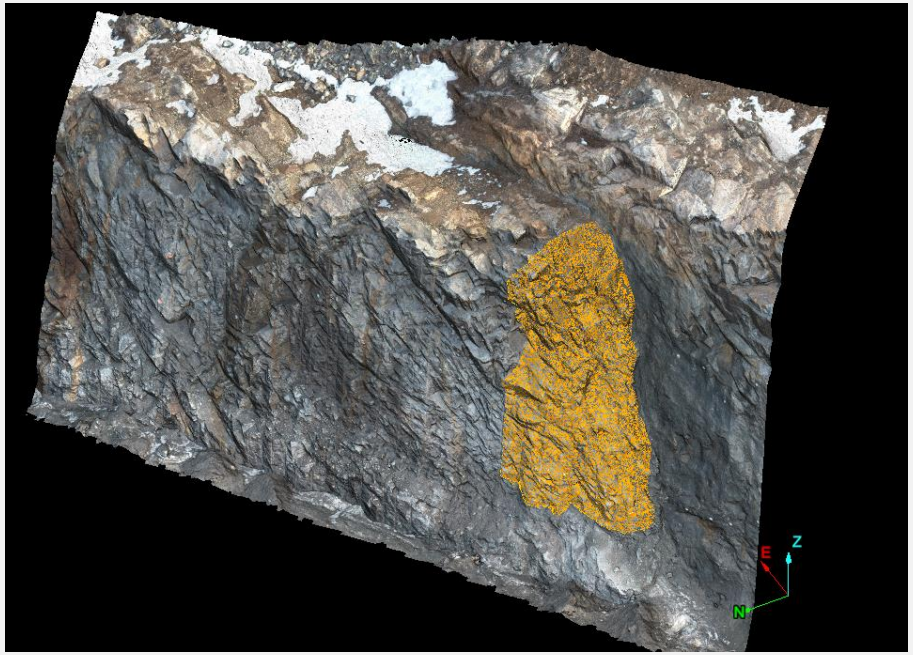


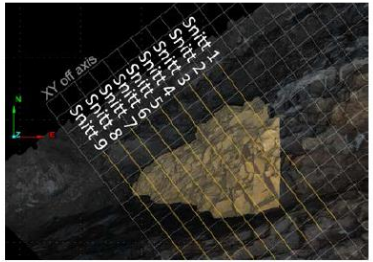


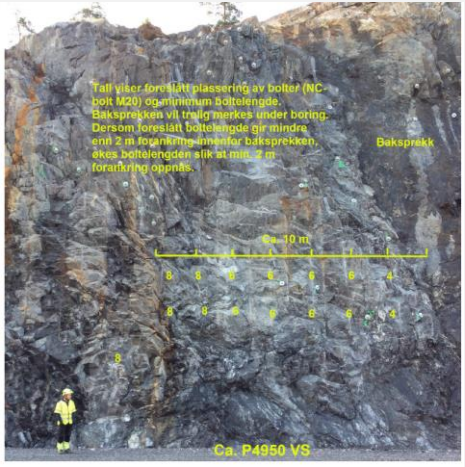


- Example from E18 Rugtvedt-Dørdahl

>> Parametric Designs of rock support







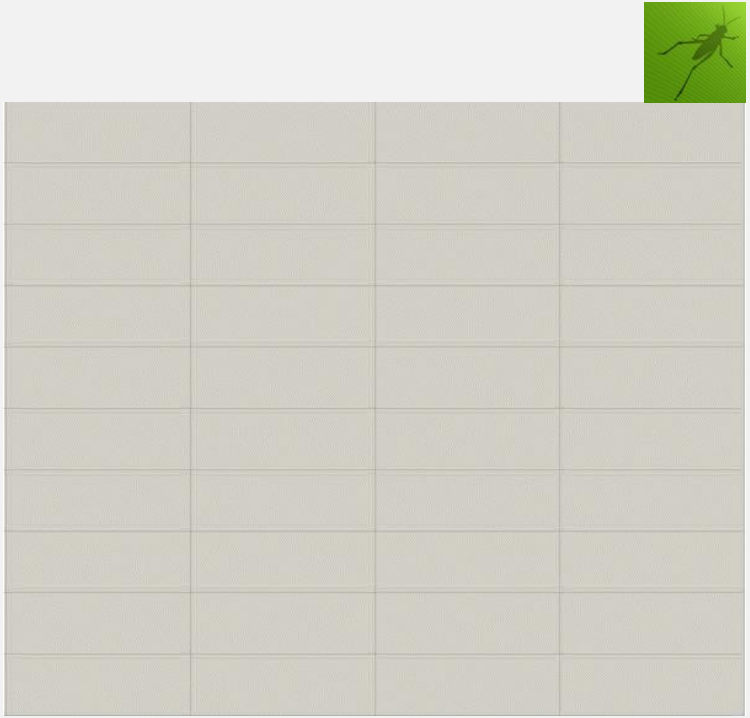
- Example from E18 Rugtvedt-Dørdahl

The what?

- A combination of **CAD software** and **programming interface** to create 3D geometries.

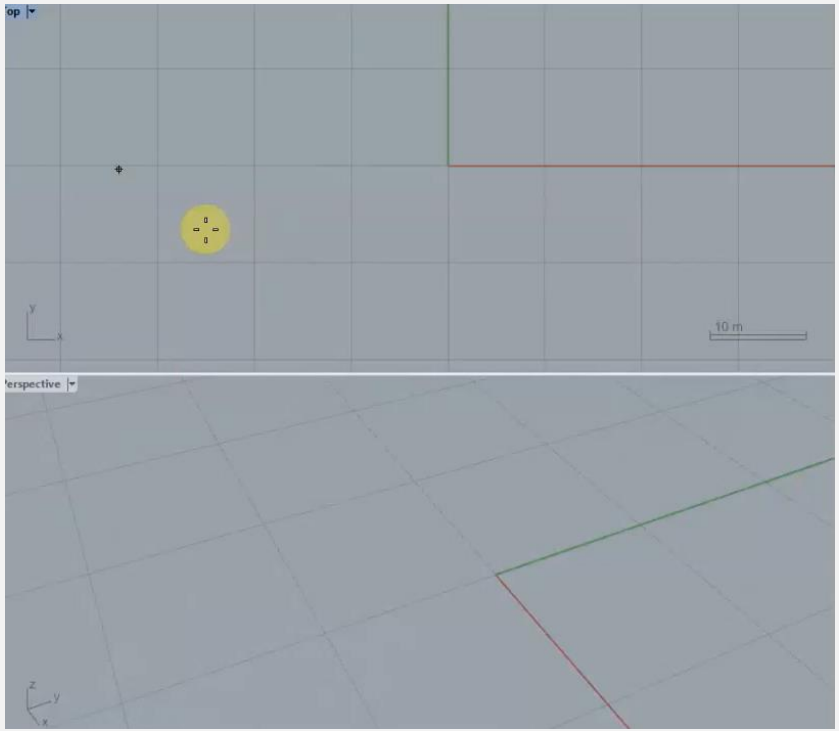
Rhino is used to visualize results (CAD)

Grasshopper is a visual programming tool used to create the geometry, and much more…



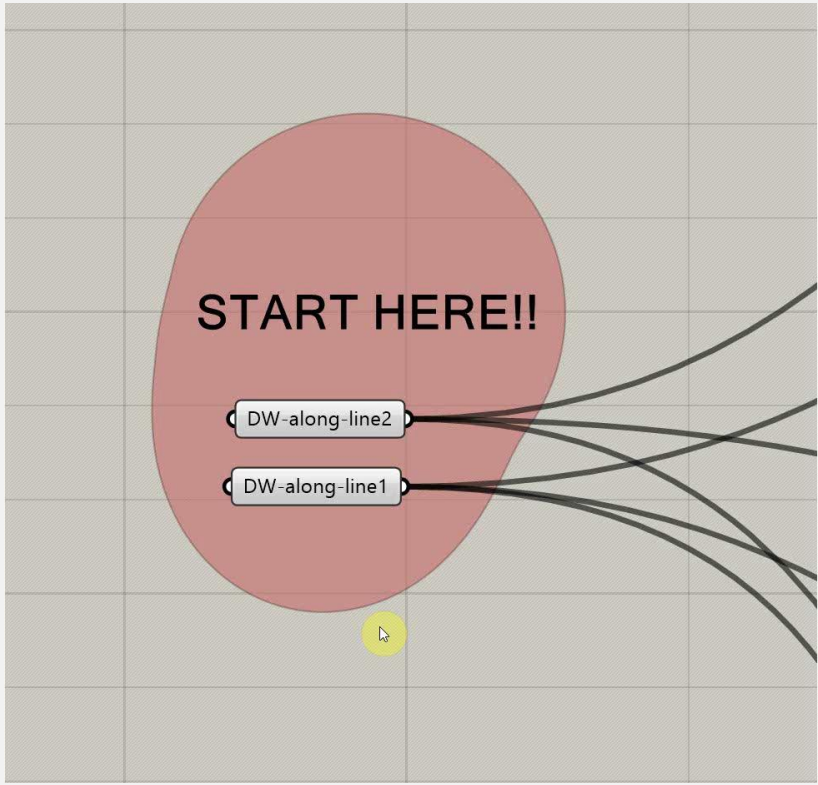
The what?

- Geometries are **parametric** – we can change the parameters to modify the model seamlessly
- Geometries are **computational** – we apply math to create the design
- Geometries can be **generative**– we can iterate the process based on goals to obtain the best solution

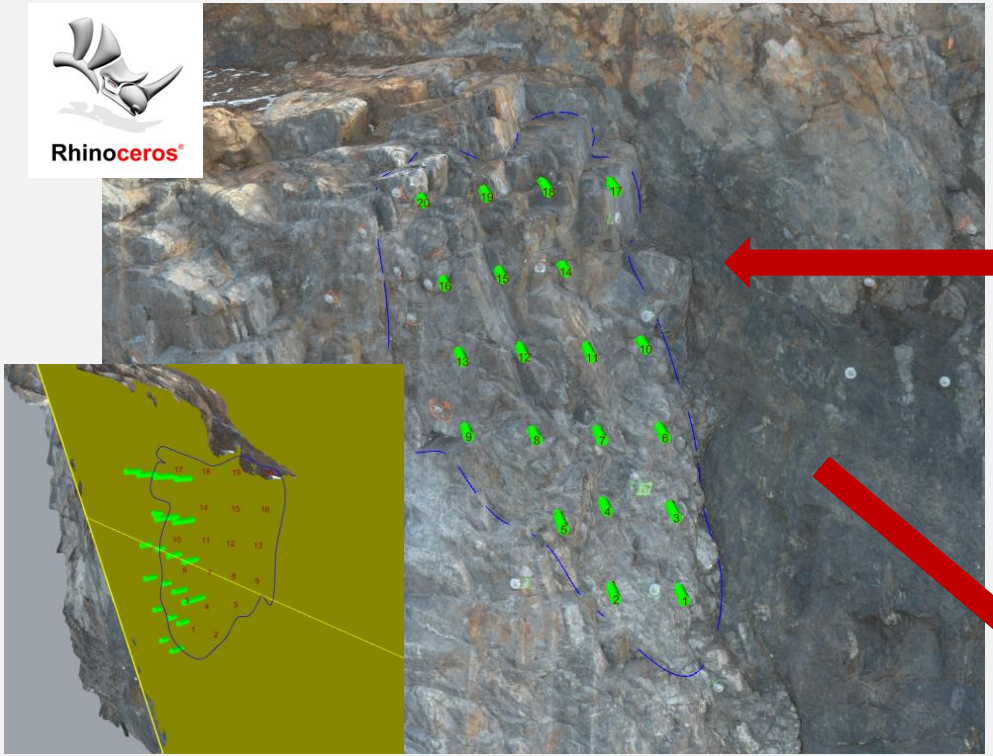


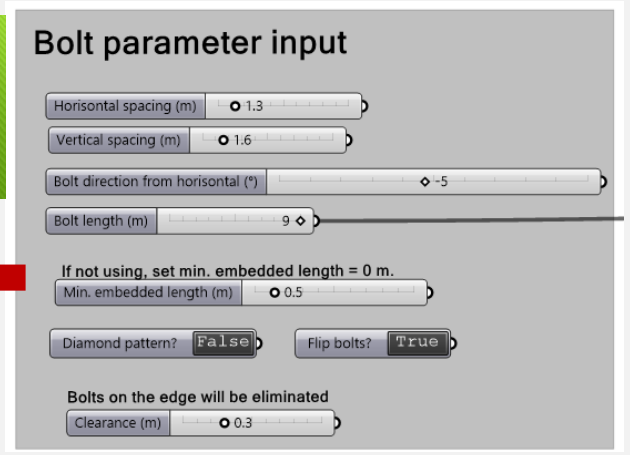
The how?

- It's like scripting – but simply more **intuitive**
- We can create **complex** geometries in 3D with little effort – fast and efficient
- On this geometry we can perform **evaluations** and **analysis**
- We can then **communicate** our design and results using BIM and VR, or export to drawings.
- Suitable for development of **dicipline models** in rock support, rock grouting and geotechnical constructions.



Parametric model of rock support in rock slope





A	B	C	D	E	F	G	H	I	J
Bolt length (m)	Number		Bolt Number	Bolt Length	X Coord	Y Coord	Elevation	Plunge	Azimuth
1.5	0		1	2	21.769567	-5.198002	145.587504	-5	124
2	3		2	3	22.649115	-4.275823	145.587504	-5	124
2.4	2		3	2	22.27705	-5.436059	147.040024	-5	124
3	5		4	2.4	23.325751	-4.682682	147.040024	-5	124
4	4		5	4	23.267962	-3.466384	147.040024	-5	124
5	4		6	2.4	22.715908	-5.511941	148.492543	-5	124
6	2		7	3	23.386757	-4.53564	148.492543	-5	124
8	0		8	4	24.194884	-3.633321	148.492543	-5	124
10	0		9	5	25.149276	-2.800825	148.492543	-5	124
12	0		10	2	23.577395	-5.836122	149.945063	-5	124
Total	20		11	3	23.897317	-4.709063	149.945063	-5	124
			12	4	24.729813	-3.791556	149.945063	-5	124
			13	5	25.294281	-2.762885	149.945063	-5	124
			14	3	24.708527	-4.80247	151.397583	-5	124
			15	5	25.157685	-3.610079	151.397583	-5	124
			16	6	25.504664	-2.507321	151.397583	-5	124
			17	3	24.370203	-5.708706	152.850103	-5	124
			18	4	25.128399	-4.718655	152.850103	-5	124
			19	5	25.595238	-3.601407	152.850103	-5	124
			20	6	26.031181	-2.432927	152.850103	-5	124

#onsafeground

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