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GUIDELINES FOR OPTIMIZATION OF TERRESTRIAL LASER SCANNING SURVEYS OVER GULLY EROSION AFFECTED AREAS

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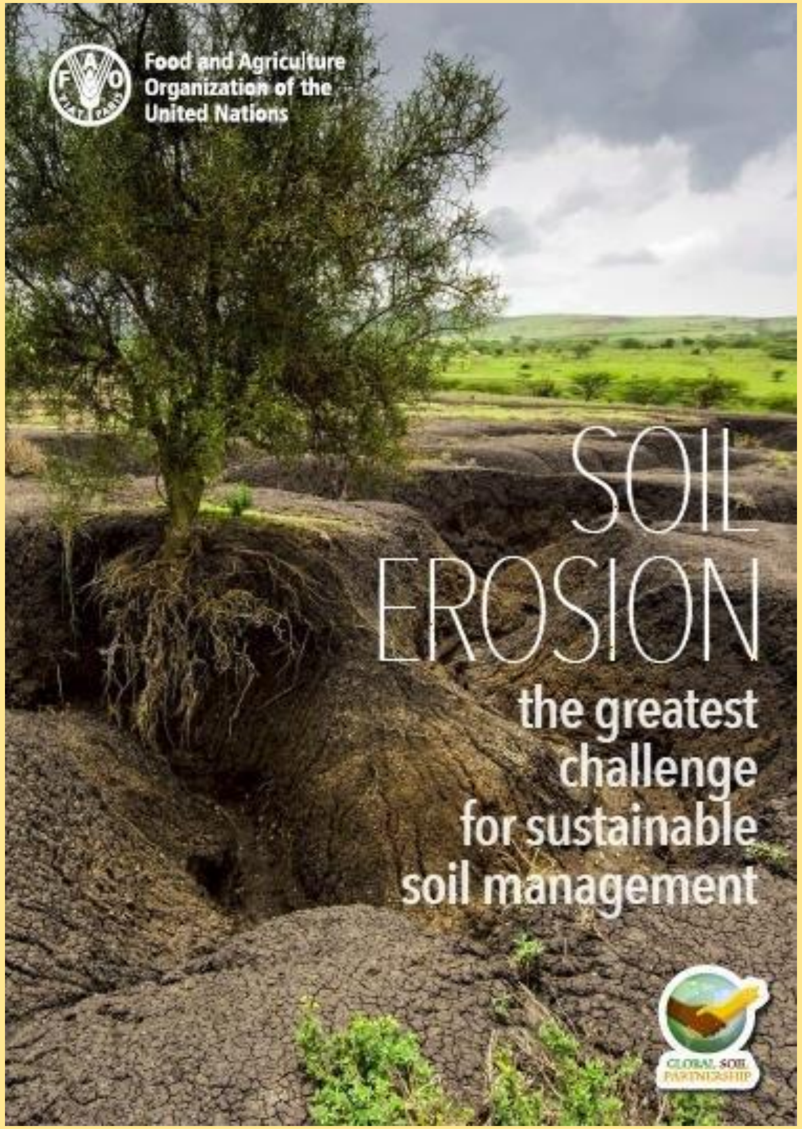
Introduction

- **Soil erosion** is a global threat that causes gradual soil degradation and removal → **gully erosion** represents **most intense** type of soil erosion

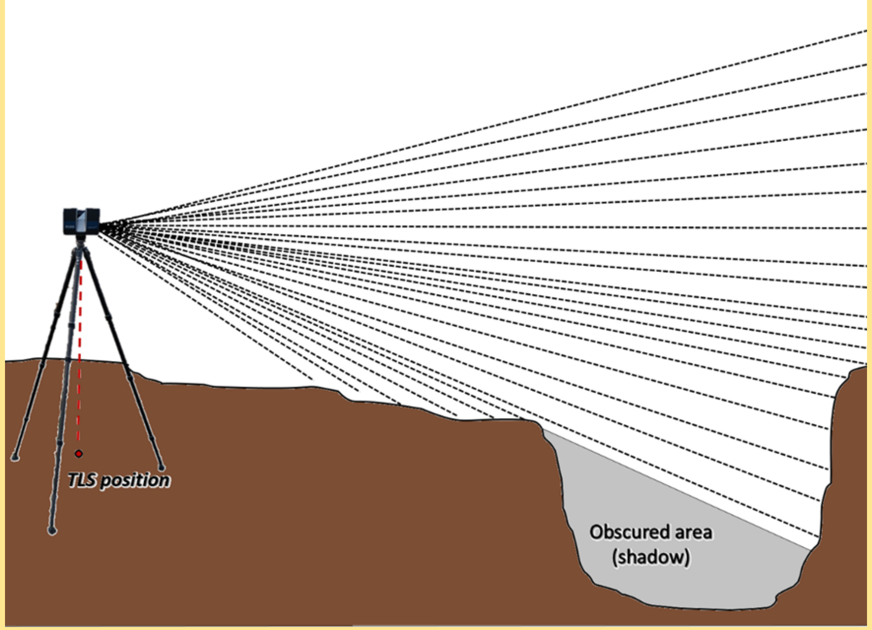
- Understanding of **soil erosion dynamics** crucial for prevention of various negative effects

- **Terrestrial laser scanning (TLS)** represents a state-of-the-art topographic modelling technique → **highly-accurate detection and quantification of spatio-temporal changes induced by soil erosion**



Limitations of terrestrial laser scanning

- Pronounced **terrain roughness and complex surface topography** of certain gullies can lead to significant **limitations and challenges** in field scanning surveys
- Due to the time or resource constrains planning and preparation phases have been avoided or neglected in many TLS surveys → **on-site survey planning**
- **Non-systematic TLS survey approach → obstructed areas → introduction of errors in model quality**



Study objectives

- **Main study objective →** *Development of new systematic survey methodology for* ***optimization of terrestrial laser scanning surveys over gully erosion affected areas***

- Guidelines for TLS surveys which would allow multi-temporal detection, quantification and monitoring of gully erosion induced spatio-temporal changes

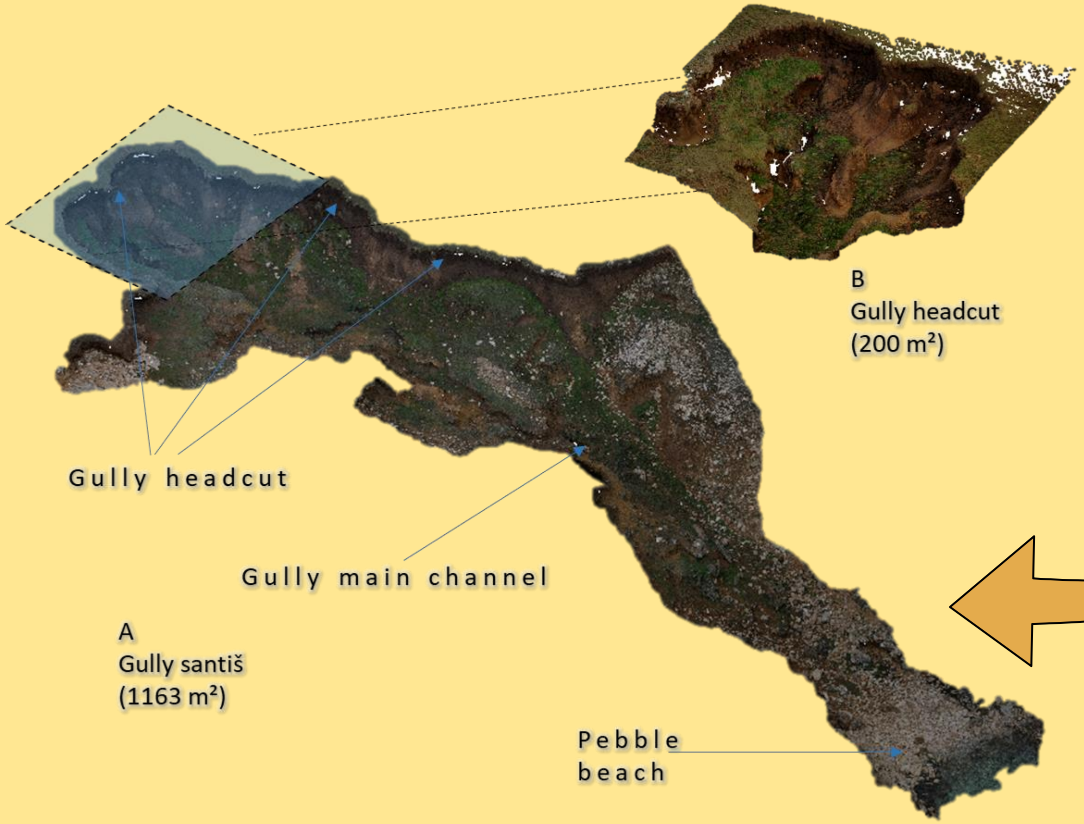
- Special emphasis was given to the following phases of TLS surveys :

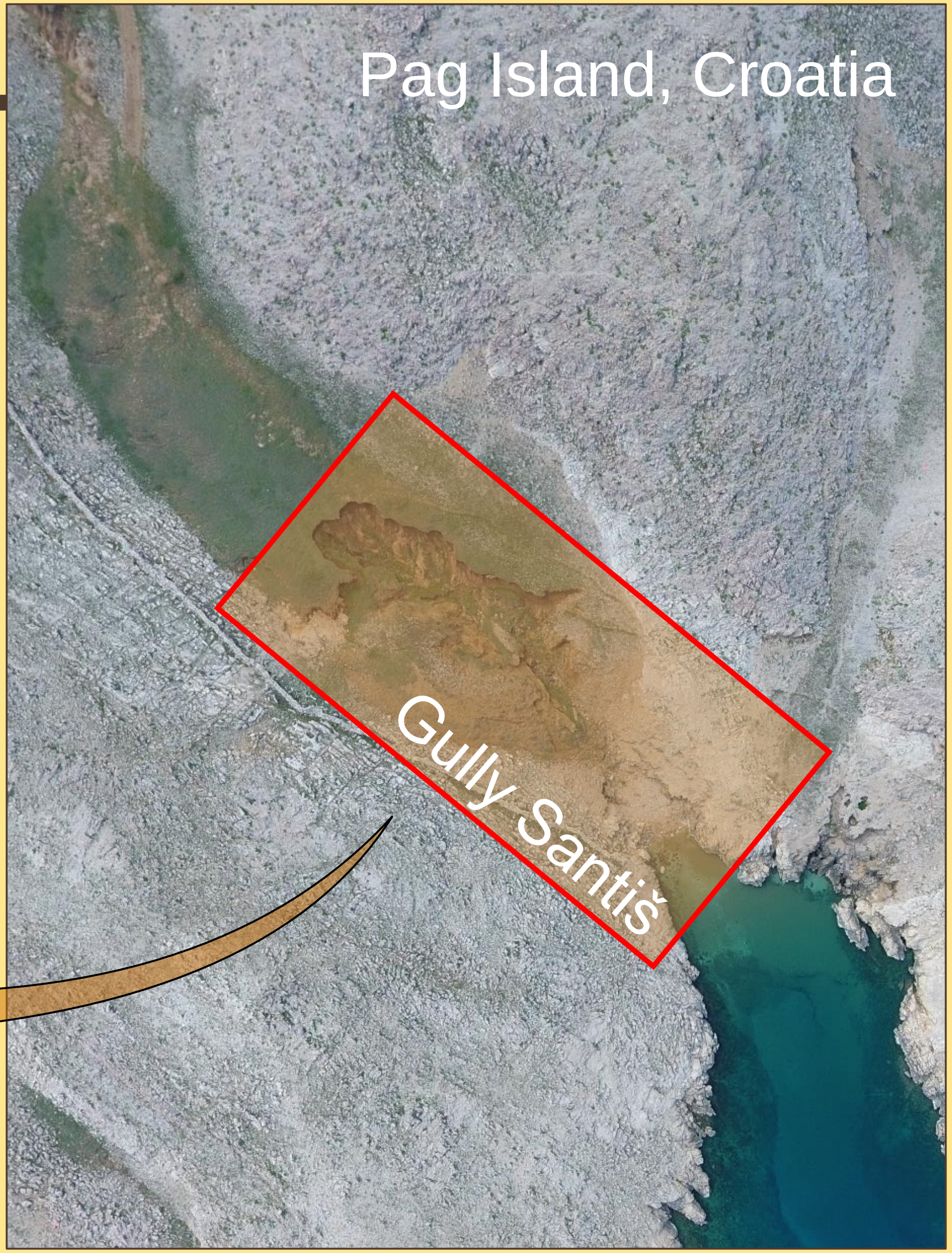
  1) planning
  2) preparation
  3) implementation

  } **accurate and repeatable TLS surveys**

Study area

- **Gully Santiš** (1163 m²) → active gully located on Pag Island, Croatia
- Recent traces of intense gully erosion

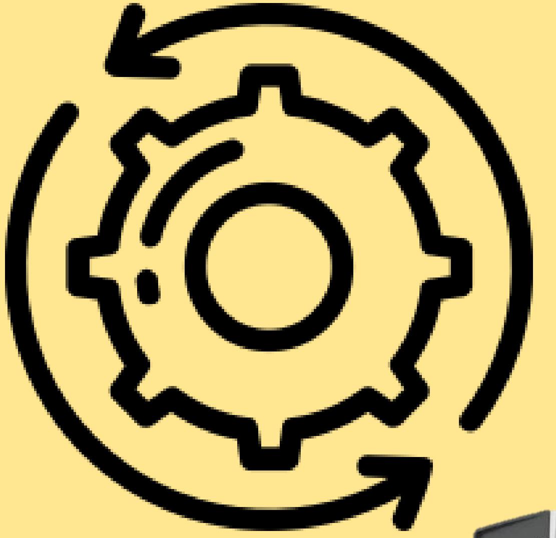




https://sketchfab.com/3d-models/3d-model-of-gully-santis-croatia-22510902813b4e1890ef2b3a47b55793

Methodology

- Developed systematic survey methodology based on following **four steps**:



1) *Survey planning phase*
2) *Field preparations*
3) *Multi-temporal field TLS survey*
4) Creation and validation of gully models

- **Survey characteristics were adjusted** to the specifications of used terrestrial laser scanner → **Faro Focus M70**

1) Survey planning phase

- Survey planning phase includes following **substeps**:

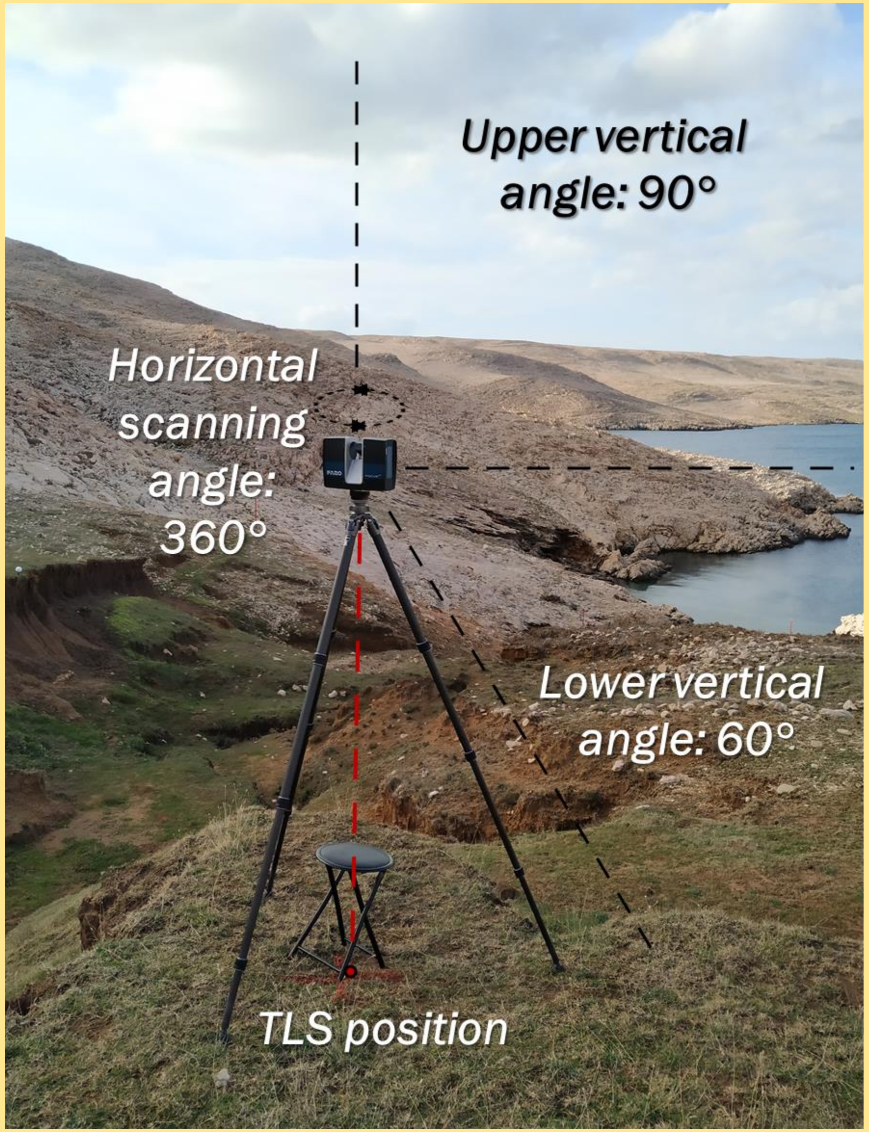
1.1. *Definition of study area extent* → **extent of gully Santiš**

1.2. Determine total number of scans → **available survey time** (8 x 0.5 h)

- scanning parameters in Faro M70 had to adjusted accordingly (resolution: ½; quality: 3x)

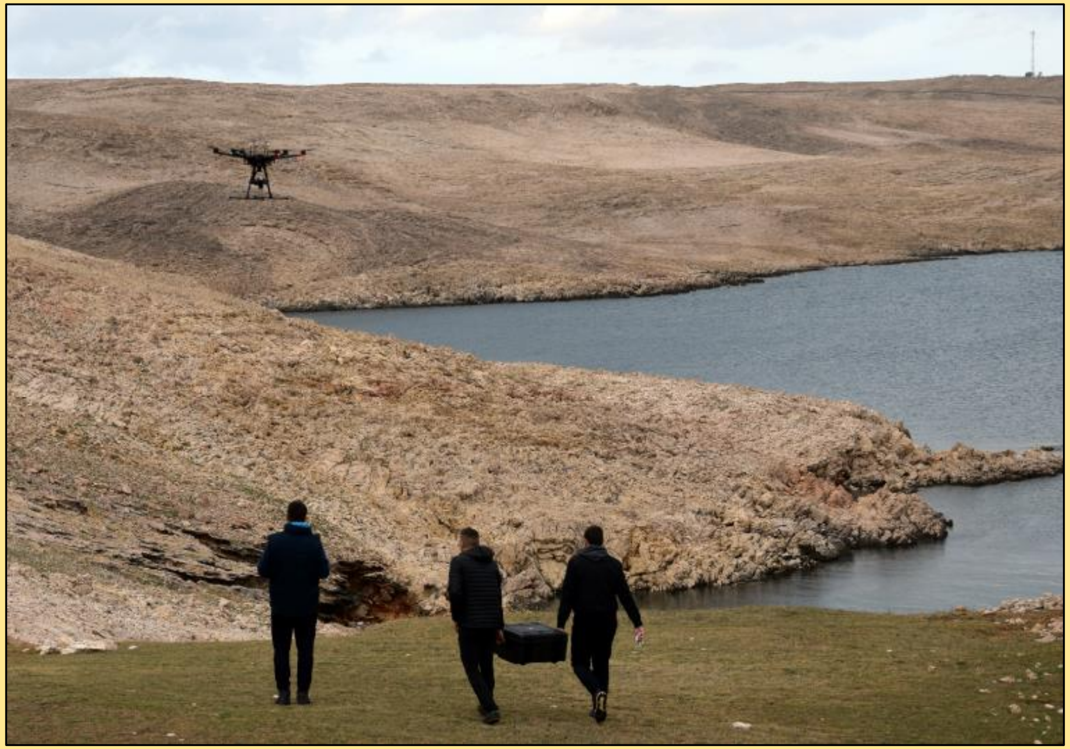
1.3. Find optimal positions for these scans → **visibility analysis (*Interactive visibility tool*)**

- more than 100 potential laser scanning positions → **VHR DEM** required



1) Survey planning phase

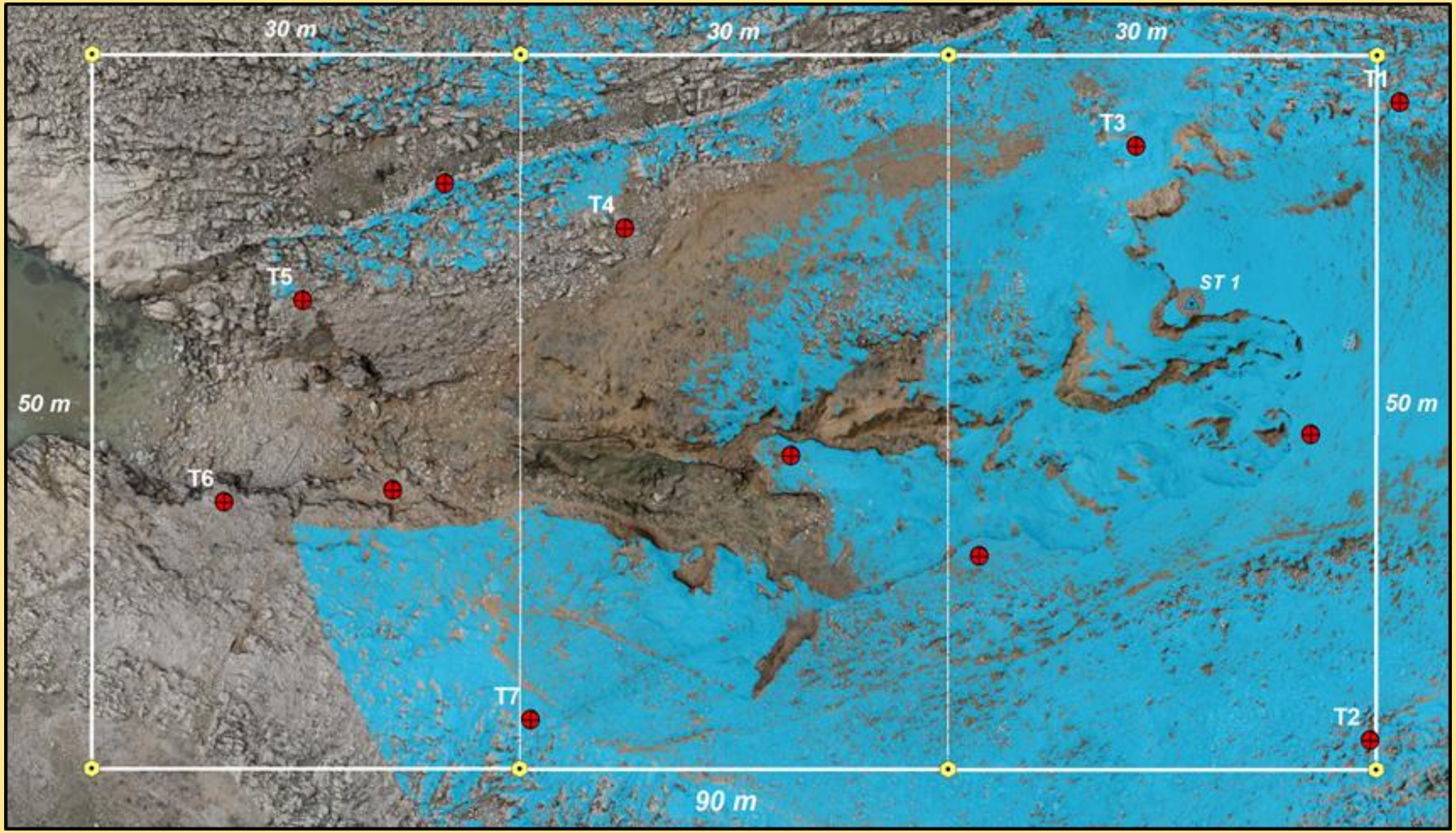
- Creation of VHR DEM (2 cm) and digital ortophoto image (0.5 cm) of gully Santiš → UAV photogrammetry (RAPS)



Repeat aerophotogrammetric system (RAPS) → DJI Matrice 600 PRO + other components

1) Survey planning phase

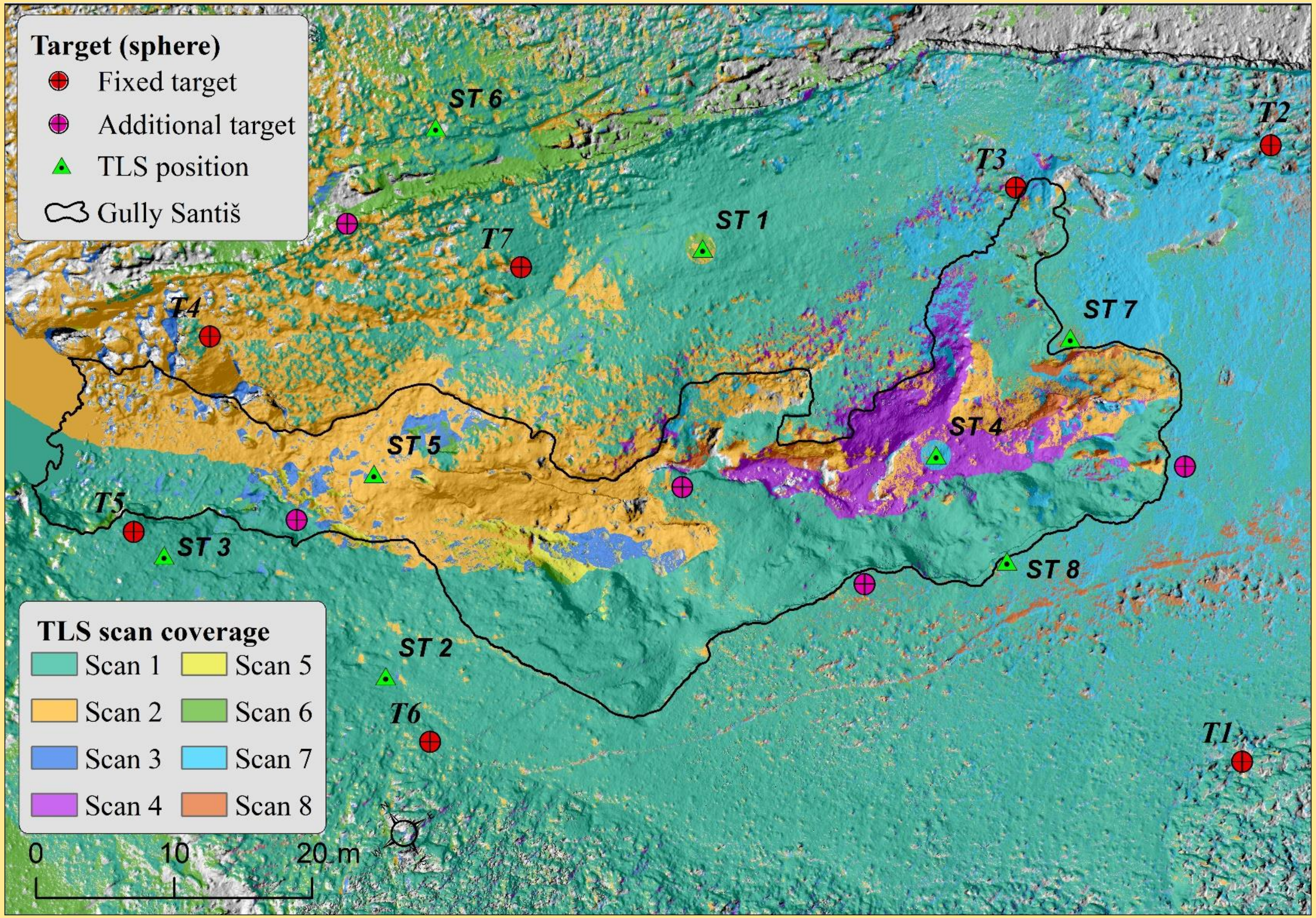
All scanning locations had to be out of active soil erosion zones!!!



Results of visibility analysis carried for chosen (ST1) laser scanning position

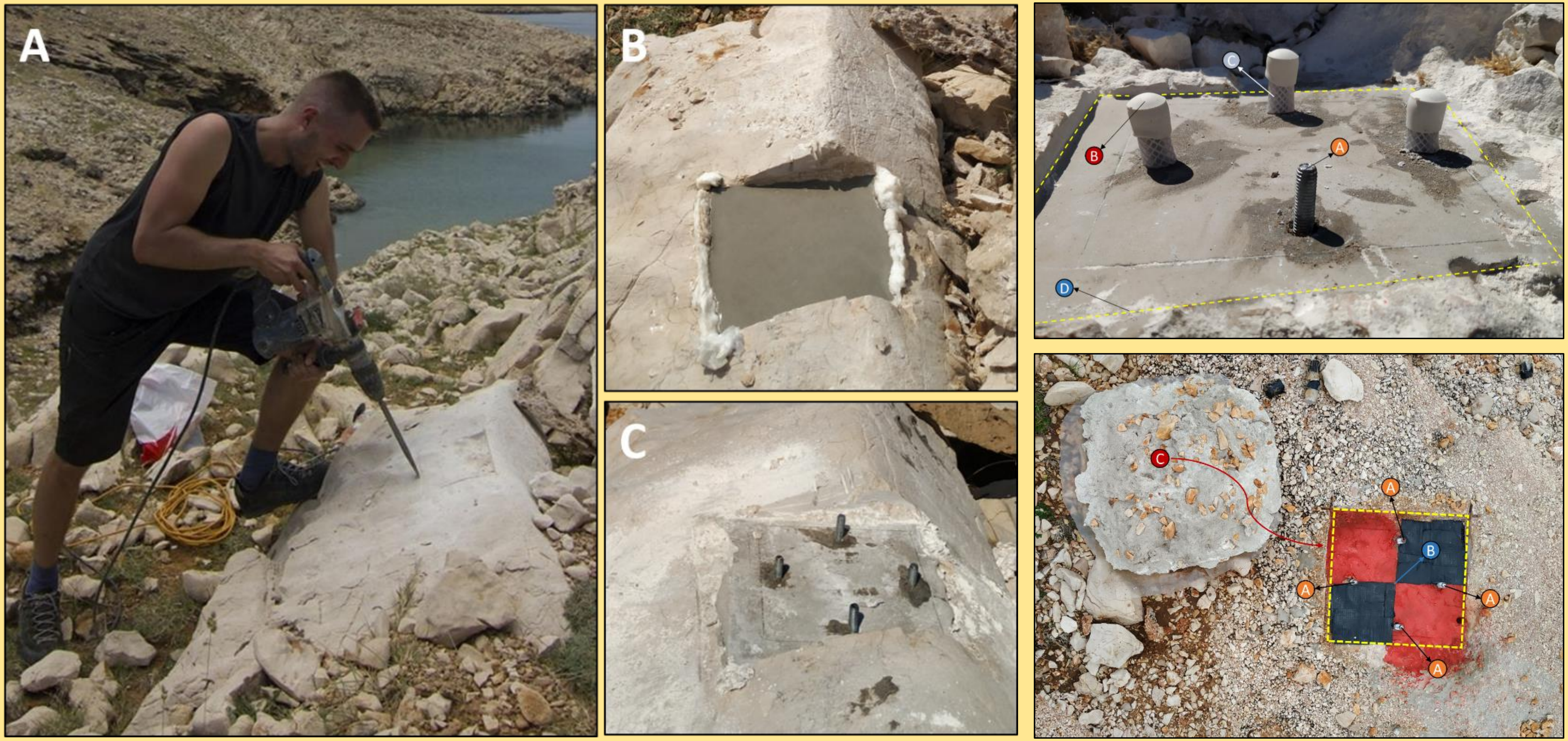
1) Survey planning phase

- **96,93 %** of study area covered by **8 planned scans**
- **1127.43 m²** of area in total
- High percentage of scans overlap → **high point cloud density**



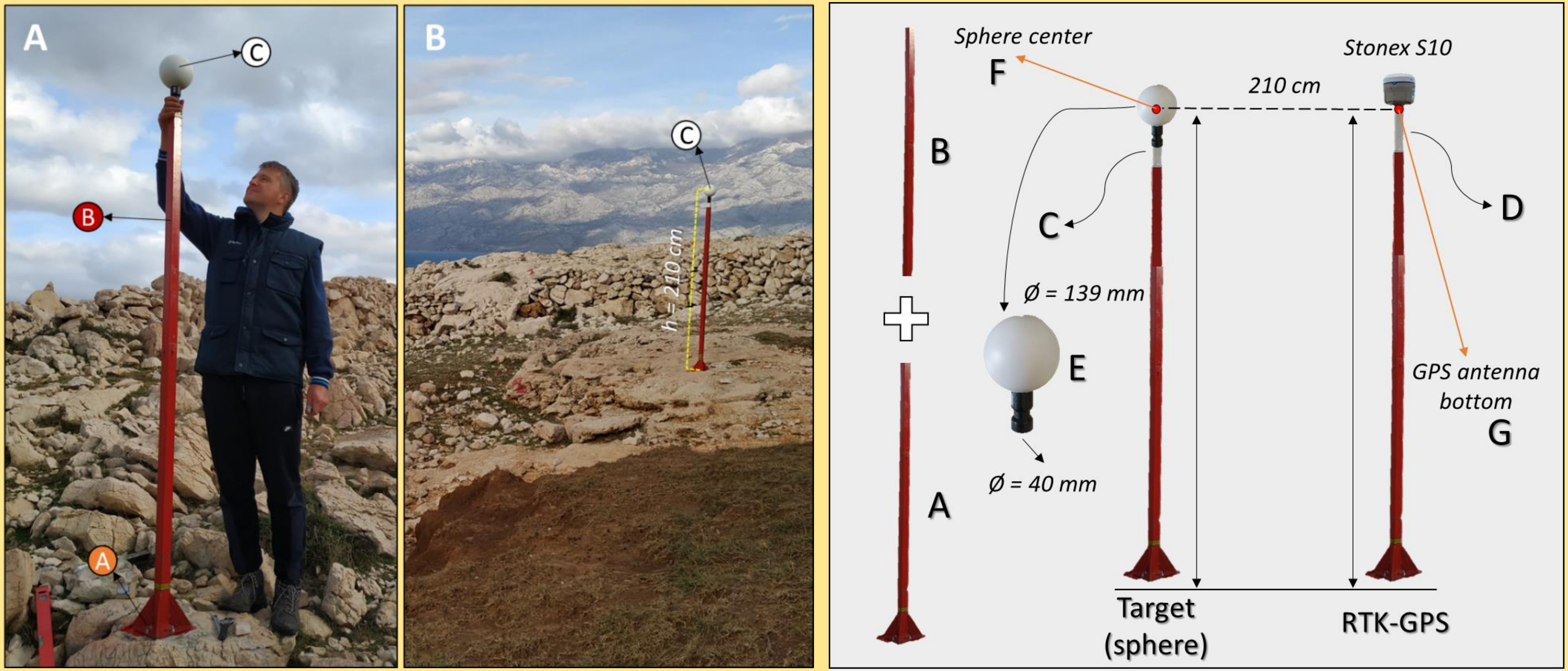
Results of visibility analysis based on 8 chosen locations

2) Field preparations



Field creation of permanent local coordinate system

2) Field preparations



8 identical scanning positions, 7 permanent targets, 5 additional targets

3) Multi-temporal field TLS survey

- **Initial TLS survey** carried on **December 17th, 2019.**
- **Second TLS survey** carried on **December 04th, 2020.**
- **To be continued…**
  - **December 2021**
  - **December 2022**
  - **December 2023**

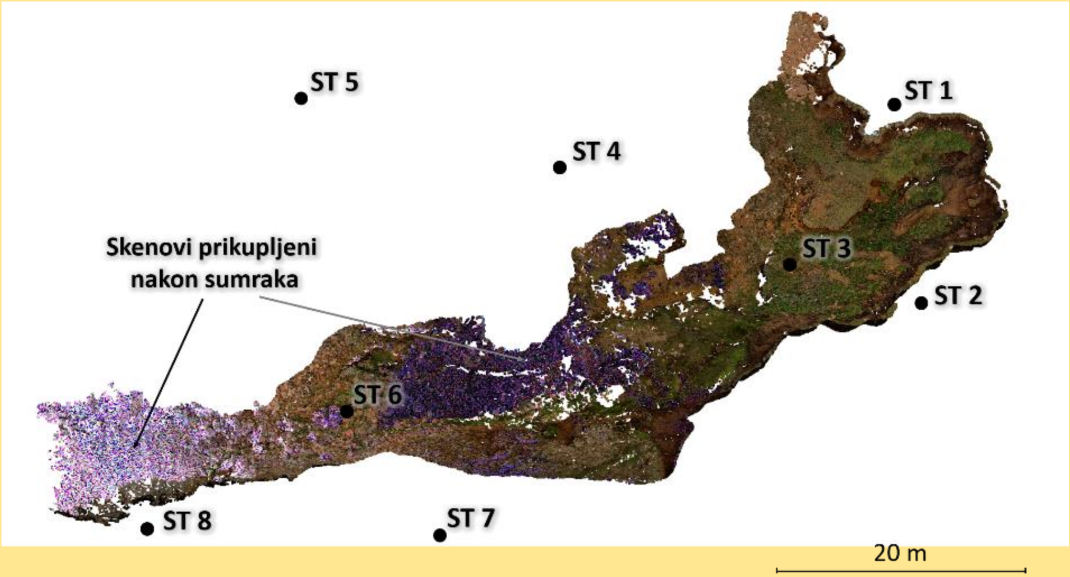
Initial TLS survey

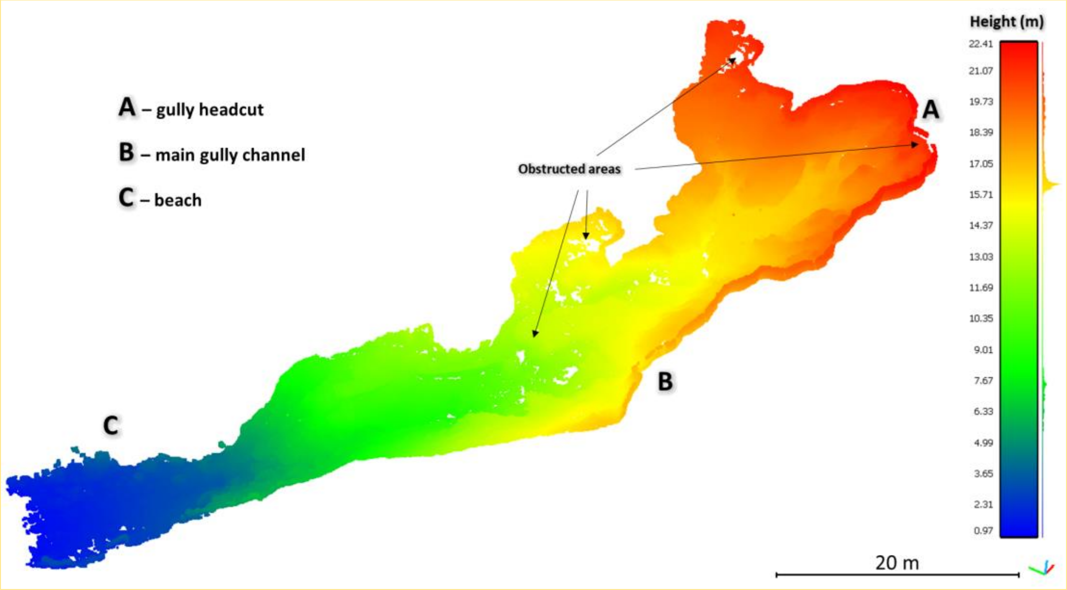
4) Creation and validation of gully models

- Collected scans were processed in **Faro Scene software**

- Registered scans used for creation of point cloud with around **368 mil.** points

- **134 149 819 points within study area**





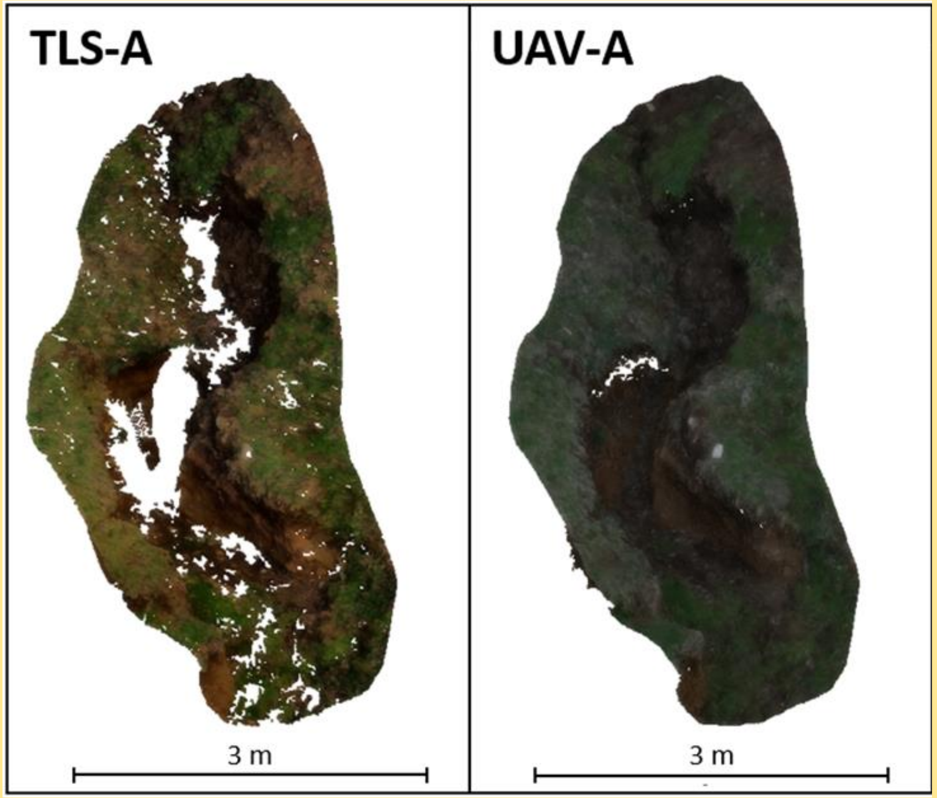
Achieved coverage of the study area

- Created point cloud successfully covered whole study site → **exception of small obstructed areas**
- **94.56 % of study area covered by carried TLS survey**(1066.05 m²)
- Most of complex gully features covered by created point cloud
- Only 35.65 m² of study area not covered (3.07 %)

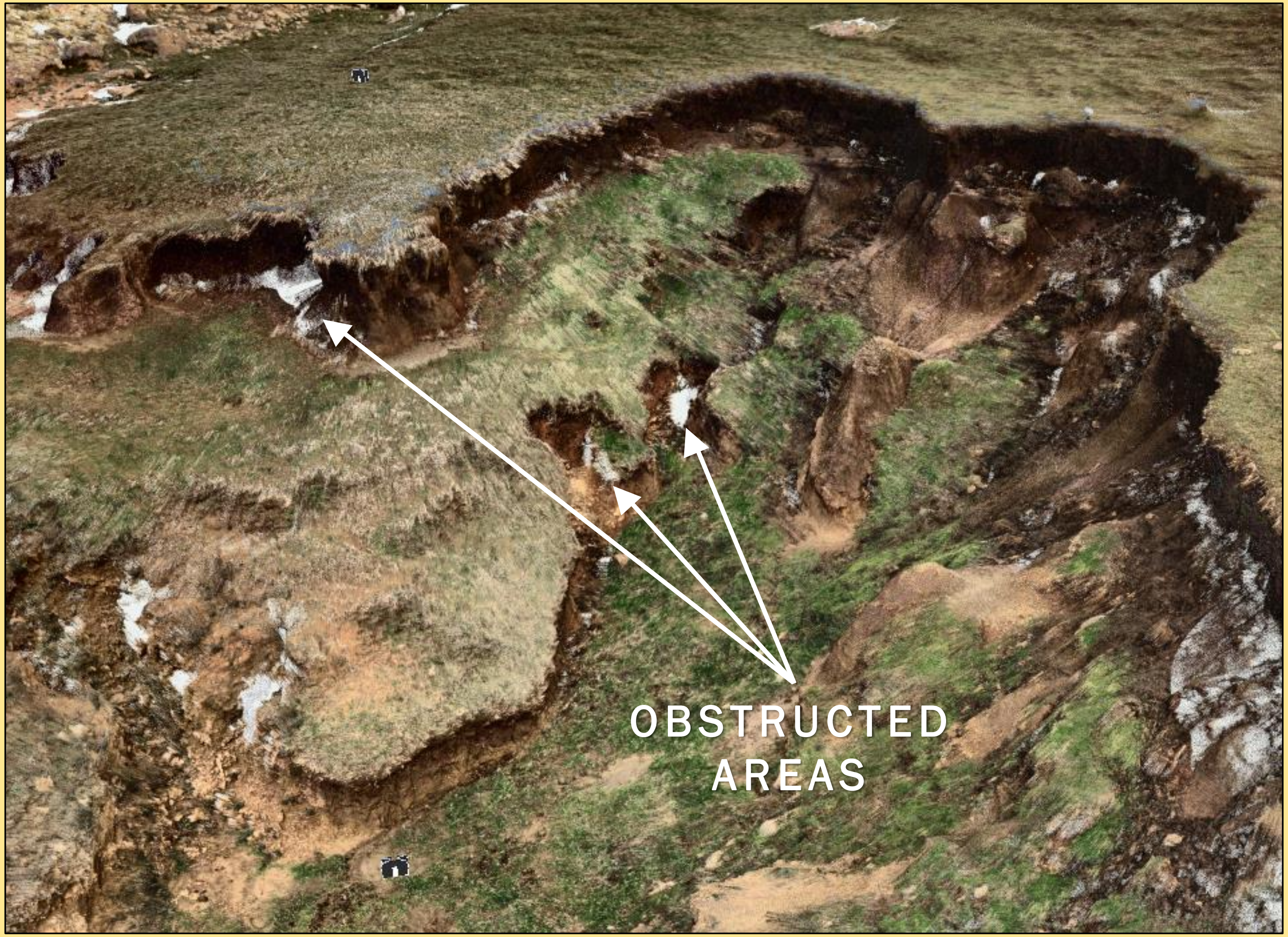
Headcut represented in initial point cloud

Achieved coverage of the study area

- Complex **overhangs** at main **gully headcut** covered with only few "**shadows„**
- **Important for monitoring of headcut retreat rate!!!**
- Most of obstructed areas are within very **narrow and deep micro channels** within main gully channel



Achieved coverage of the study area



Potential causes for coverage deviation

- Deviaotin from planned study area coverage:

achieved = 94.56% vs. planned = 96.93%

- **Possible causes of coverage deviation:**

1. **Errors in VHR DEM used for visibility analysis** → *headcut overhangs, narrow channels, vegetated areas, etc.*
2. **Potential very small deviations in positioning of TLS** → *rough terrain*
3. Potential small deviations in **created permanent local coordinate system**
4. **Spatio-temporal changes** → VHR DEM created from data collected few weeks before laser scanning

Conclusion

- *New systematic survey methodology for optimization of terrestrial laser scanning surveys over gully erosion affected areas is developed →* ***repeatable and accurate multi-temporal scanning***

- **Around 95% of complex terrain of chosen study area was sucesfully scanned**

- **Created permanent local coordinate system is basis for future multi-year TLS surveys→** surveys will be continued within the 5-year frame

- **Developed methodology (*guidelines*) could be used for scanning of silimar complex geomorphological features**

Thank you for your attention

- Questions ?

August 2019

December 2019