CLAYTON LAKE DINOSAUR TRACKSITE PROJECT: PALEONTOLOGY BY DRONE

Michael A. Kvasnak, Althea M. Atherton, Bryan Burn, Melodi King, Amber Palmer, Michael Pitula, Tara Spurlock, John Beltran, Spencer G. Lucas, John B. Rogers, Richard P. Watson and Theresa Watson

(CNM Media Services)

Introduction/Background

- Mike Kvasnak (Kuh-vaz-nick)
- 5th year student in 2yr Geographical Information Systems (GIS) program at CNM
  - Hope to complete the program in Spring 202?
  - Completed small Unmanned Aircraft Systems (sUAS) certificate and obtained FAA Part 107 (sUAS pilot) license along the way
- BS in EE from Clarkson University 198?
- Served 8 years in USAF
  - Image processing and telescope control systems
- Currently working for Boeing at the Starfire Optical Range, Kirtland AFB
  - Nothing to do with dinosaurs or rocks, or GIS, for that matter
- Involvement
  - When they asked for volunteers I forgot to take a step back
  - Actually, I really enjoy working with Dr. Lucas and the CNM team
  - Interested in Maps, Drones, Maps, Remote Sensing, Maps, Photogrammetry and Maps

Overview/Summary

- The use of small unmanned aircraft systems (sUAS), i.e., drones and photogrammetry, in the fields of paleontology, archeology, and geology are relatively recent developments.
- The commoditization of drone technology over the past five or so years combined with now readily available structure-from-motion, photogrammetry, and three-dimensional (3-D) modeling software has led to the ability to improve the scientific collection of field data and then create 3-D models of these natural features.
- In the Spring of 2019 a team of 15 students from Central New Mexico Community College (CNM) and scientists from the New Mexico Museum of Natural History and Science (NMMNH) and CNM, spent a week at Clayton Lake State Park and Dinosaur Trackways in an effort to:
  - Continue and extend the research of Dr. Spencer Lucas of NMMNH
  - Try new techniques in photogrammatic data collection developed by Dr. Richard Watson of CNM.

Overview/Data

- During the five days of on-site work, three types of image data were collected:
  - Drone – more on these later
  - Terrestrial – Handheld photography using a standard SLR camera (Sony A6000)
  - LiDAR – Light Detection And Ranging (radar with light, sub-mm resolution)
- The data were then processed through Pix4D photogrammetry software to create 3-D densified mesh models and a high precision digital surface model (DSM) of the dinosaur tracksite.
- A unique aspect of this project was the creation of a website to showcase and visualize these dinosaur tracks and tracksite, to expand public awareness and education about the site and aid in developing future research directions.

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On-Site Field Work

- Clean site to expose tracks and remove clutter
- Survey site to establish georeferencing
- Collect Terrestrial Data
- Collect sUAS Data
- Collect LiDAR Data

Site Preparation

- Clearing vegetation and loose rocks that would affect imagery
- Identify exemplar tracks for terrestrial imaging

(CNM Media Services)

(Cannon)

Uncovering New Tracks

(CNM Media Services)

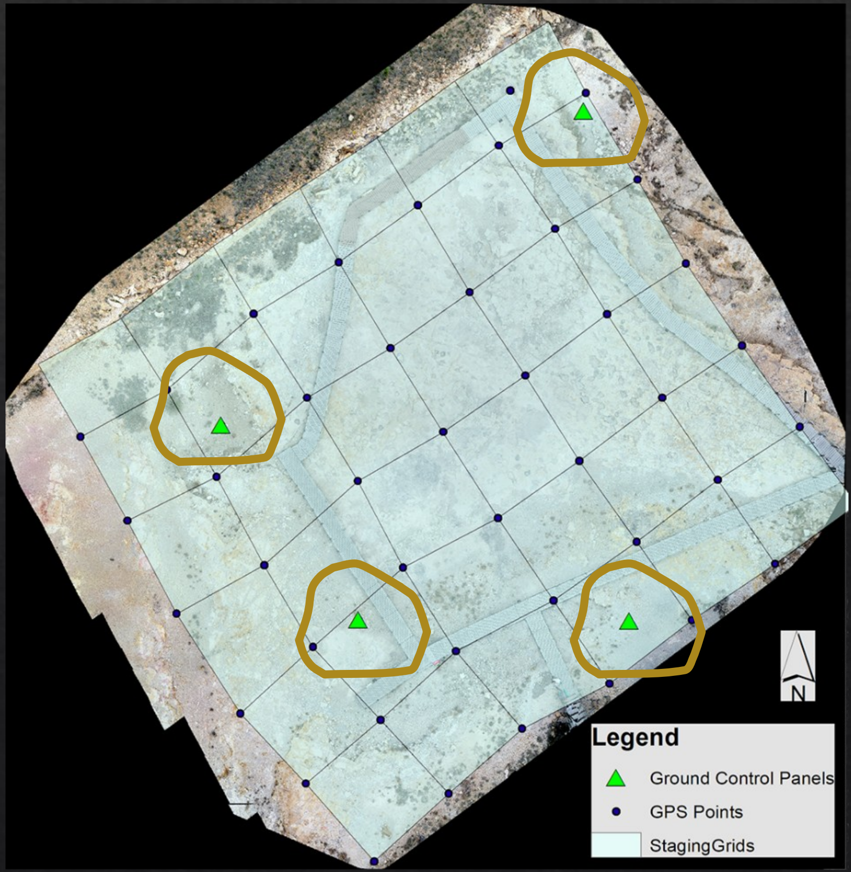
Georeference Set Up Process

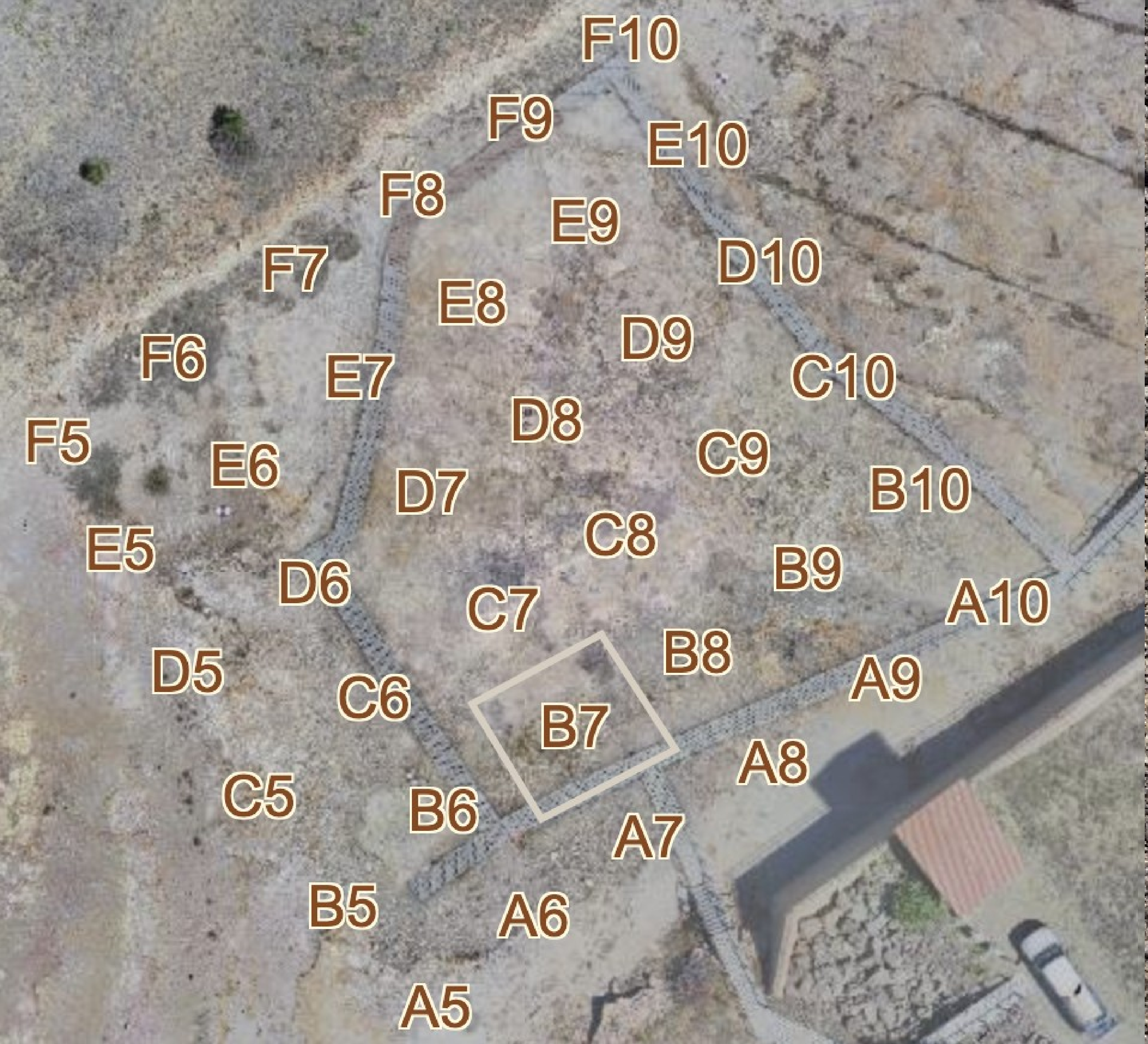
- GPS Base station
- Measured 20 x 20 ft collection grid
- Placed Ground Control Points (GCPs)
- Real Time Kinematic (RTK) GPS readings
- Overall georeference accuracy of 3.1 mm (0.12 in)
  - Cell phone – 5m
  - Handheld (Garmin) – 3m
  - Differential GPS – 1m
  - Online Positioning User Service (OPUS) – 1cm
  - Real Time Kinematic (RTK)
  - Post Processing Kinematic (PPK)

Ground Control Points (GCP) & GPS Operations

- Four 2 ft x 2 ft panel
- GPS Recorded using New Mexico State Plane Coordinate system
- Spatial Reference System EPSG: 2257

- OPUS Differential GPS
- Real Time Kinematic (RTK)
- Pix4D georeferences all models

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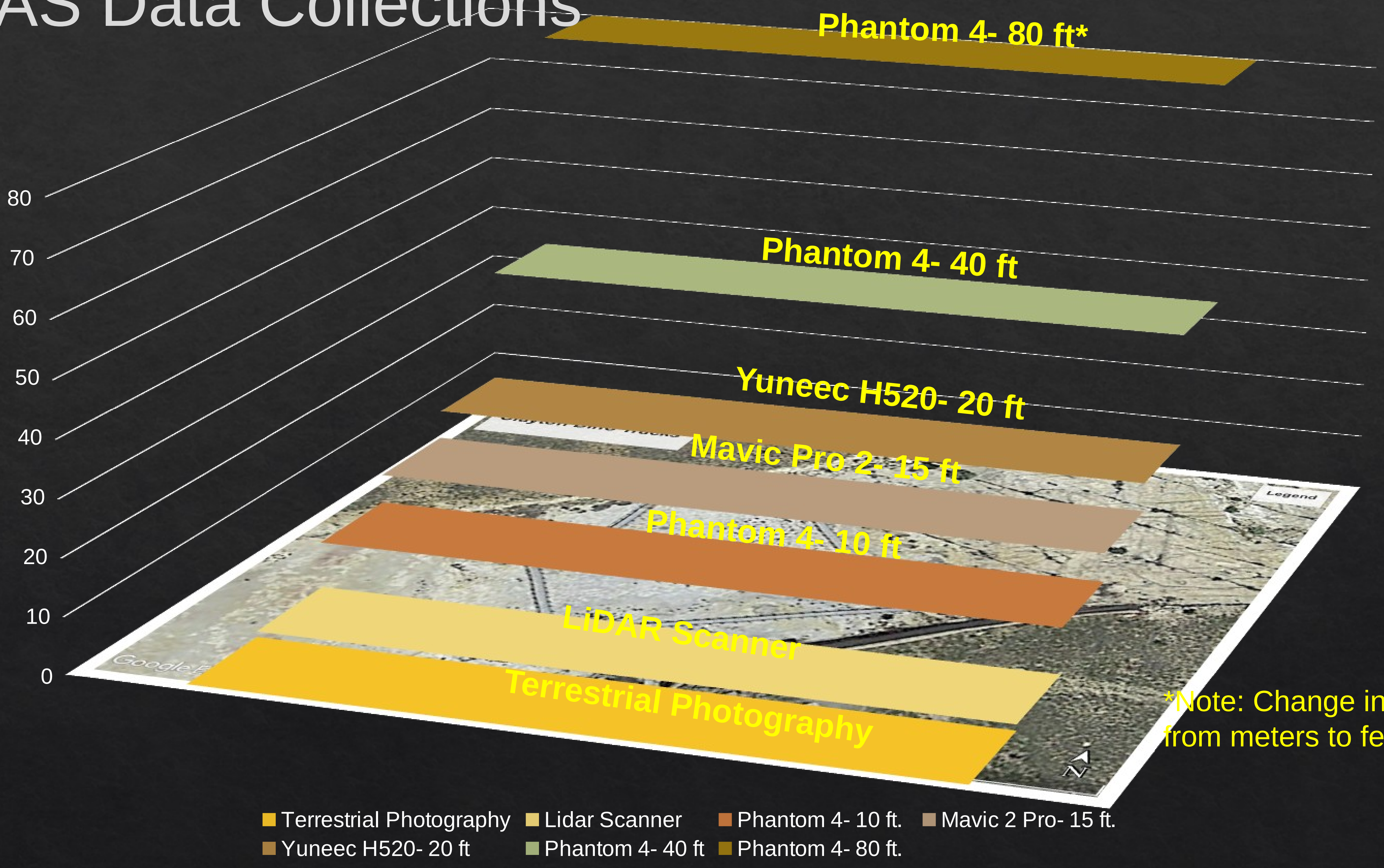
Grid
corner

Data Collection Tools, Methods, Software, and Presentation

- Tools
  - sUAS
  - Terrestrial
  - LiDAR
- Methods
  - sUAS Flights
  - “Brian Cannon Technique”
- Software
  - Pix4D
- Products/Presentation
  - 3D Models
  - Web sites

sUAS Data Collections



*Note: Change in units from meters to feet

UAS Sensor Systems & Resolutions

- Yuneec H520
  - Flight Attitude: 27m
  - Estimated Flight Time: 27 minutes
  - Sensor Size: 1”
  - Ground Spatial Distance: 8.0mm
- DJI Phantom 4 Pro
  - Flight Altitude: 25m
  - Estimated Flight Time: 3’ 47”
  - Sensor Size: 1”
  - Ground Spatial Distance: 6.8mm
- DJI Mavic 2 Pro
  - Flight Altitude: 10m
  - Estimated Flight Time: 14’ 39”
  - Sensor Size: 1”
  - Ground Spatial Distance: 2.3mm

(CNM Media Services)

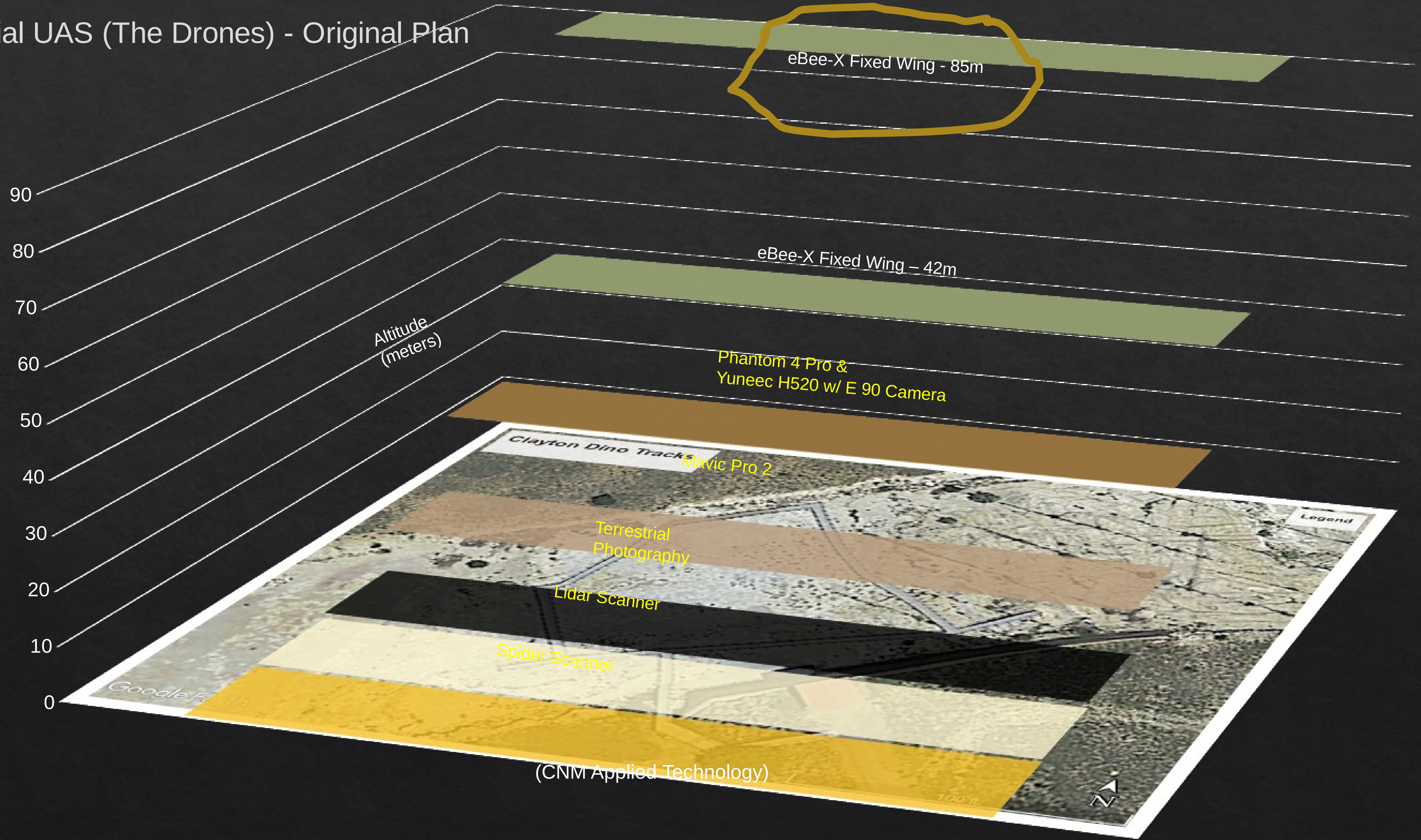
Why use UAS to study footprints?

- Allows footprints to be preserved digitally
- Shows detailed 3D footprint morphology
- Allows us and other scientists to study footprints remotely using our data
- Temporal monitoring of footprint integrity so we can see how the tracks degrade over time.

(Petti et al., 2018)

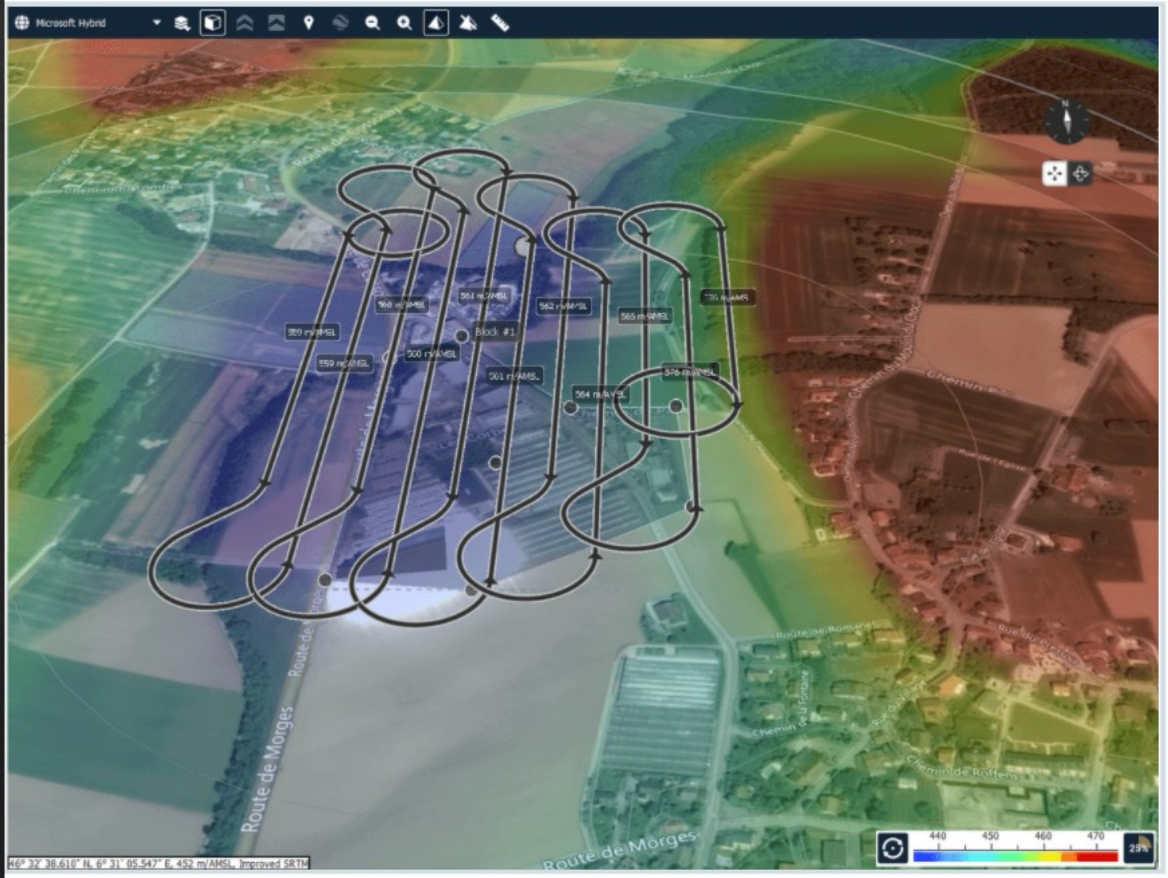
(CNM Media Services)

Aerial UAS (The Drones) - Original Plan



(CNM Applied Technology)

SenseFly eBee X Fixed Wing



Side scanning sensor for obliques
Large turn around radius
Winds too high

Three Drones, Six Flights, Two Days, Lots of Wind
1,261 image files, 13.3 GBytes





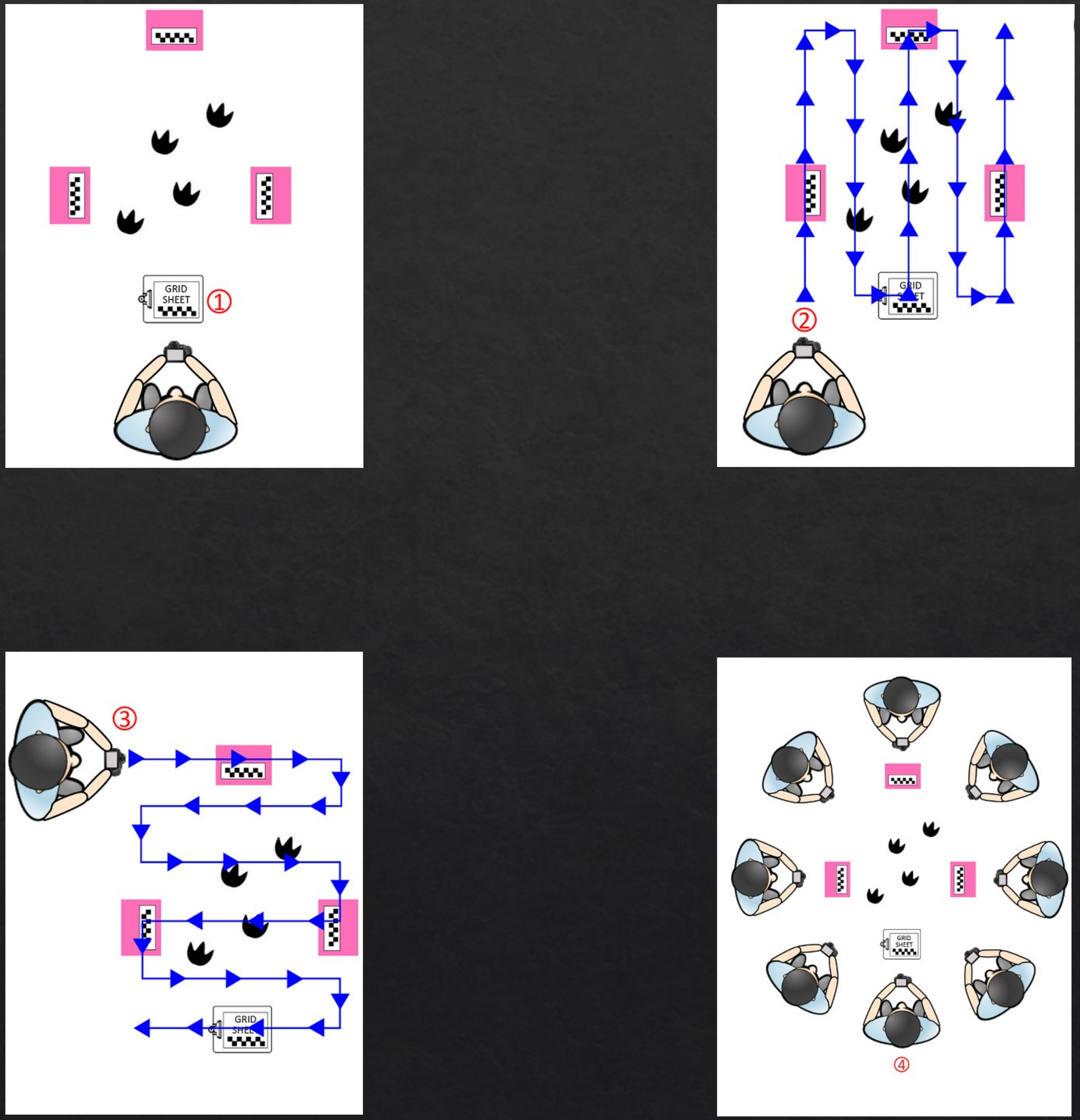

(CNM Media Services)

Terrestrial Data Collection

- Sony A6000 with a 16-50 mm Zoom Lens
- Set to 16 mm
- Aperature Priority Mode to help with
- exposure control
- Auto Focus

Terrestrial Process:

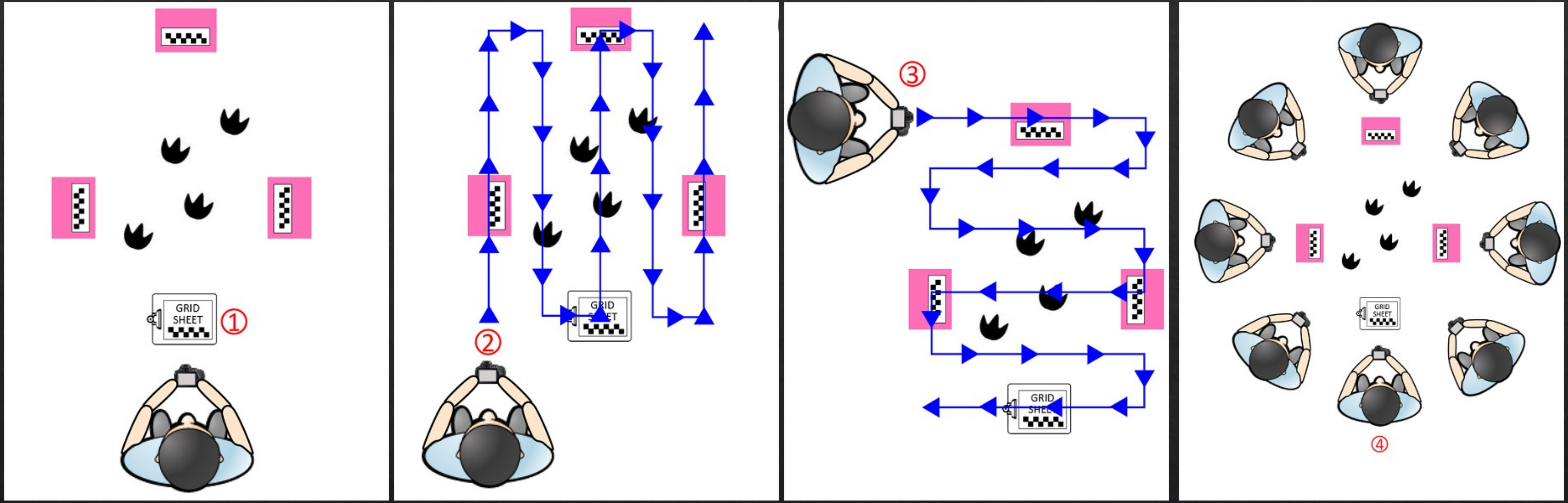
- In a Spring 2019 class, we evaluated several methods of collecting terrestrial photos to create track models
- Ultimately, we decided on the “Brian Cannon Method”, named after one of our classmates
  - Simple
  - Efficient



(Cannon)

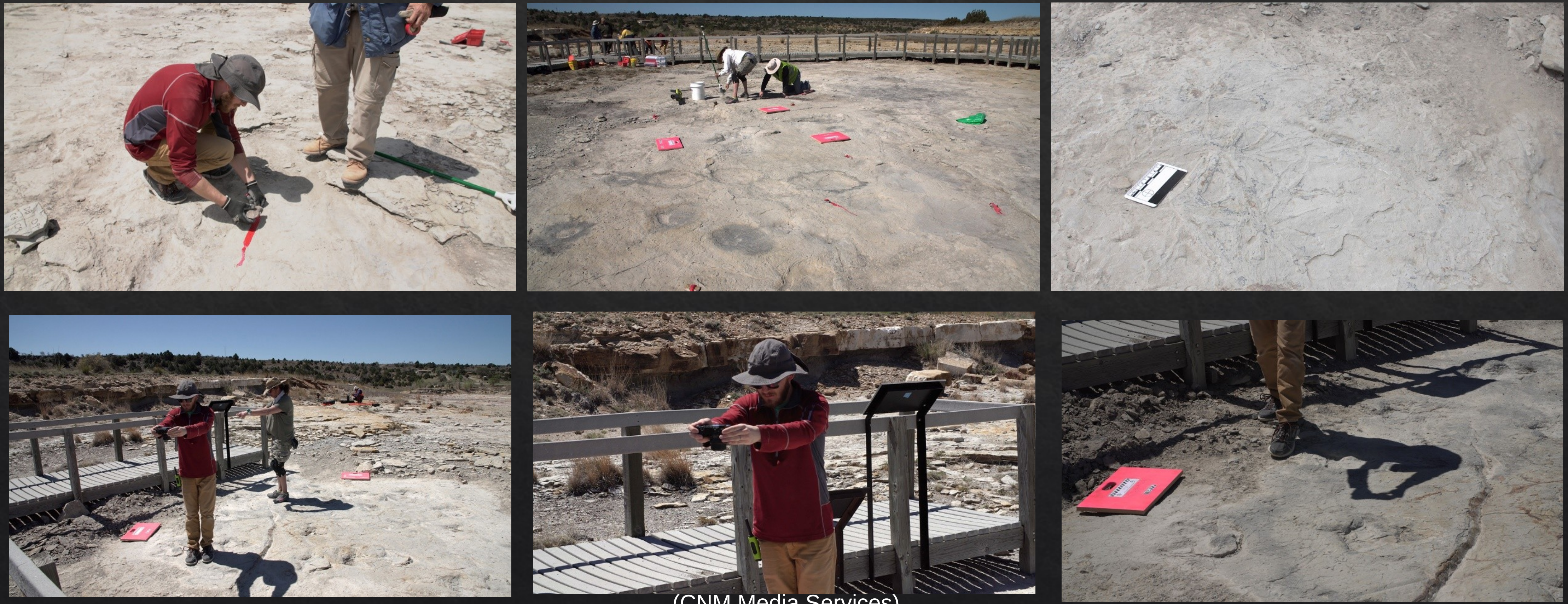
Terrestrial Photogrammetry

- “Brian Cannon Method”



- ❖ Important aspects of the terrestrial data collection was the sun angle, shadows and the amount of overlap in the photos > 80% desired
- ❖ Shadows will cause the software to process them into the model
- ❖ Fortunately we had a relatively cloudy day with mostly uniform lighting
- ❖ The oblique photos allow the Pix4D software to fill in the shadows on the edges of the tracks

3,600+ Track Photos Collected



(CNM Media Services)

3,632 Files, 29.9 GBytes

(Atherton)

LiDAR

- Trimble
  - Tripod mounted
  - Moved to various locations around the site
  - ~ 300 meter range
  - Collected data, haven’t post-processed yet

Processing Started On-site for Quick Look Analysis

(CNM Media Services)

The leading photogrammetry software for professional drone mapping

Quality Report

Generated with Pix4Denterprise version 4.5.2
Preview

Important: Click on the different icons for:

Help to analyze the results in the Quality Report

Additional information about the sections

Click here for additional tips to analyze the Quality Report

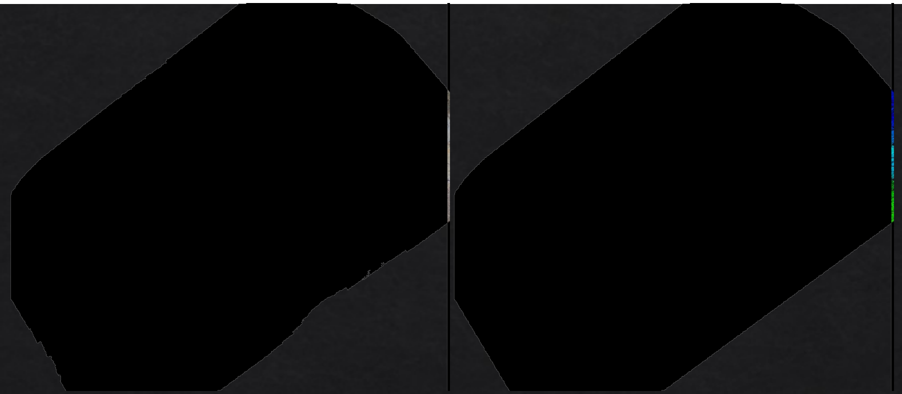
Summary

Project	All_Drones_Img_Balanced
Processed	2019-10-23 17:02:26
Camera Model Name(s)	FC6310_8.8_5472x3648 (RGB), L1D-20c_10.3_5472x3648 (RGB), E90,23mm_8.3_4856x3640 (a96fea5f2a3c4e5c41d262bcf8bc1a4a) (RGB)
Average Ground Sampling Distance (GSD)	0.31 cm / 0.12 in
Area Covered	0.015 km² / 1.4521 ha / 0.01 sq. mi. / 3.5902 acres
Time for Initial Processing (without report)	02h:08m:33s

Quality Check

Images	median of 60697 keypoints per image
Dataset	1041 out of 1043 images calibrated (99%), all images enabled
Camera Optimization	4.04% relative difference between initial and optimized internal camera parameters
Matching	median of 17669.9 matches per calibrated image
Georeferencing	yes, no 3D GCP

Preview



Results/Products

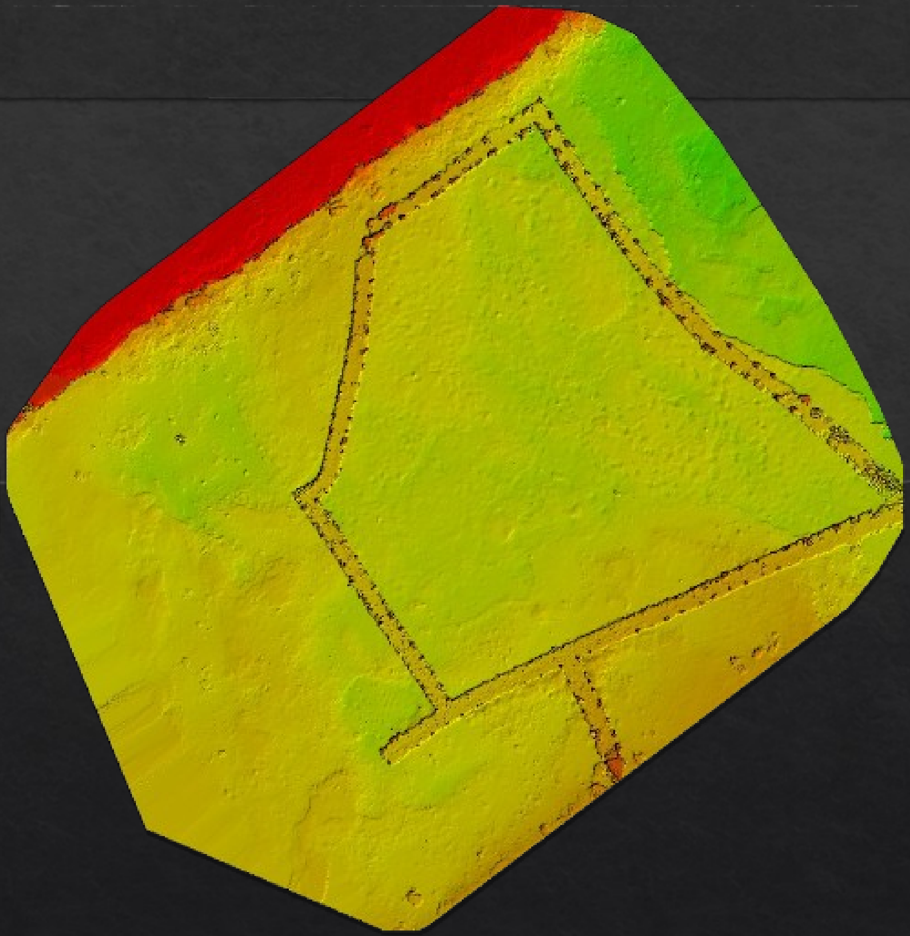
- Orthoimages
  - Ground Sampling Distance 3.1 mm (0.12 in)
- Digital Elevation Models
- Contour interval maps
- 3D models
  - 23 Track models, 843 Mbytes
  - 8 site models created from sUAS data, 412.5 MBytes
- Total Data Collected and Processed 4,893 files, 44.4 GBytes
- Geotiffs
- Websites

Now that we have the Data Cool Things can be Done

- The fusion of the image data collected of these dinosaur tracks at multiple heights and resolutions with geospatial reference data has resulted in a highly accurate orthophotograph and DSM of the entire tracksite. From this DSM and orthophoto additional tracks not originally observed in the previous site surveys are now apparent.
- Current efforts are on-going to process the tens of gigabytes of images and produce scaled 3-D models of the tracks and identify additional potential tracks.
- These models can then be used to determine the size, weight, and stride length of the individual creating the track. Additionally, 3-D models suitable for website viewing and 3-D printing are being created.

Products - Computer Generated Maps

Photo Mosaic (Orthoimages)



Digital Elevation Model

Figure 1: Orthomosaic and the corresponding sparse Digital Surface Model (DSM) before densification.

(CNM Applied Technology)

Drone Photos Were Merged to Create Site Model

3D Models are Created using Photogrammetry

Prior to Our Work this was the only Map of the Tracksite

Published by Gillette and Thomas in 1985

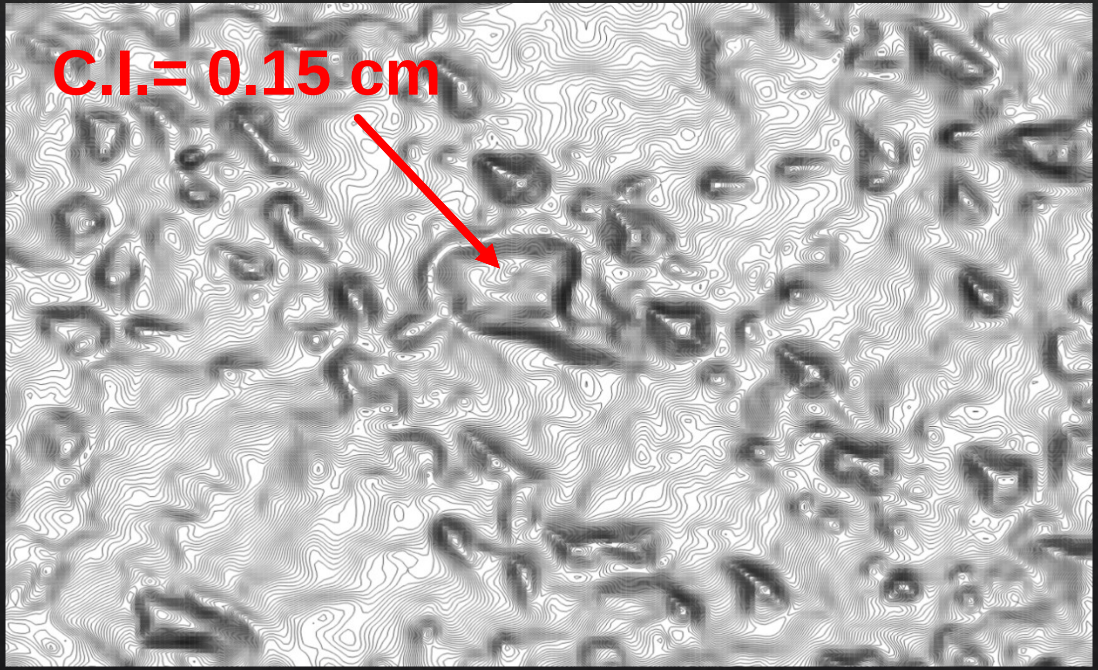
Made by pace and compass

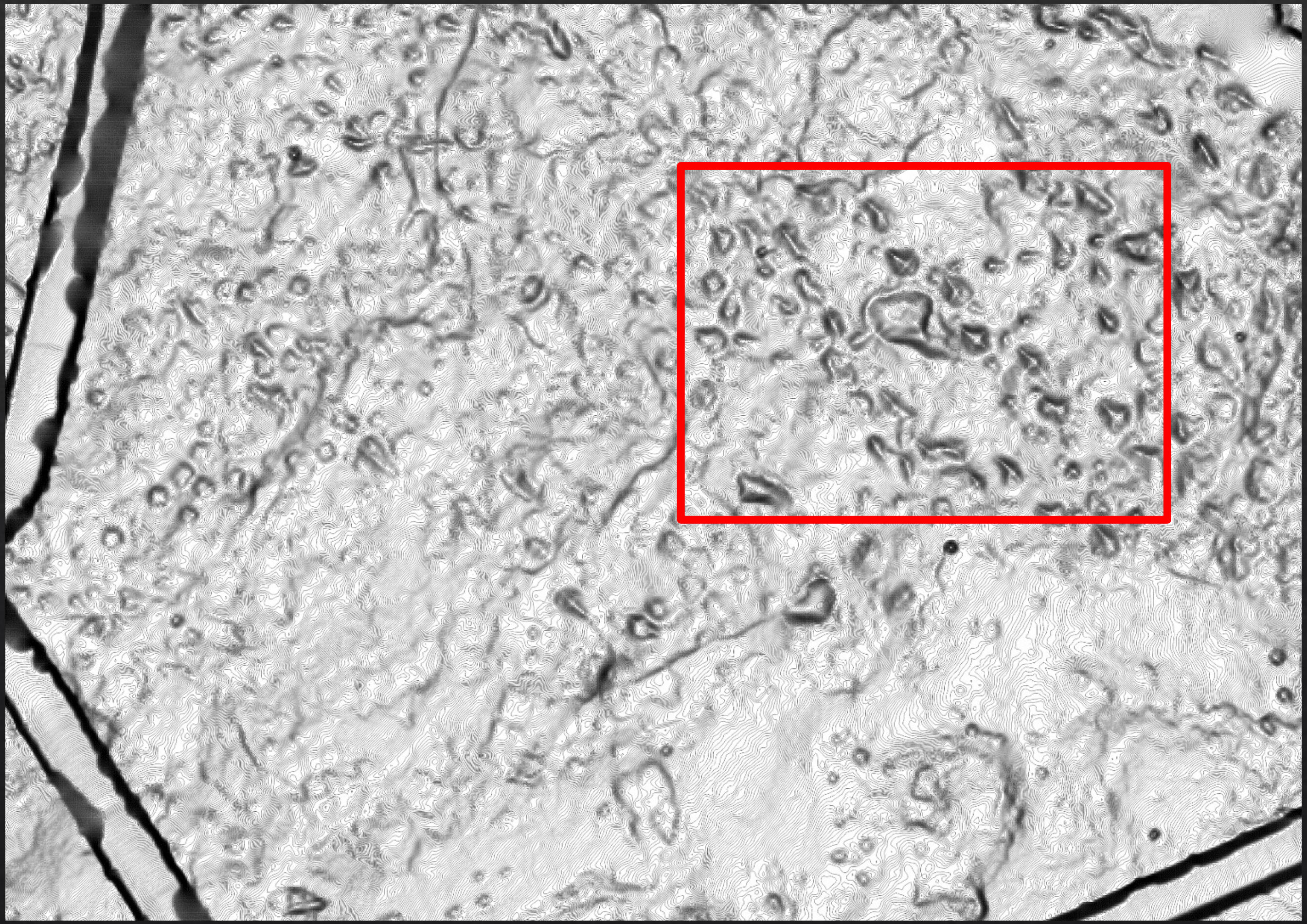
It is remarkably detailed and difficult to replicate

(Gillette and Thomas)

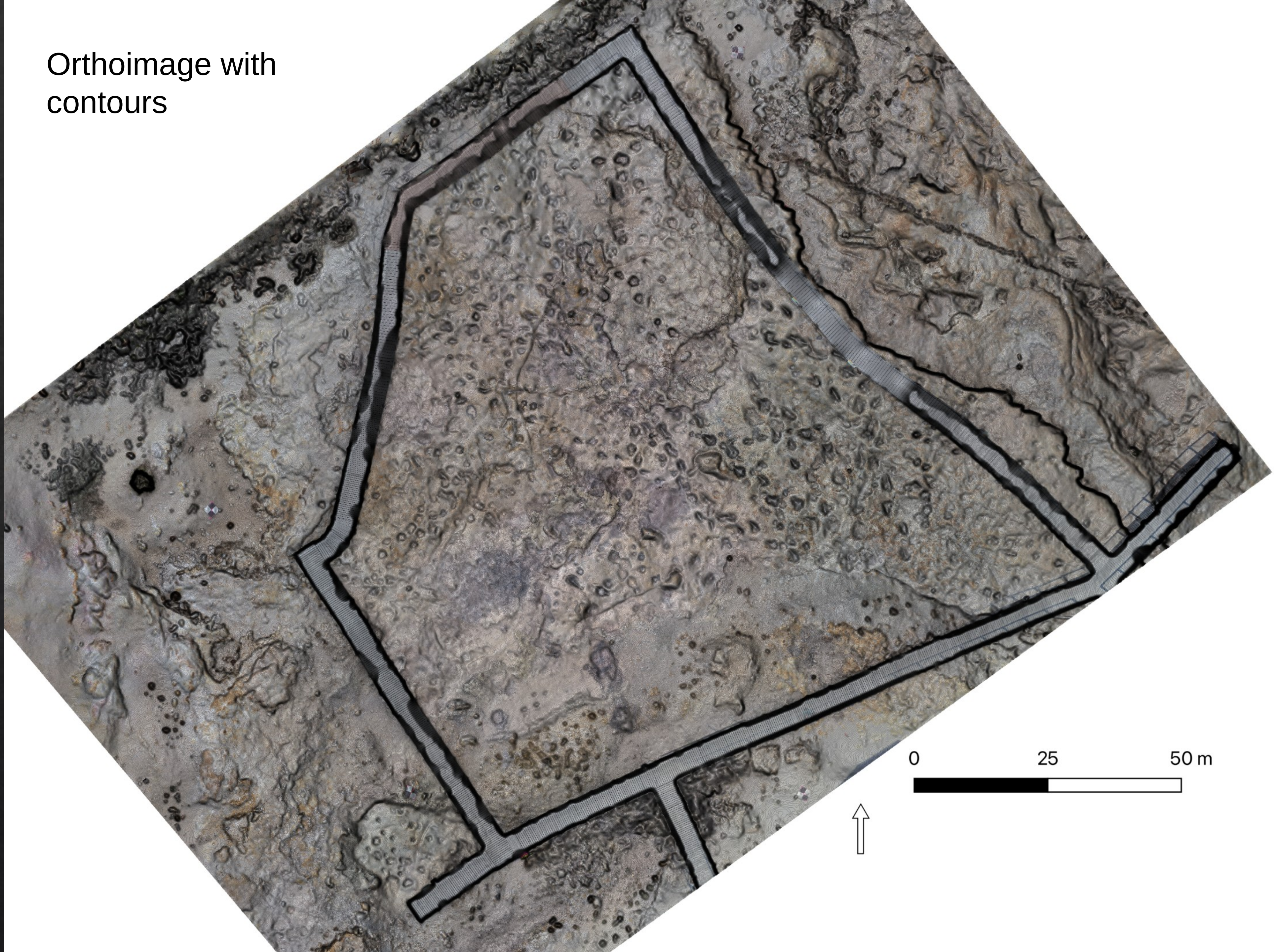
Now We Have A 3D Model

3D Model allows creation of contour maps at varying resolutions and provides the ability to zoom to areas of interest





Orthoimage with contours

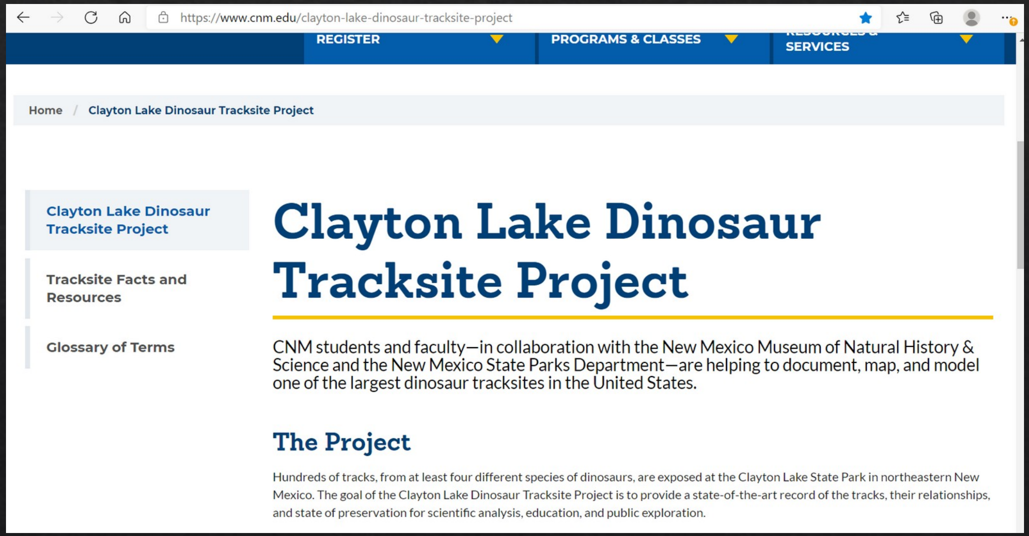


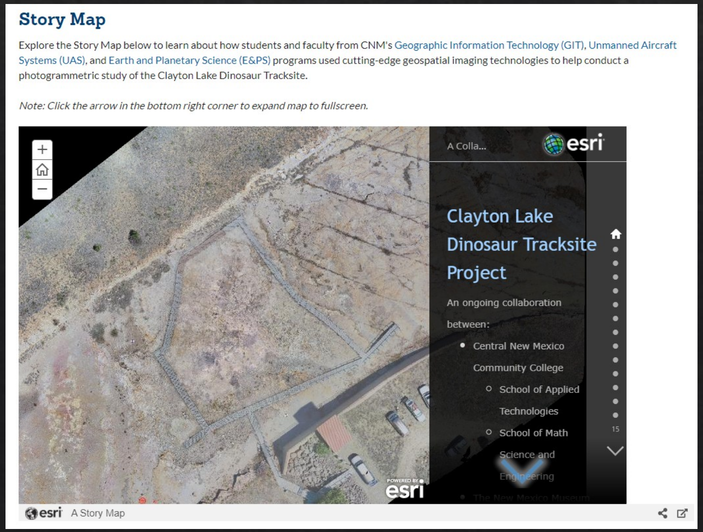
Project Mission

- Recording of the Clayton Lake Dinosaur Tracksite for the purpose of providing archival data documenting the current state of preservation and exposure of the tracksite for the purpose of resource management and to further scientific study.
- The applications of state-of-the-art geospatial imaging technologies (photogrammetric mapping and modeling using UAS-based imagery and terrestrial photography, and LiDAR) will be used to provide multiscale documentation of the tracksite.
- To educate the public about Clayton Lake State Park and ichnology, the study of trace fossils.
- The resultant data sets will provide both an archive and publicly available data for scientific analysis and exploration.

Web Site/Education

- Two web sites have been created
- CNM
  - Provides overview and entry point to educational information
- ArcGIS online
  - Provides story map and interactive maps and 3D models



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C8
C9
Q02
Dinosaur
Ornithopod (Caririchnium)
Track ID
Q02
Grid Location
C8/C9
3D Model
More info
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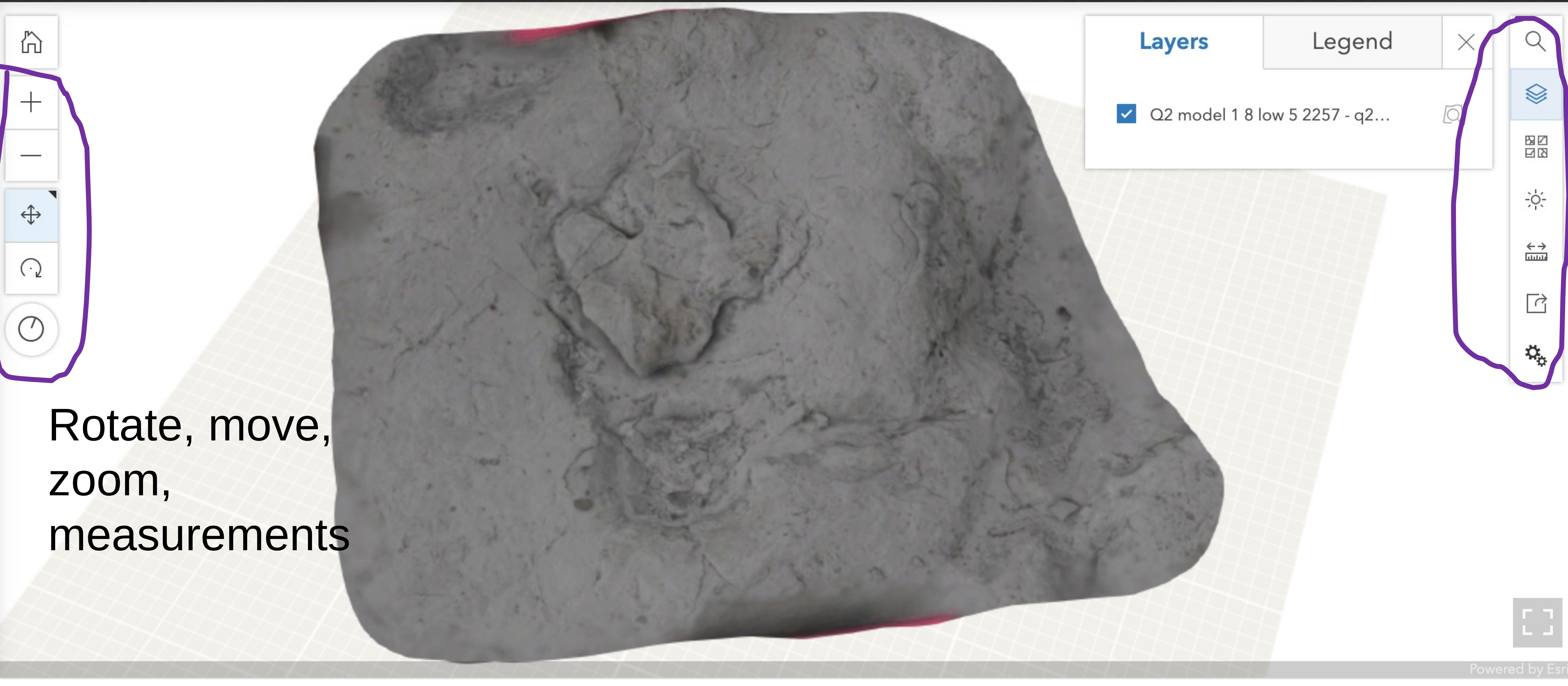

Rotate, move, zoom, measurements

For more information, go to ArcGIS Online Web App

https://cnmgit.maps.arcgis.com/apps/MapJournal/index.html?appid=eae82ecda461468591b138440edde18a

What Can We Learn From Dinosaur Tracks?

- Which dinosaurs lived there
- Stride length
- Interdigital angles
- Hip height
- Pace angulation
- Weight
- Speed
- Paleoclimate
- Dinosaur behavior

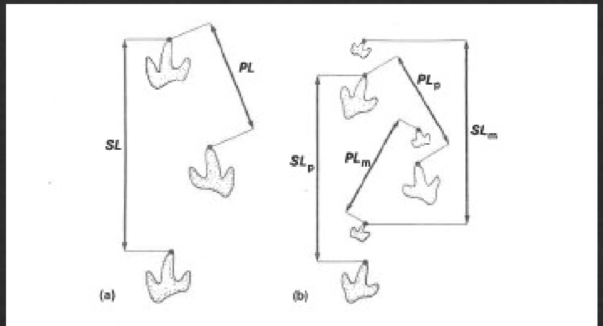

Figure 4.10 Stride length (*SL*) and pace length (*PL*). (a) Stride length and pace length in the trackway of a bipedal dinosaur. (b) Stride length and pace length in the trackway of a quadrupedal dinosaur; manus and pes must take strides of equal length (SL_m and SL_p, respectively), though their paces need not be equal in length (PL_m and PL_p, respectively). All measurements are made between corresponding points in two footprints.

(Thulborn)

(Atherton)

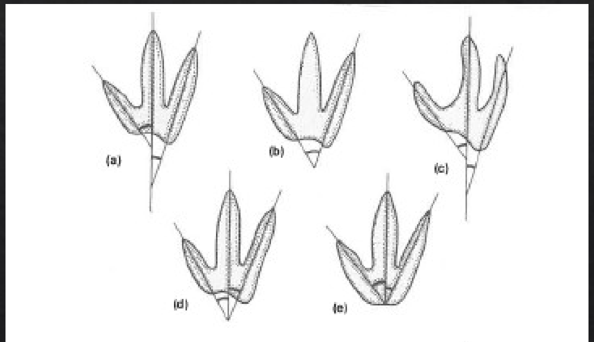

Figure 4.5 Interdigital angles, measured between the axes of two digits. (a) Two interdigital angles (II–III and III–IV) measured between digital axes representing lines of best fit. (b) Total divarication, measured between axes of the innermost and outermost digits. (c) Digital axes fitted only approximately to curved digits. (d) Interdigital angles measured on the assumption that all digital axes radiate from a single point (compare diagram a). (e) Interdigital angles measured on the assumption that all digital axes radiate from a single point at the rear margin of the footprint.

(Thulborn)

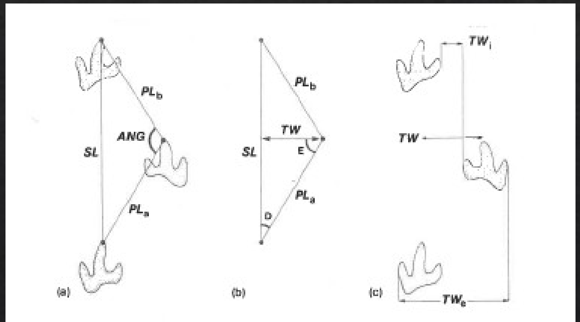

Figure 4.11 Pace angulation (*ANG*) and trackway width (*TW*) in the trackway of a biped. (a) With measurements of two successive paces (PL_a and PL_b), and of the stride they encompass (*SL*), it is possible to calculate pace angulation (*ANG*) using equation 4.1, in text. (b) The angulation pattern, representing the triangle formed by paces and stride in diagram (a); width of the angulation pattern (*TW*) can be calculated using equations 4.2 and 4.3, in text. (c) Various measurements of trackway width, namely: minimum trackway width (TW_i), between inner margins of left and right footprints; width of the angulation pattern (*TW*), as in diagram (b); maximum trackway width (TW_o), between outer margins of left and right footprints. All measurements of trackway width are at right angles to the midline of the trackway.

(Thulborn)

Project Participants

- Richard P. Watson, Ph.D.
- John Rogers, M.S
- Spencer G. Lucas, Ph.D.
- John Beltran
- Melo King
- Mike Kvasnak
- Althea Atherton

- Brian Cannon
- Tara Spurlock
- Bryan Burns
- Michael Torres
- Michael Rogers-Oty
- Steven Rospopo
- Rick Leonhardt
- Scott Ernst

CNM’s
Earth & Planetary Sciences (E&PS)
&
School of Applied Technology (UAS and GIS programs)

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Questions?