One World Terrain

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Agenda

- **Introduction to One World Terrain**
  - Scope and Products
- **Giving meaning to the Mesh**
  - OWT production capabilities
- **Standard standards**
  - OWT Well Formed Format (WFF)
- **Accuracy and Correlation**
  - Common 3D Surface Model
  - Geo-registration of Insets

Abstract

- This presentation discusses the use of satellite, aerial and drone collected imagery and LIDAR data in the automated 3D terrain data production capabilities under development by the U.S. Army's Synthetic Training Environment (STE) One World Terrain (OWT) program.
- **1. Giving meaning to the Mesh:** The primary objective of the OWT production capabilities is to automatically, using photogrammetry, create 3D polygon meshes from imagery and transform these imagery-derived meshes into segmented and attributed geospatial component data that support meaningful interaction in the reasoning and rendering systems of the U.S. Army STE training systems.
- **2. Standard standards:** Maturing and extending industry standard data containers and adopting NGA-based data dictionaries provides for unambiguous definition of all geospatial components represented in the OWT Well Formed Format (WFF) for surfaces and features, with metadata identifying imagery sources and vintages, defining per-pixel geolocation accuracy, per-pixel surface material classification, component types, etc.
- **3. Accuracy and Correlation:** With a common 3D Surface Model, created with 0.5 meter resolution and at three meter Spherical Error at 90% (SE90) as the reference, OWT imports, georegisters, and integrates insets, and exports positionally accurate and component correlated combined content, supporting both U.S. Army operational systems and STE training systems.

Introduction to One World Terrain

STE One World Terrain (OWT) Scope

- **Prototype project to provide a central geospatial data server and worldwide geospatial data for the Synthetic Training Environment (STE) systems One World Terrain (OWT) program**

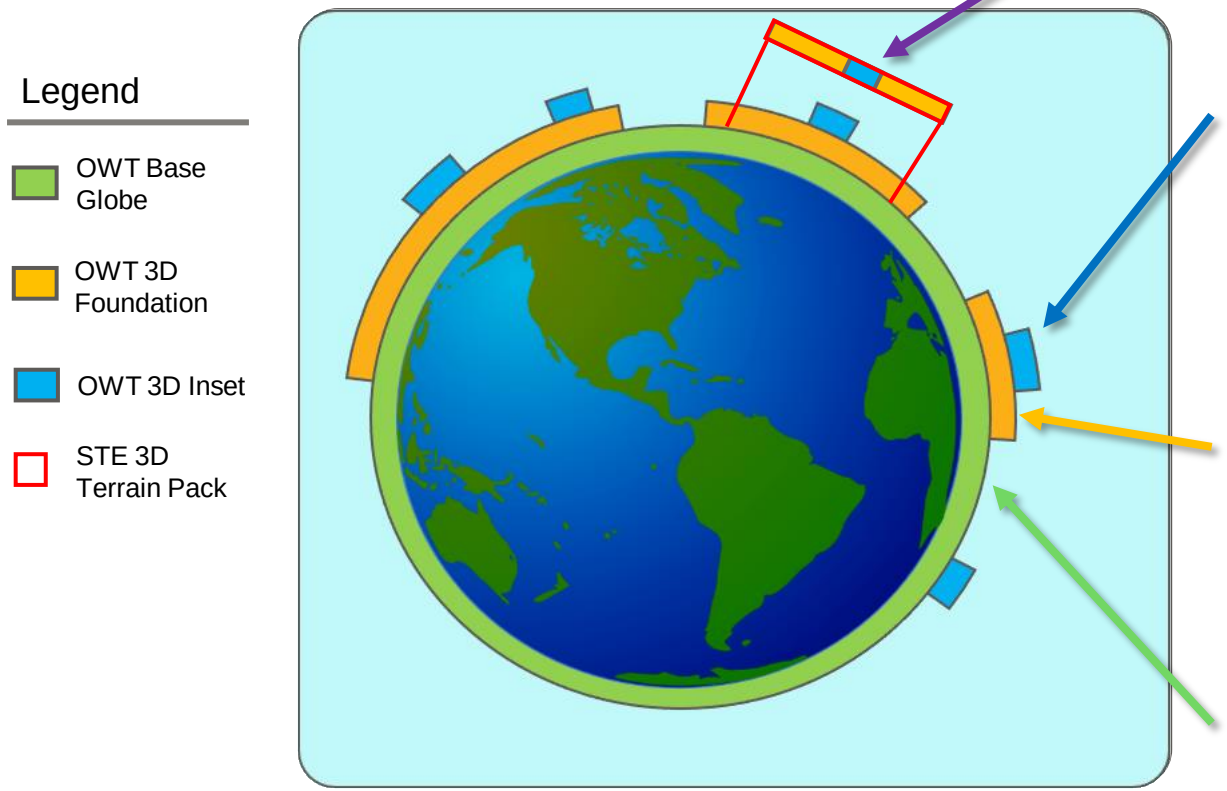
- **One World Server (OWS)** System
  - Hardware and Software
  - Import, Processing, Storage and Delivery of the OWT Data

- **One World Terrain (OWT) geospatial data**
  - **3D Geospatial Terrain Data**
    - IOC Sites: FT Hood, FT Benning, FT Drum, JBLM and FT Leonard Wood
    - Many, many other locations worldwide
  - **3D Models**
    - Moving, relocatable, vegetation, textures and clutter 3D models

- **OWT Well Formed Format (WFF)**
  - Format specification for 3D geospatial data, comprehensive training support

OWT Data Stratum Concept

OWT Stratum - A geographic area or feature component that is a gradation of resolution in the One World Terrain' ordered system



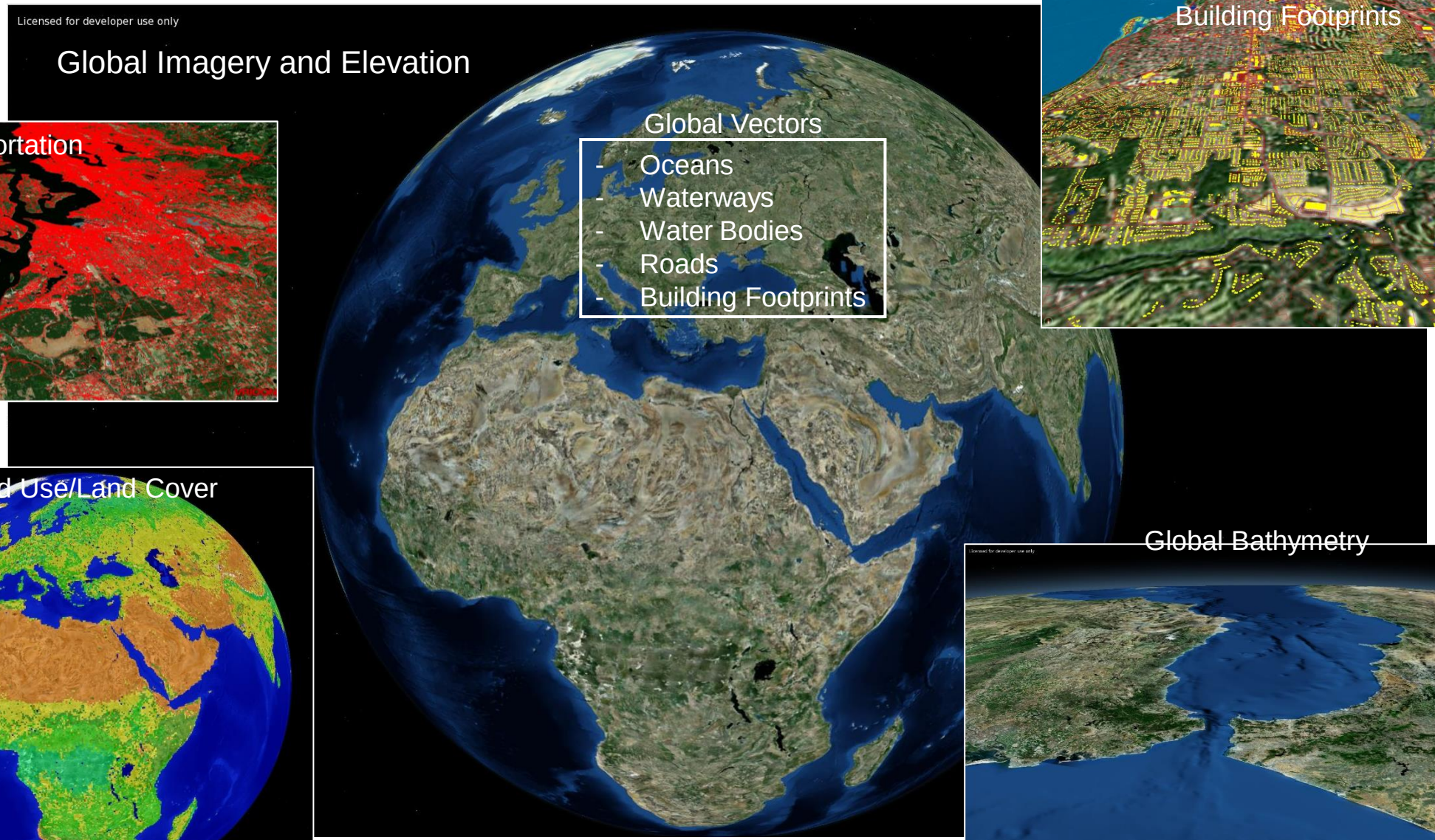
OWT STE 3D Terrain Pack
- One World Terrain, contained in a STE 3D Terrain Data Pack, is best available data of selected area of interest
- Composed of OWT 3D Foundation Data providing regional coverage with OWT 3D Insets representing local and site coverage

OWT 3D Insets – Local/Site Coverage
- Provides higher resolution terrain data including buildings with interiors for dismounted soldier-based training
- Provides higher resolution environmental data including buildings for ground vehicle-based training
- Provides landmark models for navigation aid for air and ground vehicle-based training
- Provides vertical obstruction and cultural clutter

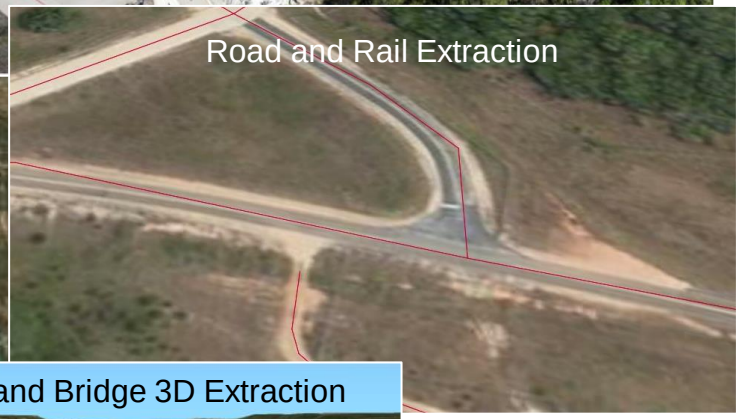
OWT 3D Foundation – Regional Coverage
- Provides positional accuracy data (3meter SE90) to ensure correlation with the real world
- Provides satellite imagery derived 3D Terrain Model decorated with extracted buildings and bridges for air and ground vehicle-based training
- Provides background to higher resolution 3D insets
- Used for georegister higher resolution insets to ensure correlation of insets

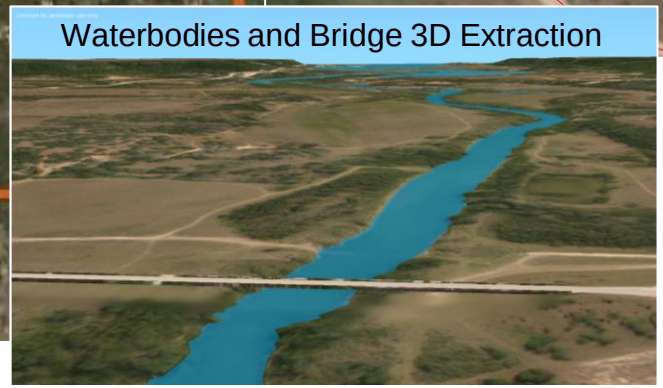
OWT Base Globe – Global Coverage
- Provide worldwide coverage of lower resolution data
- Provides global context for selection of area of interest
- Provides vector data for decorating the Base Globe with 3D procedurally generated content

The OWT Base Globe



3D Terrain Pack - Ft Hood STE Sample

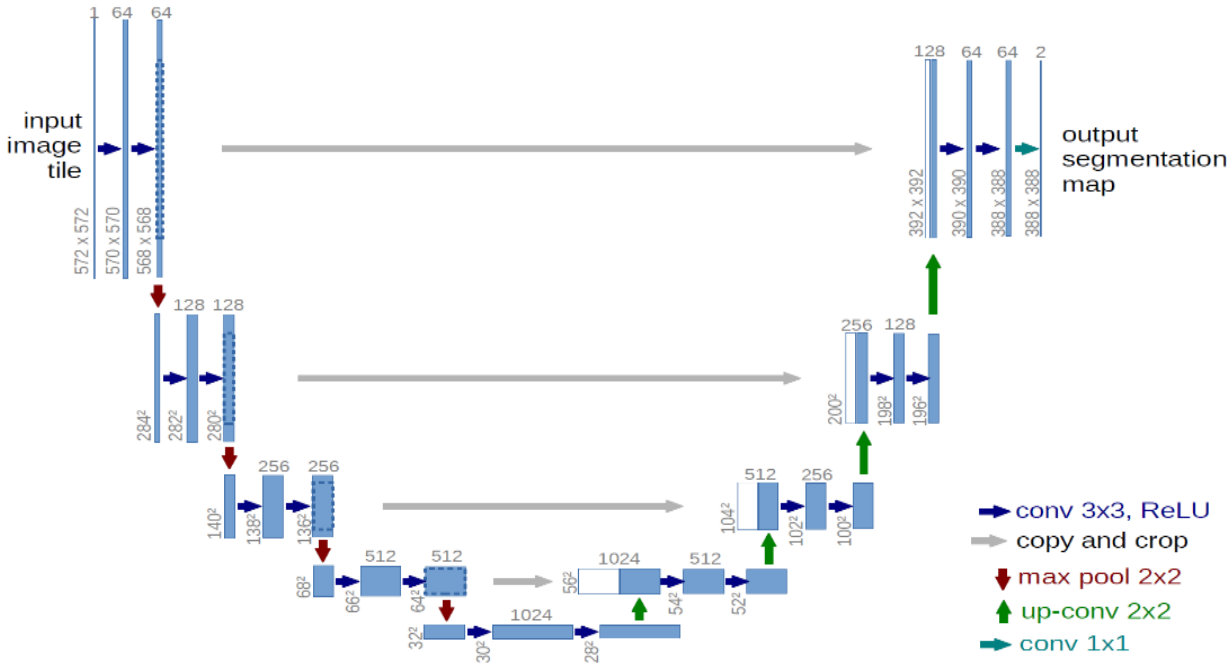


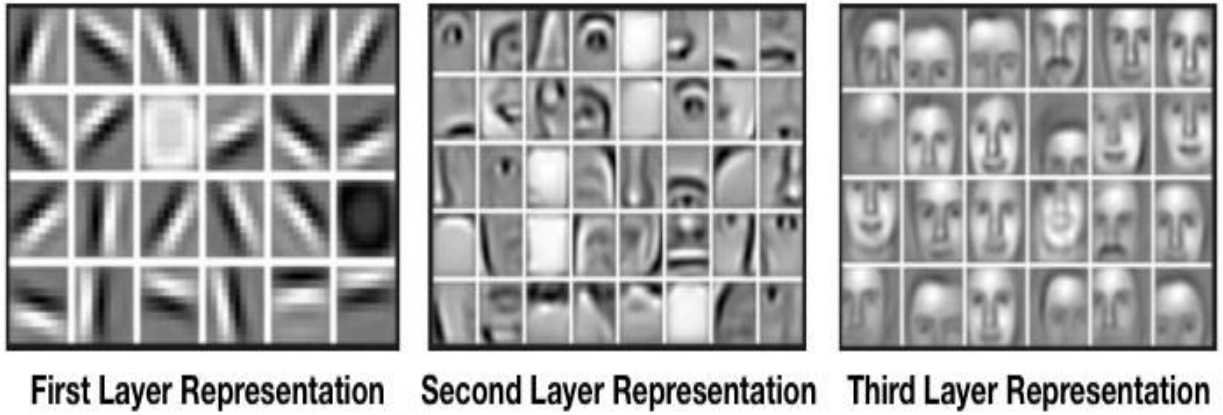


Giving meaning to the Mesh

AI & Machine Learning for OWT

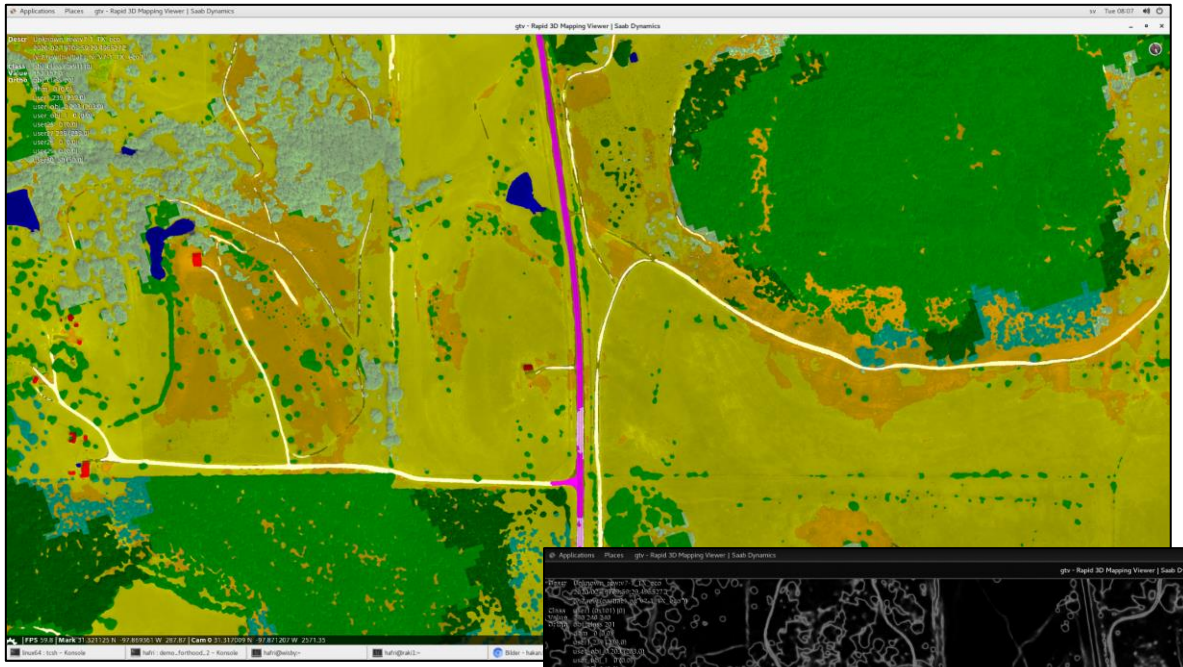
- Maxar uses Deep Learning to automatically classify the content in our 3D-models
- Deep neural networks perform pixel-wise classification (semantic segmentation)
- An ensemble of fully convolutional networks are used
- Deep neural network – No handcrafted features
- Supervised feature learning – features are learned using labeled input data
- Convolution kernels used to detect patterns and structures
- U-Net – Network architecture for semantic segmentation
- ResNet50 – 50 levels of feature sets



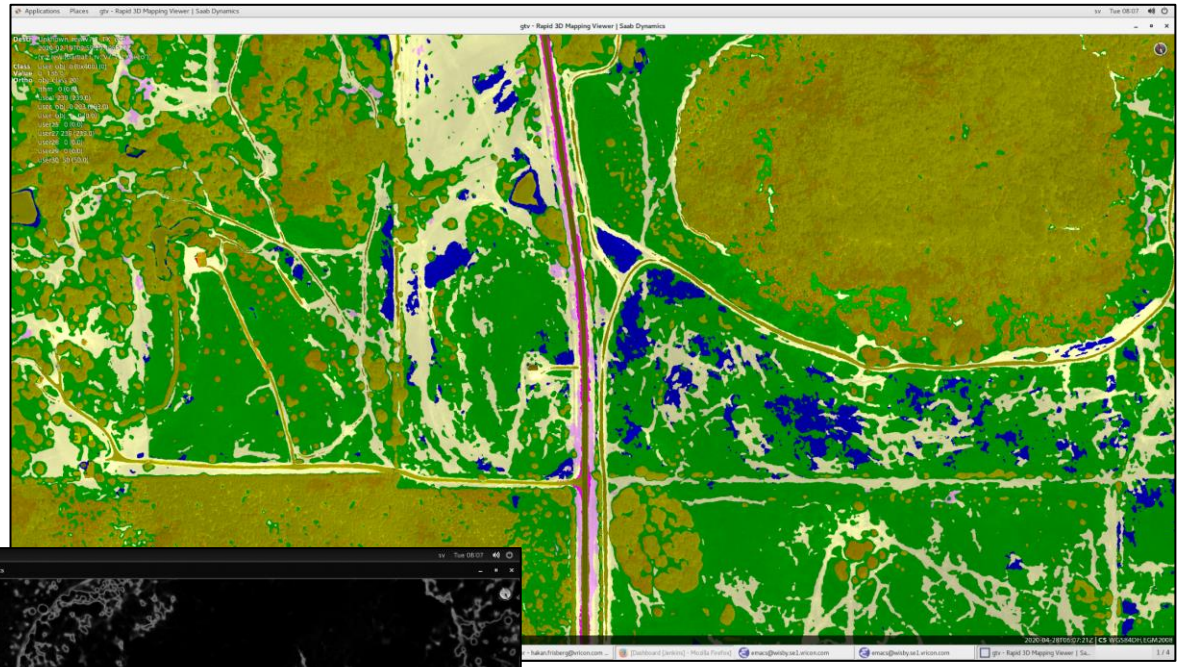


First Layer Representation | Second Layer Representation | Third Layer Representation

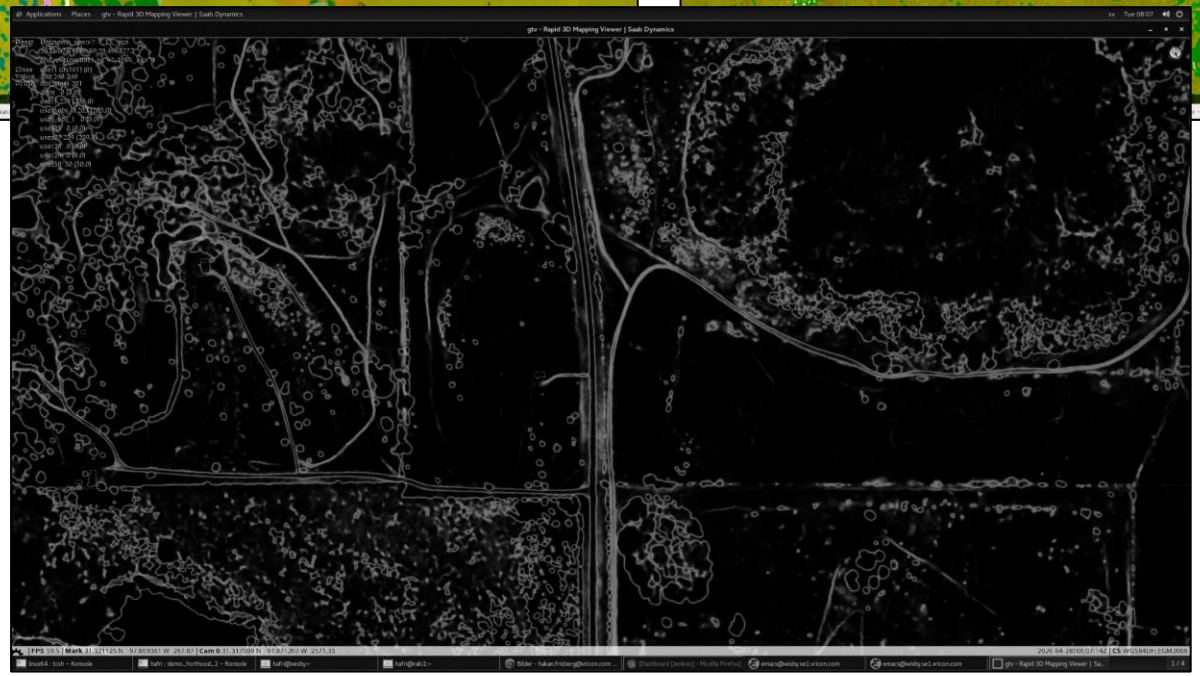
Machine Learning based Land Classification



Highest probability class



Second highest probability class



~Second highest probability

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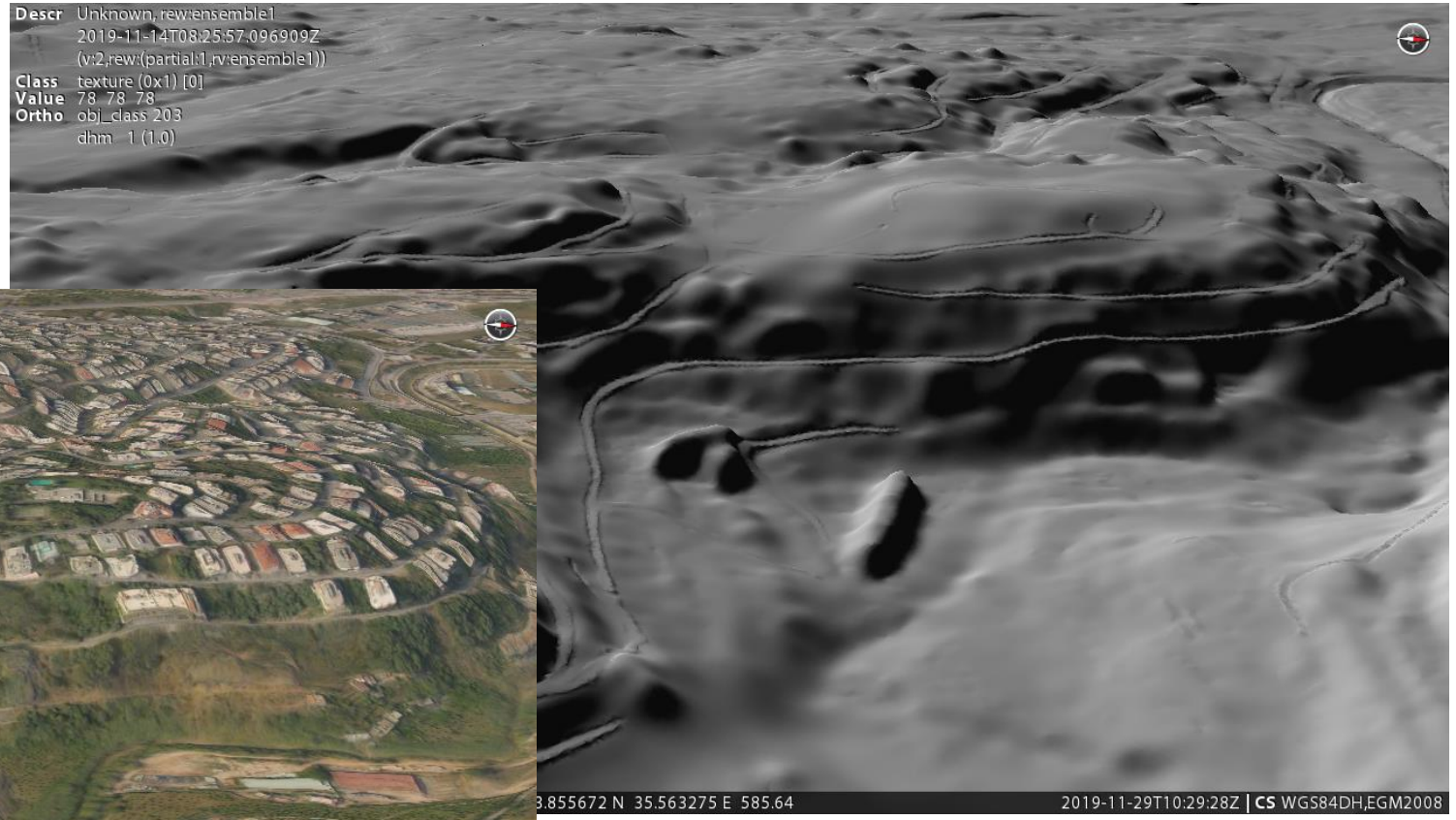
Terrain Model – Bare Earth Surface



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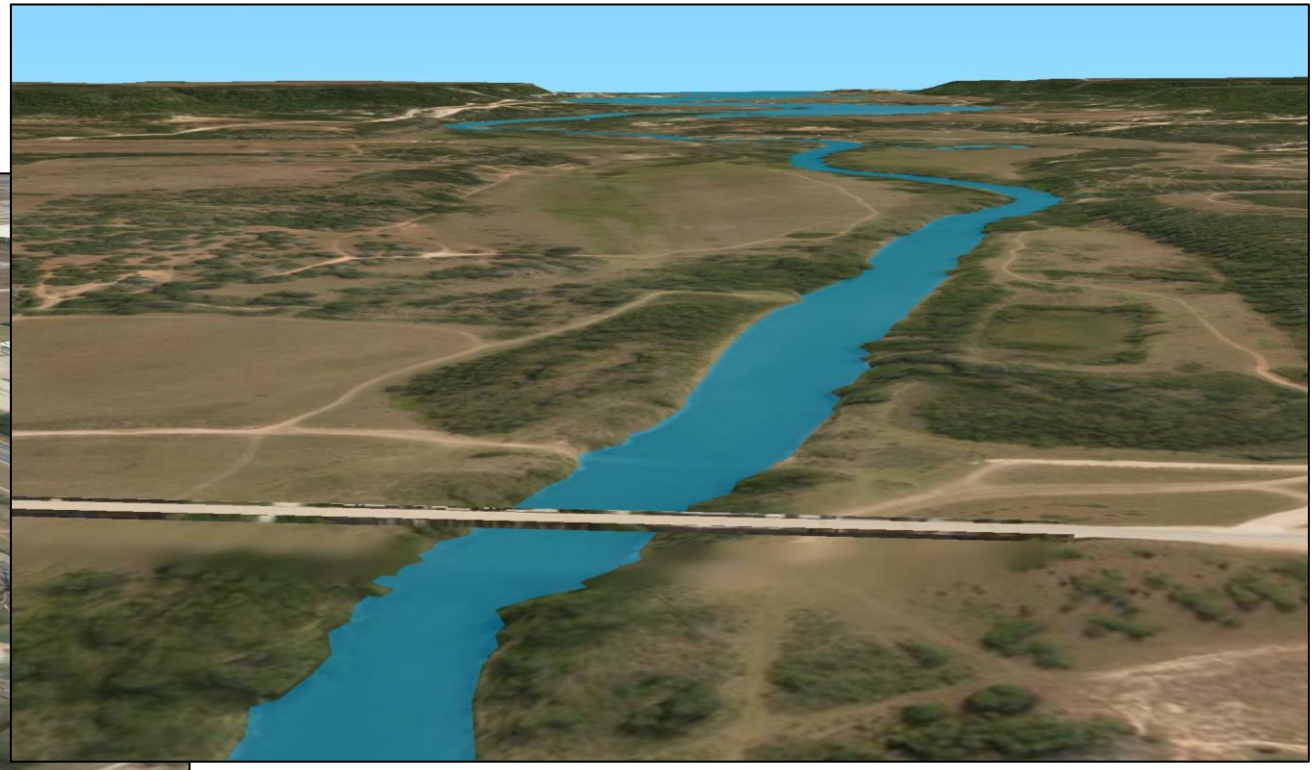
Building and Bridge Extraction

3D Building Extraction



3D Bridge Extraction

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Vector Feature Extraction

Roads Extraction

Building Footprint Extraction

Waterbody Extraction

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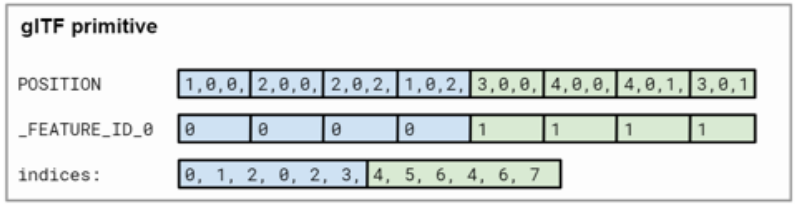
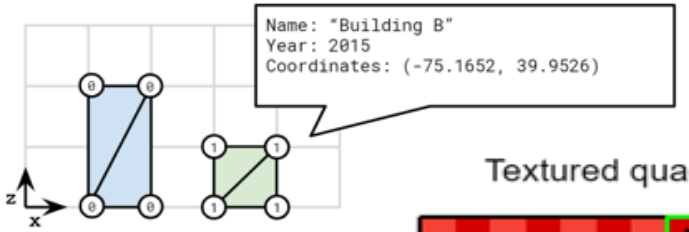
Rich Metadata Population

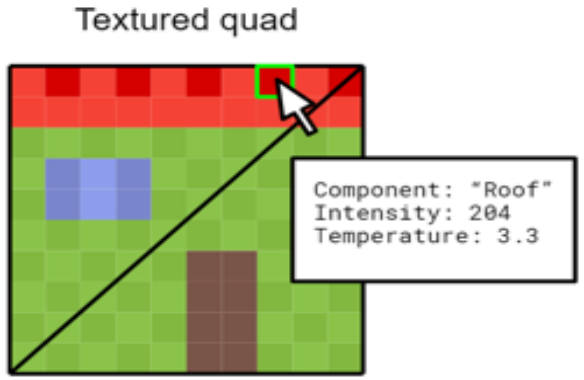
- Feature identifier (up to per-vertex)
- Feature attributes (up to per-vertex)
- Structure Component (per-vertex)
- Land Use/Land Cover Classification (per-texel)
- Building Material Definition (per-texel)
- Non-visual spatial data - volume, area, etc. (per-vertex)
- Accuracy - covariance matrices (per-pixel or per-vertex)



Feature Table

Feature ID	Name	Year	Coordinates
0	"Building A"	1999	-75.1653, 39.9524
1	"Building B"	2015	-75.1652, 39.9526

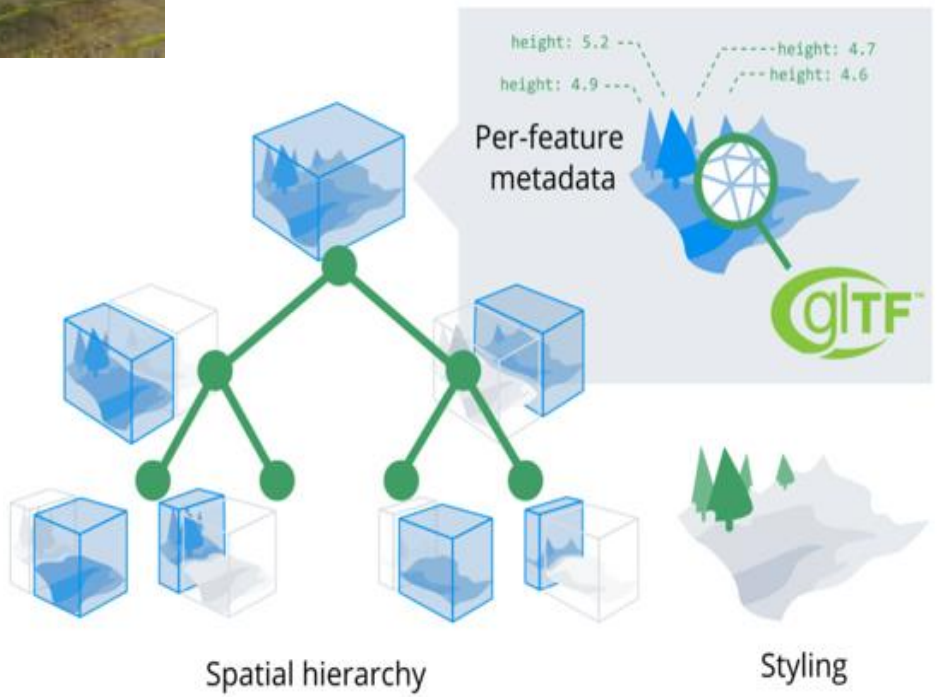




Standard standards

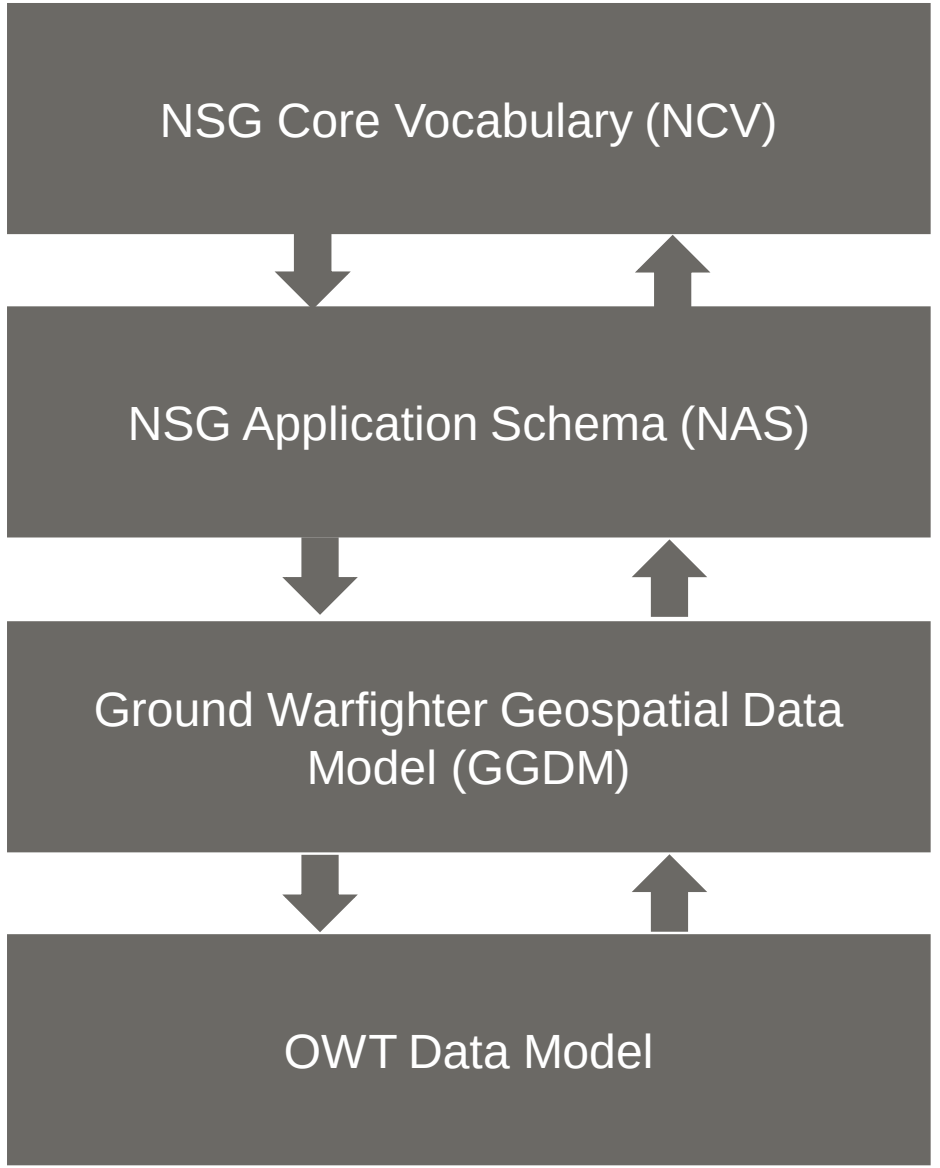
3DTiles and glTF

- Efficient streamable massive heterogeneous 3D geospatial datasets
  - Terrain & imagery, 3D buildings, photogrammetry, point clouds, BIM models, interiors, etc.
- Visualization + analysis
- Combine:
  - Flexible spatial data structure in JSON
  - “Runtime ready” binary tile formats
  - Khronos glTF open standard for 3D models
  - Vertex/polygon-level attribution
  - Declarative styling
- OGC Community Standard



STE OWT DM/DD Selection

- STE Cross Functional Team (CFT) formed a Data Model (DM) and Data Dictionary (DD) Tiger Team that selected GGDM
- OWT has defined the approach to incorporate the STE CFT selected DM into the Well-Formed Format (3DTiles/glTF)
  - Use native feature and attribute names near term
  - Transition to recommended DM as soon as possible
  - Support evolution of 3DTiles/glTF standards to add required feature and attribute labels



Accuracy and Correlation

Relative Accuracy Requirements

- Product accuracy and post spacing
  - The absolute accuracy is defined as the difference between a point in the Vricon data product and its true position.
  - The relative accuracy is defined as the difference in distance between two points in the model and the true distance, where the distance between the two points is equally distributed within 500 meters.
  - Both the absolute and relative accuracy is defined in a statistically relevant selection of distances/points equally distributed within a 10*10 km area.
- The Maxar production process does not require GCPs to achieve the specified accuracy.
  - The specified product accuracies are strictly a function of the 3D production process and the input metadata from the original commercial satellite images.
  - The Maxar production process has been validated using more than 1,500 ground control points on all continents.

Product Accuracy (meter)	Relative vertical LE90	Absolute vertical LE90*	Relative horizontal CE90	Absolute horizontal CE90 *	Relative spherical SE90	Absolute spherical SE90
3D Surface Model	1	3	1	3	1	3
DSM	1	3	1	3	na	na
DTM**	1	3	1	3	na	na
True Ortho	na	na	1	3	na	na
Point Cloud	1	3	1	3	1	3
DHM**	1	3	1	3	na	na
3D Building**	1	3	1	3	na	na
3D Vegetation**	1	3	1	3	na	na

* Corresponding absolute vertical RMSE = 1.8 meter, absolute horizontal RMSE = 1.4 meter as applicable.

** -DTM: Based on ground points in visually open areas from a satellite point of view.
-DHM: Based on included features when combined with the Vricon DTM.
-3D Buildings: Based on box-shaped buildings. Other buildings are simplified in the extraction process to reduce complexity. Samples with comparable accuracy and overall quality are available on request. The stated relative accuracy assumes a flat, visually open area from a satellite point of view around the building, as an unambiguous reference.
-3D Vegetation: Based on living, fully grown trees with a canopy of more than 5x5m, disregarding format discretization effects. For pointy trees, the height is approximated with best effort. Samples with comparable accuracy and overall quality are available on request. The stated relative accuracy assumes a flat, visually open area from a satellite point of view around the vegetation, as an unambiguous reference. The stated absolute accuracy assumes use with Vricon DTM.

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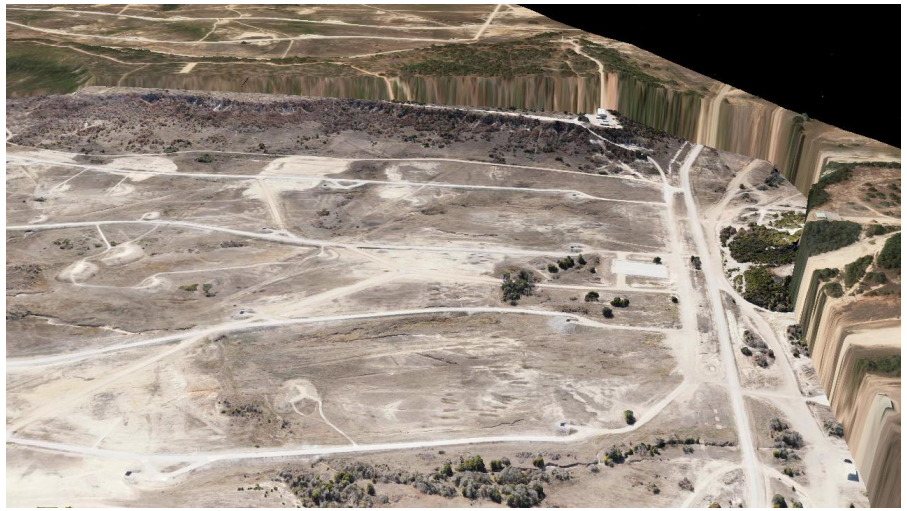
P3DR – 3D to 3D Registration

Automatically align insets into Maxar 3D Foundation Data

Before P3DR



After P3DR

Satellite Imagery Derived Surface Model

Georegistered Drone Collect Inset

Questions

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