

Bosnian-Herzegovinian American Academy of Arts and Sciences

# 12<sup>th</sup> Annual Days of BHAAAS in B&H

International Symposium on Innovative and Interdisciplinary Applications of Advanced Technologies



## Application of 3D scanning for repairing the damage to the Zagreb mosque after the earthquake

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June 24<sup>th</sup> – 27<sup>th</sup>, 2021 - Mostar, Bosnia and Herzegovina



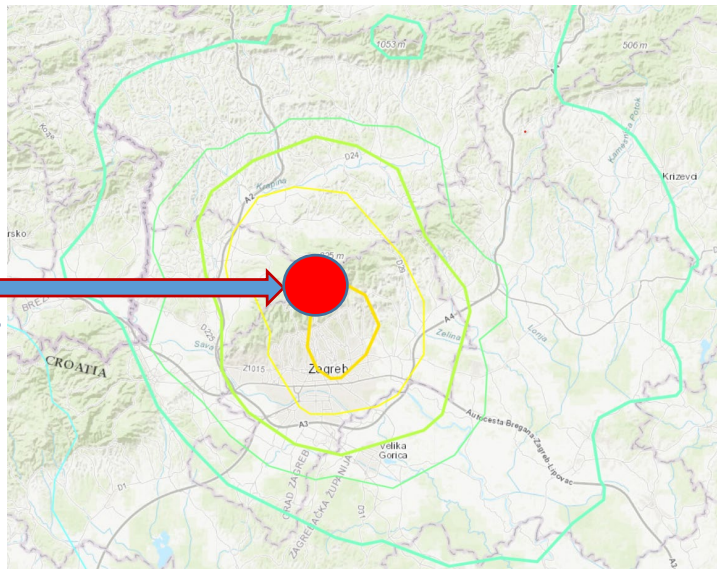
## ...introduction

- natural hazards (floods, earthquakes...) often cause minor and major damage to the infrastructure around us
- for the purpose of inspection and monitoring of various damages (buildings, bridges...) advanced technologies have been used in the last few years
- primarily mean on laser scanning, drone imaging, GNSS measurements, application of lidar technology, satellite missions, remote sensing

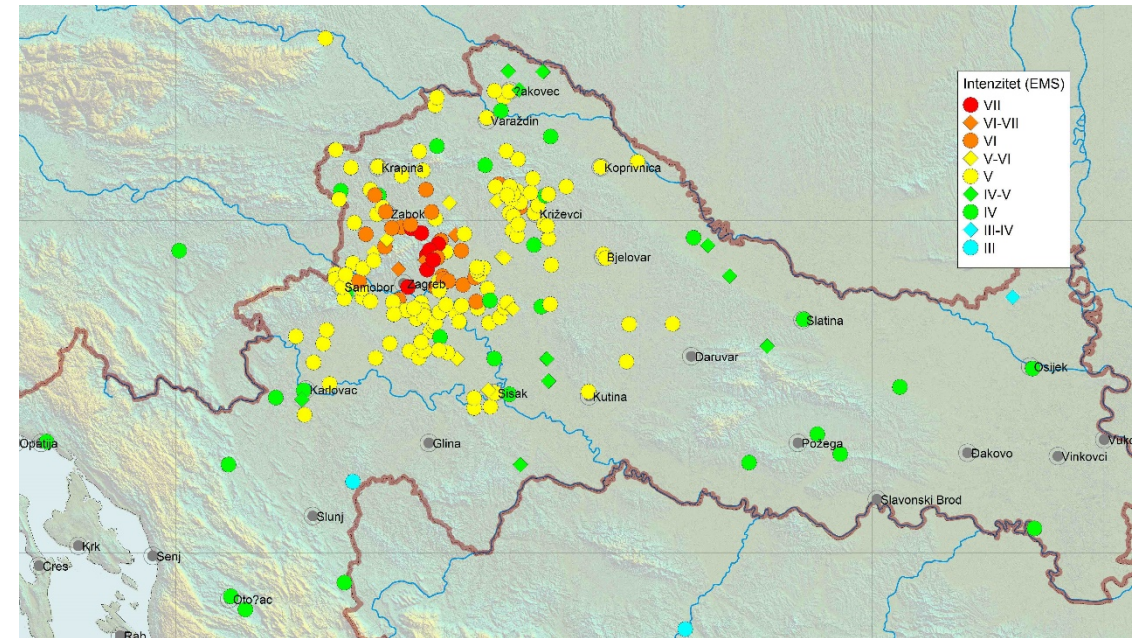


## ..about Zagreb earthquake 22<sup>nd</sup> March 2020

- at approximately 6:24 am on the morning of 22<sup>nd</sup> March 2020 a strong earthquake has shaken the Croatian capital
- magnitude was 5.5 M with an epicenter 8 kilometres north of the city centre



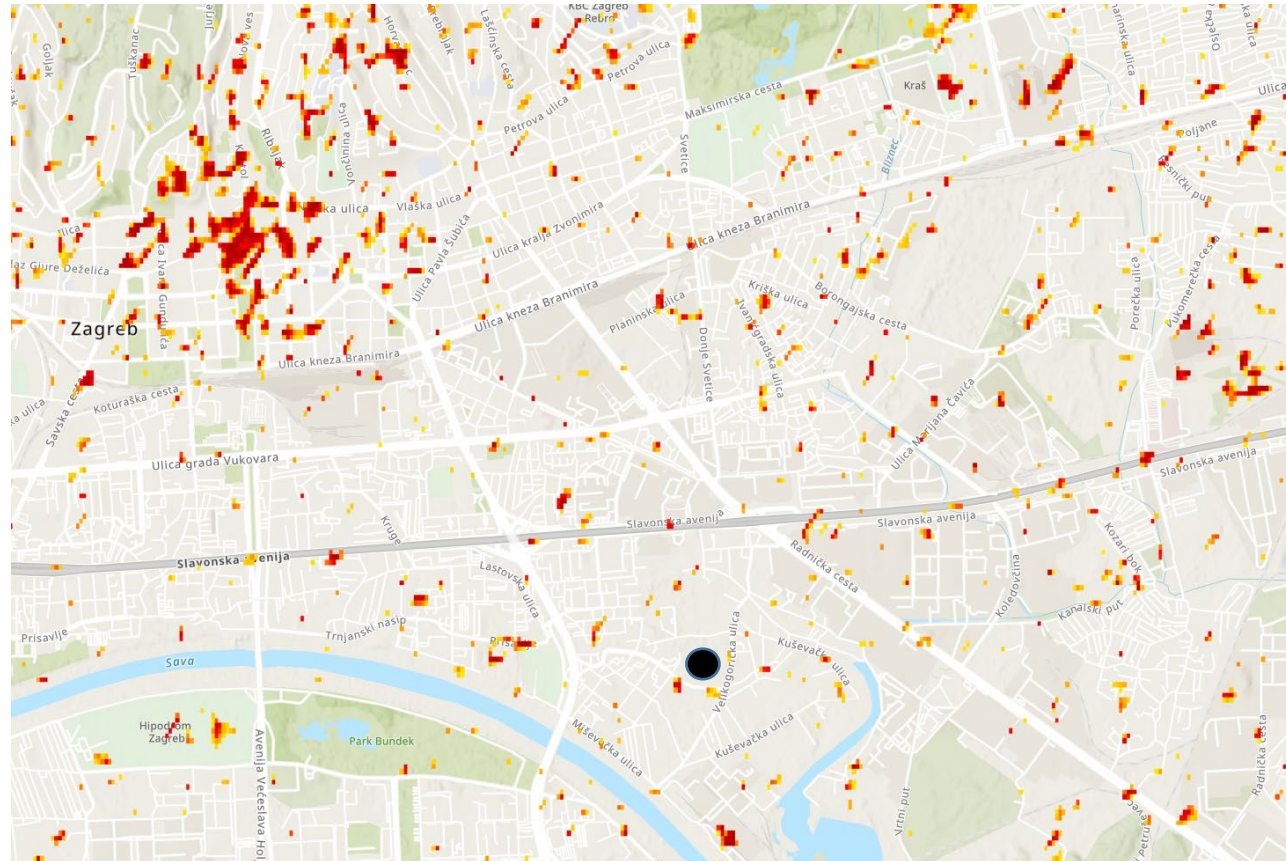
epicenter



source: [http://www.pmf.unizg.hr/geof/seizmoloska\\_sluzba](http://www.pmf.unizg.hr/geof/seizmoloska_sluzba)



## ..about Zagreb earthquake 22nd March 2020



ARIA Damage Proxy Map (Copernicus Sentinel-1) on 3/23/2020 for the Croatia Earthquake

[source: https://maps.disasters.nasa.gov/](https://maps.disasters.nasa.gov/)



## .. consequences of Zagreb earthquake

- unfortunately - one person died from his injuries
- total of 27 people were injured in the earthquakes in Zagreb
- a lot of destroyed bulidings





## .. consequences of Zagreb earthquake

- one of the damaged buildings was Zagreb mosque
- after a preliminary inspection by construction experts, a couple of minor damages were found
- the main damage was found on the upper part of the dome
- the glass cracked and the frame was damaged





..Zagreb mosque...main damage



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## ...about Zagreb mosque



source: Nodilo, B. (2013) *Prva gradska džamija*

- the Zagreb Mosque, located in the city of Zagreb, is the largest mosque in Croatia
- the construction began in 1981. and finished in 1987.
- spreads over more than 10 000 m<sup>2</sup>
- consists of a mosque with a minaret, an Islamic high school (madrasa) which since 2008 is a gymnasium with the right of public access, a library, common social rooms, an administrative building, a residential part, an economic part, etc.
- the mosque and the Islamic Center operate and a restaurant that is highly regarded and visited





## ...about Zagreb mosque



religious, social and cultural center

- wedding ceremonies held in the mosque
- the Islamic Gymnasium operates within the mosque and the Islamic Center
- high school with the right of public access, integrated into the Croatian education system, originally founded in 1993 as a madrasa, an Islamic high religious school
- the Islamic Center also includes the women's choir of the Arabesque Mosque in Zagreb, which is musically affirmed with its performances and sound carriers outside Zagreb
- the city kindergarten Jasmin is also open in the Islamic Center, for all children, regardless of religion
- the mosque is also adorned with a sports center with a playground of the Nur Football Club



## ... project of renovation

- president of the Meshihat and Mufti of Zagreb Aziz ef Hasanović and the persons who led the reconstruction invited experts from the University North and the company Geomatika-Smolčak d.o.o. with the aim of repairing the damage places
- the goal was to determine the dimensions of the glass and the frame that was to replace the damaged parts
- the main problem - high height and inaccessibility of damaged parts
- after preliminary inspection on day April 30 2020. experts from the University North and the company Geomatika-Smolčak d.o.o. have performed the necessary measurements
- due to the conditions, classical geodetic measurements could not be applied and it was decided to use the geomatic method - 3D laser scanning



## ... 3d laser scanning and GNSS measurements

- total station Trimble SX-10
  - ✓ Angular Accuracy: 1"
  - ✓ EDM Technology: Lightning 3DM
  - ✓ EDM Accuracy: 1 mm + 1.5 ppm Prism / 2.0 mm + 1.5 DR
  - ✓ Servo: Robotic
  - ✓ Maximum Distance Range: 5 500 m
  - ✓ Additional Features: Scanning & enhanced VISION
  - ✓ Scanning Speed: 26 000 points per second
  - ✓ Scanning Range: 600 m
  - ✓ Laser Class and Ingress Protection: Laser Class 1M & IP55





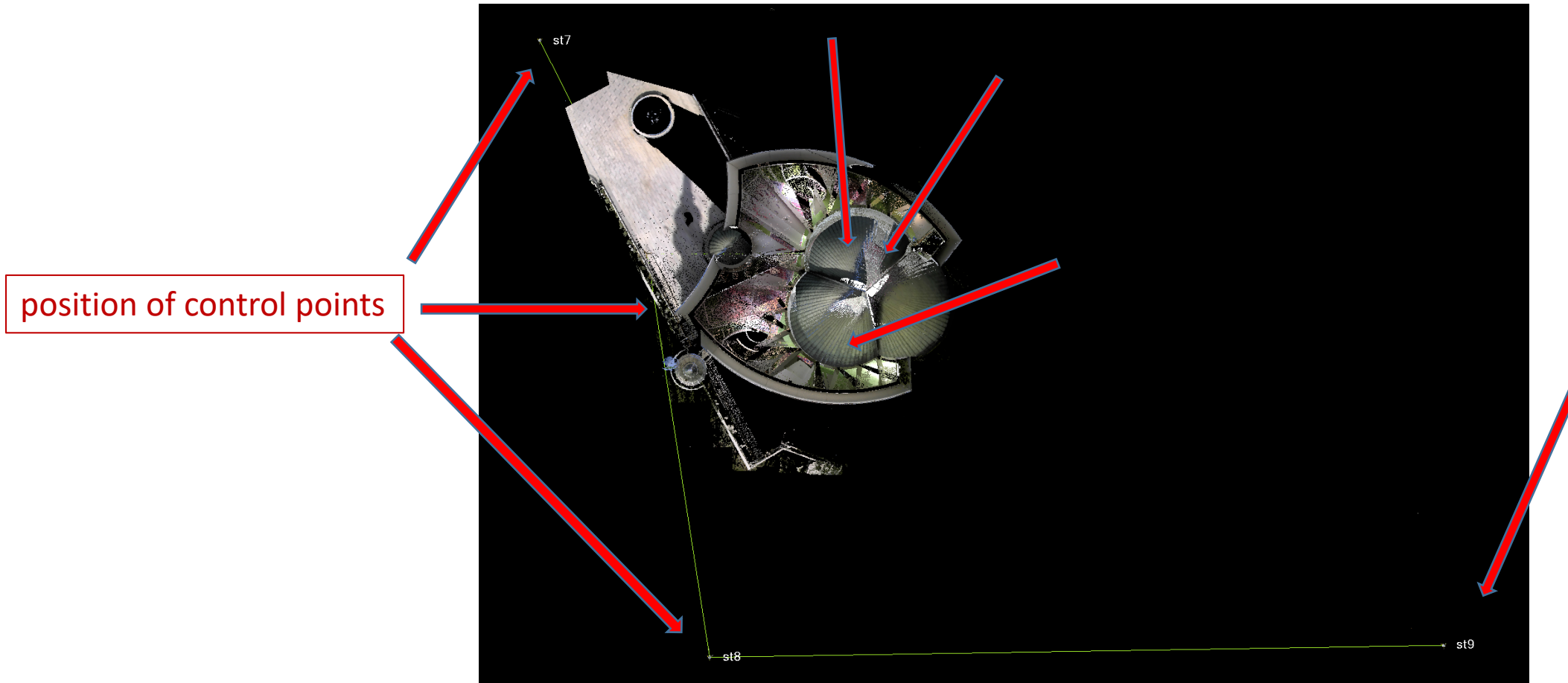
## ... method of measurements

- method of forced centring
- orientation on the points with coordinates (directly overlapping of scans in software)
- standard mode of scanning - for whole surroundings
- super fine mode – for damage part of dome/rectangle
- the project consisted of two parts
  - laser scanning of the interior of the mosque  
(primarily referring to the upper part of the dome)
  - laser scanning of the exterior of the mosque





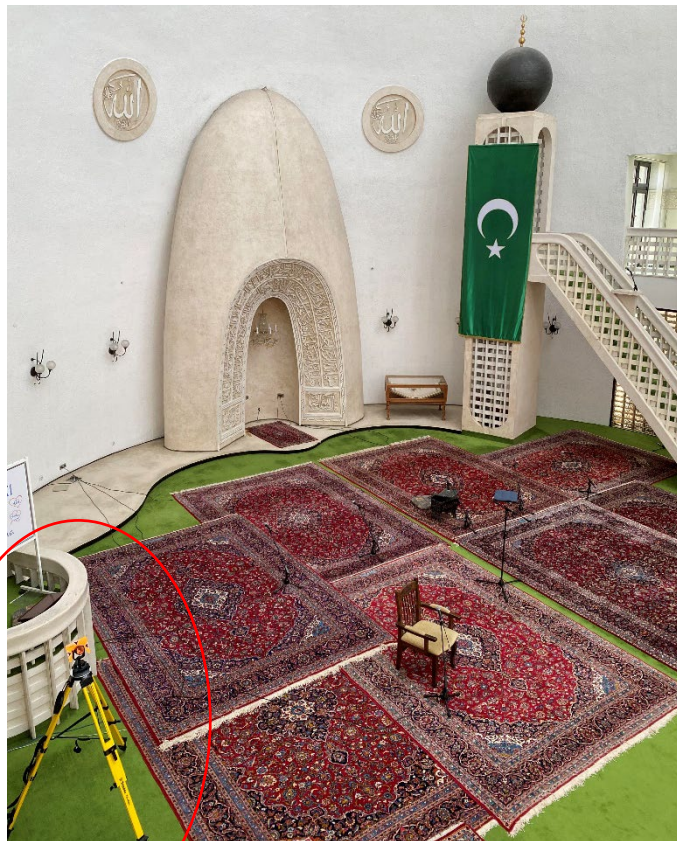
... project of renovation





### ... Interior network

- network for scanning: inside 3 points & outside 4 points



## ... project of renovation

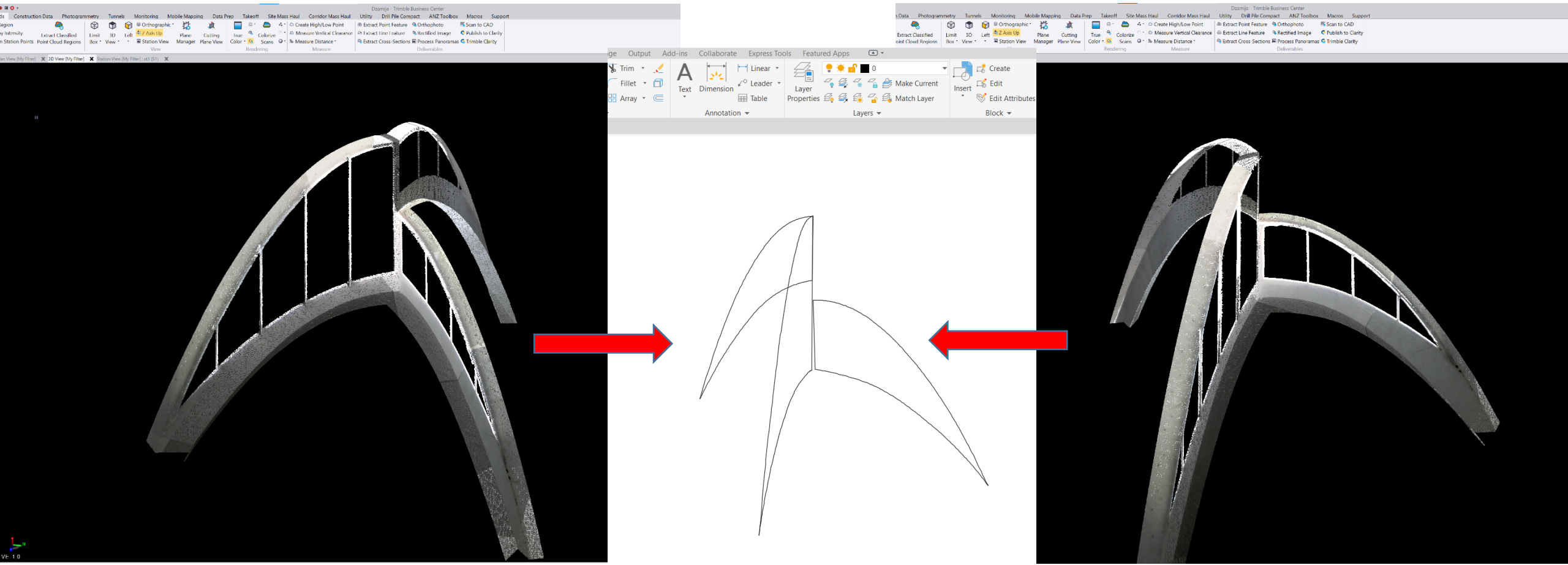
- the upper part of the dome was scanned separately
- during the measurement - strong light from the sun that illuminated the entire interior of the mosque
- we had interference when performing laser measurement but at the same time - we saw all the splendor of the design and architecture of the Zagreb mosque





... after cloud data processing

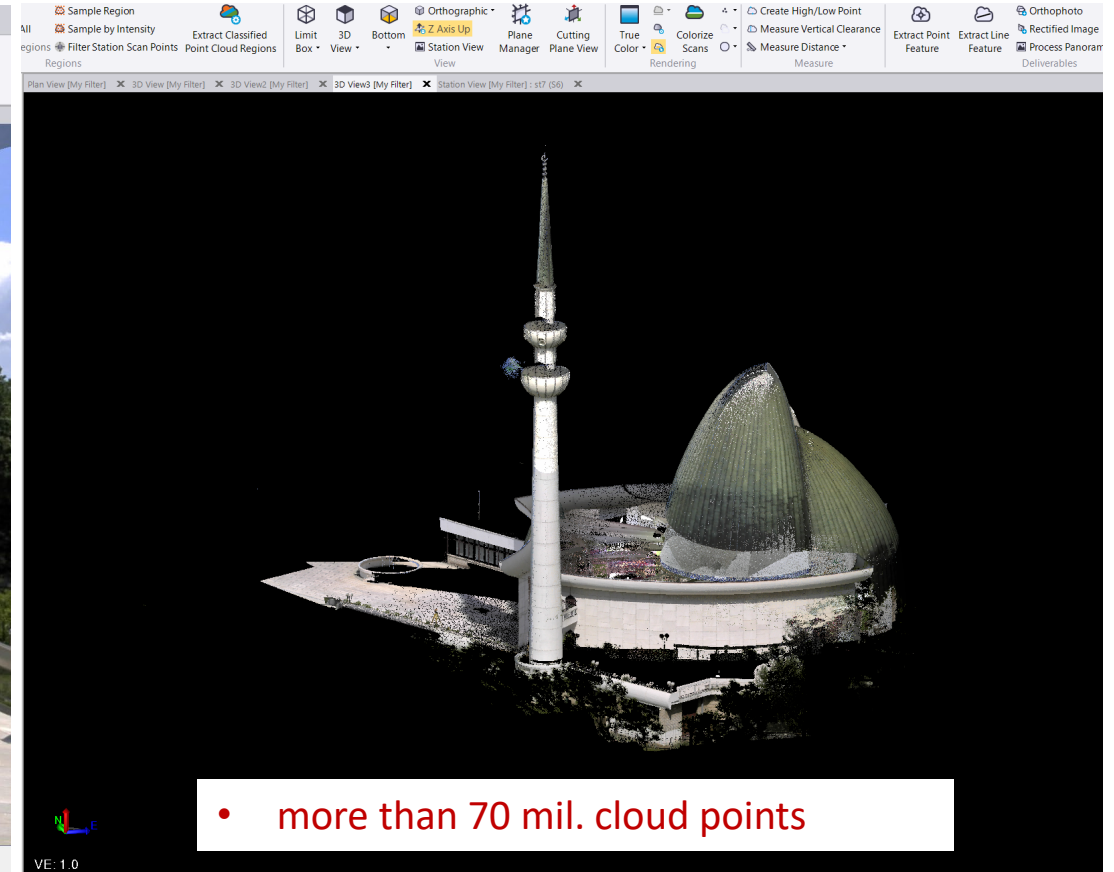
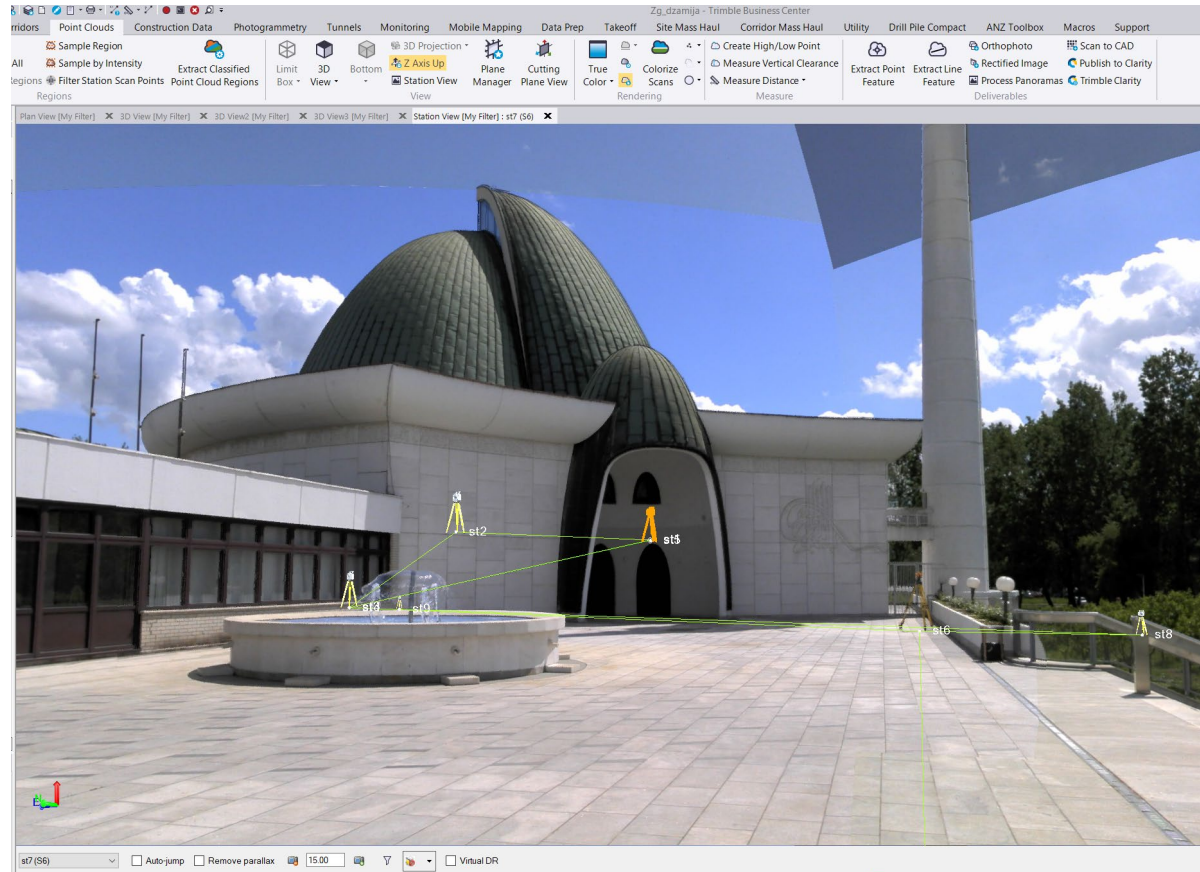
- export cloud in CAD format







## ... project of renovation





## ...laser scanning of Mihrab

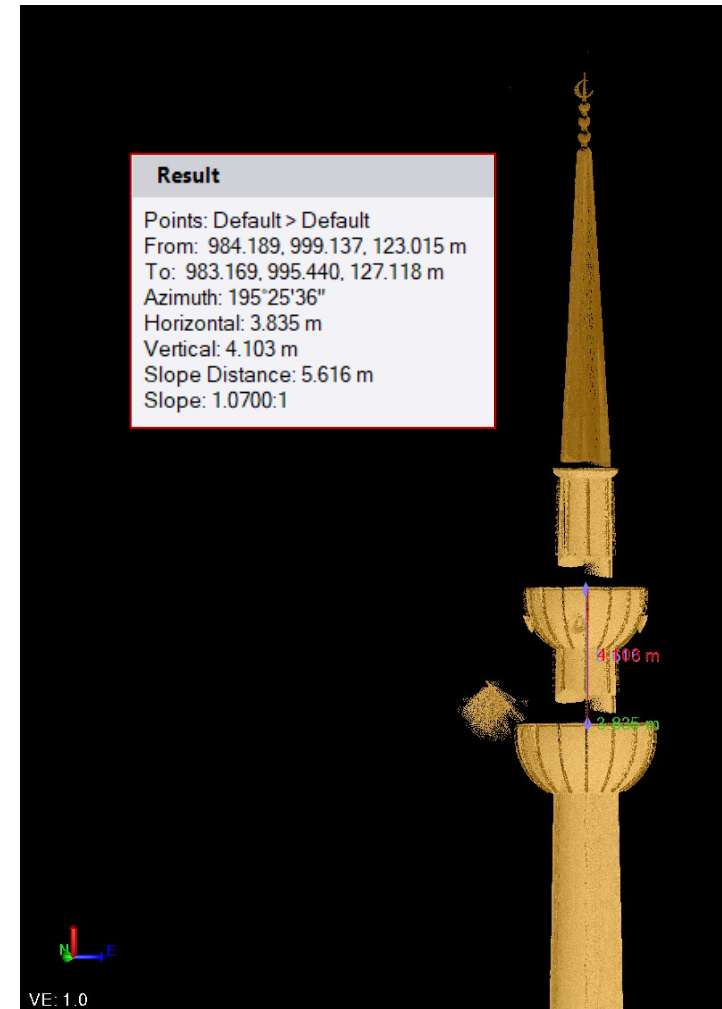
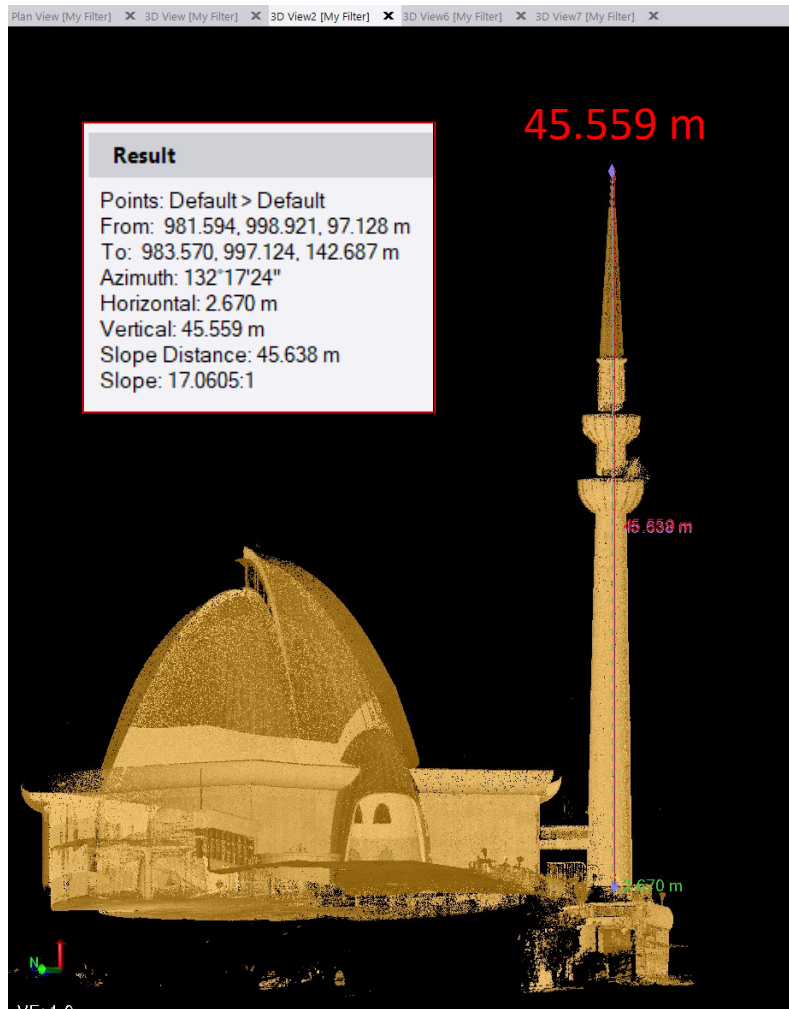
- historical and cultural sights
- 3d view of the actual situation for:
  - ✓ future renovations
  - ✓ tourist promotions
  - ✓ cultural analysis
- ....



frame of scanning



... elements of minaret from cloud points





## ...statistical information

**Registration Report (using Extracted Scans)**

User Name: DankoM Date: Fri Jun 18 09:22:45 2021  
 Length Measurement Units: Meters Project Name: Dzamiija  
 Coordinate System: X, Y, Z

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Overall Cloud-to-Cloud Error: 2.09 mm

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**st1** - 1 Station(s) with Points in Common -

Object Name	Cloud-to-Cloud Error	Coincident Points (%)	Confidence (%)
st2	1.43 mm	41%	100%

**st2** - 1 Station(s) with Points in Common -

Object Name	Cloud-to-Cloud Error	Coincident Points (%)	Confidence (%)
st3	1.50 mm	31%	100%

**st8** - 1 Station(s) with Points in Common -

Object Name	Cloud-to-Cloud Error	Coincident Points (%)	Confidence (%)
st9	1.98 mm	26%	0%

**st7** - 1 Station(s) with Points in Common -

Object Name	Cloud-to-Cloud Error	Coincident Points (%)	Confidence (%)
st9	3.30 mm	4%	0%

**st1** - 1 Station(s) with Points in Common -

Object Name	Cloud-to-Cloud Error	Coincident Points (%)	Confidence (%)
st9	2.22 mm	4%	0%

2.09 mm

- more points – better precision
- 4 mode:
  - ✓ coarse
  - ✓ standard
  - ✓ fine
  - ✓ superfine



...demanding structural and construction works



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...final result





## ...conclusion

- natural disasters are a part of our lives, as well as the consequences of such events
- advanced technology and a modern approach to monitoring of consequence make it easier to inspect and make decisions after such events and this project has shown how the application of 3D technology helps to eliminate the effects of earthquakes
- in addition to repairing the consequences for the Zagreb mosque, the first cloud model was created that will help in the future in further technical monitoring and control of this religious, cultural and social center



**Thank you for your attention!**

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**<https://bhaaas.org>**