TERRESTRIAL LASER SCANNING AND APPLICATION IN GEODETIC ENGINEERING

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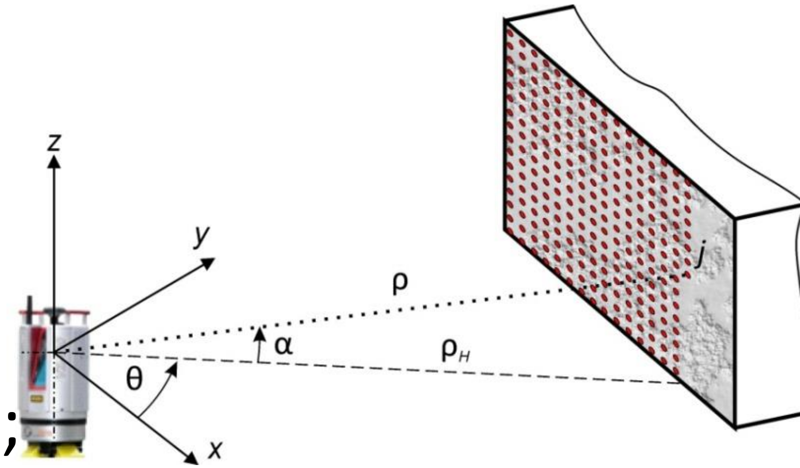
TLS method and data workflow

- Realistic and accurate 3D model → reverse engineering, architecture, civil engineering, urban planning, heritage documentation, etc.;
- Terrestrial laser scanner → very high spatial density of the acquired data and very high geometric accuracy;
- TLS workflow involves: measurement planning, setting up a survey reference frame, scanning, registration and/or georeferencing of scans, point cloud 3D modelling and analysis;

From scanning to information…

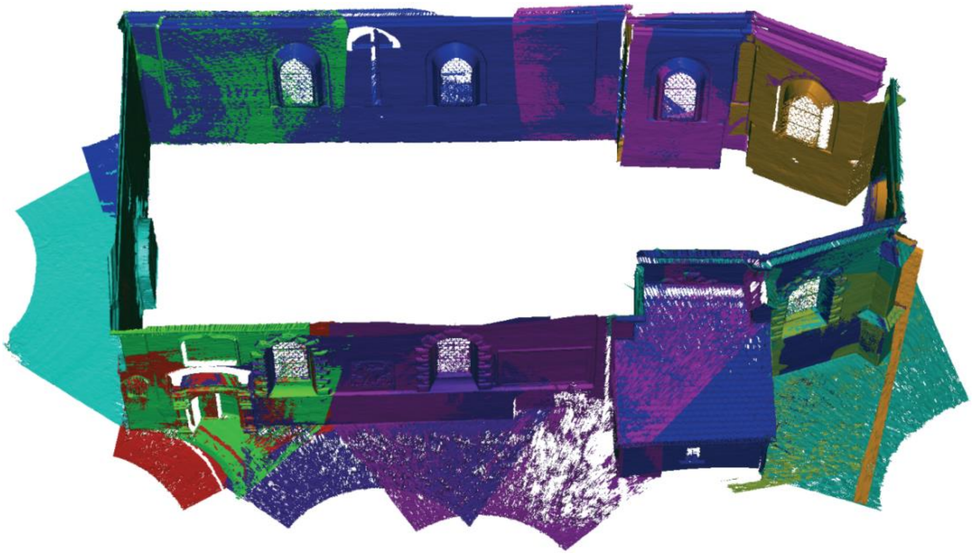
- Point cloud
  a. Range and directions measurements → 3D information;
  b. + intensity → 4D information;
  c. + RGB value of 3D point

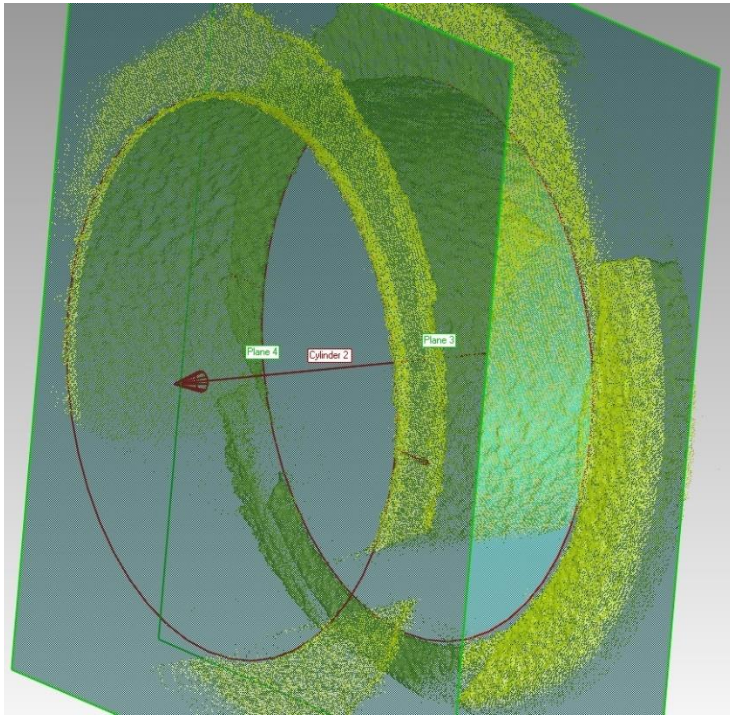


a. b. c.

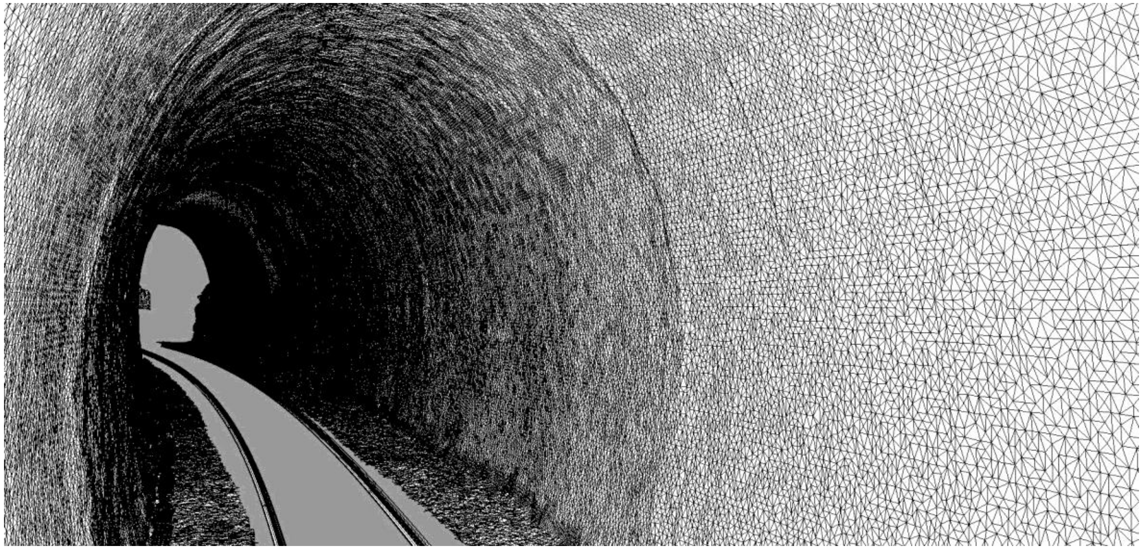
From scanning to information…

- Registration and georeferencing;
- 3D model;
  a. Parametric surfacing,
  b. 3D meshing.



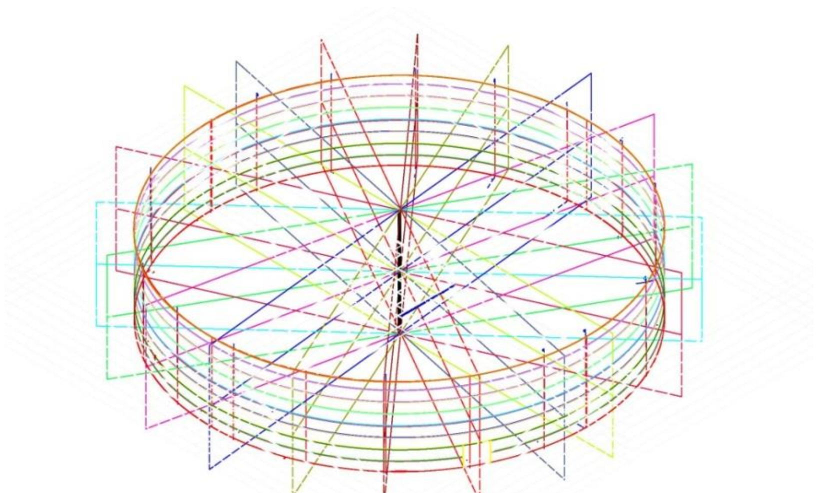


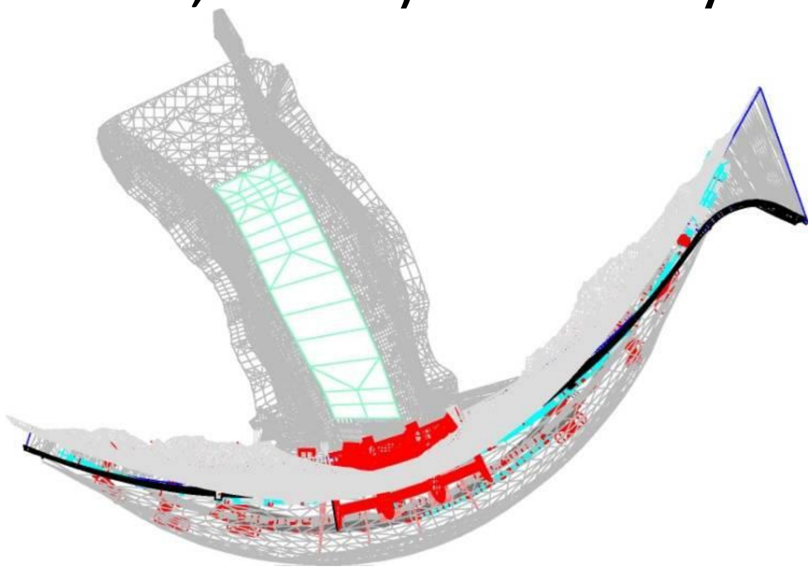
Lola, 2014.

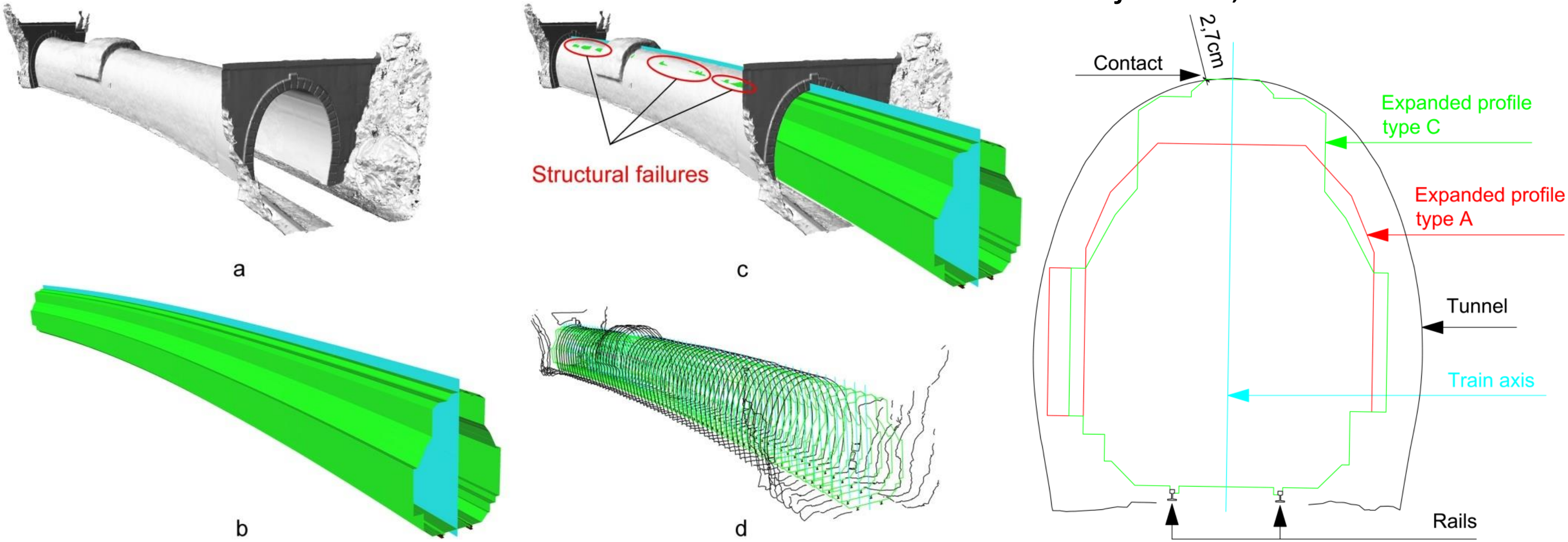


Pruga Nikšić-Podgorica railway, 2012.

CAD products (3D models, intersections, views) and analysis.

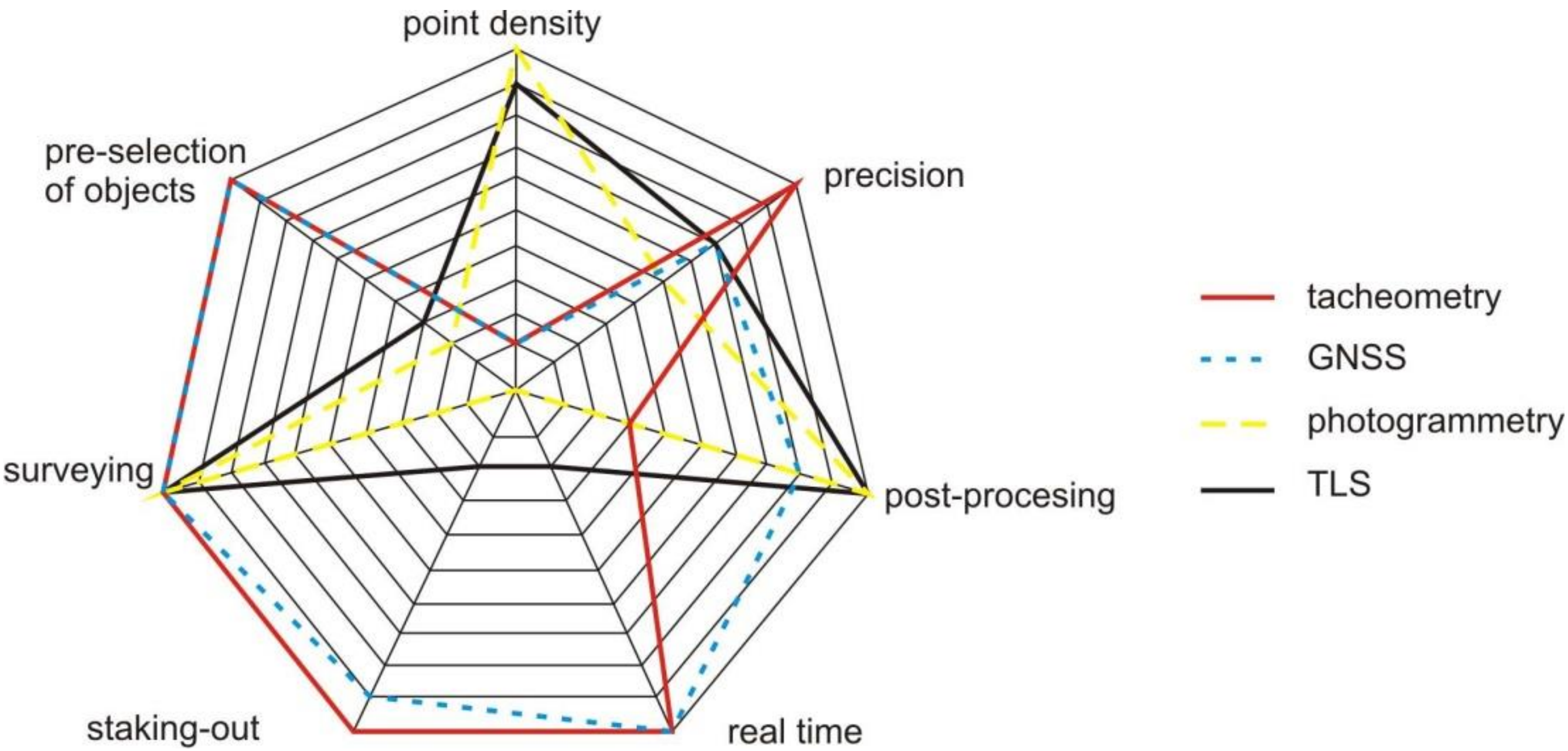

Oil reservoirs, Smederevo, 2010.


Mratinje Dam, 2010.



Nikšić-Podgorica railway, tunnels, 2012.

TLS over traditional surveying instruments and methods

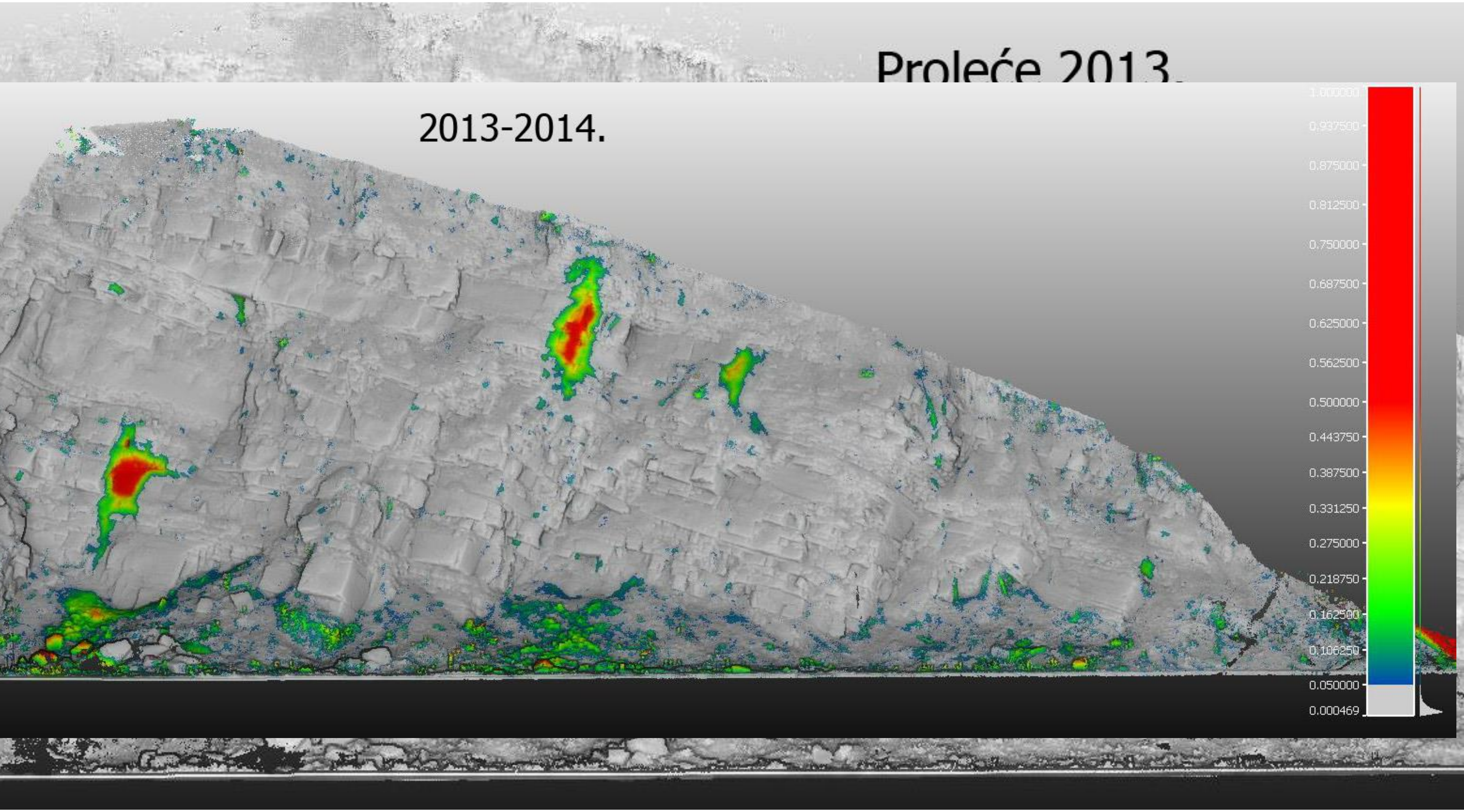


The main features of the commercial TLSs for use in architecture

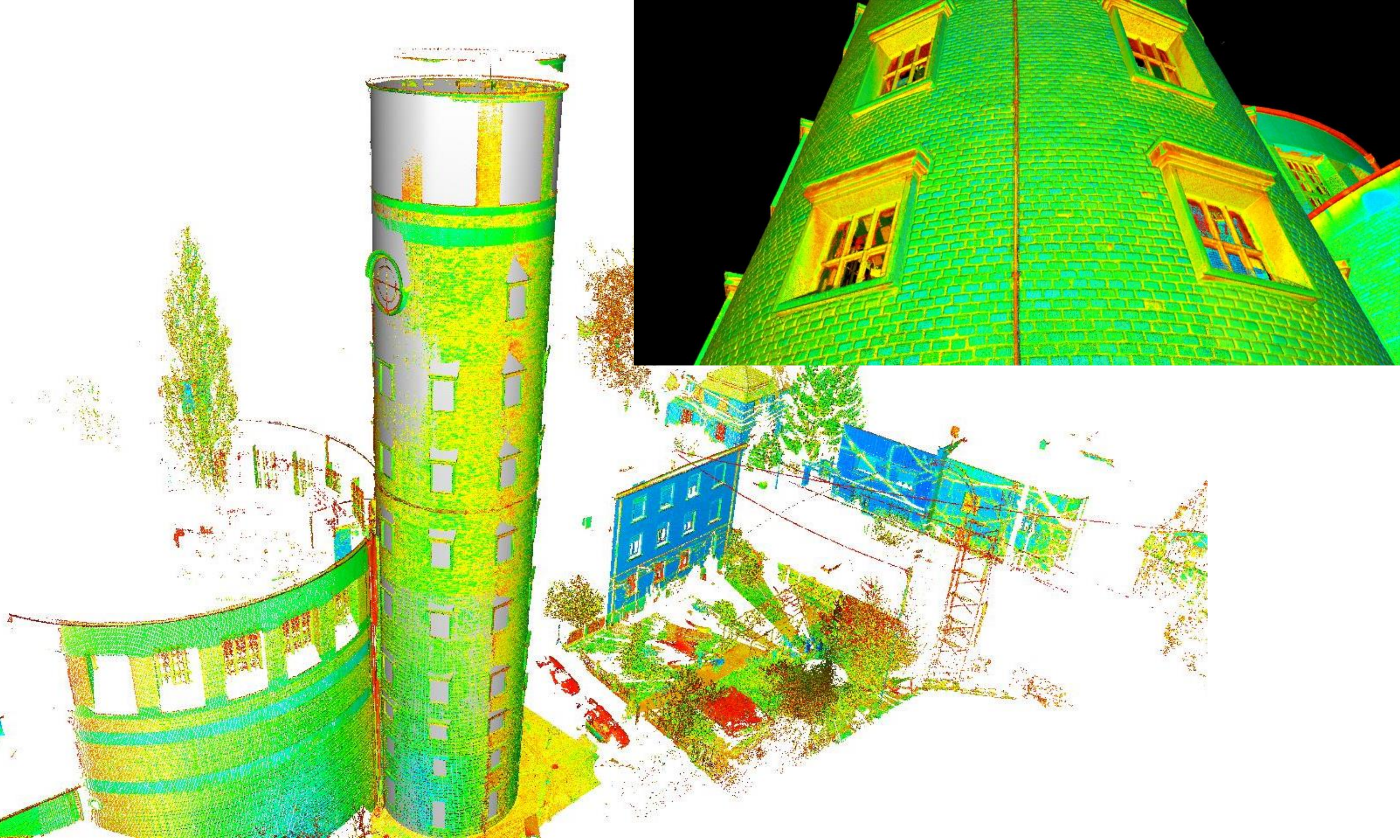
Manufacturer / Model		Precision	Resolu-tion	Speed [pts/s]	Field of view [°]	Range [m]
Leica Scan Station P20		3D position: 3 mm/50 m Linearity: < 1 mm Angular: 8" Targets: 2mm	up to 0.8 mm/ 10 m	up to 1 million	360/270	120
Riegl VZ-400		3D position: 5 mm/100 m	1.8"	42000 122000	360/200	600
Zoller+ Fröhlich IMAGER 5010		Range:1.2 mm/50 m, 3.8 mm/100 m Angular: 25" Model: 2 mm	V: 1.4" H. 0.7"	1.016 x 10^6	360/320	187
Trimble CX 3D		Position: 7.3 mm/50 m Range: 2 mm/50 m Angular: 15"/25" Model: 3 mm	7"	54000	360/300	80
FARO Focus3D		Range: 2 mm/25 m	30"	0.976 x 10^6	360/305	120
Optech ILRIS-3D		Range: 4 mm/100 m Angular: 16.5"	4"	-	40/40	1200

Typical TLS engineering application

Landslide monitoring

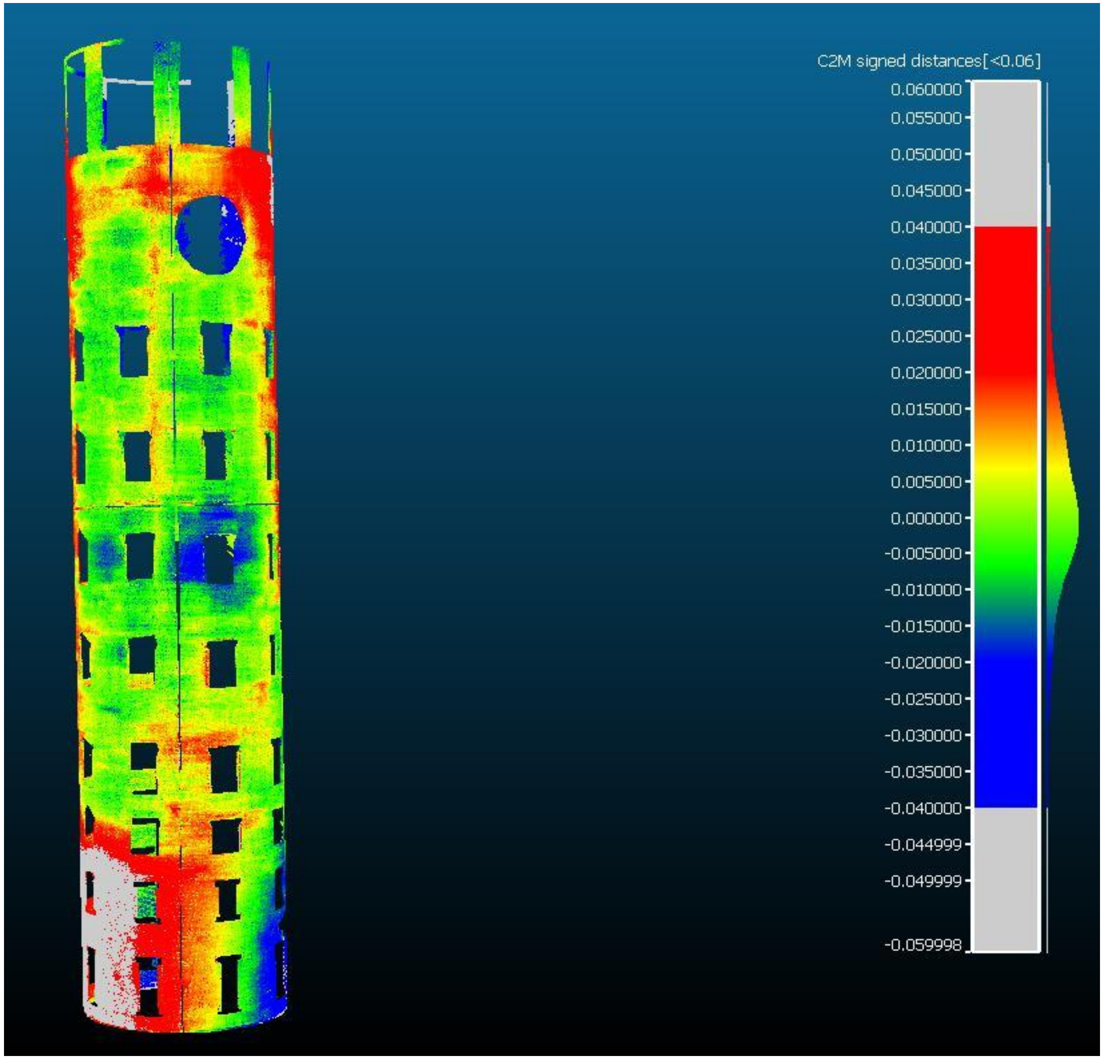


Landslide, road M-22, near Ljig.



Geometry analysis, Saint Anthony of Padua Church, 2015.

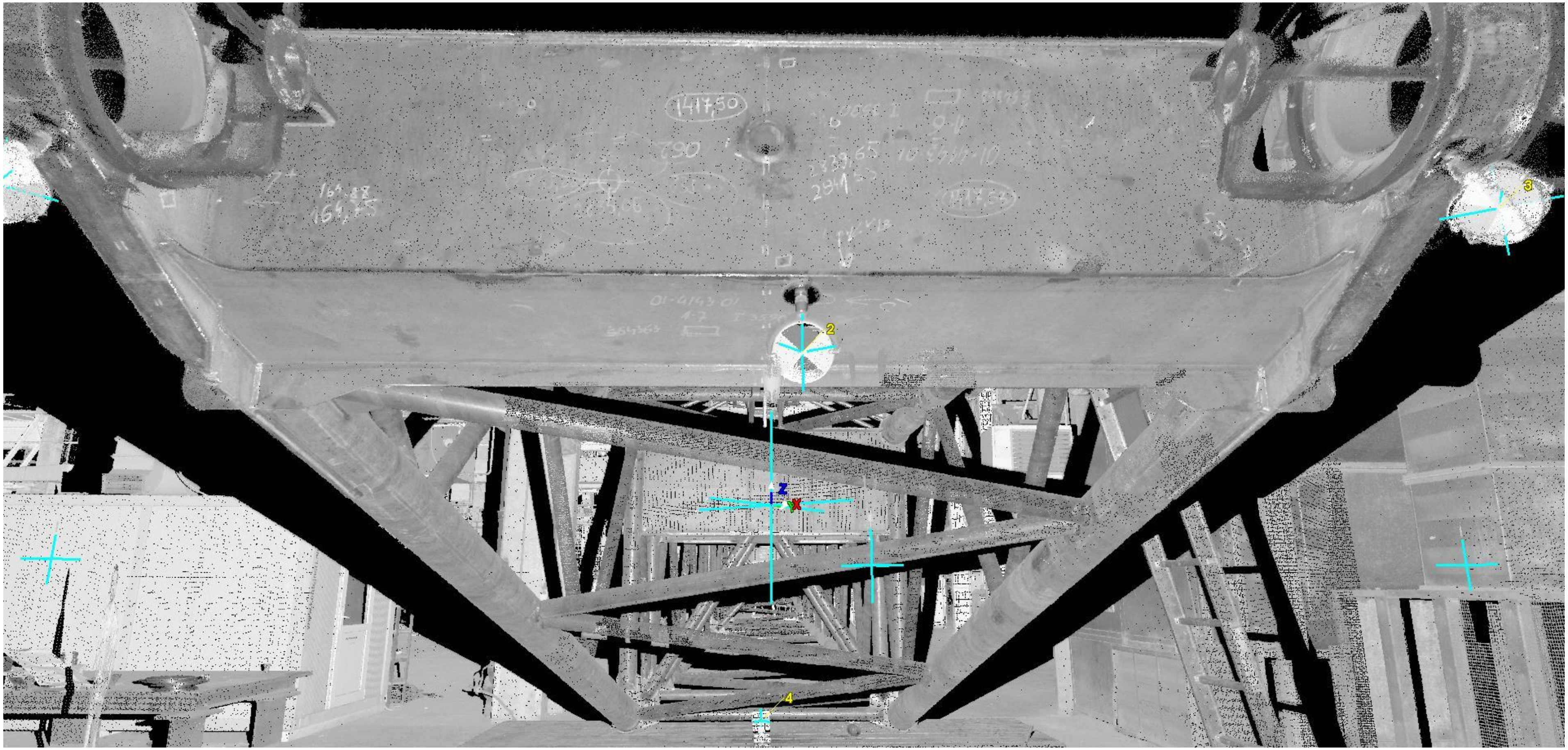
Geometry inspection of tower



Cylinder Fit Quality:
(Derived from cloud with 213 304 075 points)

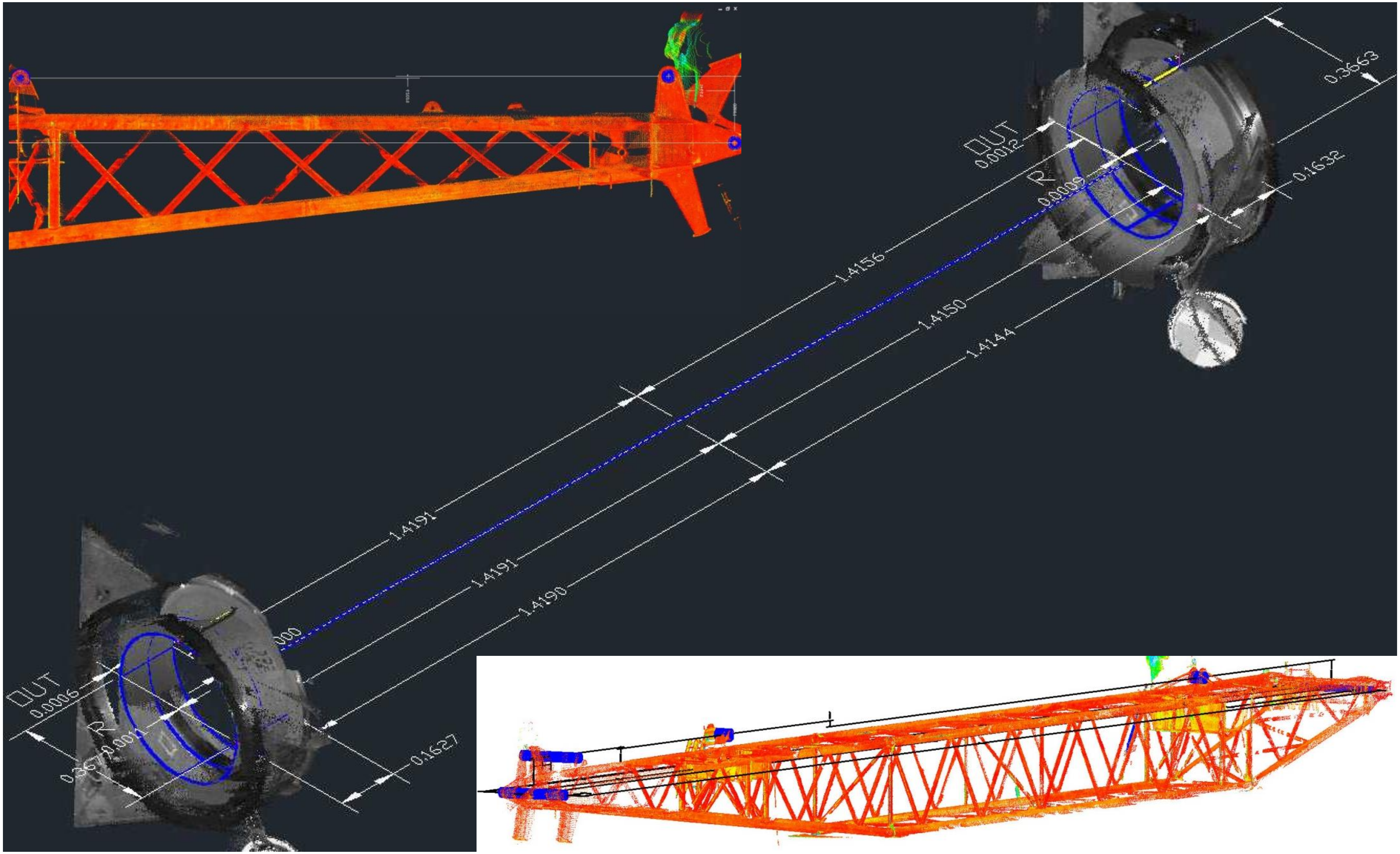
Standard Deviation (1σ) = 5 mm
Cylinder Diameter = 8,962 m
Height = 42,999 m
Total height = 47,393 m
Tilt = 1° 27`40"
Tilt in horizontal plane = **1,208** m

As built geometry analysis of crane, Lola, 2015.



Mechanical engineering, Point cloud, XYZ+I

Tolerances and „as built“

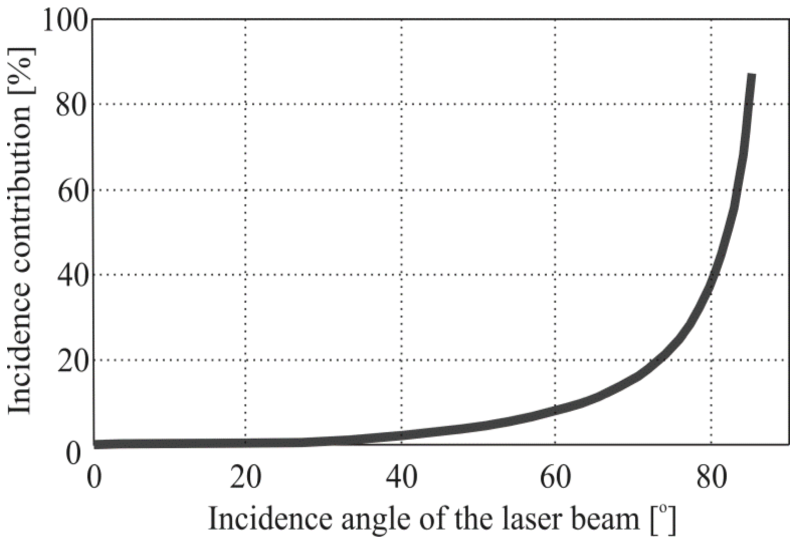


Lola, 2015.

Railway tunnels - geometry inspection, 2012.

Design and optimization of laser scanning for tunnels geometry inspection

narrow and elongated objects → unfavourable case to provide geodetic measurements of a sufficient **accuracy** and **reliability**

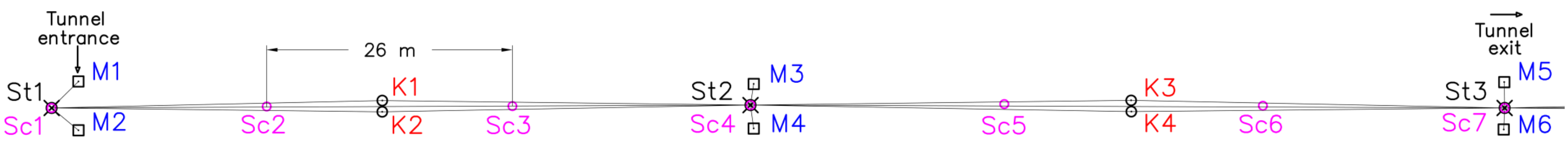


Design factors:

- incidence angles
- tunnel geometry
- georeferencing approach

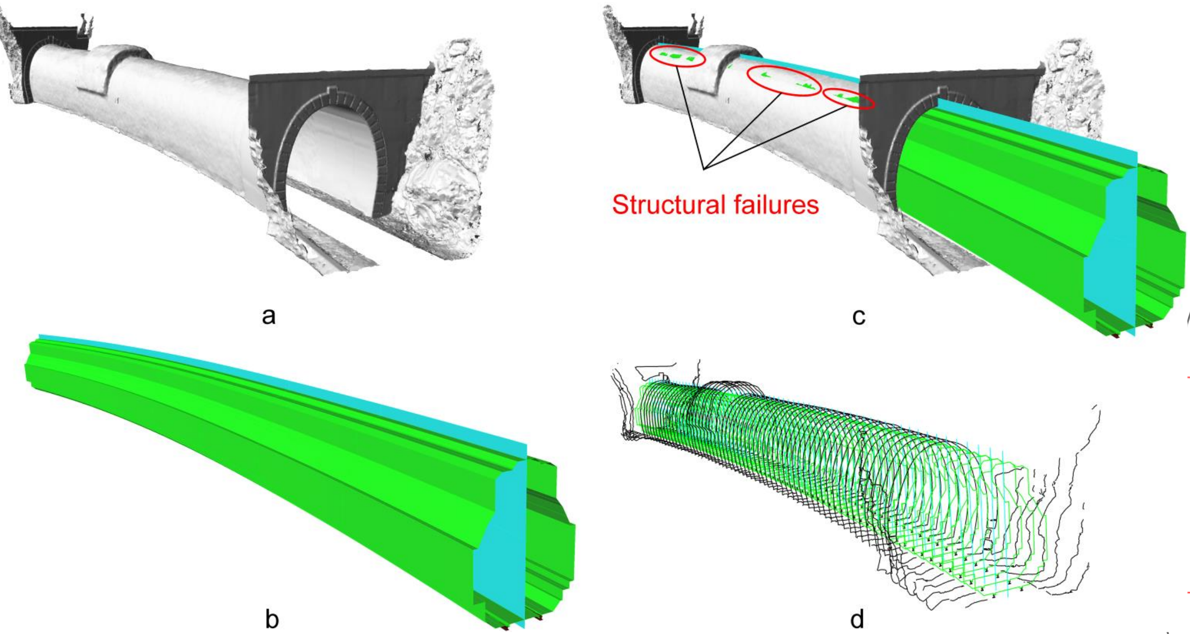
The criterion of variance component significance:

$$B^2 \leq \frac{2\alpha - \alpha^2}{(1-\alpha)^2} \cdot A^2 \qquad B \leq \frac{1}{3} \cdot A, \;\; \alpha = 0.05$$



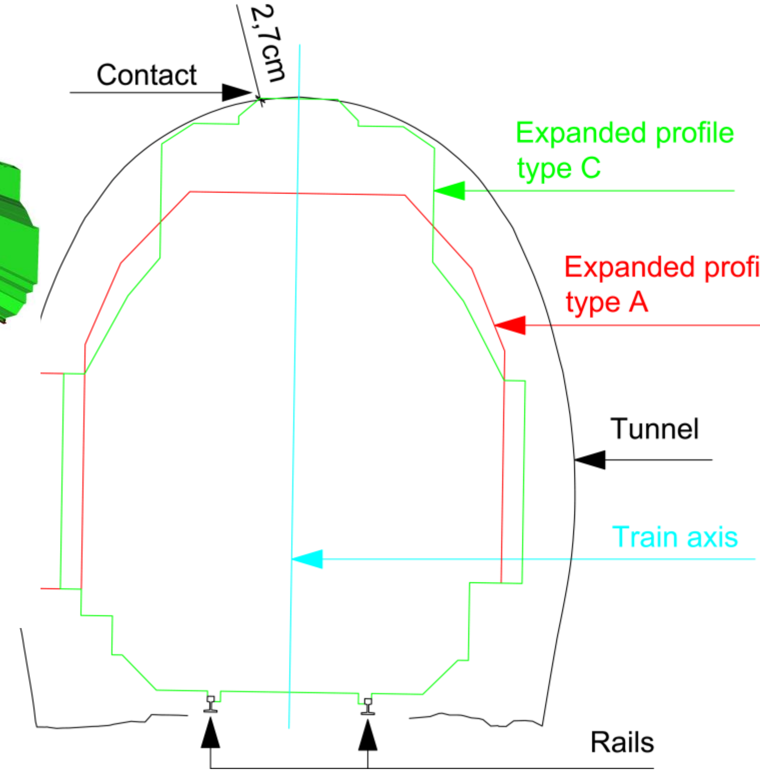
Position of the control points (S_t, M and K) and scanner positions S_c in a section of example tunnel.

Modelled tunnel and expanded profile of the train

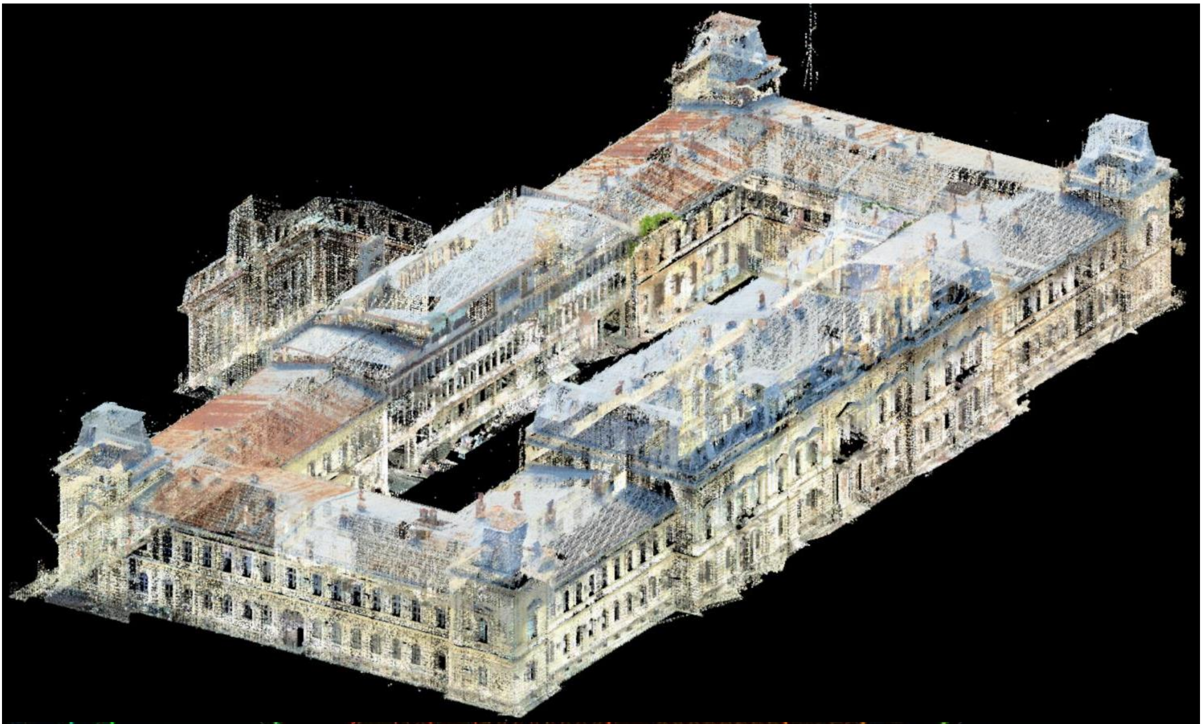


(a) tunnel surface, (b) expanded profile of the train, (c) estimated clearances and failures and (d) 1 m cross sections; The tunnel mesh is created from the scan data. The expanded profile of the train is modelled in respect to the surveyed positions of the rails

Example of a tunnel cross section



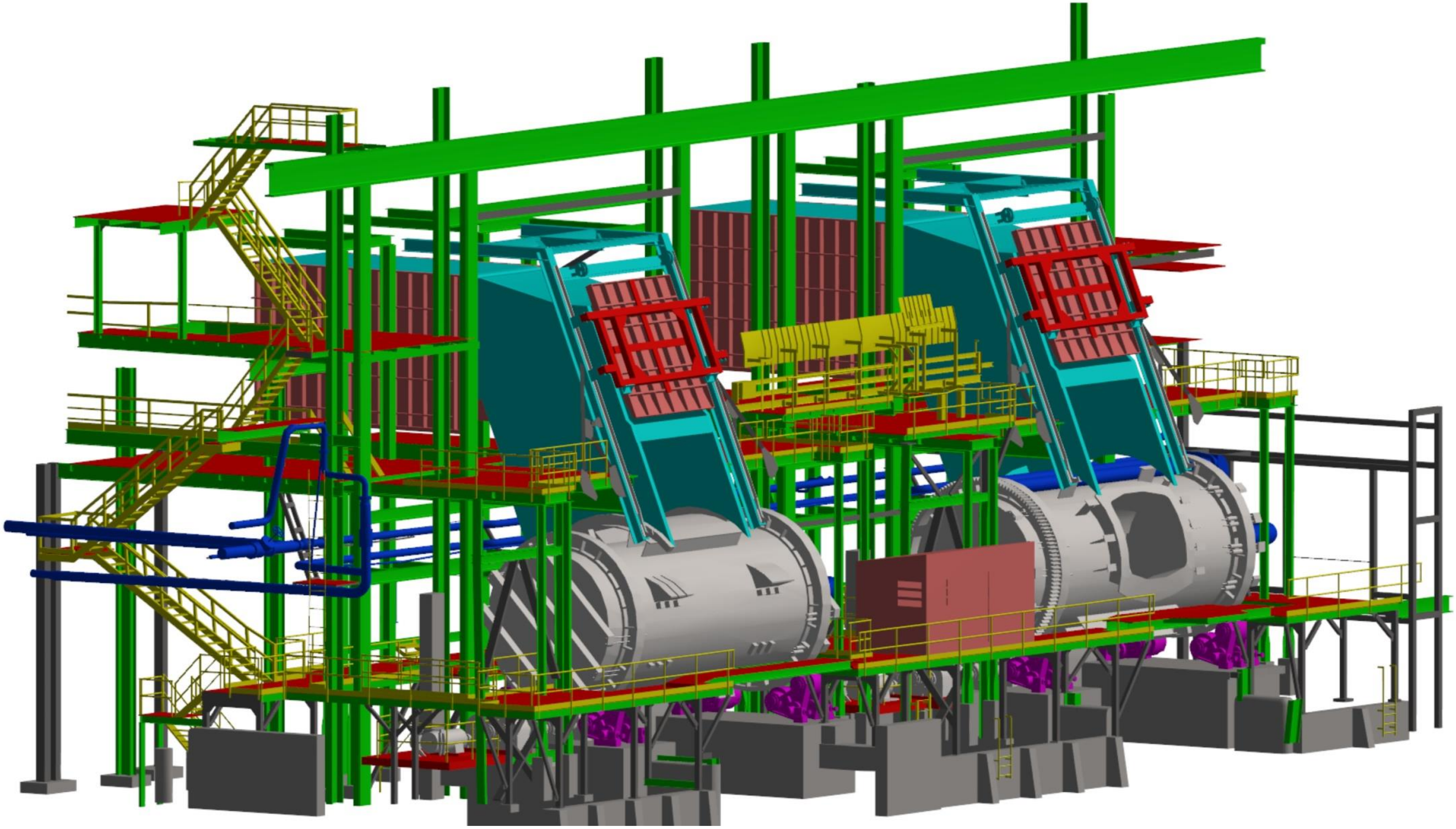
Geometry and clearances of a tunnel and expanded profile of the train. Detected contact of the expanded profile of the train with tunnel sheeting



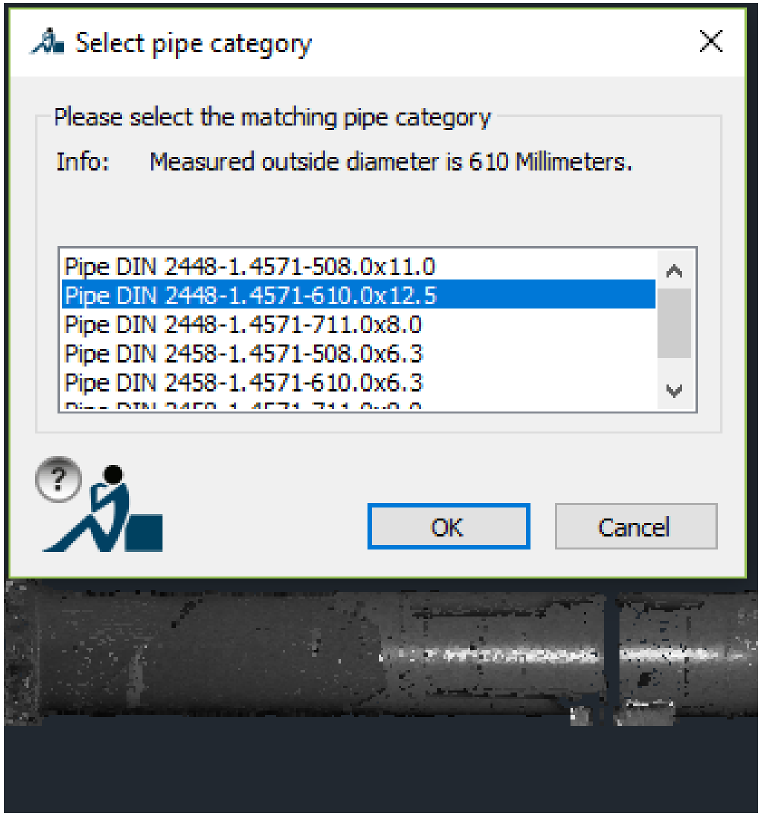
Revitalization of the facade, Požarevac district office, 2014.

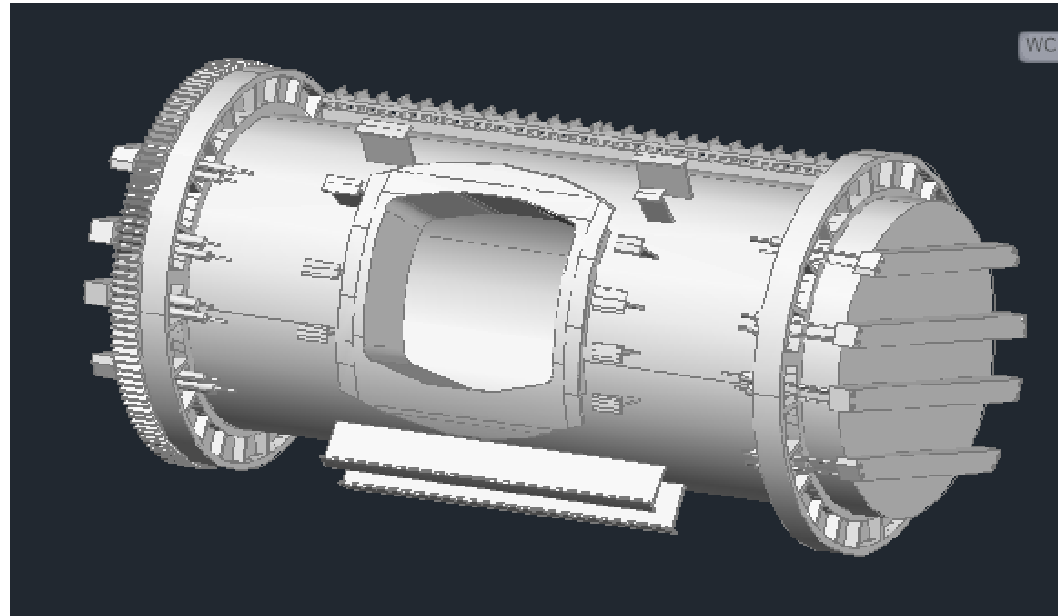
Architectural drawings

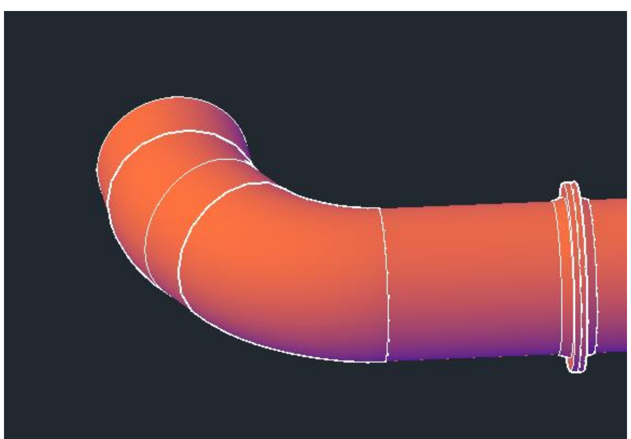
Ore smeltery, RTB Bor, 2015, Parametric model

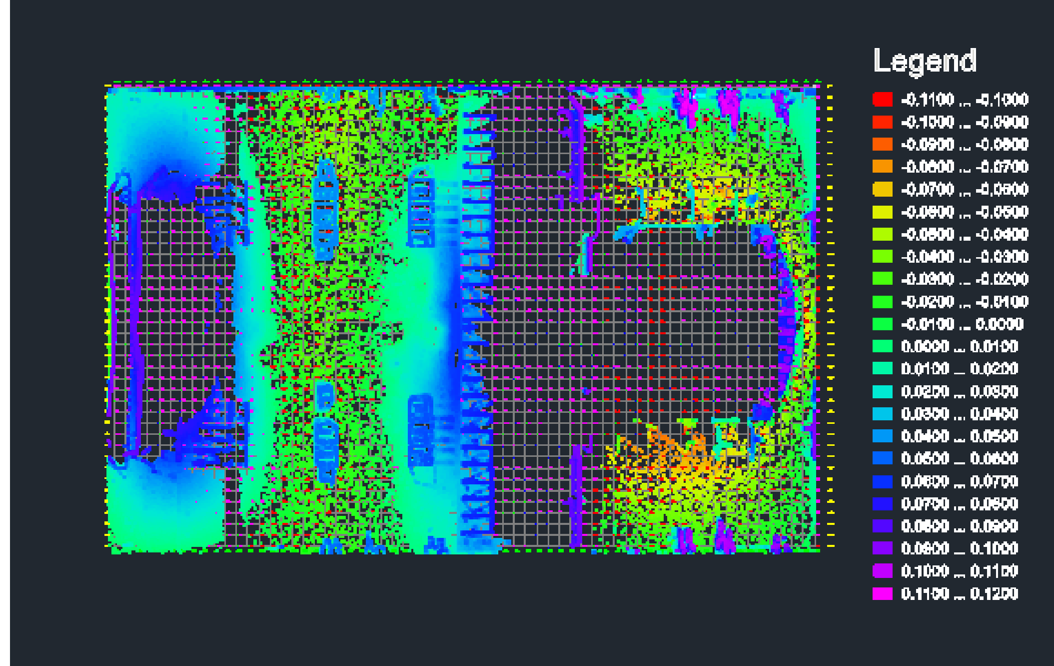


Modeling and Expertise, Ore smeltery, RTB Bor, 2015.





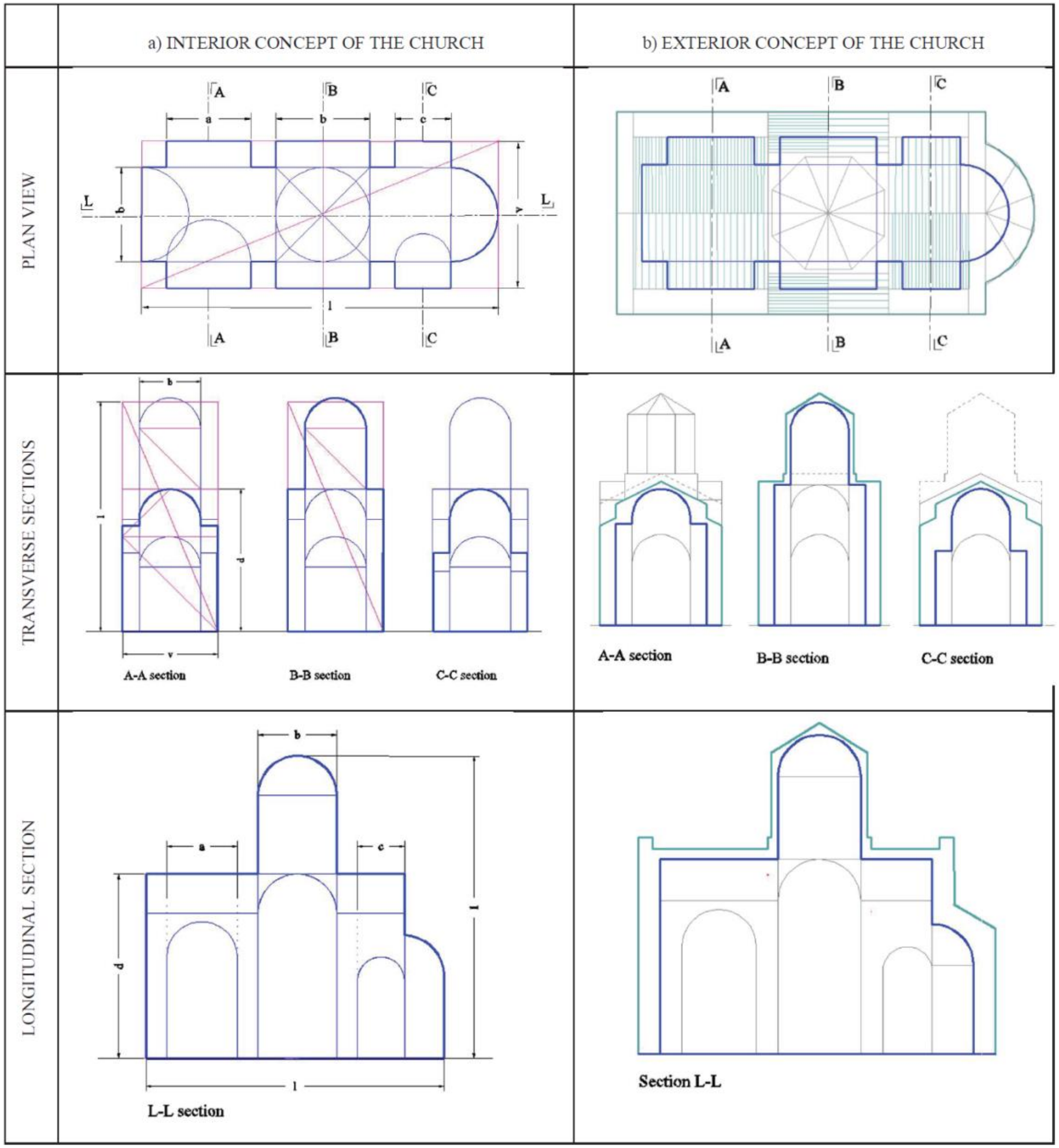


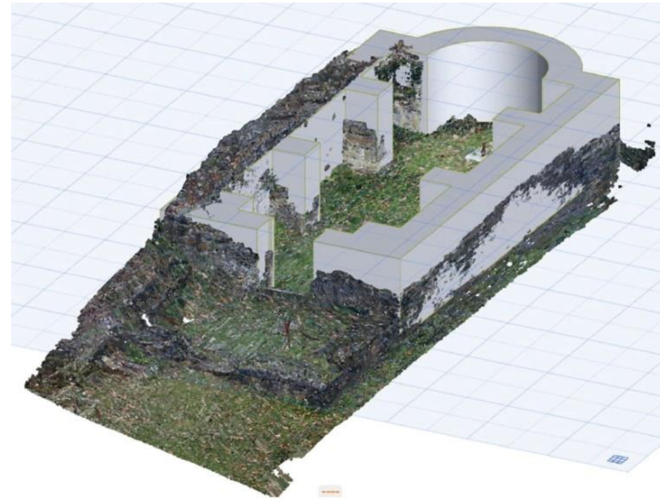


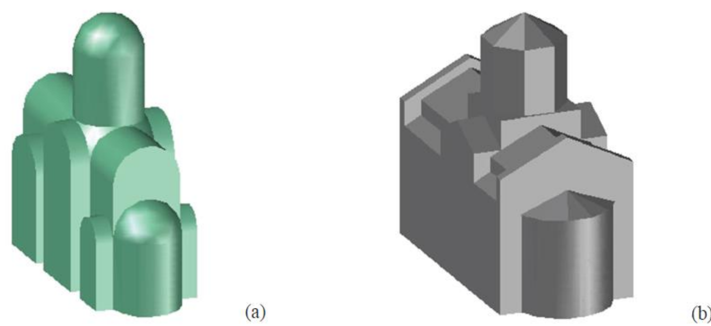
Medieval monastery reconstruction

Kasteljan, Kosmaj 2016.
XYZ+RGB

Re-emerging from ash…







Exterior and interior
concept of the church





Spinix statue,

Faculty of civil engineering,
Belgrade, 2014.

- Technological innovations are pushing the feasibility boundaries, while basic engineering approach remains the same;

Technology of the future generations

MORE FROM SCIENTIFIC POINT OF VIEW:

- Pandzic Jelena, Pejic Marko, Bozic Branko, Eric Verica (2017) **Error model of direct georeferencing procedure of terrestrial laser scanning**. AUTOMATION IN CONSTRUCTION. 78 , pp.13-23.
- Pejic Marko, Ogrizovic Vukan, Bozic Branko, Milovanovic Branko, Marosan Stevan Dj (2014) **A simplified procedure of metrological testing of the terrestrial laser scanners**. MEASUREMENT. 53 , pp.260-269.
- Pejic Marko, Bozic Branko, Abolmasov Biljana, Gospavic Zagorka (2013) **Design and optimisation of laser scanning for tunnels geometry inspection**. TUNNELLING AND UNDERGROUND SPACE TECHNOLOGY. 37 , pp.199-206.

Thank you for your attention