APPLICATION OF UAS REMOTE SENSING FOR CULTURAL HERITAGE PRESERVATION AND ARCHAEOLOGY

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AGENDA

- Introduction
- UAS Flight Ops for Photogrammetry and LiDAR
- Application Case Study
  - The Republic of Kosovo
  - Tularosa Creekside Village

2021-STUDENT VIDEO

INTRODUCTION-OVERVIEW

- Rapid technological gains associated with all UAS are bringing remote sensing technologies to bear in exciting ways.
- Using small unmanned aircraft systems (sUAS) to gain aerial perspectives for remote sensing with cameras and LiDAR is truly benefiting cultural heritage preservation and archaeological work.
- Photogrammetric products derived from sUAS captured images are providing precise and detailed data.
- LiDAR-equipped sUAS are also making precise and detailed data available for analysis.
- Novobërda fortress in the Republic of Kosovo and Creekside Village, Tularosa Basin, New Mexico provide excellent examples of photogrammetric work and LiDAR derived analysis products resulting from the use of sUAS-bone sensors.

UAS FLIGHT OPERATIONS AND PHOTOGRAMMETRY

- Equipment
  - DJI Matric 600
  - DJI Matric 210
  - DJI Phantom 4 Pro V2
  - DJI Inspire I and II
  - DJI Mavic 2 Pro and Enterprise
  - eBee and eBee Plus
- Software
  - Pix4Dmapper Pro
  - Pix4Dcapture
  - DJI GO
  - DJI GO4
  - DJI Ground Station Pro
  - Blue Marble Global Mapper

MATRICE 200 V2

BLUE MARBLE GEOGRAPHICS
MIND THE GAP BETWEEN WORLD AND MAP

PIX4D

UAS FLIGHT OPS FOR PHOTOGRAMMETRY

DEFINED

- Photogrammetry:
  - Photogrammetry is the use of photography in surveying and mapping to measure distances between objects. Imagery captured by UAS-borne cameras can be processed into georeferenced orthomosaic TIFF (Tag Image File Format) images, two dimension (2D) maps and 3D virtual models.

PARALLACTIC DISPLACEMENT

- Photogrammetric software identifies keypoints among overlapping images and enables development of virtual objects.
- Photogrammetric software calculates parallactic displacement of recognized key points and then assigns x, y and z values to identified pixels. These pixels serve as the basis for triangle mesh development and refinement as 3D virtual objects.

(CNET, 2019)

FLIGHT PATH – CAMERA POSITIONS IN THE SKY

The basic premise of photogrammetry is the art and science of obtaining useful information from the environment by processing imagery and then applying exacting measures that can provide 3D characteristics.

Figure 1. Principles of Structure from Motion (SfM) aerial imagery to photogrammetric product (Pix4D, 2022b)

OVERLAP OF IMAGES ARE IMPORTANT

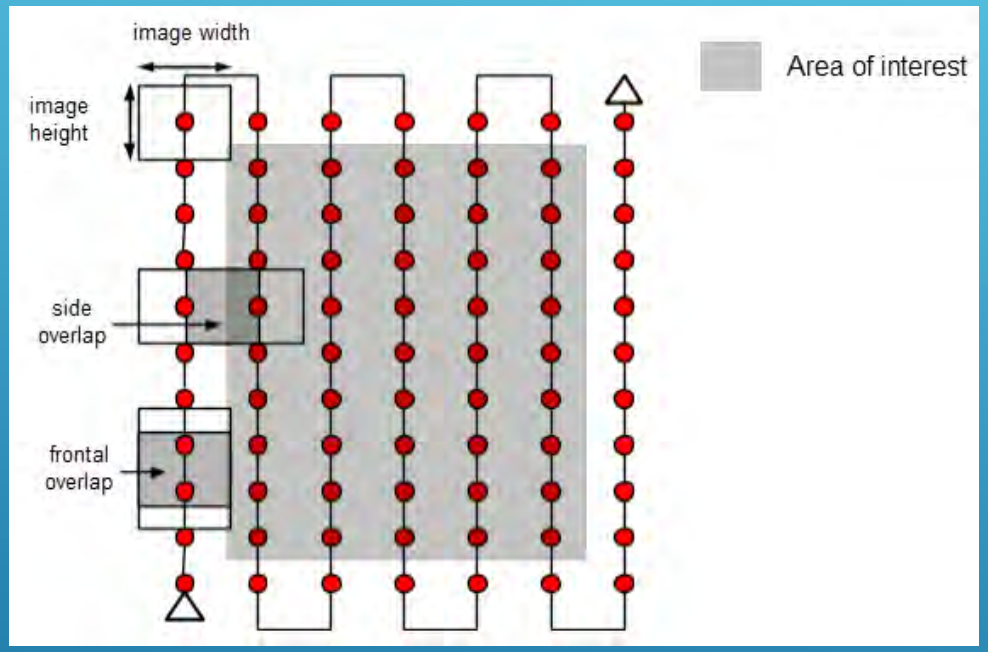
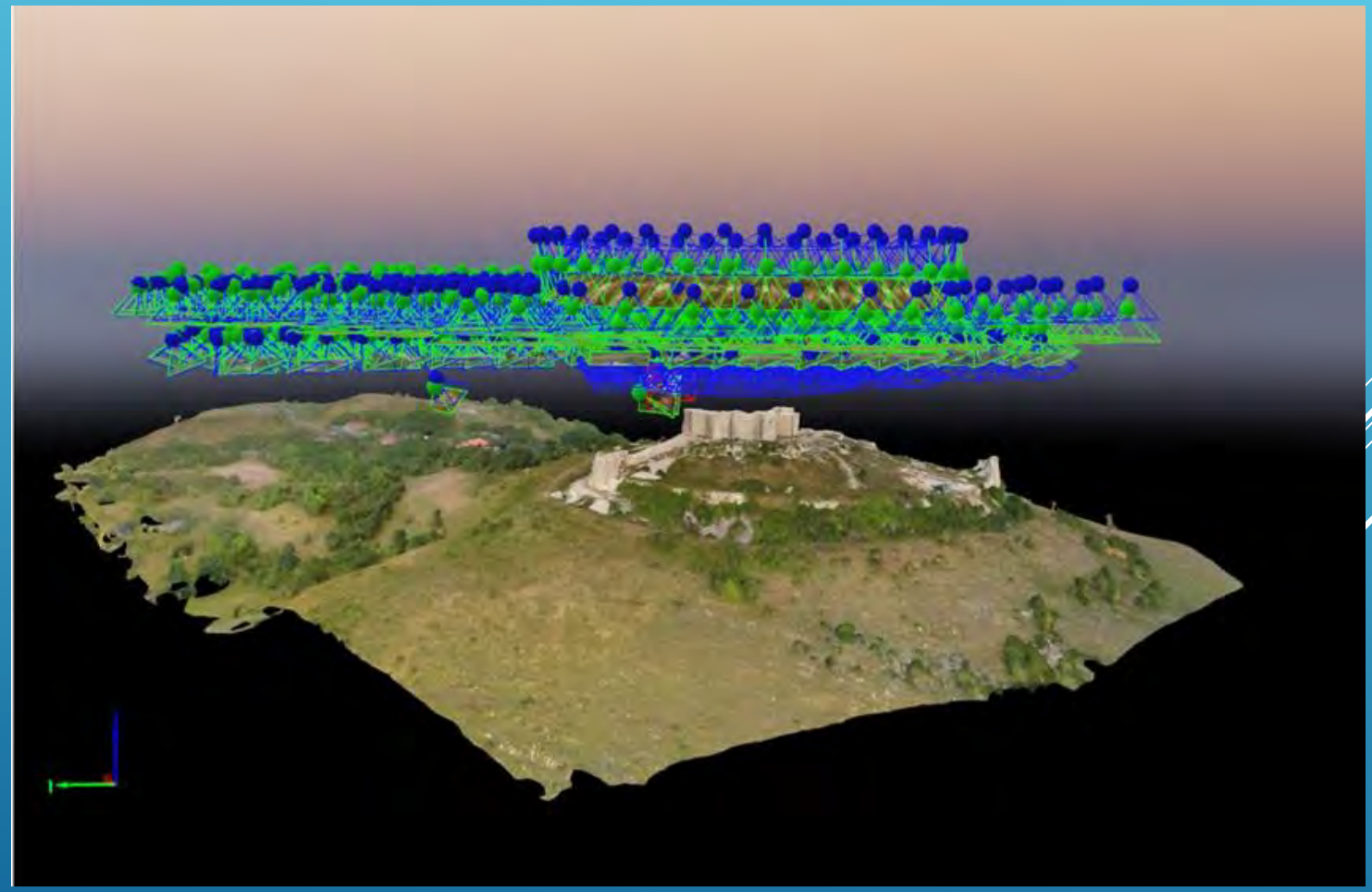


Figure 2. Flight path for aerial photography to provide parallactic perspective for recognition of key points that tie images (Pix4D, 2022b)

UAS FLIGHT OPS AND PHOTOGRAMMETRY

- Camera Locations in the Sky
- SfM (Structure from Motion)
- Blue Dots locations recorded in image EXIF
- Green Dots locations calculated by software



FINDING KEY POINTS TO MAKE TIE POINTS

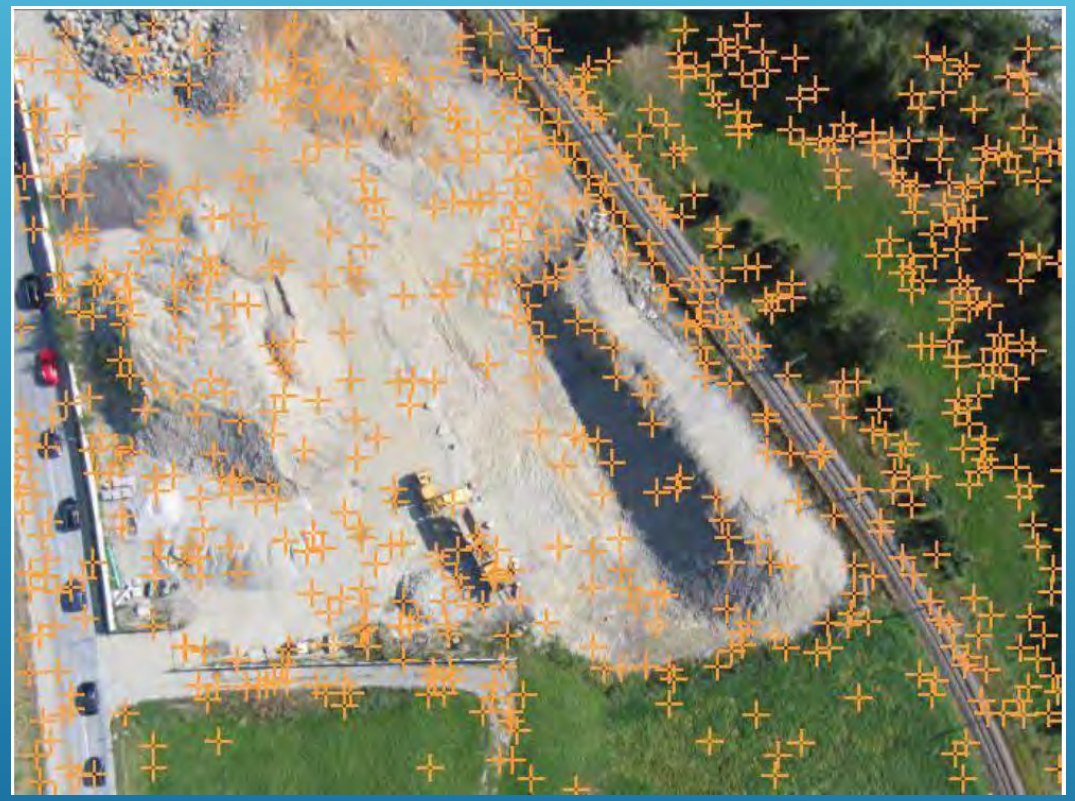


Figure 3. Key points identified in densified point cloud (Pix4D, 2022b)

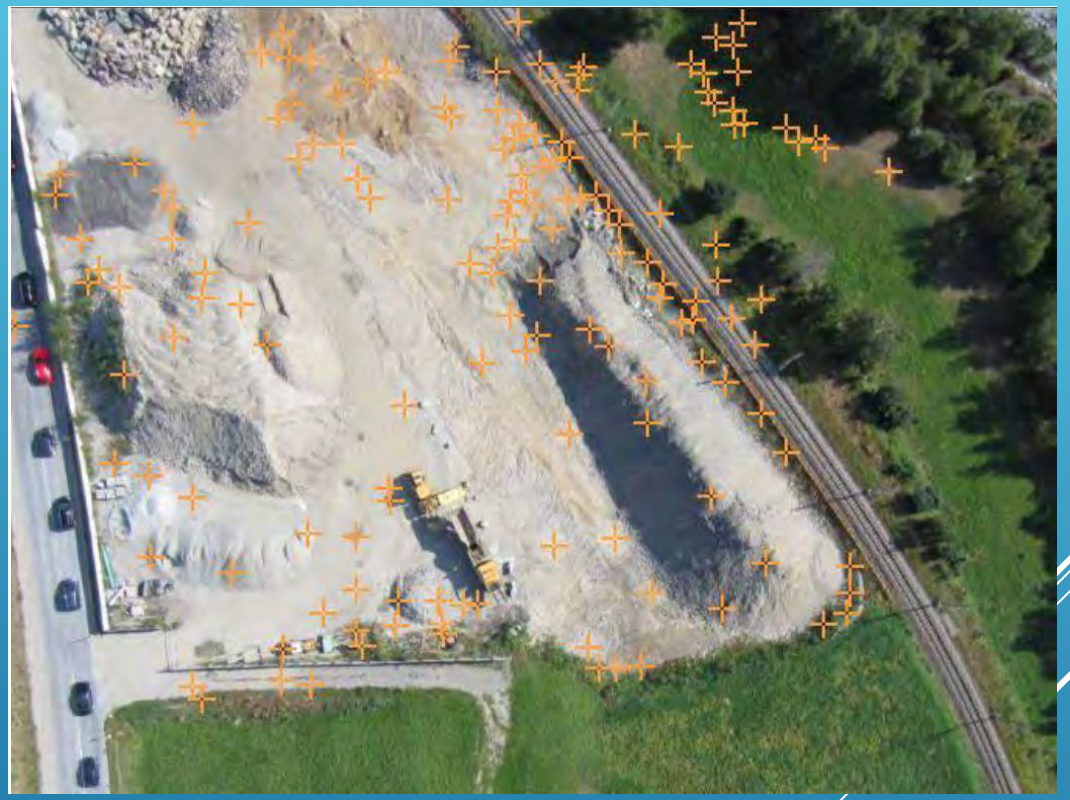


Figure 4. Automated tie points in a densified point cloud(Pix4D, 2022b)

Photo

Virtual Object

UAS FLIGHT OPS FOR LIDAR

DEFINED

- LiDAR (Light Detection and Ranging)
  - A method of active remote sensing in which LASER pulses of infrared radiation (IR) (i.e., 1040 – 1060 nm) are beamed to targeted areas on the ground. As these pulses strike objects, reflections are noted by the sensor enabling a determination of range, and for each individual return the sequencing of returns and intensity of the return.

LIDAR POINT CLOUDS

- LiDAR return will have a specific XYZ position, scan angle and calibration value. These values can then be processed and generated into a dense group of elevation points, referred to as a "point cloud."
- GNSS base station provides positional data used in post processing to make the point cloud more accurate.
  - The technique is know as post processing kinematic (PPK).
  - This process can make each LiDAR point accurate to the centimeter level.

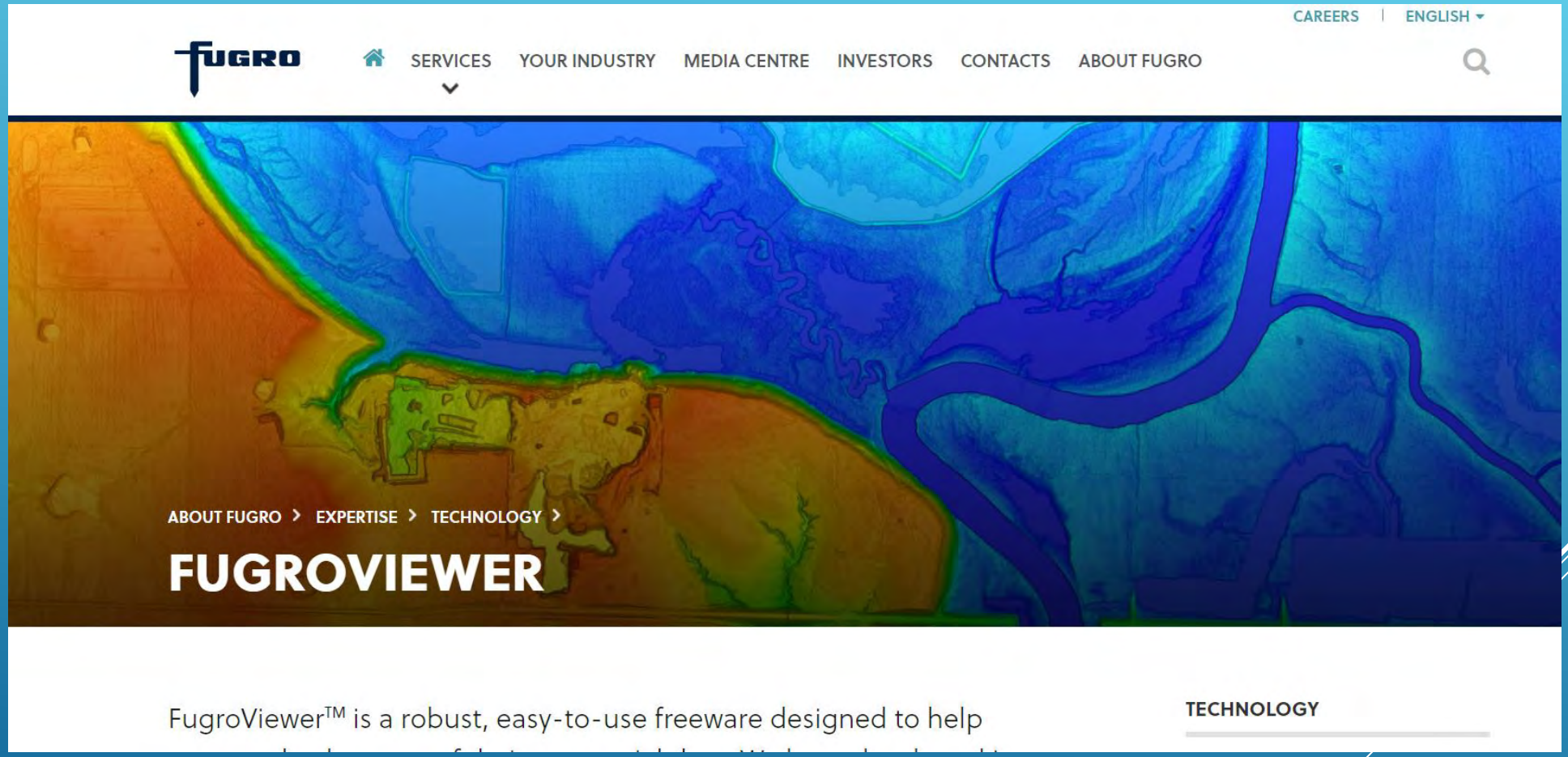
LIDAR IN APPLICATION FOR FIELD WORK

Accurate positional data is essential

Figure 4. North Base SmarTK PPK Receiver

Figure. M600 with Revolution 120 LiDAR

LIDAR POINT CLOUD VIEWING



GLOBAL MAPPER

APPLICATION CASE STUDY

The Republic of Kosovo

THE REPUBLIC OF KOSOVO

- Kosovo
- Cultural Heritage Site Documentation
- Partners US Embassy Kosovo and Cultural heritage without Borders

SERVICE LEARNING

In Kosovo, during summer terms, faculty and students completed academic course work and UAS flight operations.

- **Purpose:**
  - Gather imagery
  - **Develop three dimensional (3D) virtual objects** and **two dimensional (2D) orthomosaic maps**
  - Aid with inspecting, documenting and chronicling locations
- Why:
  - Assist with cultural heritage preservation in Kosovo
  - Bring STEM Education to Kosovo
    - Effort funded, in part, by U.S. Embassy Kosovo

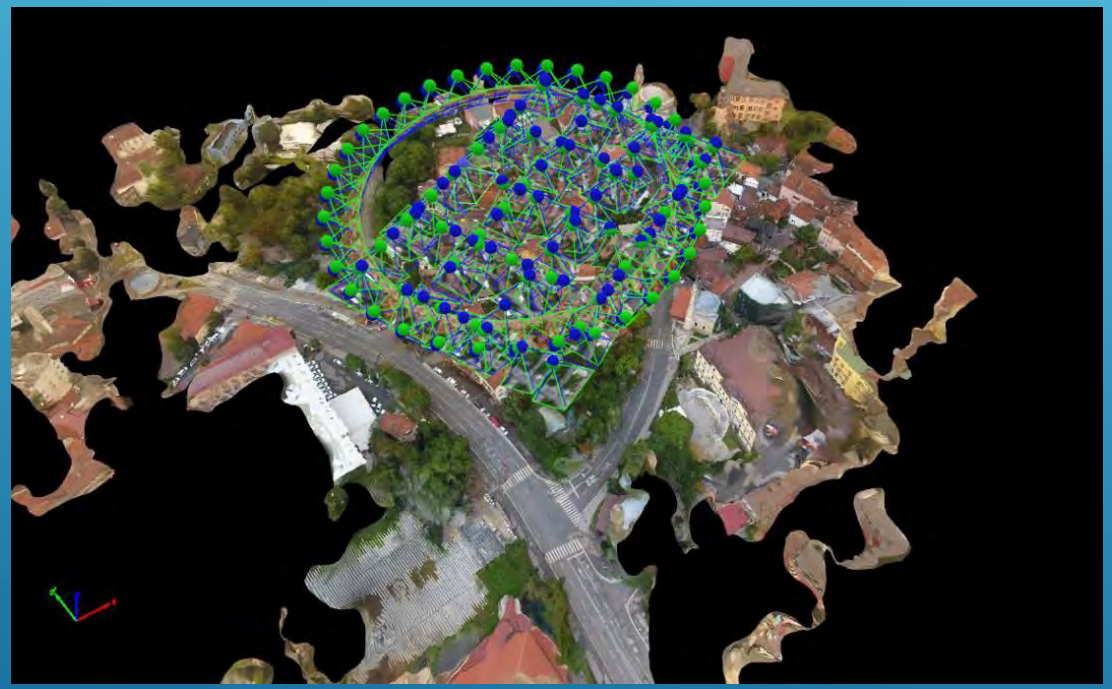
Rich and Complex History

Orthomosaic

Albanian Kulla

Ulpiana – Roman City

USE OF 3D PHOTOGRAMMETRY IN THE REGENERATION OF A HISTORIC ROAD



Prishtina Kosovo

THE REGENERATION OF THE HISTORIC ROAD

UAS FLIGHT OPERATIONS AND PHOTOGRAMMETRY KOSOVO

FLIGHT PATH

Figure 5. Plan view flight path over map Novobërda (Mapbox, 2022)

CAMERA LOCATIONS

- Pattern for flight:
  - 2 x Double Grid
  - 1 x Circle

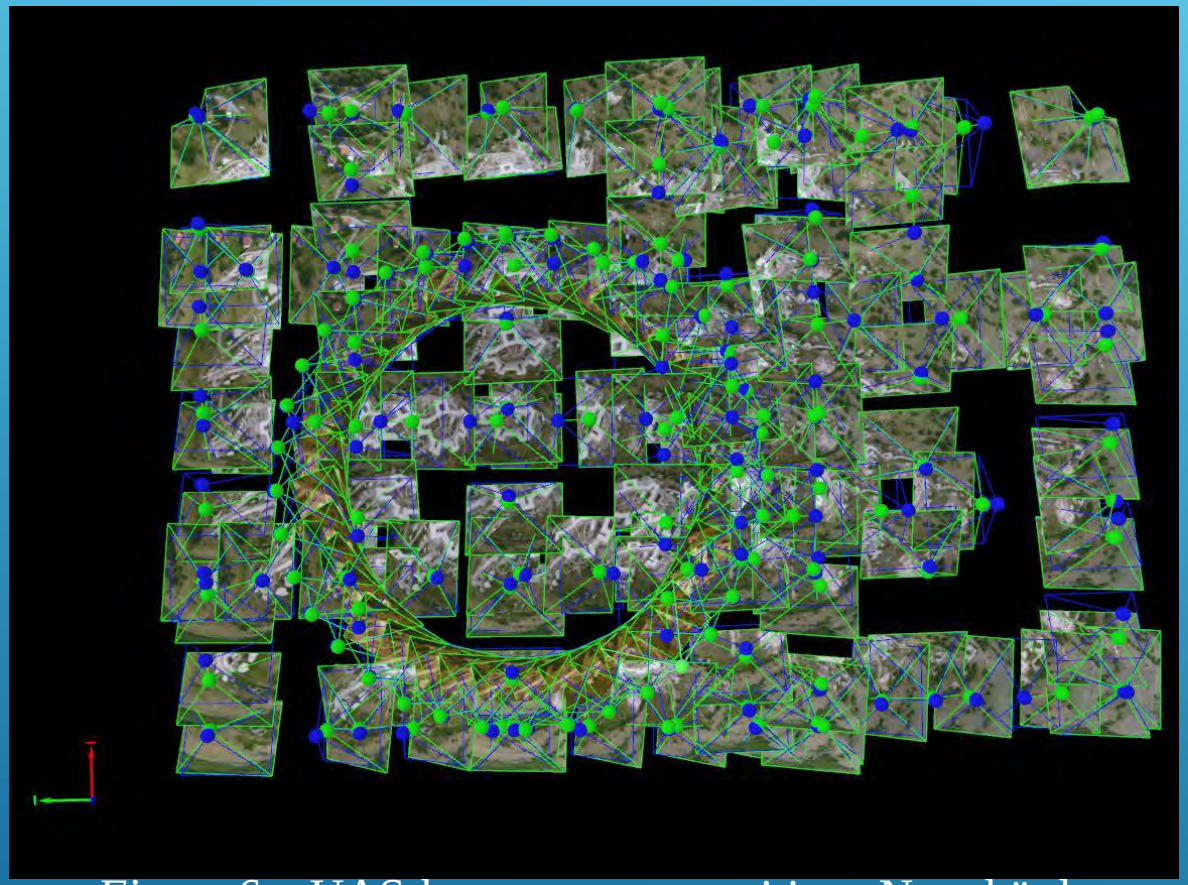


Figure 6 . UAS-borne camera positions Novobërda

ORTHOMOSAIC

- Ground Sampling Distance (GSD)
  - 3.24 cm per pixel

- RMSE
  - X 2 cm
  - Y 2.2 cm
  - Z 3.94 cm

High positional accuracy achieved with ground control points and post processing

Figure 7. Orthomosaic of Novobërda

TIE POINTS BINDING IMAGES

Figure 8. Tie Points Novobërda

POINT CLOUD

- Naturally colorized
- Similar possibilities to LiDAR derived point clouds

Figure 9. Densified Point Cloud Novobërda

VIRTUAL REALITY

- 3D Structure
- Exportable

Figure 10. Triangle Mesh Novobërda

APPLICATION CASE STUDY

Tularosa Creekside Village

UAS FLIGHT OPERATION

- LiDAR
- Photogrammetry
- Video
- Photography

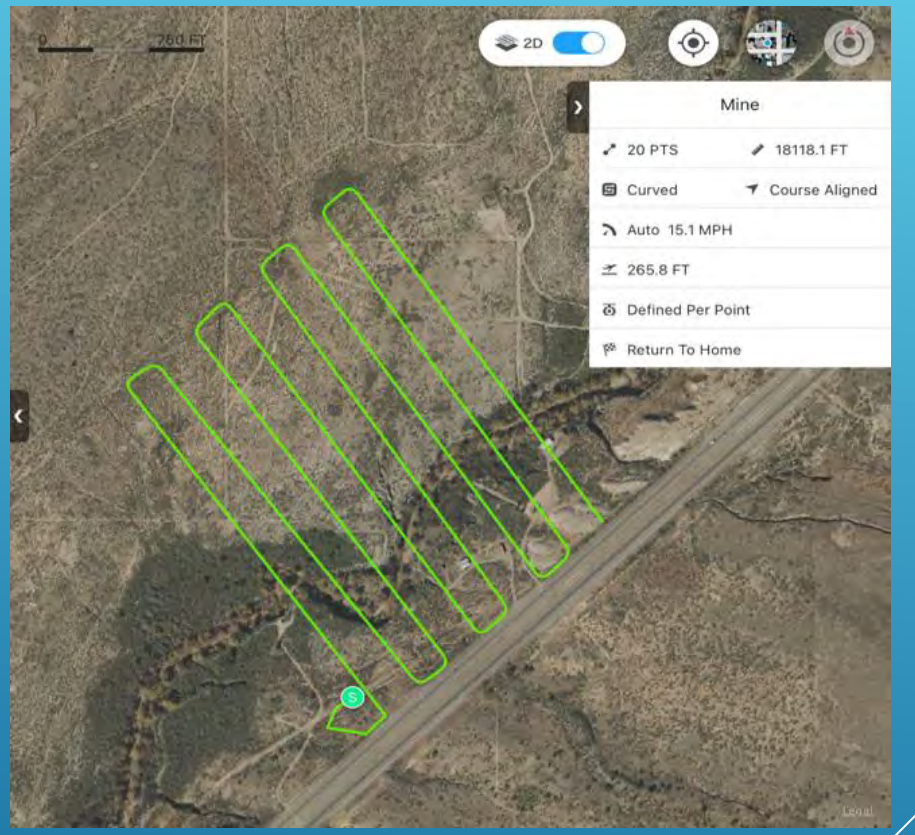
CREEKSIDE VILLAGE AREA

- Orthomosaic from photogrammetry

- 3.69 GB GEO TIFF
- 2.94 cm GSD
- RMSE
  - X 37 cm
  - Y 44 cm
  - Z 1 m

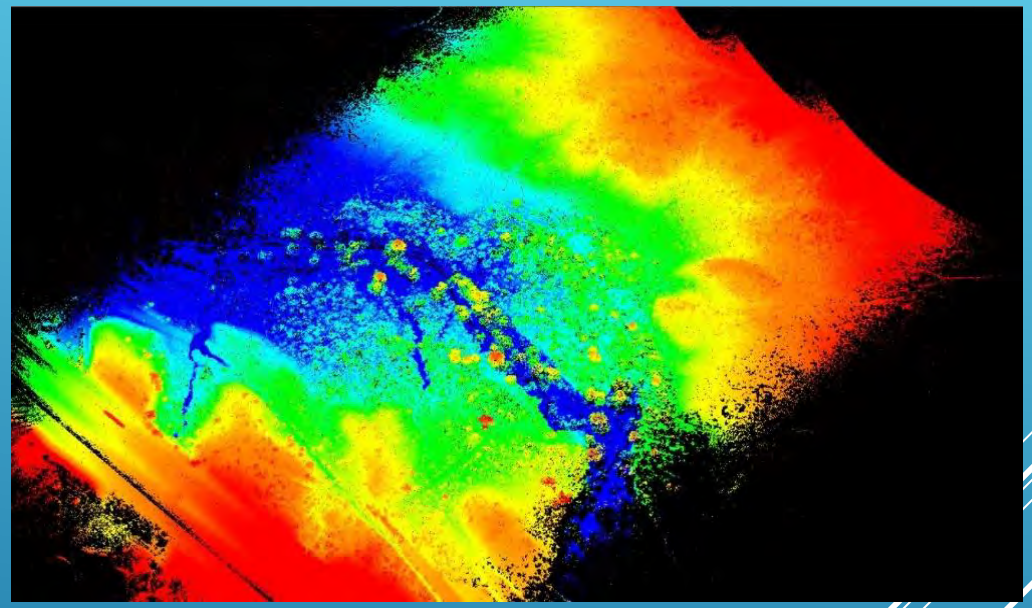
LIDAR TRANSECTS

- M600 drone
- Revolution 120 LiDAR LiDARUSA
- DJI Ground Station Pro



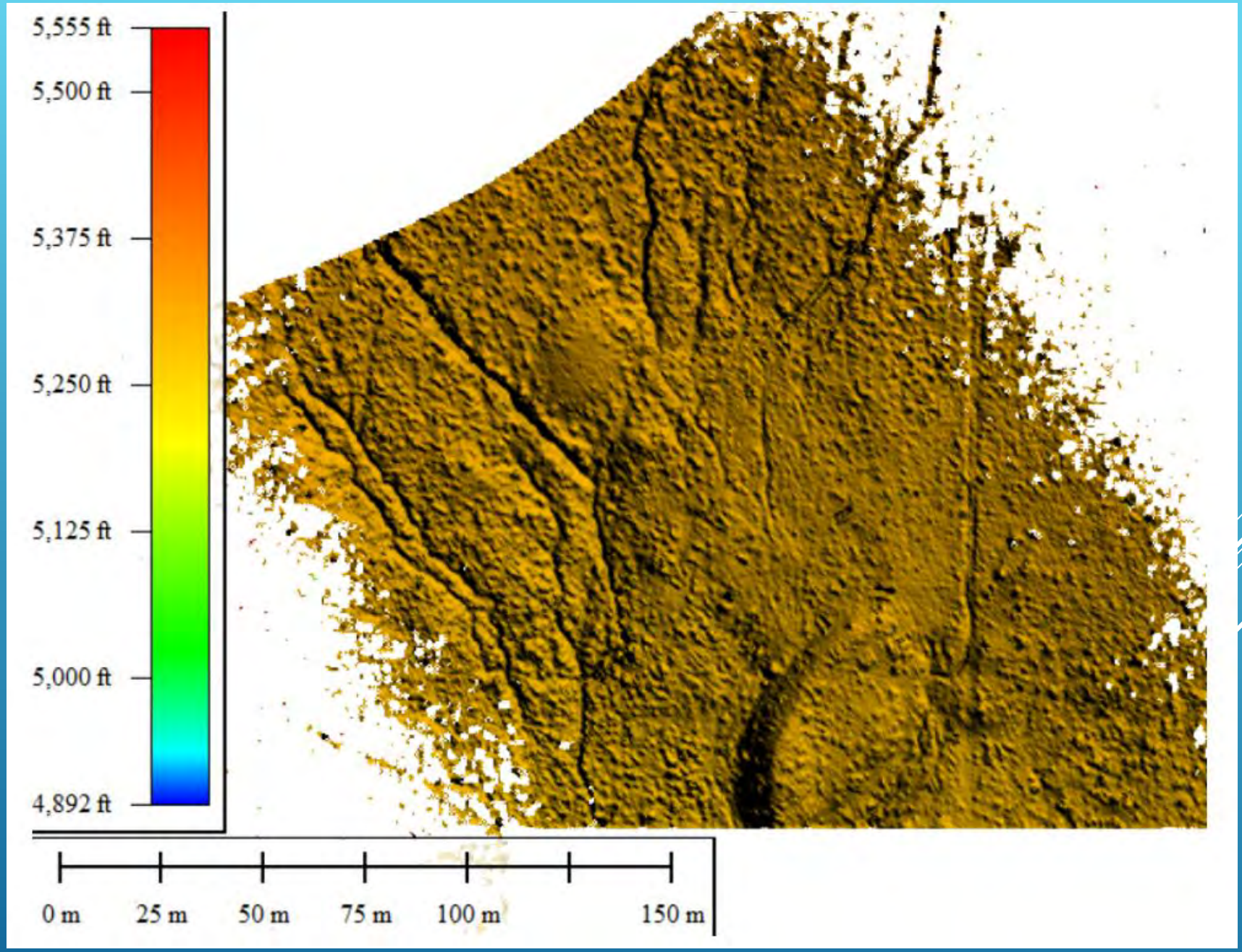
LIDAR SELECTION TULAROSA CREEK

- Creekside Village Area
- Point colored by elevation



SAMPLE DEM

- With hill shading



QUESTIONS ?

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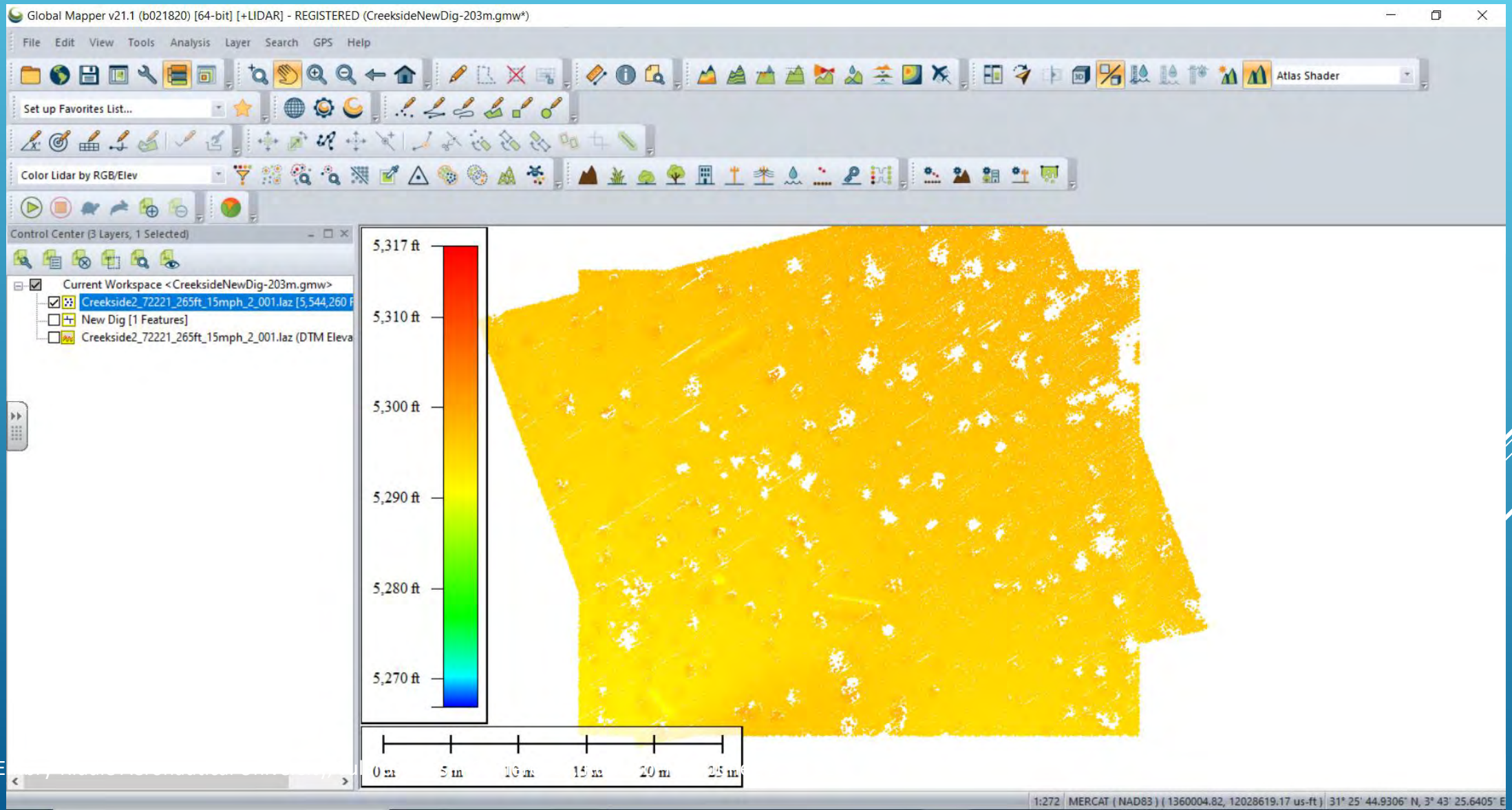
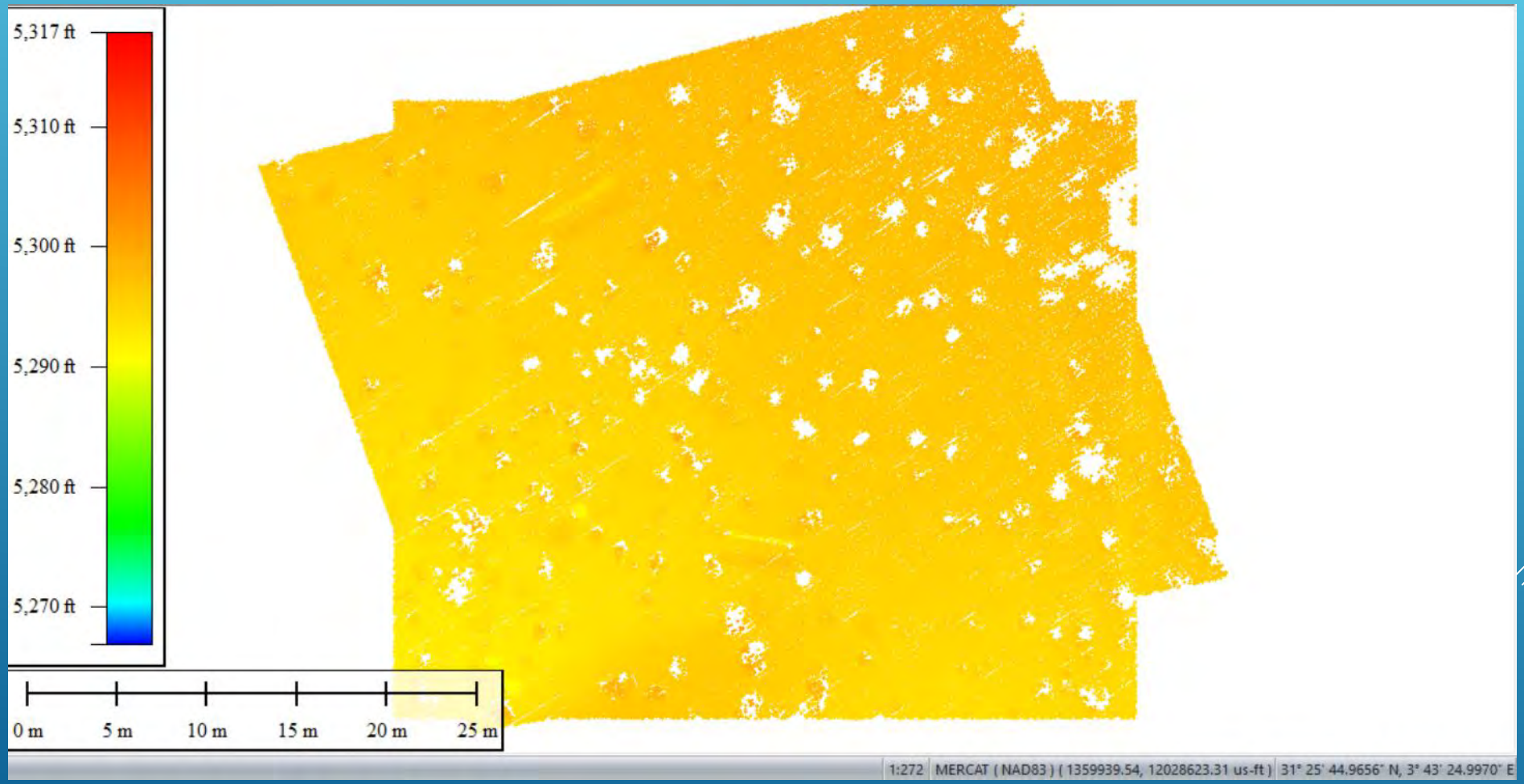
SUPPLEMENTAL

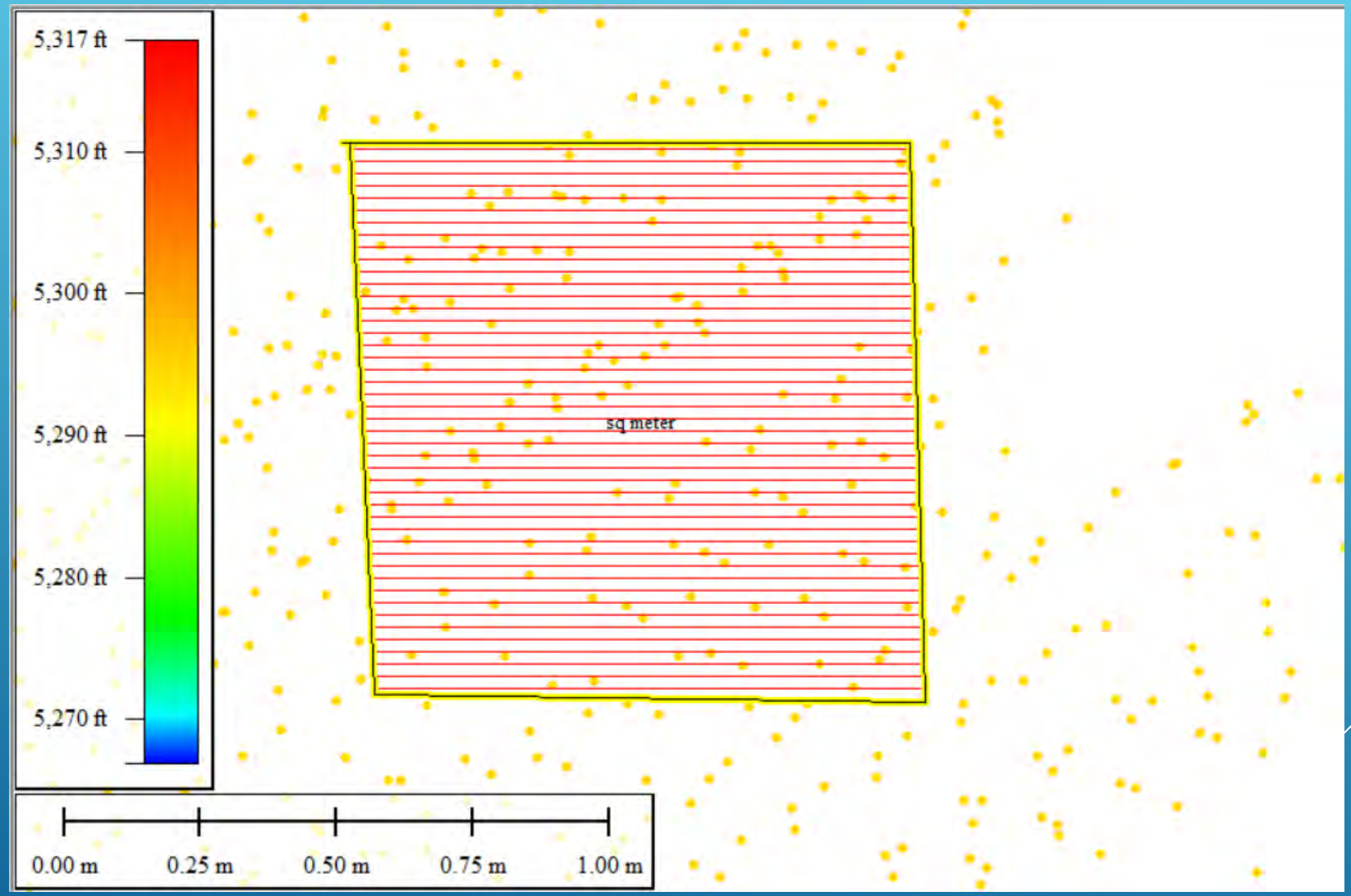
GROUND RETURNS



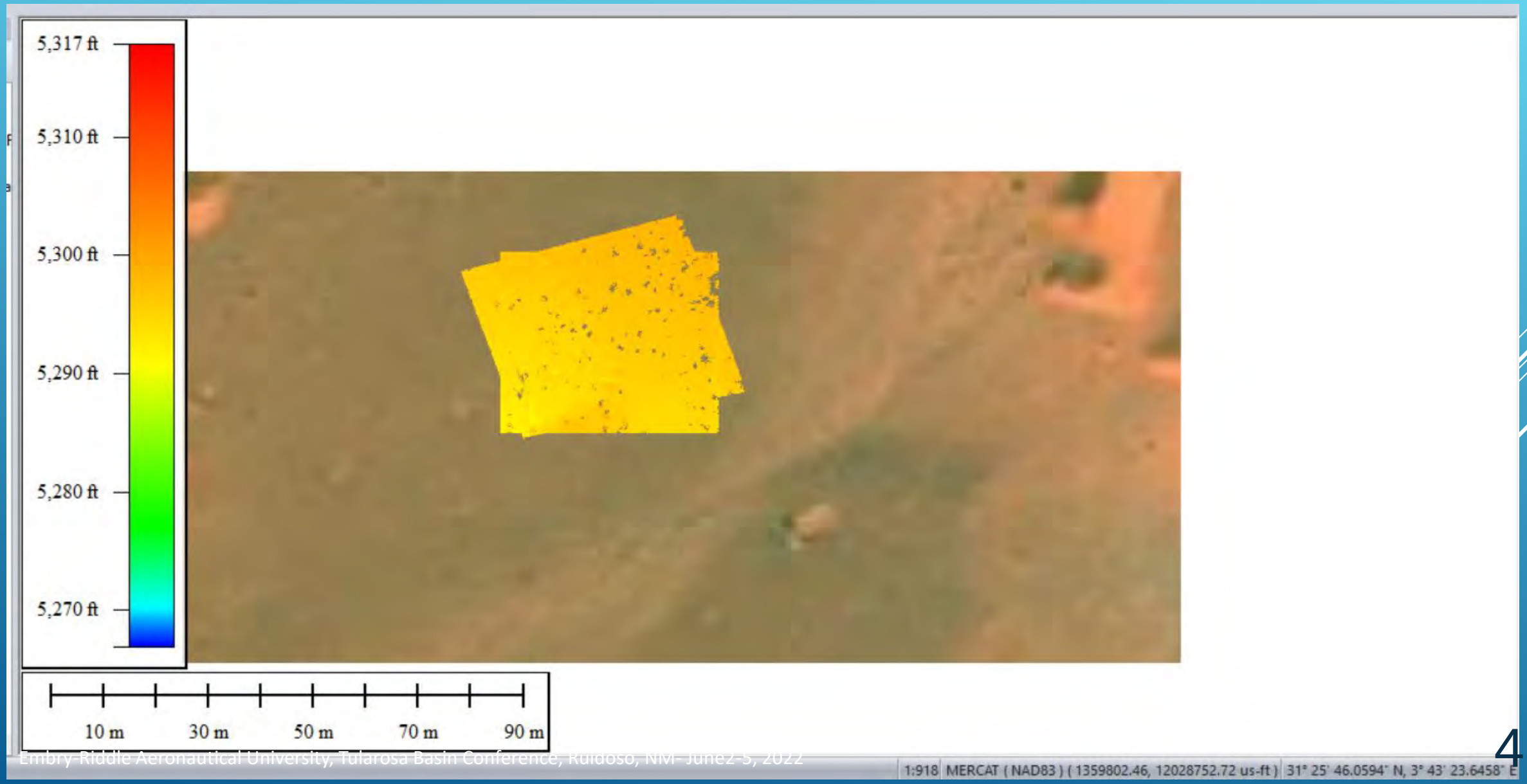
GROUND RETURNS



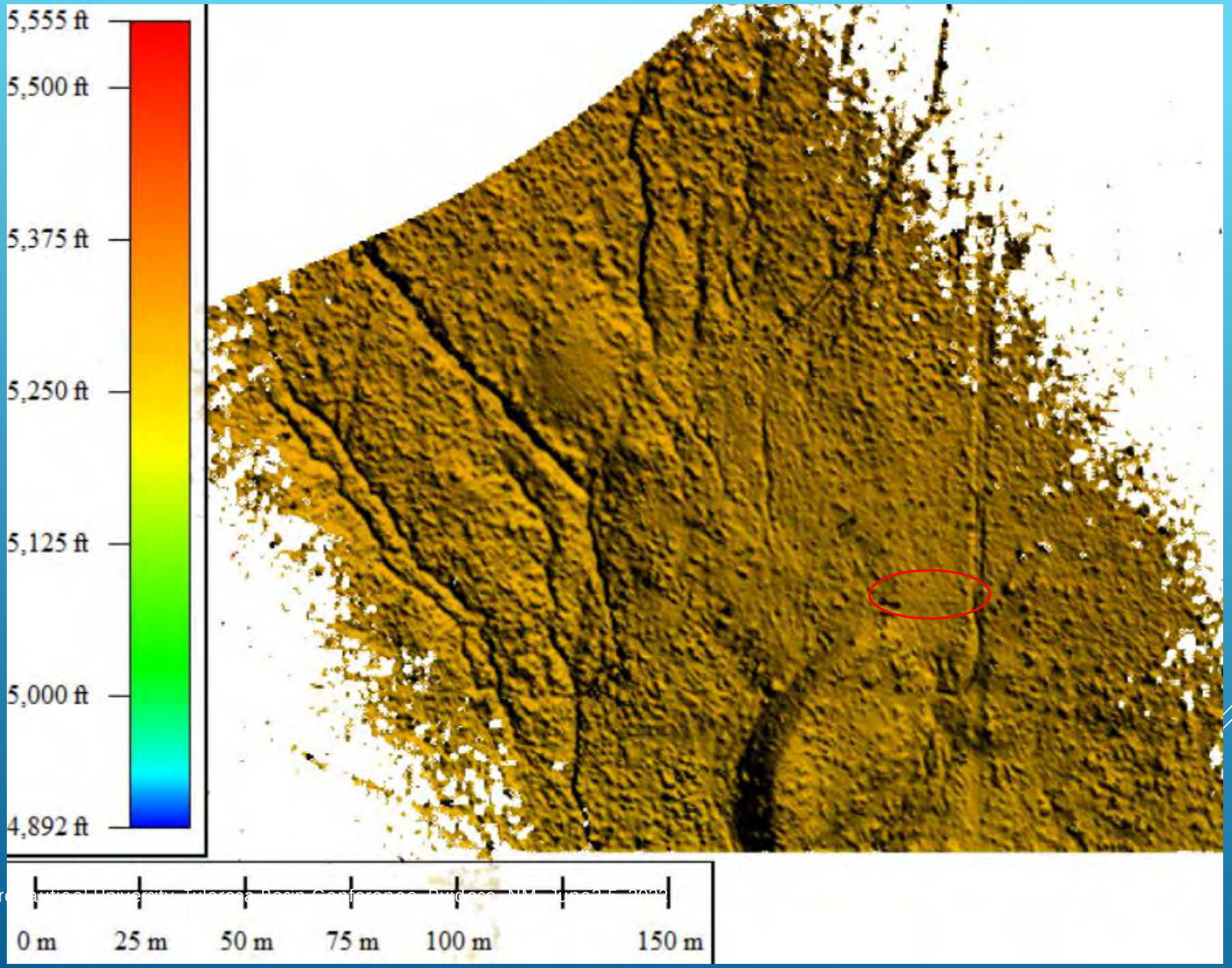
TYPICAL SAMPLE - 120 RETURNS PER SQ METER



GROUND POINT CLOUD OVER SATELLITE



DEM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5,500 ft
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5,250 ft
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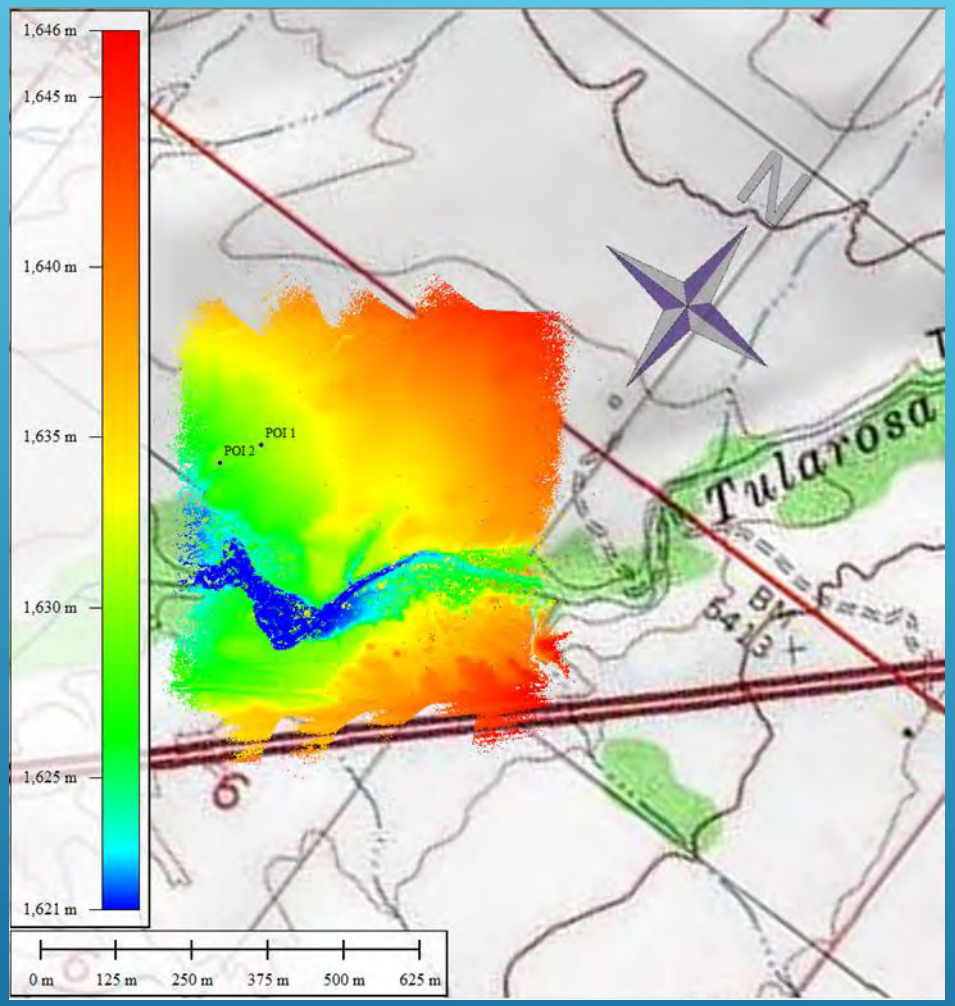
1,646 m
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