

NDIA



Powering Innovation That Drives Human Advancement

Synthetic Radar Data Generation using RF Channel Modeler (RFCM) - RADAR

27th Annual Systems & Mission Engineering Conference

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Distribution Statement A. Distribution Unlimited
Approved for Public Release

STK RF Channel Modeler (RFCM-Radar) 2024R2

Radar Signature Analysis is the art of understanding how radar signals interact with complex targets to map the various scattered radar returns.

Radar images are NOT literal images like EO/IR Images

- They are a mapping of radar scattering returns in range and doppler space.

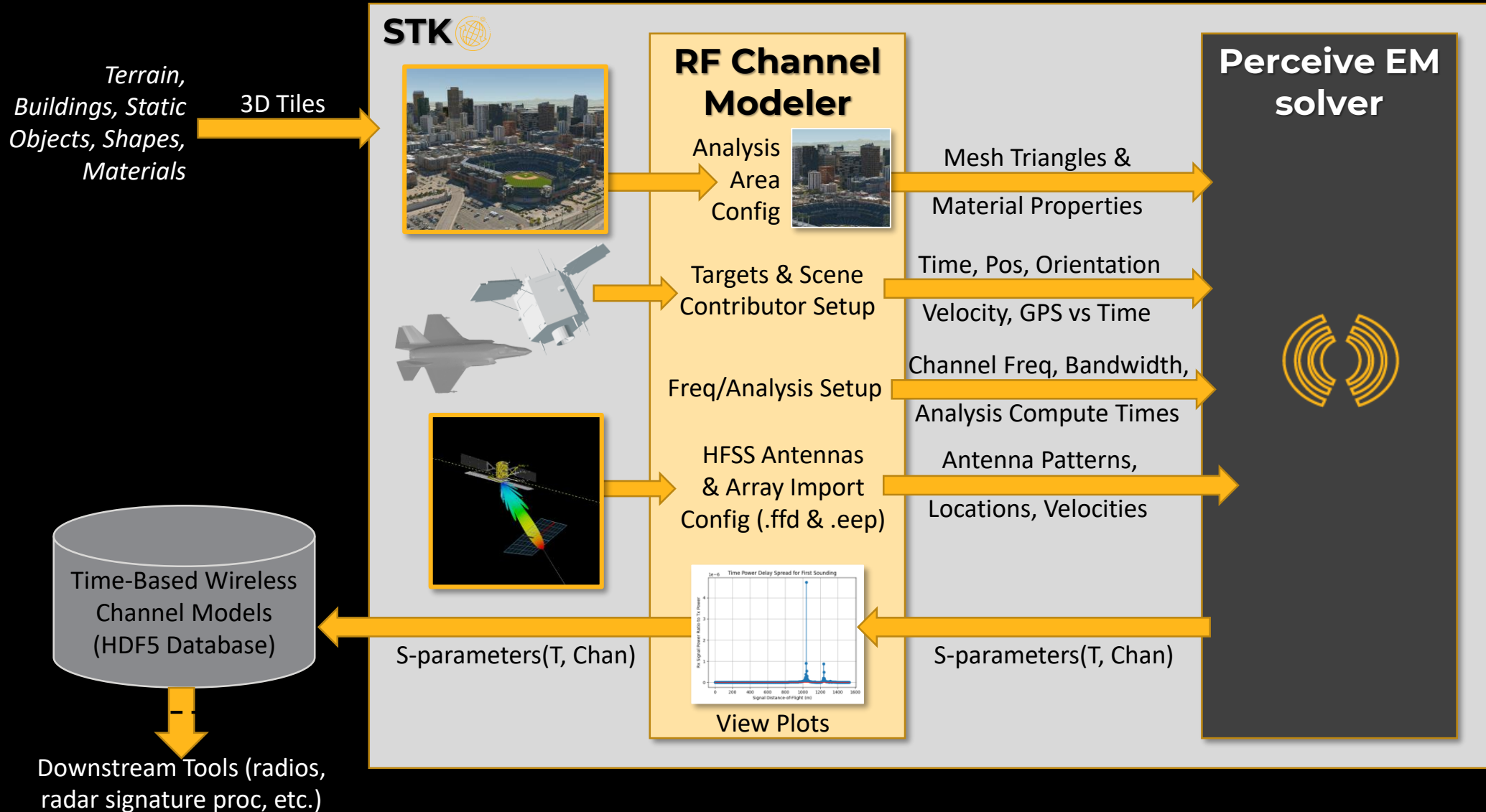
RFCM supports both SAR and ISAR IMAGE generation.

RFCM = Systems Toolkit (STK) + Ansys Perceive EM to generate:

- Raw I&Q Frequency Response Data*
- Range Time Intensity (RTI) and Doppler Time Intensity (DTI)*
- Wideband Radar Images*

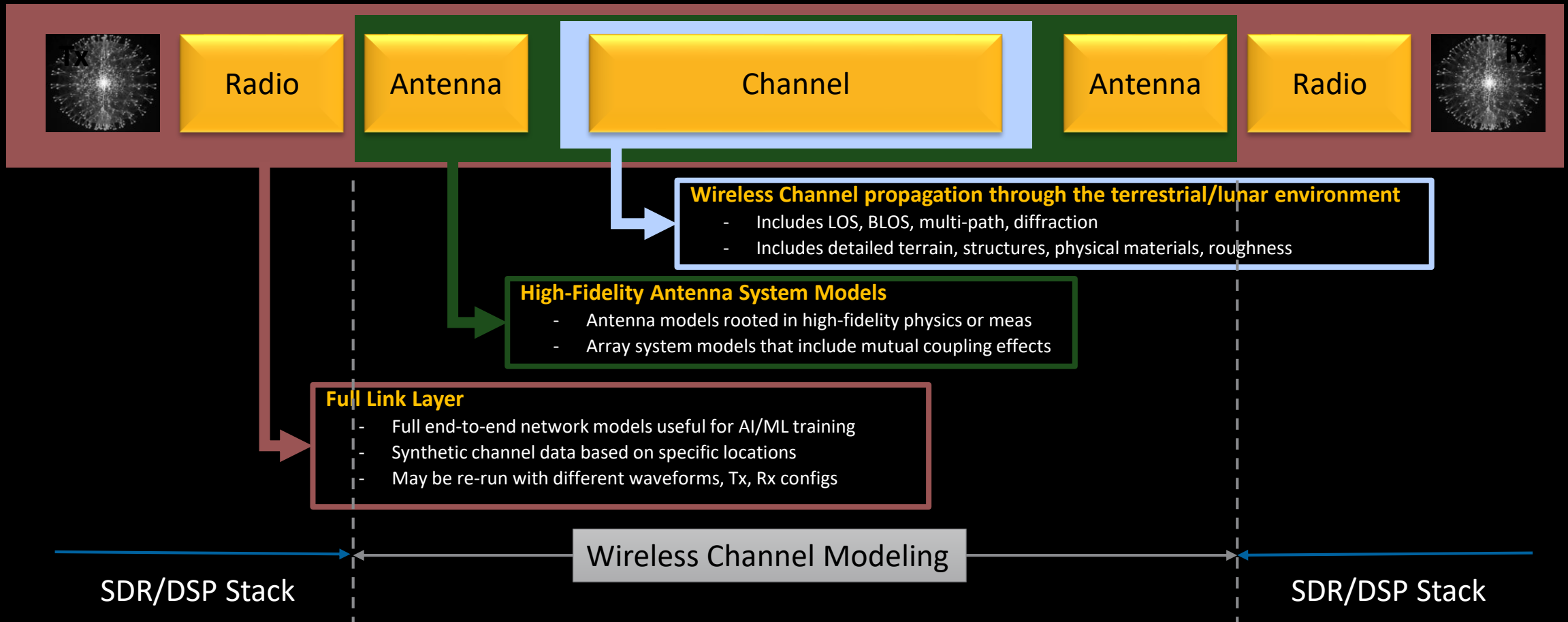
*RFCM leverages GPU-Acceleration to create data **FAST**, in Near-Real-Time.*

COMPONENTS OF RFCM 2024R2!

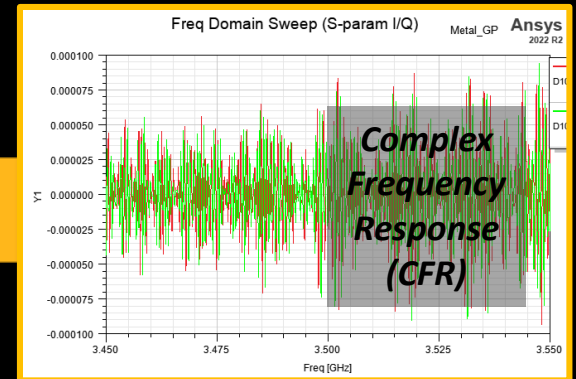
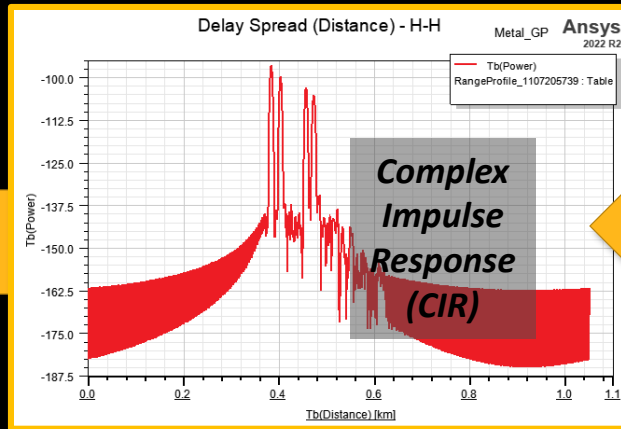


WHAT RFCM INCLUDES, AND DOES NOT INCLUDE

Radar or RF Wireless Channel Modeling: Antenna-to-antenna coupling problem in the presence of scattering geometry



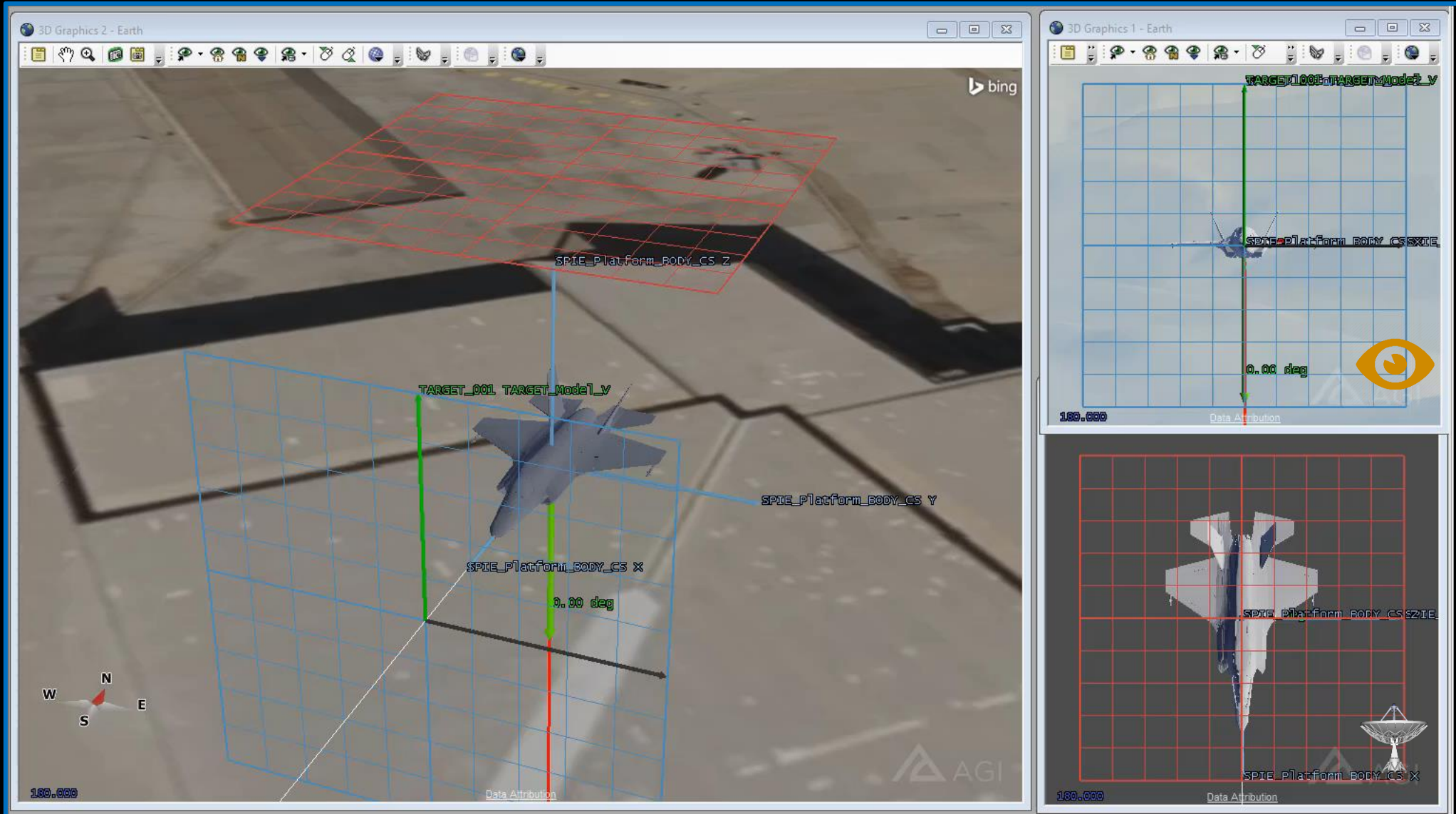
SHOOTING – BOUNCING RAYS (SBR) *plus PO forward propagation*



FFT

IFFT

INVERSE SYNTHETIC APERTURE RADAR – ISAR (Target is moving)



STK SCENARIO ORCHESTRATION

The image displays three interconnected views of a satellite scenario:

- GLOBAL VIEW:** Shows a satellite in orbit above Earth. A dashed white line indicates the satellite's orbital path. A green line connects the satellite to a ground station labeled "OBSERVER" on the Earth's surface.
- OBSERVER VIEW:** A close-up of the ground station antenna pointing towards the satellite. A green line represents the line of sight. The text "OBSERVER" is visible near the antenna.
- TARGET VIEW:** Shows the satellite from a different perspective, with a green line pointing to a target on the ground. A yellow cone of light or sensor beam is directed at the target.

A central blue circular button with a white pause symbol is positioned between the Observer and Target views. The "AGI 180:500" logo is present in the bottom left of the Observer View and the Target View.

STK SCENARIO ORCHESTRATION



OMEGA IMAGE PLANE ALIGNMENT

STK DATA EXPORT

Time (EpSec): 180.000
 1_Yaw-Z (deg): -86.535
 2_Pitch-Y (deg): 88.209
 3_Yaw-Z (deg): -153.390

Dynamic Display: TARGET - RTR_Target...

Time (EpSec): 180.000
 Magnitude (deg/sec): 0.069903

Dynamic Display: TARGET - RTR_Target...

Time (EpSec): 180.000
 Ang_Vel Angle (deg): 4.738

Dynamic Display: TARGET - EOIR_Sunli...

Time (EpSec): 180.000
 x/Magnitude: -0.414571
 y/Magnitude: 0.887022
 z/Magnitude: -0.203280
 RightAscension (deg): 115.050
 Declination (deg): -11.729

EO PRODUCT VIEW

RADAR PRODUCT VIEW

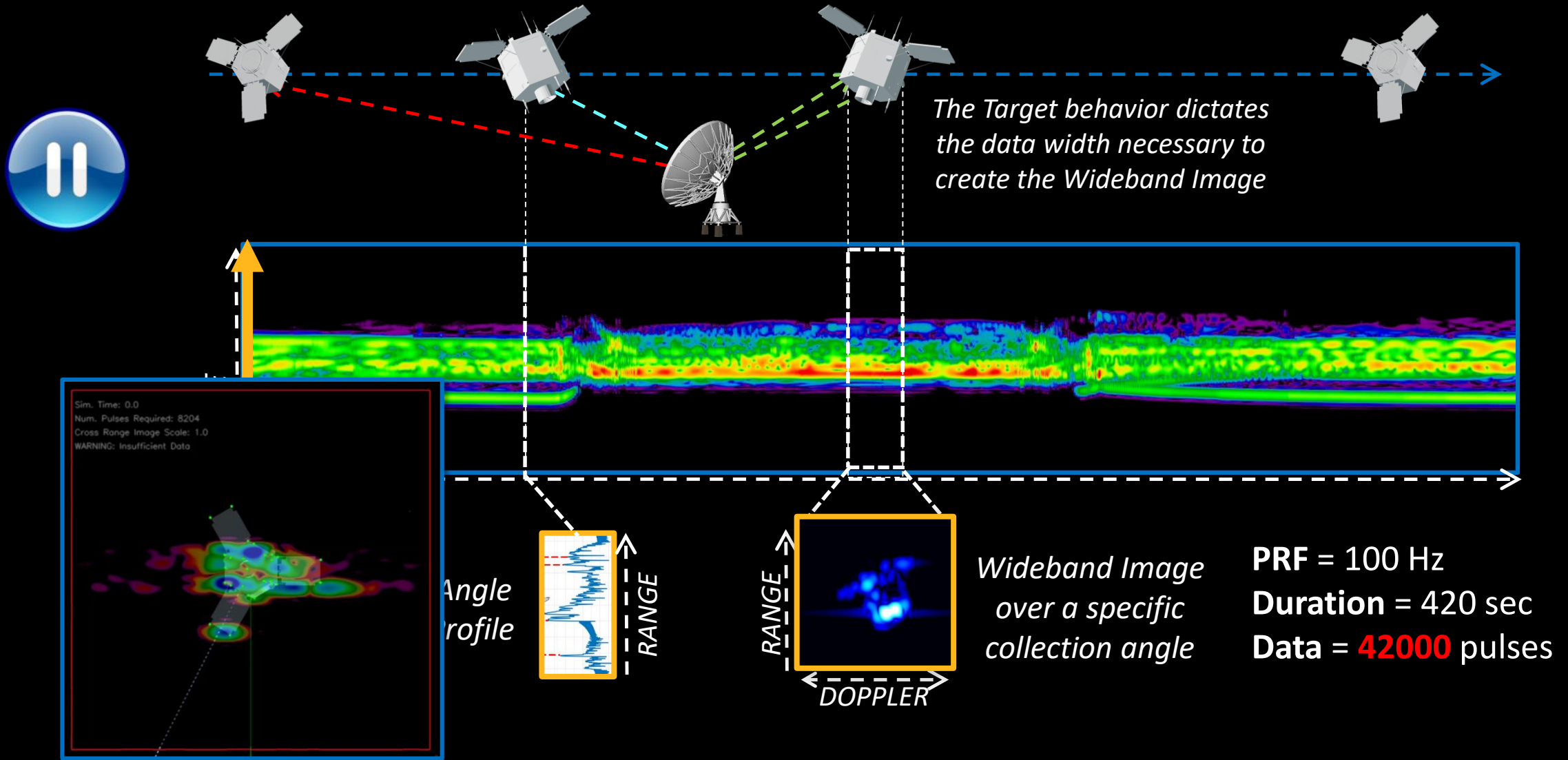
TARGET MOTION

Missile-TARGET: Angular Velocity (Target Vel. Radar Plane) - 17 Mar 2022 15:10:41

SUN ANGLE

Missile-TARGET - 17 Mar 2022 15:17:23

STK BUILDS Perceive EM INPUTS / Perceive EM GENERATES THE DATA

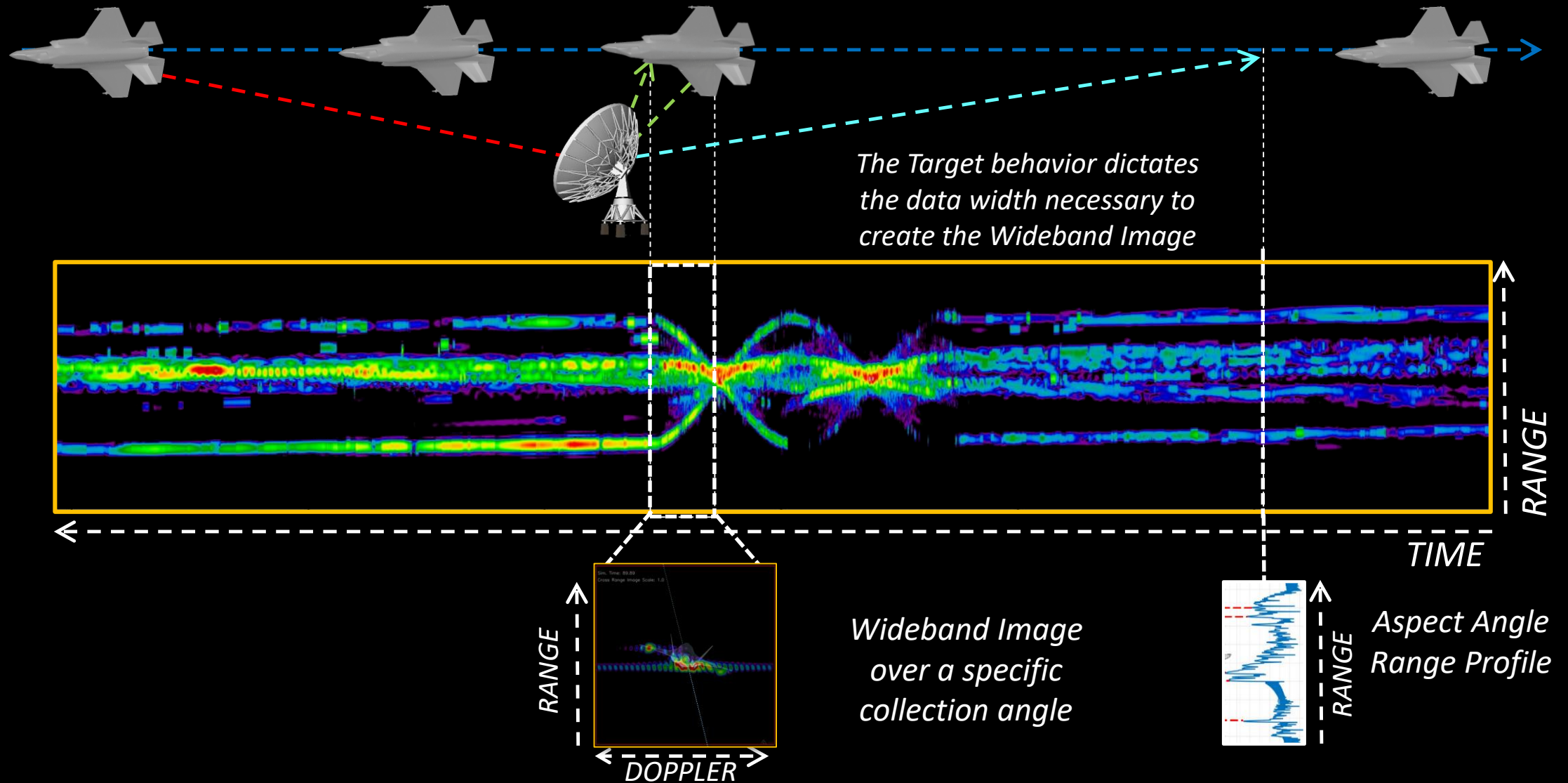


STK DISPLAYS Perceive EM OUTPUTS



The screenshot displays the STK (System Tool Kit) interface. The main window, titled '3D Graphics 2 - Earth', shows a 3D model of a satellite with a white rectangular footprint representing the sensor's field of view and a red rectangular footprint representing the EM output. The right-hand side of the interface contains two sub-windows: 'EO PRODUCT VIEW' and 'RADAR PRODUCT VIEW'. Both sub-windows show a top-down view of the satellite and its footprint. The 'RADAR PRODUCT VIEW' sub-window includes a 'WARNING: Insufficient Data' message. The AGI logo is present in the bottom right corner of each window. A scale of 180.000 is visible in the bottom left of the main window.

STK BUILDS Perceive EM INPUTS / Perceive EM GENERATES THE DATA



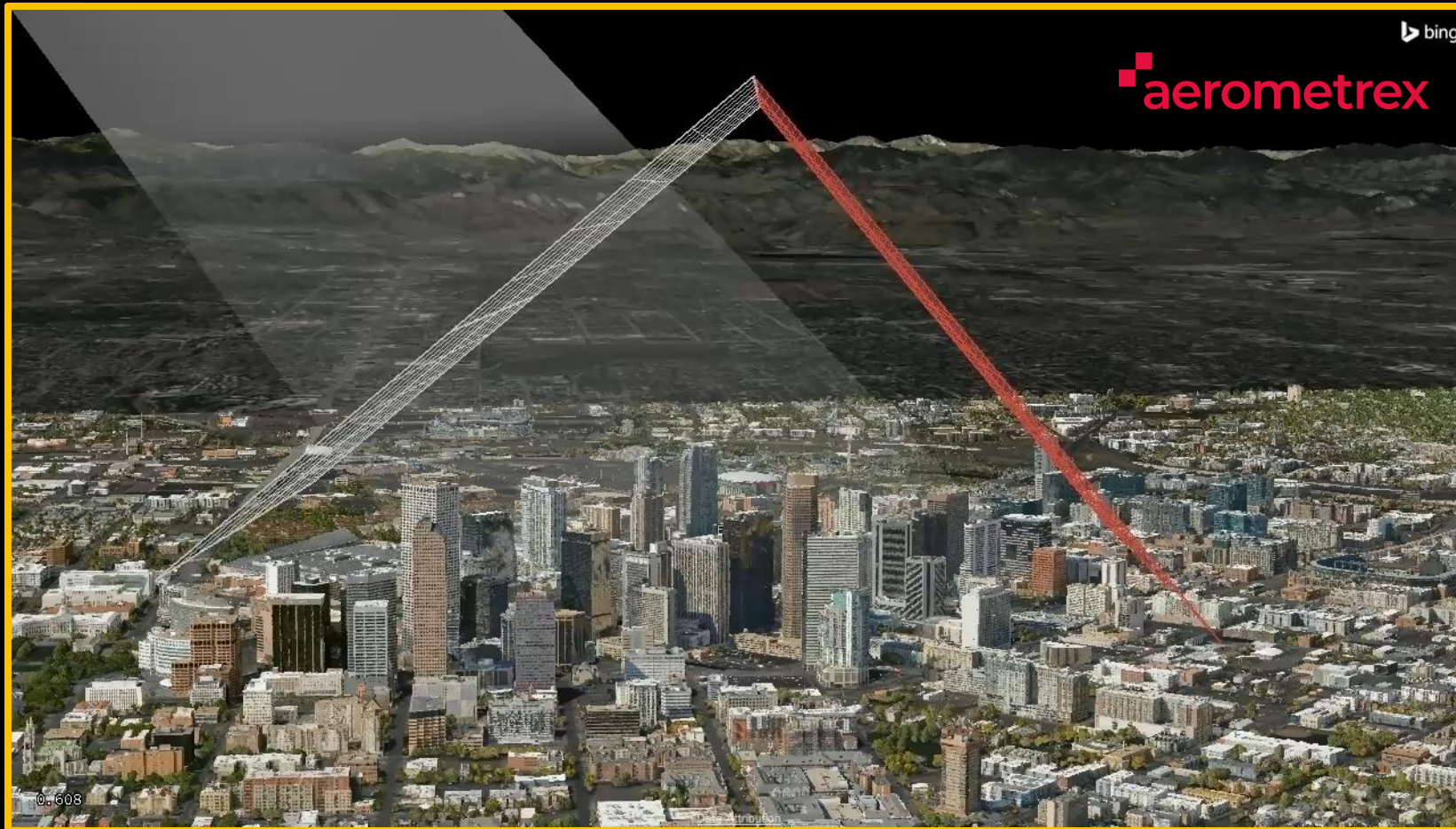
STK DISPLAYS PERCEIVE EM OUTPUTS



The screenshot displays the STK software interface with several windows open:

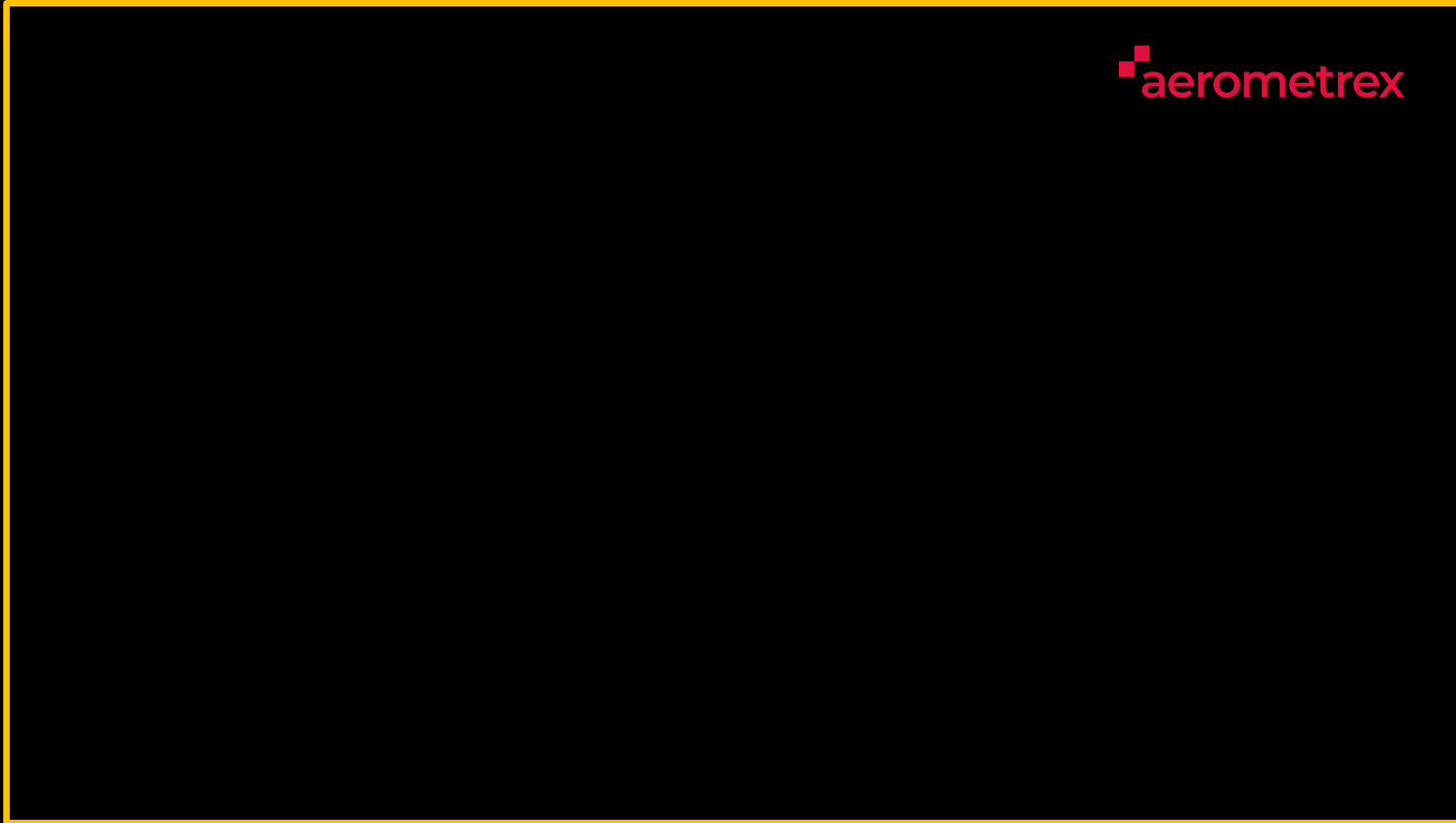
- OMEGA IMAGE PLANE ALIGNMENT:** A 3D visualization of a target aircraft in flight, with two image planes (one red, one blue) aligned to track it. A large Greek letter Omega symbol is visible in the top left.
- STK DATA EXPORT:** A red-bordered window showing export data for three dynamic displays:
 - Dynamic Display: TARGET - RTR_Target...
 - Time (EpSec): 180.000
 - 1_Yaw-Z (deg): -179.999
 - 2_Pitch-Y (deg): 16.427
 - 3_Yaw-Z (deg): 99.852
 - Dynamic Display: TARGET - RTR_Target...
 - Time (EpSec): 180.000
 - Magnitude (deg/sec): 0.068413
 - Dynamic Display: TARGET - RTR_Target...
 - Time (EpSec): 180.000
 - Ang_Vel Angle (deg): 16.408
 - Dynamic Display: TARGET - EOIR_Sunli...
 - Time (EpSec): 180.000
 - x/Magnitude: -0.365970
 - y/Magnitude: -0.349276
 - z/Magnitude: -0.862596
 - RightAscension (deg): -136.337
 - Declination (deg): -59.609
- EO PRODUCT VIEW:** A 3D view of the target aircraft with a yellow eye icon in the bottom right.
- TARGET MOTION:** A graph titled "Missile-TARGET: Angular Velocity (Target vs. Radar Plane) - 31 Mar 2022 09:23:35". The x-axis is EpSec (0 to 600) and the y-axis is Magnitude (deg/sec) (0 to 30). It shows a step function for magnitude and a linear ramp for angle. A "Show Step Value" button is present. The status bar shows "366.855,27.8244".
- SUN ANGLE:** A graph titled "Missile-TARGET - 31 Mar 2022 09:23:36". The x-axis is EpSec (0 to 600) and the y-axis is Angle (deg) (-100 to 150). It shows two curves: a green curve for Right Ascension and a red curve for Declination. The status bar shows "316.22, -99.2539".
- RADAR PRODUCT VIEW:** A 3D view of the target aircraft with a radar sensor and a color-coded radar return on the aircraft. The status bar shows "Sim. Time: 0.0" and "WARNING: Insufficient Data".

STK SCENARIO ORCHESTRATION *(Synthetic Aperture Radar - SAR)*



HI-FIDELITY SCENES ARE REQUIRED FOR SAR DATA GENERATION:

Aerometrex provides superior high resolution photogrammetry data of Denver



RFCM DATA GENERATION *(Denver City)*

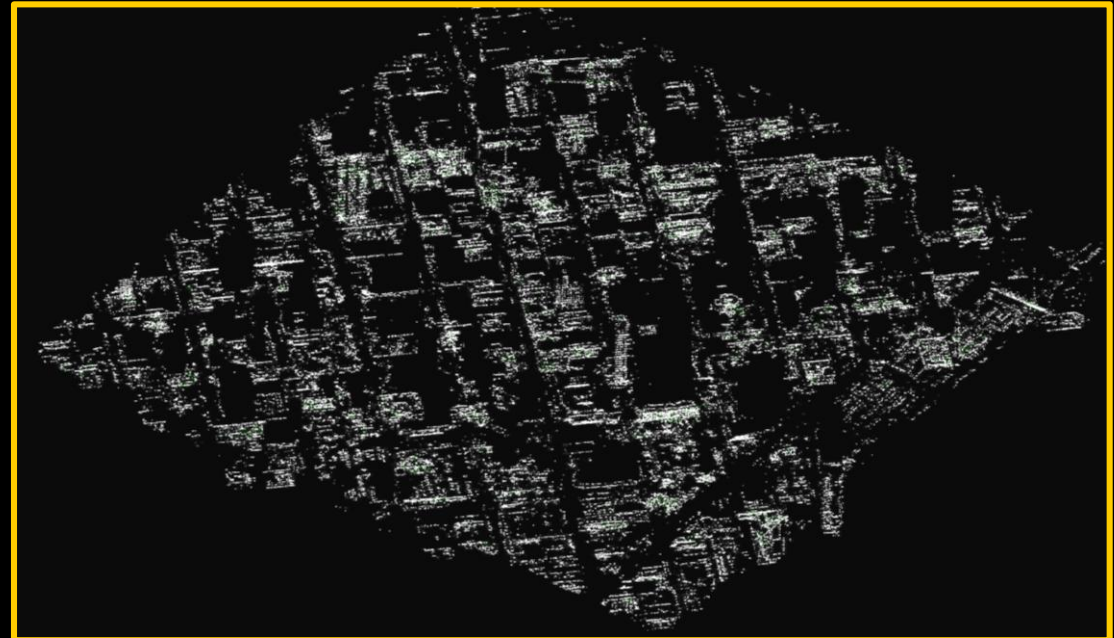
Denver High Rise Data Generation

Aerometrex Model



The 3D model scene of Denver was provided by Aerometrex

SYNTHETIC Data (60 db Dynamic Range)



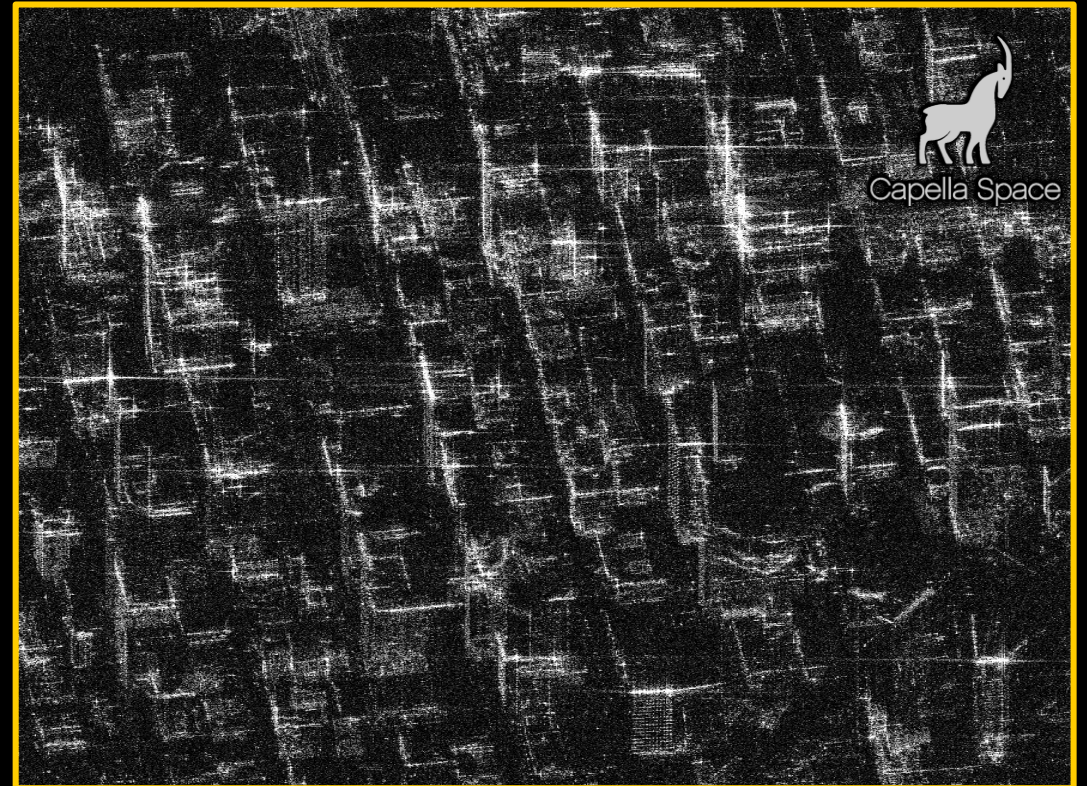
RFCM DATA VS REAL MEASUREMENTS *(Denver City)*

Real vs Synthetic SAR Imagery

SYNTHETIC Data (60 db Dynamic Range)

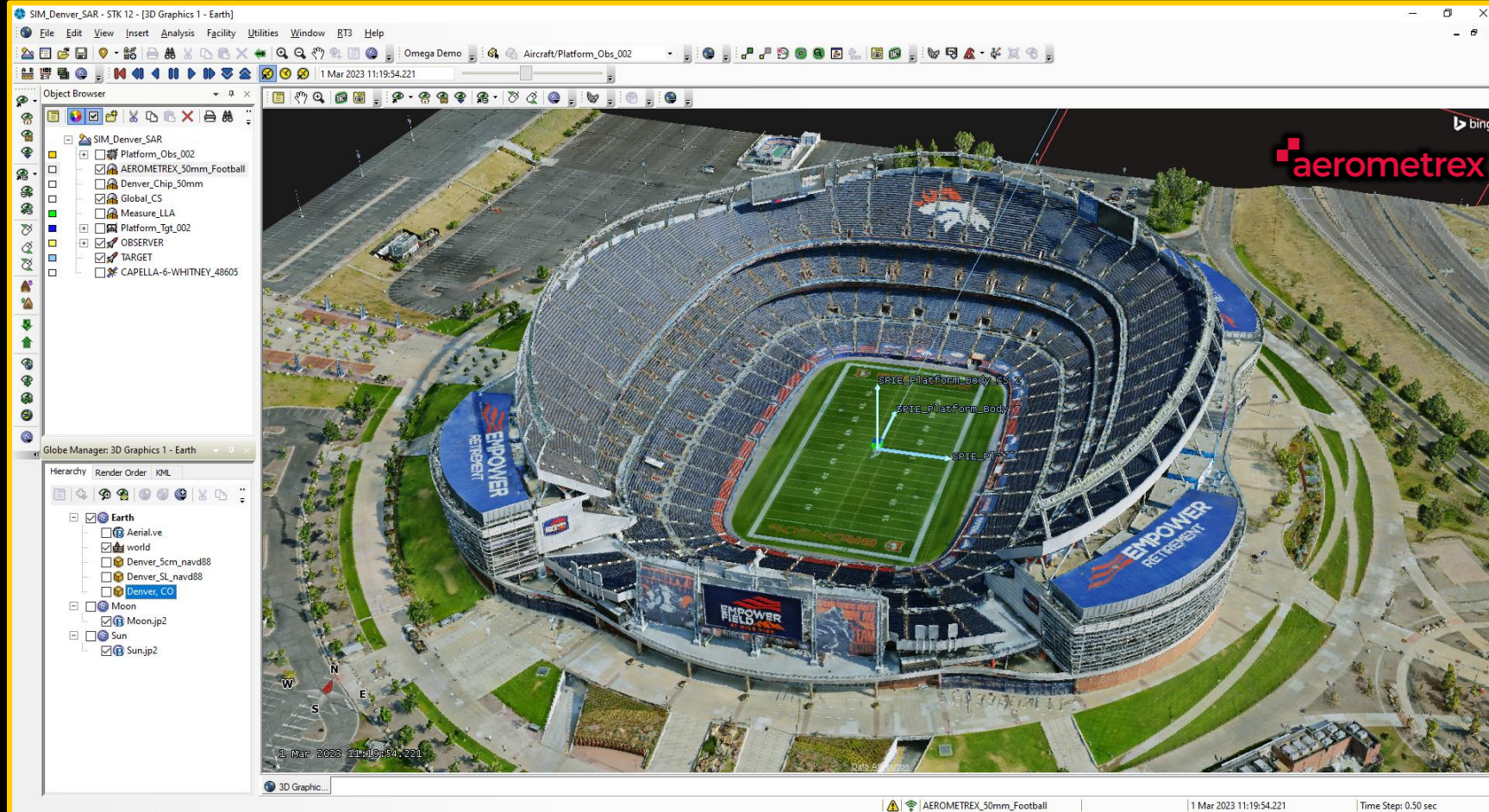


REAL Capella 1 Mar 2023 Collection



GREAT MODELS - GENERATE GREAT DATA

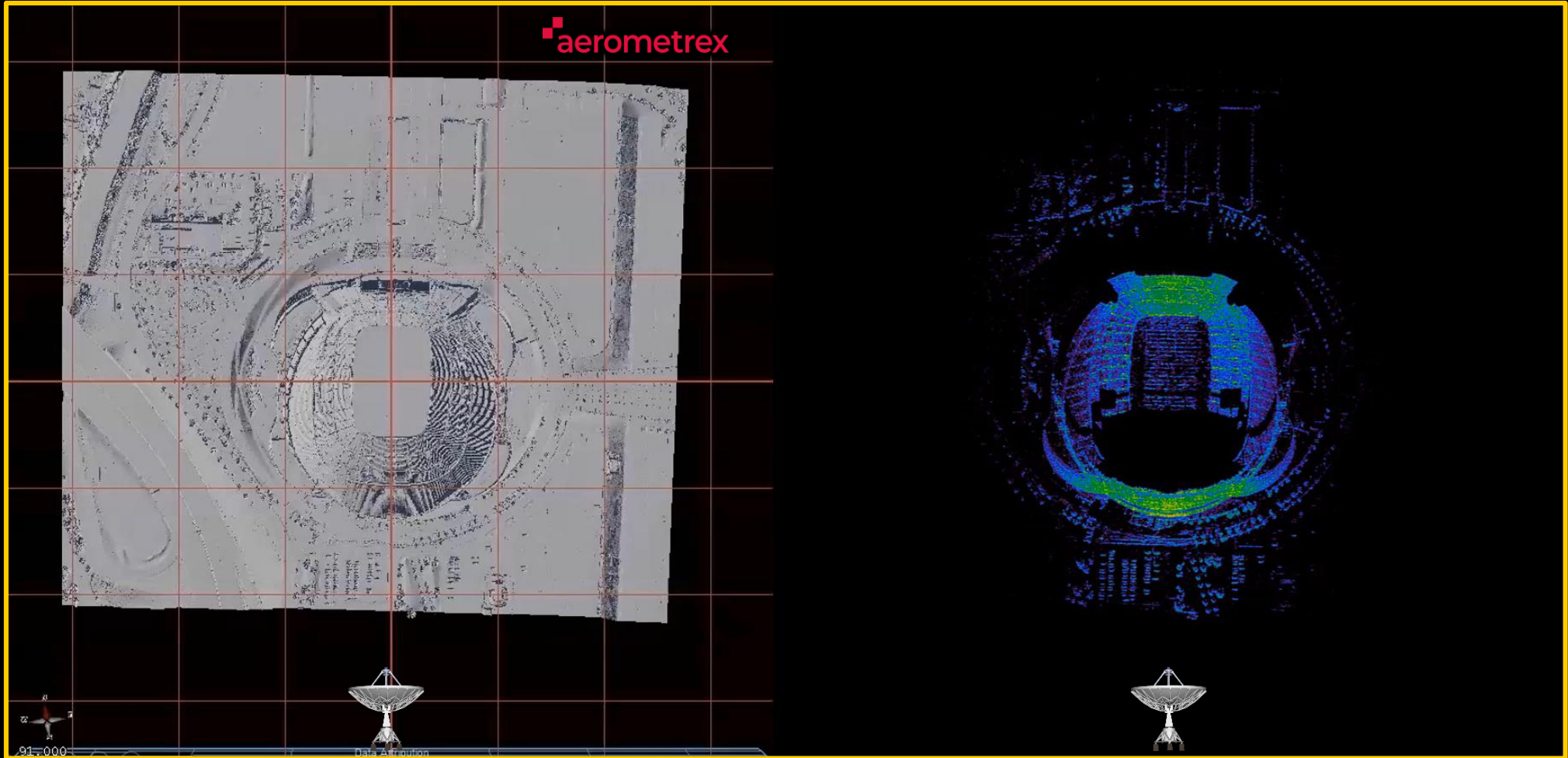
(Resolution Matters - Denver Data provided by Aerometrex)



The 3D model scene of Denver was provided by Aerometrex

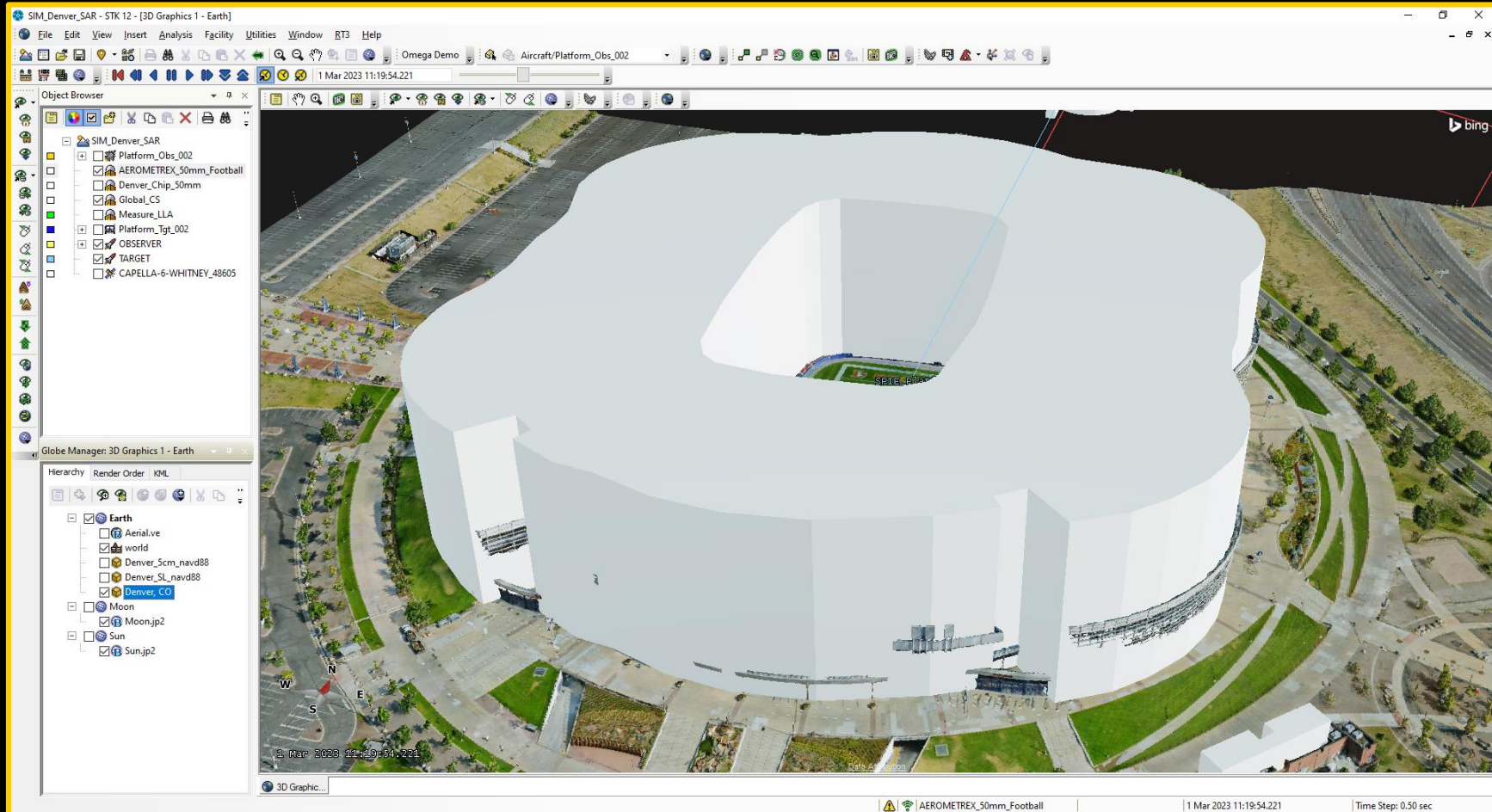
GREAT MODELS - GENERATE GREAT DATA

(5cm Resolution Model from Aerometrex)



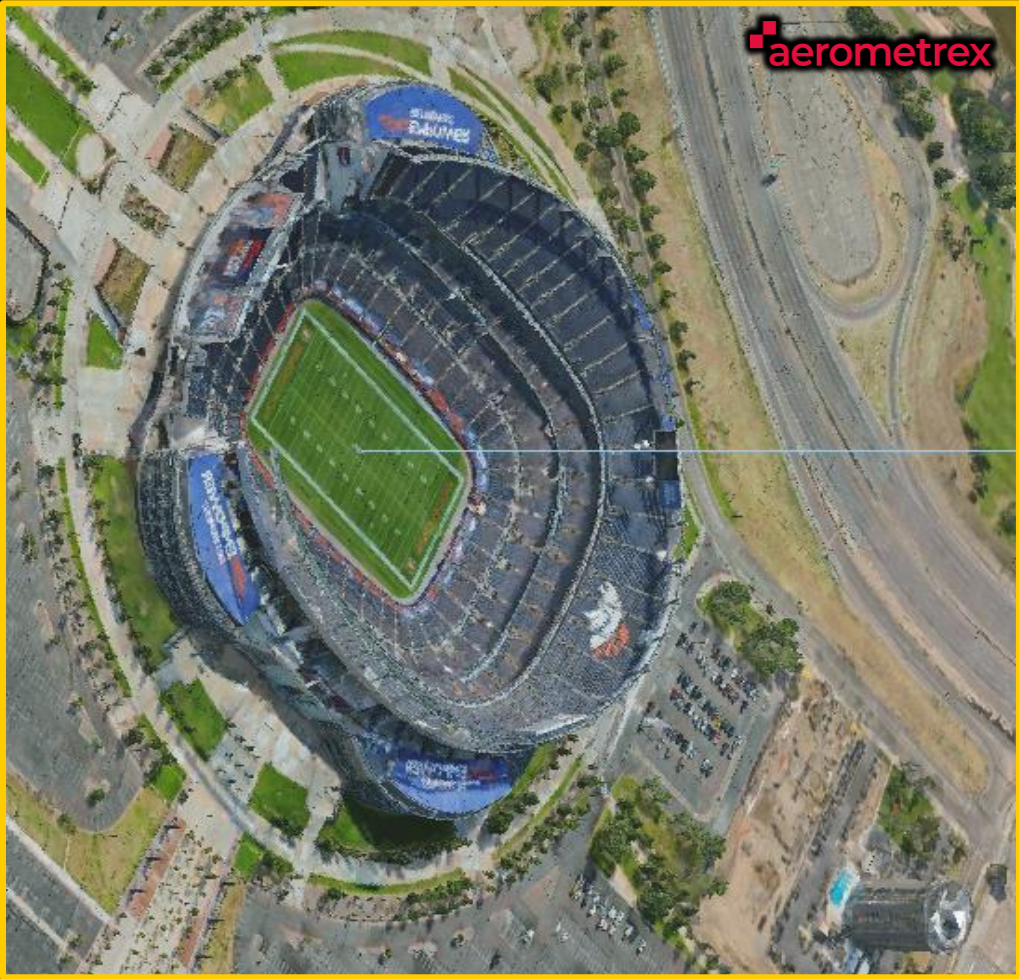
OPEN STREET MAPS NOT SUITABLE FOR HIGH RESOLUTION IMAGES

(Much lower resolution, not suitable for Synthetic Radar Images)

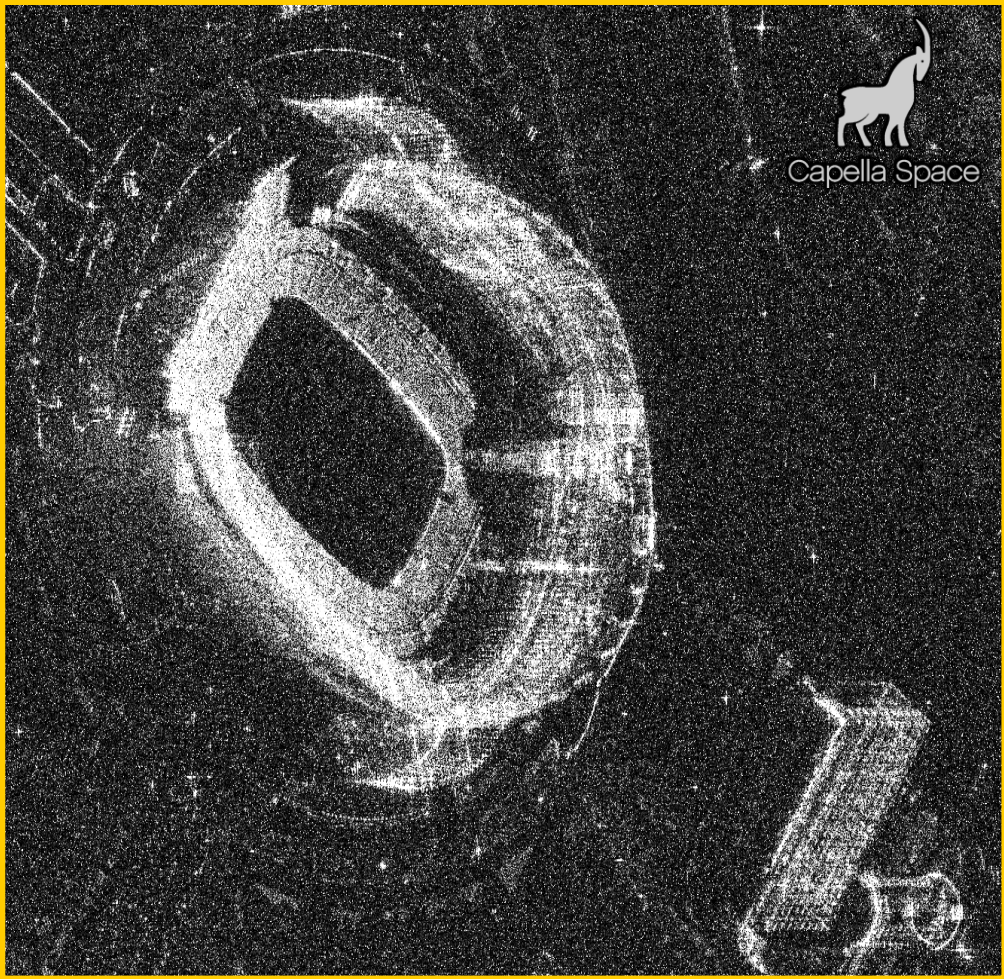


RFCM SUPPORTS DATA ANALYSIS (Capella 6)

Aerometrex Model



REAL Capella 1 Mar 2023 Collection

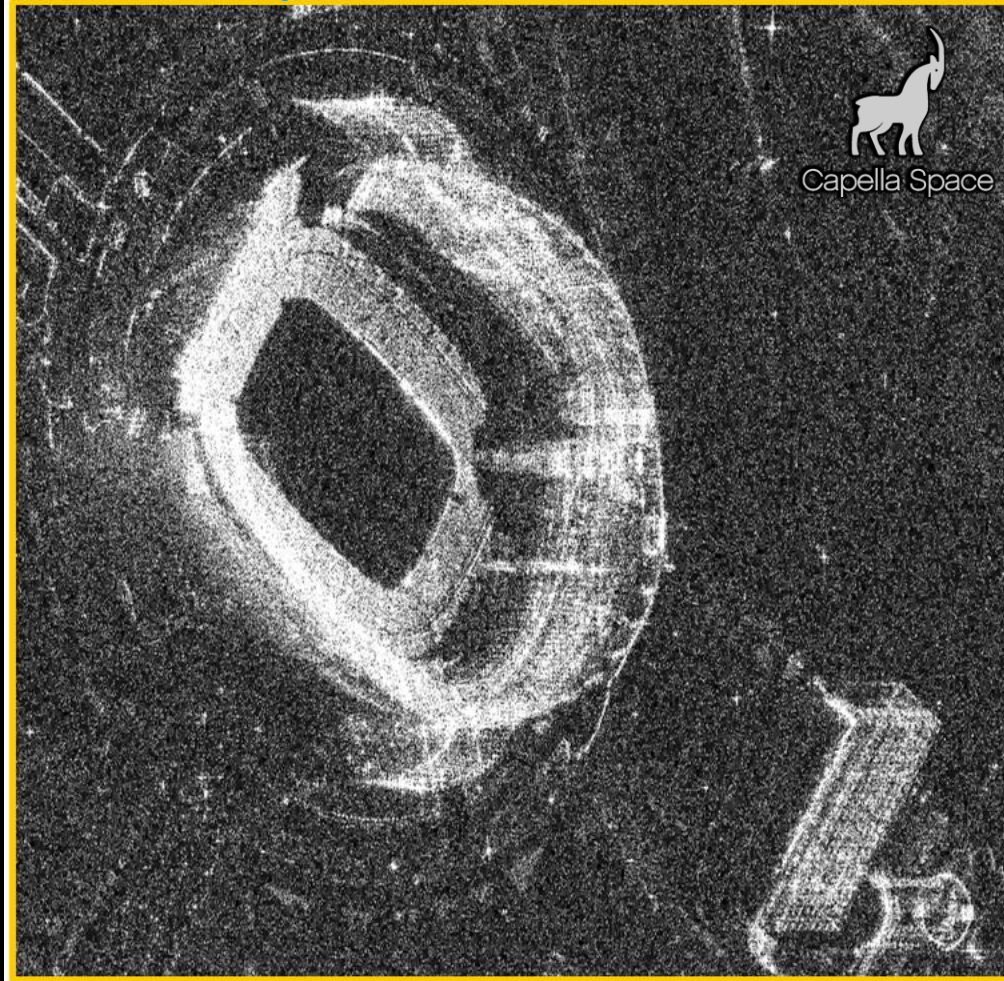


The 3D model scene of Denver was provided by Aerometrex

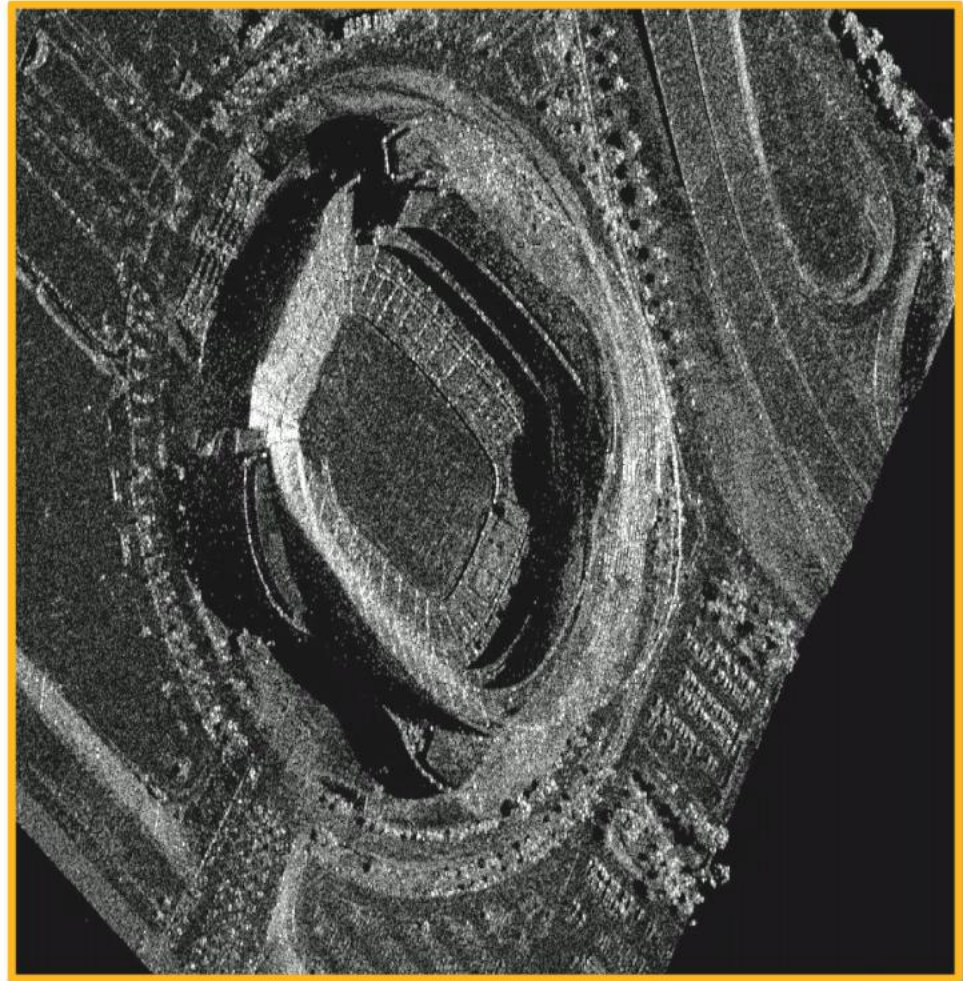
RFCM DATA VS REAL DATA MEASUREMENTS *(Denver Stadium)*

Real vs Synthetic SAR Imagery

REAL Capella 1 Mar 2023 Collection



SYNTH_Data_60dB_1-Bounce



WHO BENEFITS?

- **INTELLIGENCE/DATA ANALYSIS** (*Interpret the data*)
 - Complex target behavior impact on data
 - Maximizes data utilization, image refinement, validate assessments
 - Controlled target data generation for signature analysis and understanding
- **COLLECTION PLANNING** (*How should I operate my sensor*)
 - Test design (Cooperative Collection)
 - Operations (Noncooperative Collection)
- **AI/ML** (*Create validated data necessary to train algorithms*)
 - Generate data for all Target types, configurations, orientations/angles and Target behavior
 - Realistic synthetic data can train algorithms that will work with real data

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PROJECT LOCH NESS TARGETS

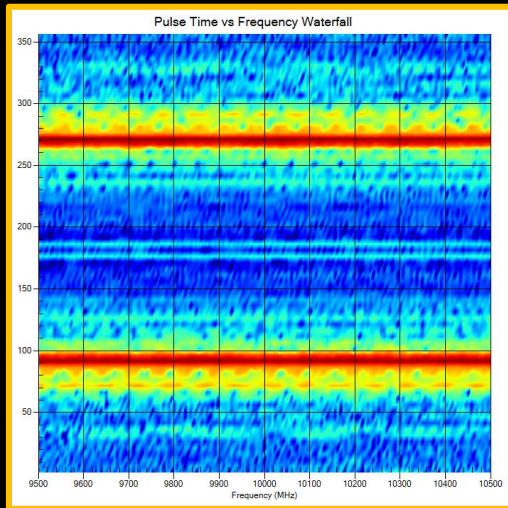
Supports AI Algorithm **TRAINING**



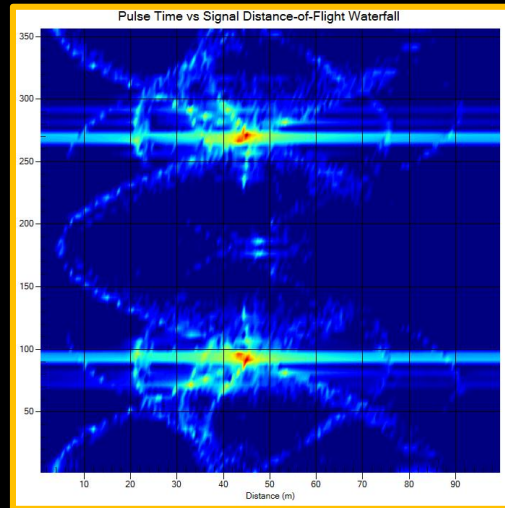
EACH TARGET CONTAINS:

1. **FREQUENCY** and **RANGE** Response Data (I&Q Data)
2. **IMAGE** files for any angle

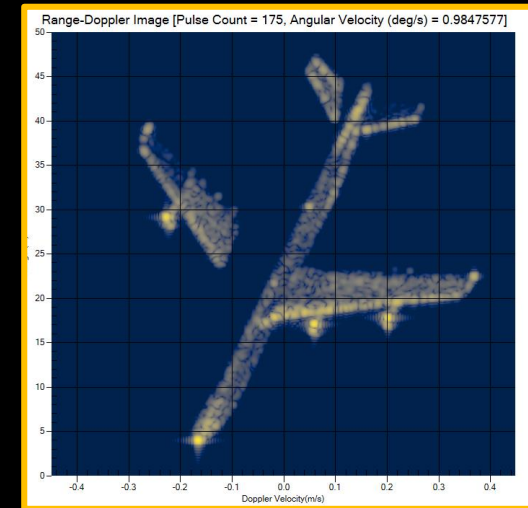
FREQUENCY RESPONSE



RANGE RESPONSE

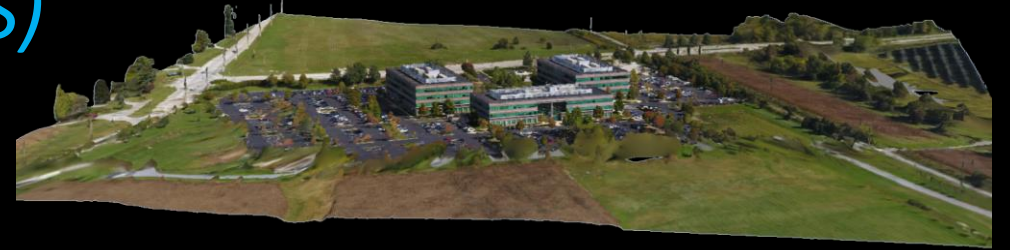


WIDEBAND IMAGE



PROJECT LOCH NESS SCENES (3D TILES)

Supports AI Algorithm **VALIDATION**

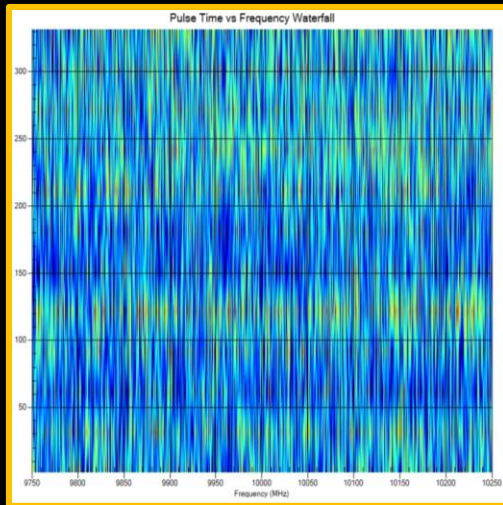


EACH SCENE CONTAINS:

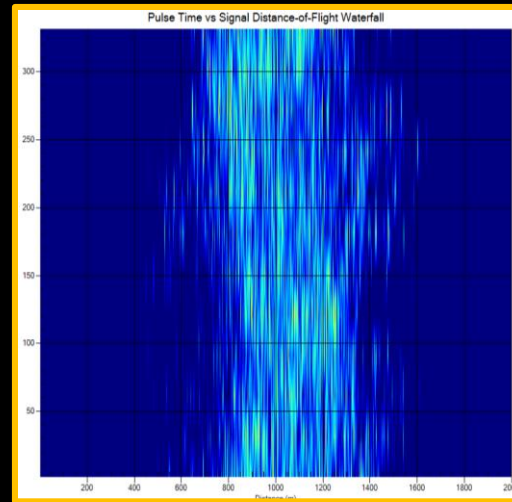
1. **FREQUENCY** and **RANGE** Response Data (I&Q Data)
2. **IMAGE** files for any angle



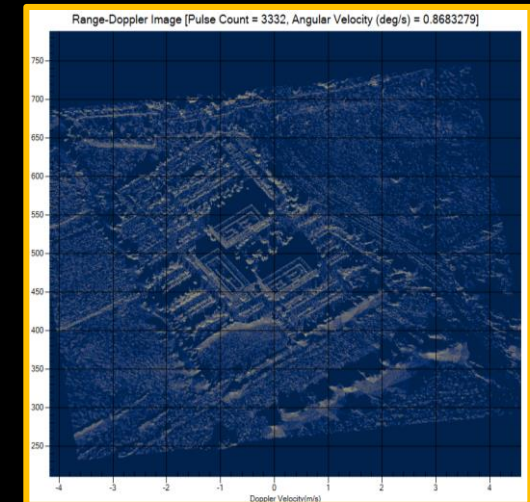
FREQUENCY RESPONSE



RANGE RESPONSE



WIDEBAND IMAGE





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ADDITIONAL CAPABILITY (MULTI BOUNCE – CAVITY RESPONSE)

