NDIA 2012

Missile Simulation in Support of Research, Development, Test Evaluation and Acquisition

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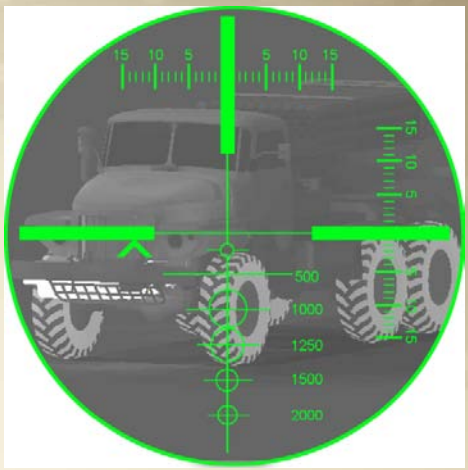
Pre and Post Test Flight Construction

Live Fire Pre and Post Flight Reconstruction

Live tests are costly.



Simulations are used in advance of the flight to simulate expected conditions. This information may be used to make adjustments or recommendations prior to test.

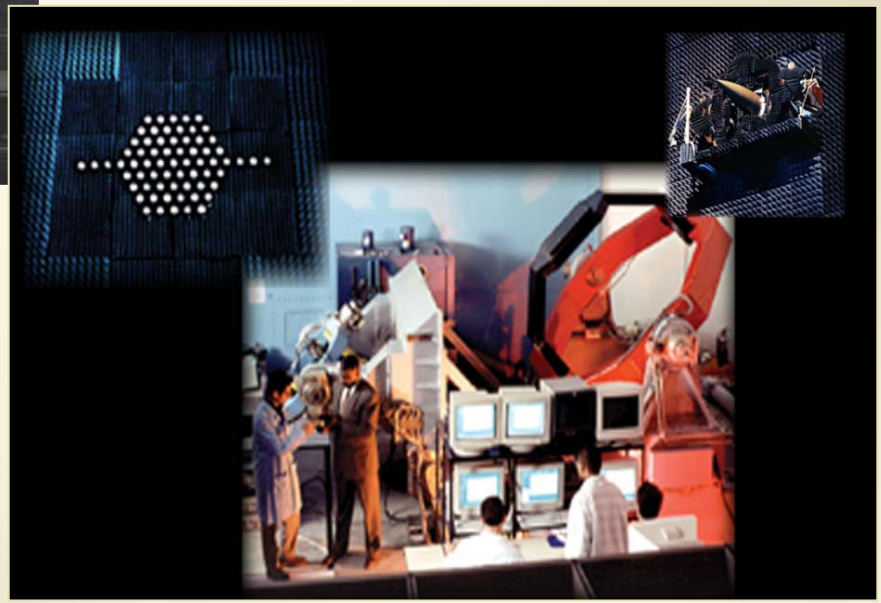
Simulations are used after flight to make determinations about performance. These data may also be used for verification purposes.

The use of models in these simulations allow for scenario excursion and robust treatment of the exercise.

Sensor and System Performance Assessments

Hardware in the Loop

- Used to assess system performance using actual system hardware as well as software
- Models are presented to the system



All Digital Simulation

- Used to analyze and visualize system performance from launch to target interception
- Models are incorporated into the simulation and the loop is “closed”

All Digital Simulation

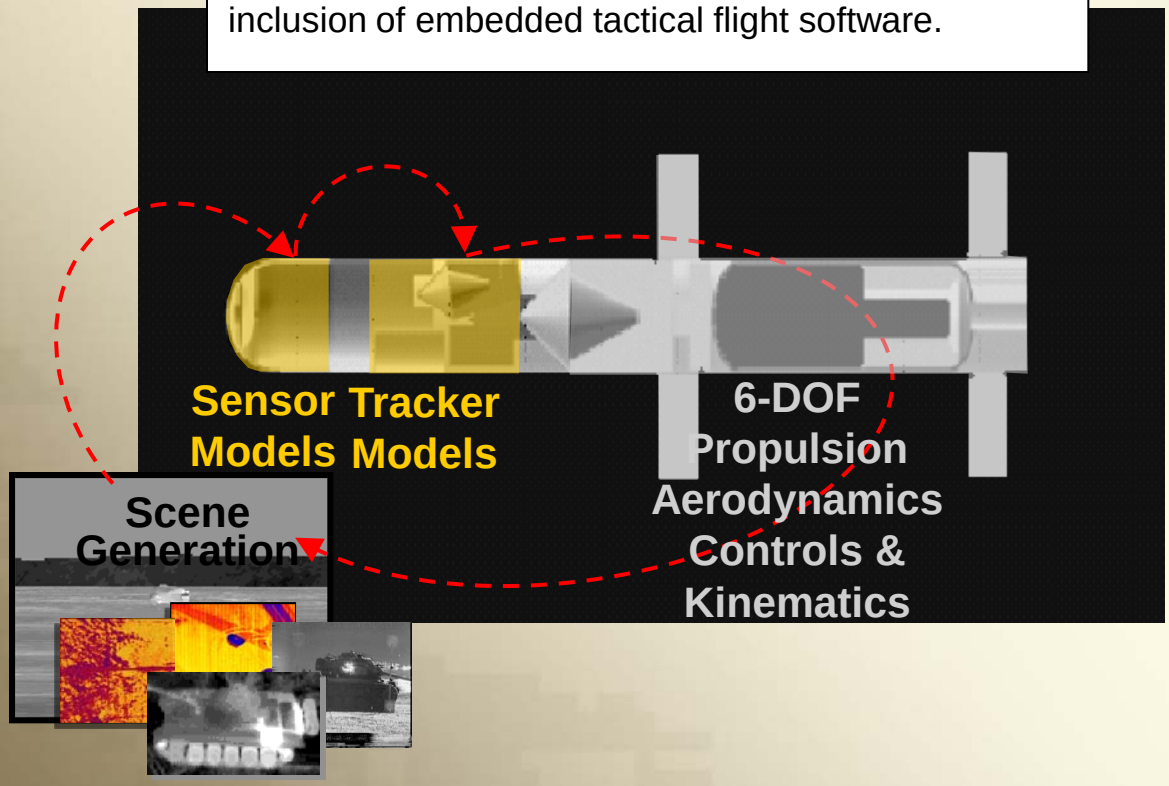
The Common Scene Generator in compilation with a system IFS gives designers the capability to do numerous “what if” excursions during development

The incorporation of validated models to the Common Scene Generator makes it a useful tool in preparation for formal developmental and operational test exercises

The simulation, along with its component models, are generally accredited for use in supporting developmental and operational test activities

All Digital Integrated Flight Simulation

An **Integrated Flight Simulation (IFS)** is characterized by the integration of highly detailed component models, high-fidelity synthetic image generation for stimulation of tracking algorithms, and inclusion of embedded tactical flight software.



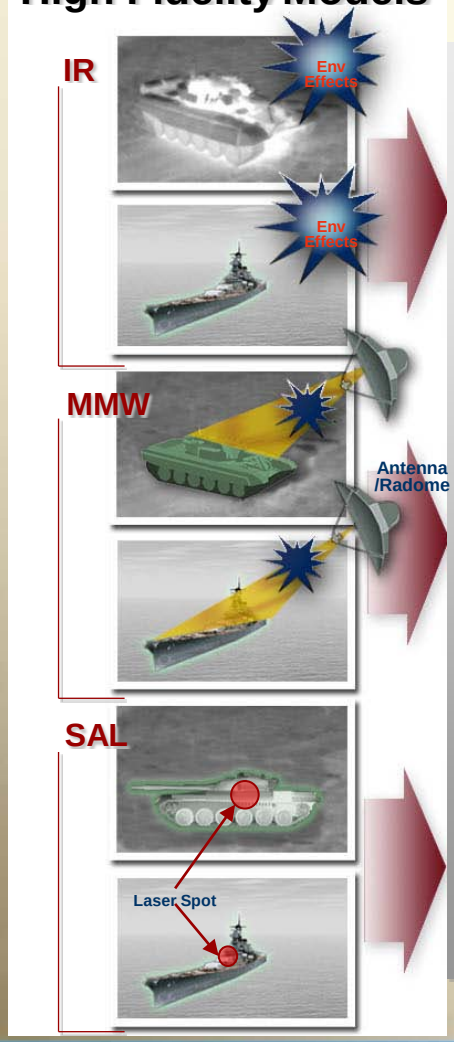
Integrated flight simulation extends traditional 6-DOF with:

- **Tactical GNC**
- **Tactical Track Algorithms**
- **High Fidelity Sensor Models**
- **High Fidelity Scene Generation**

Sensor Development and Sensor and System Performance Verification

Scene Flow Diagram

High Fidelity Models



Scene Generator

Common Scene Generator (CSG)

- High Fidelity Scene Generation
  - Targets
  - Clutter
  - Range Gates
- Countermeasures
  - Atmosphere
  - Weather

Sensor Models

IR
Optics, MTF, NEDT, Readout Electronics

MMW
Antenna, Waveform Generation, Pulse Compression, RF electronics

SAL
Dome/Optics/Detector, Analog Electronics, Time Resolved Pulse

Tactical Code

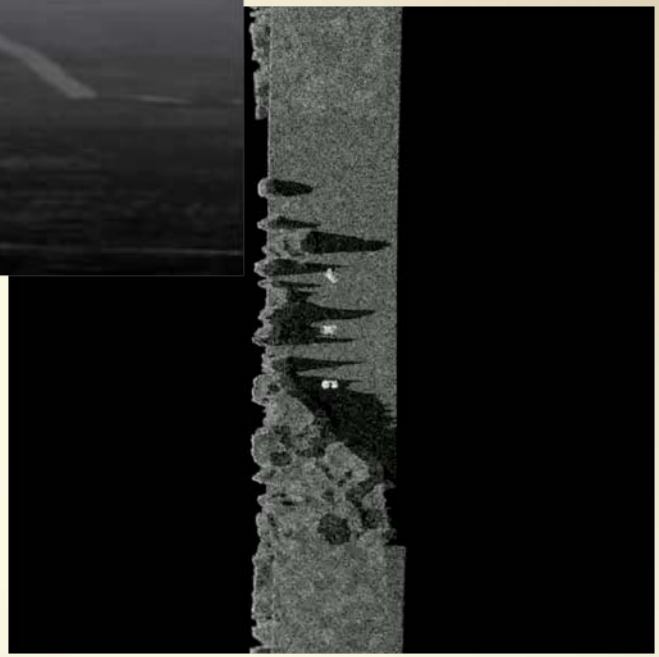
Tactical Software and Firmware

Sensor and System Performance Verification

All Digital CSG Overview

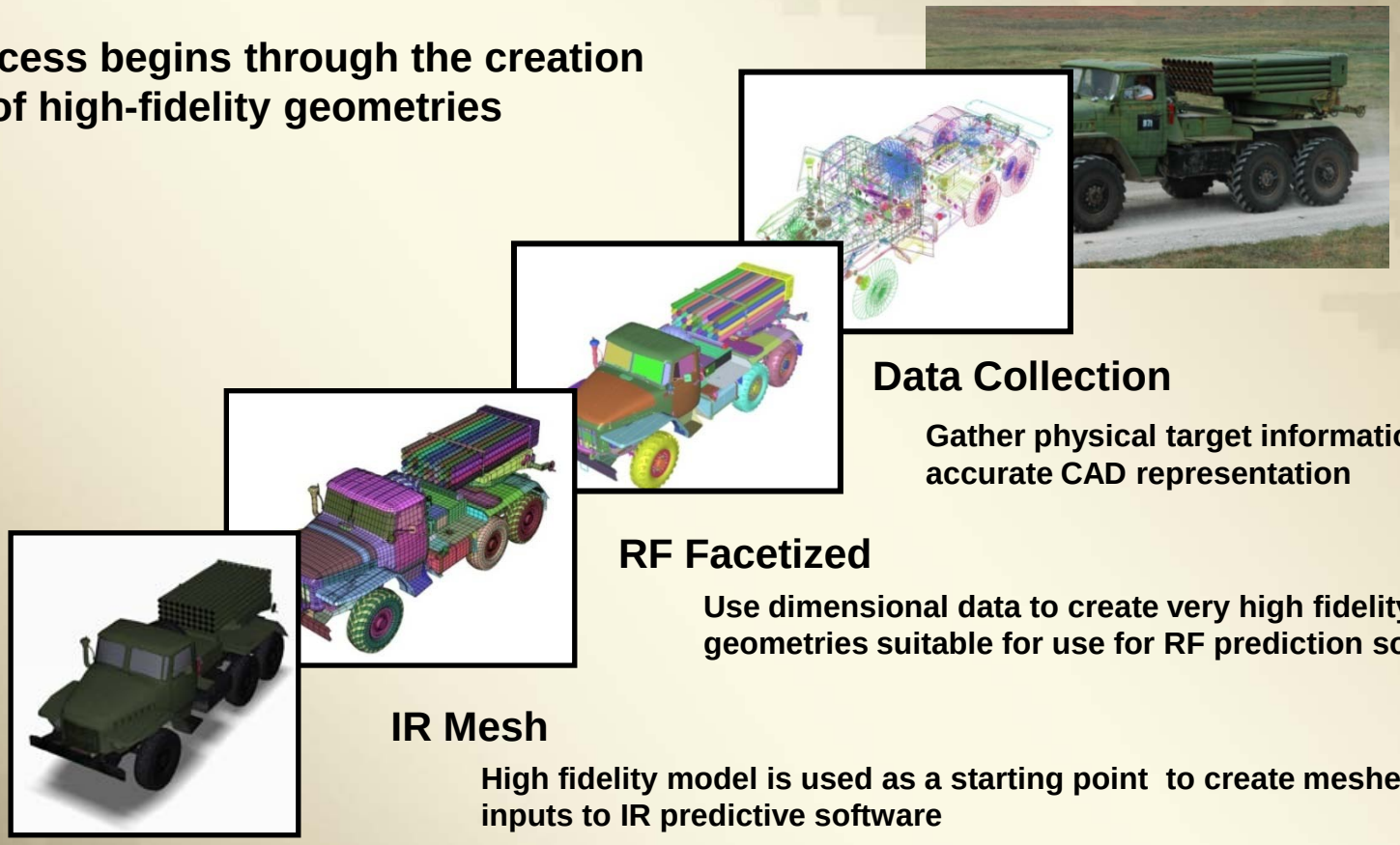
The Common Scene Generator (CSG) calculates the energy in the environment that is presented at the seeker dome over the waveband of a given seeker.

- **Infrared (IR)**
  - **Calculates either blackbody equivalent temperature (degrees Kelvin), radiance ($W/cm^2/sr$), or photon radiance ($ph/s/cm^2/sr$) based on emitted and reflected energy in the environment.**
- **Semi-Active Laser (SAL)**
  - **Calculates the energy density in Joules/cm^2 based on energy emitted by a designator that reflects or scatters back toward the sensor.**
- **Millimeter Wave (MMW)**
  - **Calculates the energy return from clutter and targets based on geometry, radar antenna and waveform characteristics and presents to the sensor in complex I/Q samples (volts).**
- **GroundTruth**
  - **Generates an image color-coded by pixel for target, background and obscured target**
- **Visual**
  - **Renders terrain and objects with no spectral calculations**



Geometry Development Process

The process begins through the creation of high-fidelity geometries



Data Collection

Gather physical target information for accurate CAD representation

RF Facetized

Use dimensional data to create very high fidelity target geometries suitable for use for RF prediction software

IR Mesh

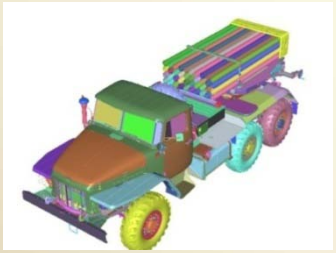
High fidelity model is used as a starting point to create meshes that are inputs to IR predictive software

Visualization Model

High fidelity model is used as a starting point to create low fidelity models used training and visual simulators

Simulation Inputs are Created Predictively

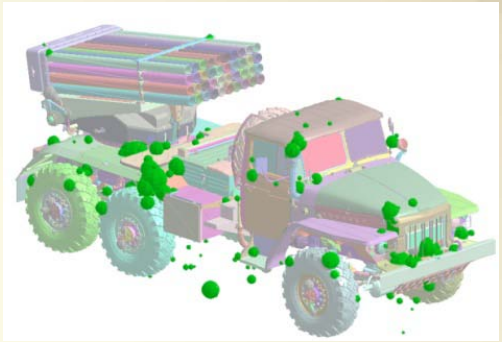
Additional processing is needed to generate physics based inputs for simulations



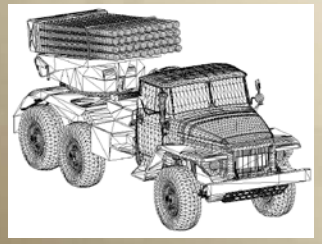
Facetized Model

Radio Frequency Signature Software

Radio Frequency Back Scatter, Azimuth and Elevation Dependent



Meshed Model



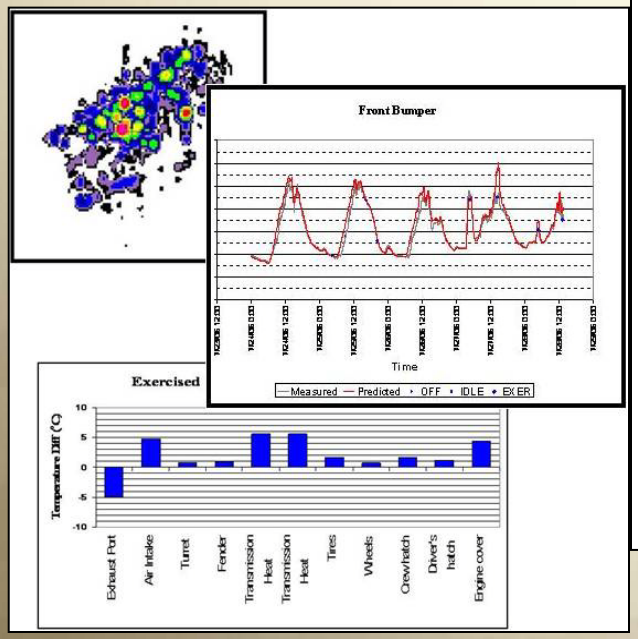
Infrared Signature Software

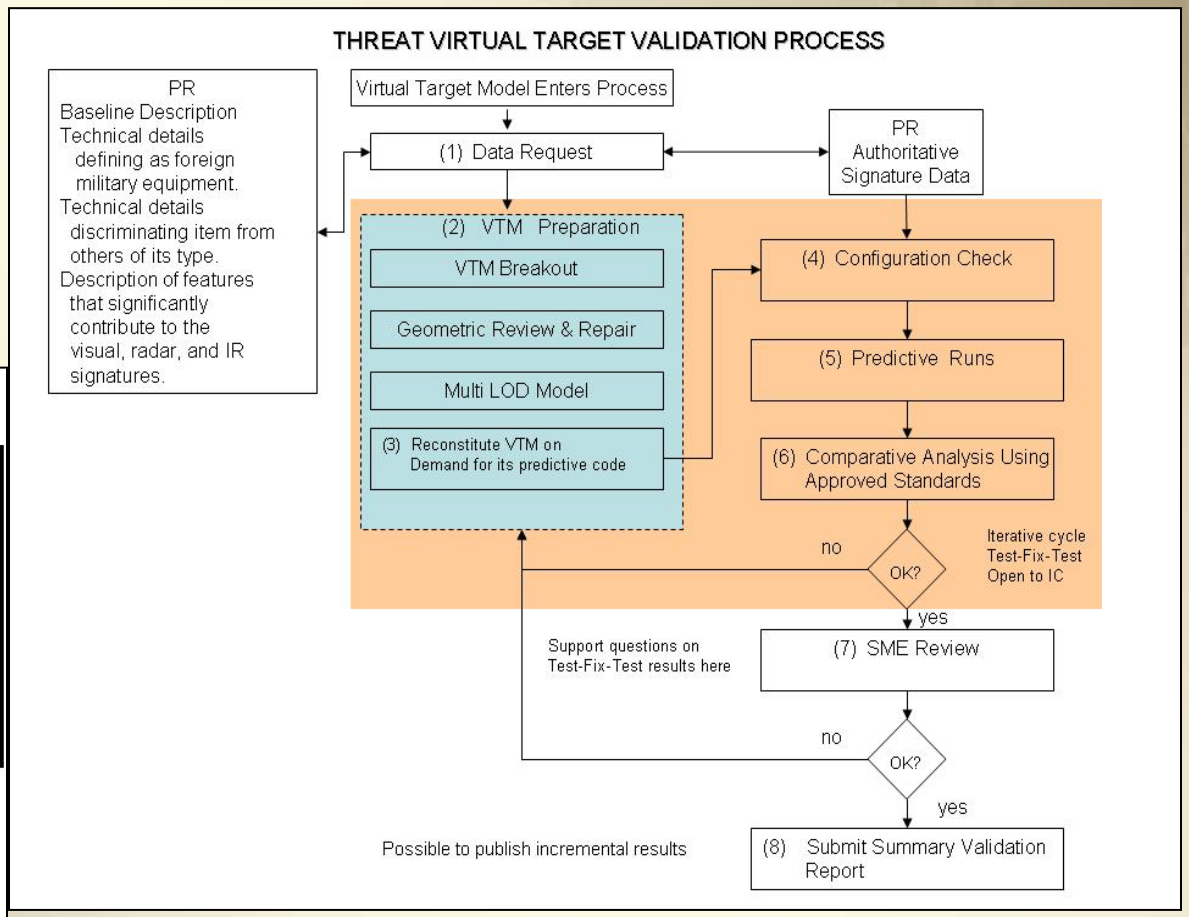
Infrared and Semi Active Laser Textures, Temperature or Radiance

Validation

Virtual Targets are vetted through a validation process to:

- **Ensure geometric fidelity**
- **Ensure physical and spectral accuracy**





An Example

A customer has a requirement to test system performance against a particular set of vehicles in a location in the United States.

Said customer would like to have an analysis of the test scenarios before actually flying the hardware.

Let us choose our locations to be:

Eglin Air force Base, Florida

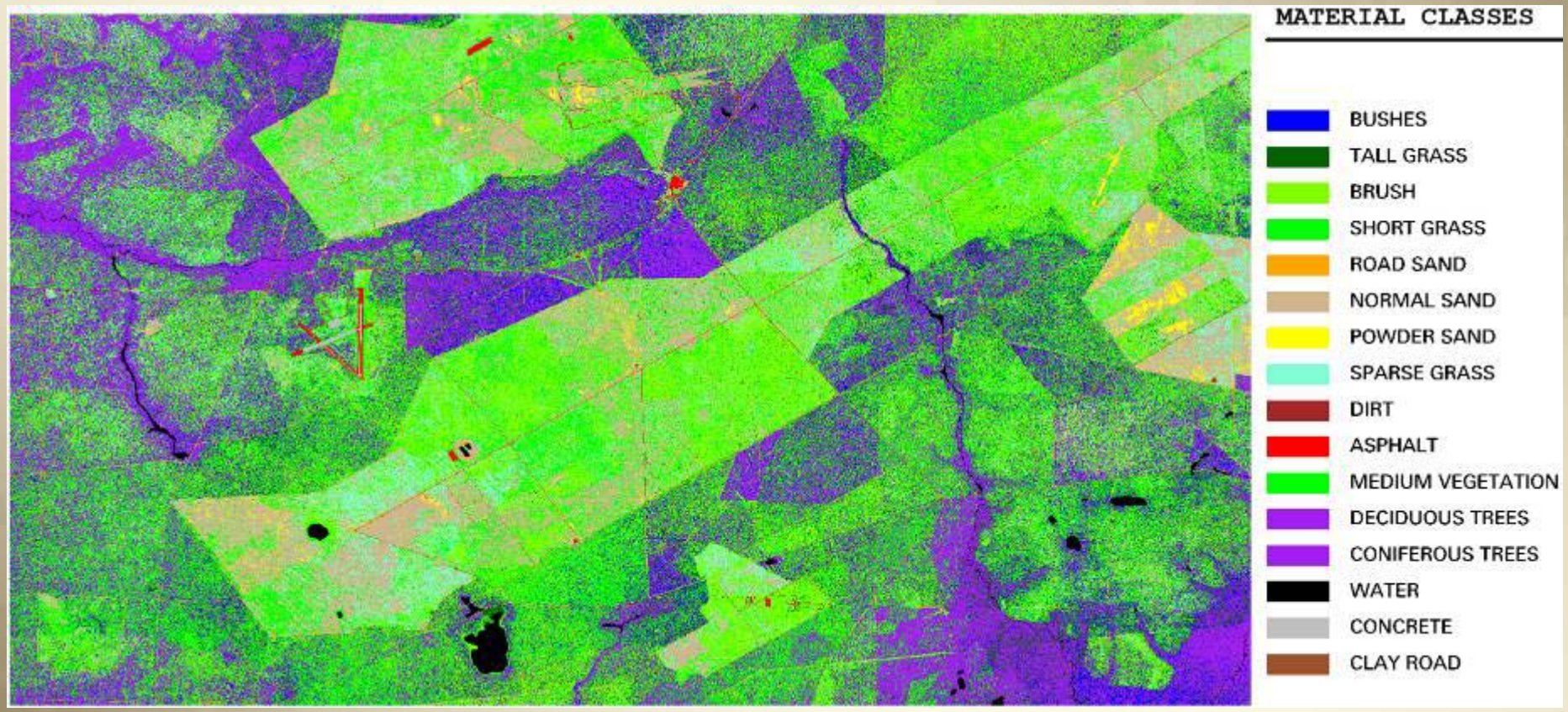
Background

AMRDEC has established a methodology to create high-fidelity terrain backgrounds in which to utilize virtual targets

This methodology involves:

1. **The identification of the area of interest**
2. **The identification of discrete clutter types**
3. **Prediction of the environment using an Infrared tool known as EOVIEW**
4. **Methodical data collection of Radar data of the discrete clutter types**
5. **Scene creation in CSG**
6. **Insertion of virtual targets**
7. **Simulation is run for both Radar and Infrared in CSG with targets and backgrounds**

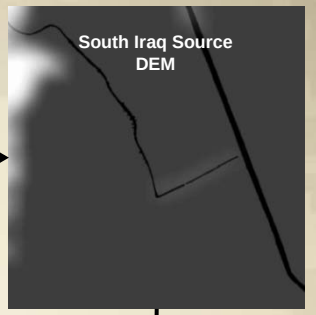
The identification of the area of interest
Class Map Example



Terrain Characterization and Model Development Process

Source Data

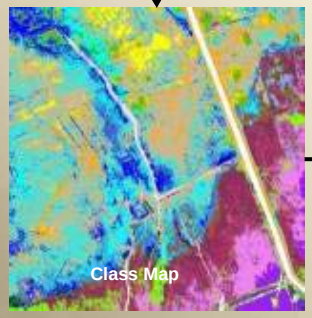
- Satellite Imagery
- Aerial Survey Photos

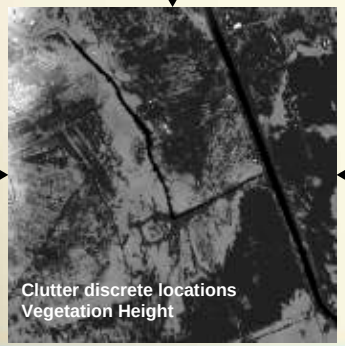


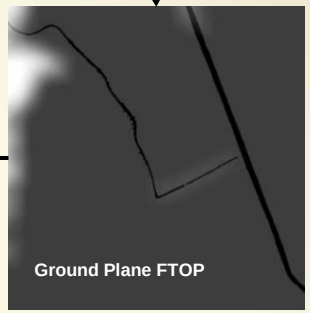
Material Classification Process

Object Placement Map (OPM) Derivation Process

DEM RESAMPLE PROCESS







Clutter Discrete Development

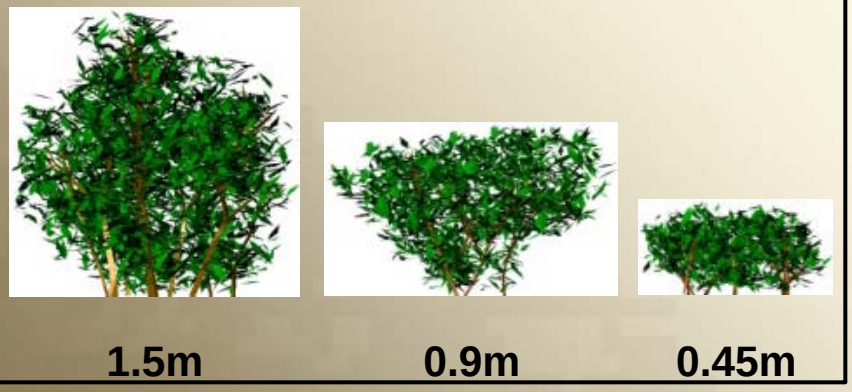
Yaupon Holly Bush

2m 1m

Turkey Oak Bush

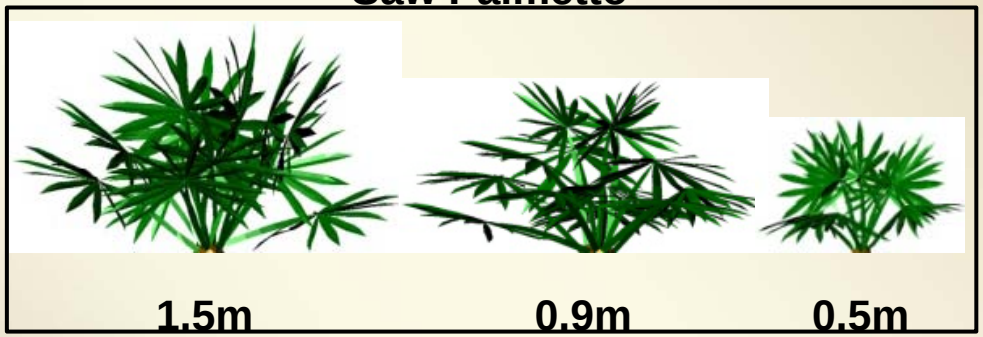
1.5m 0.9m 0.45m

Live Oak Bush



1.5m 0.9m 0.45m

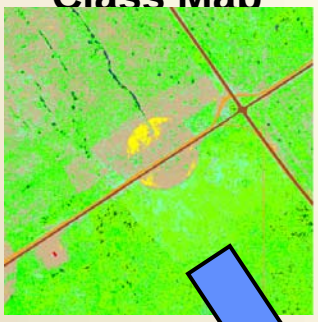
Saw Palmetto



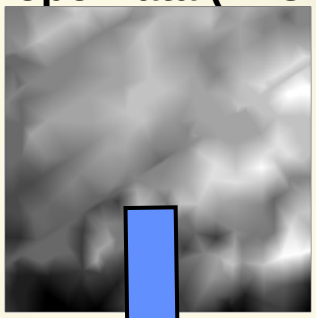
1.5m 0.9m 0.5m

IR Terrain Signature Calculation Process

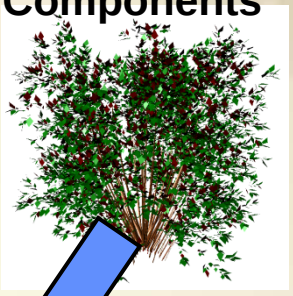
Class Map



Topo Data (FTOP)



Scene Components



Virtual Target

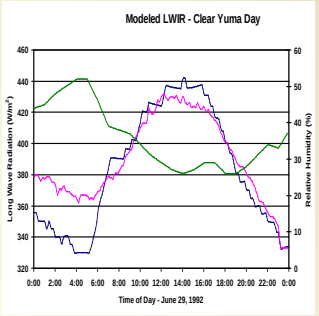
Build OPM

Material Properties for Each Class

- Absorptivity
- Emissivity
- Thermal Conductivity
- Specific Heat
- Etc.

Thermal Solver

Weather Data



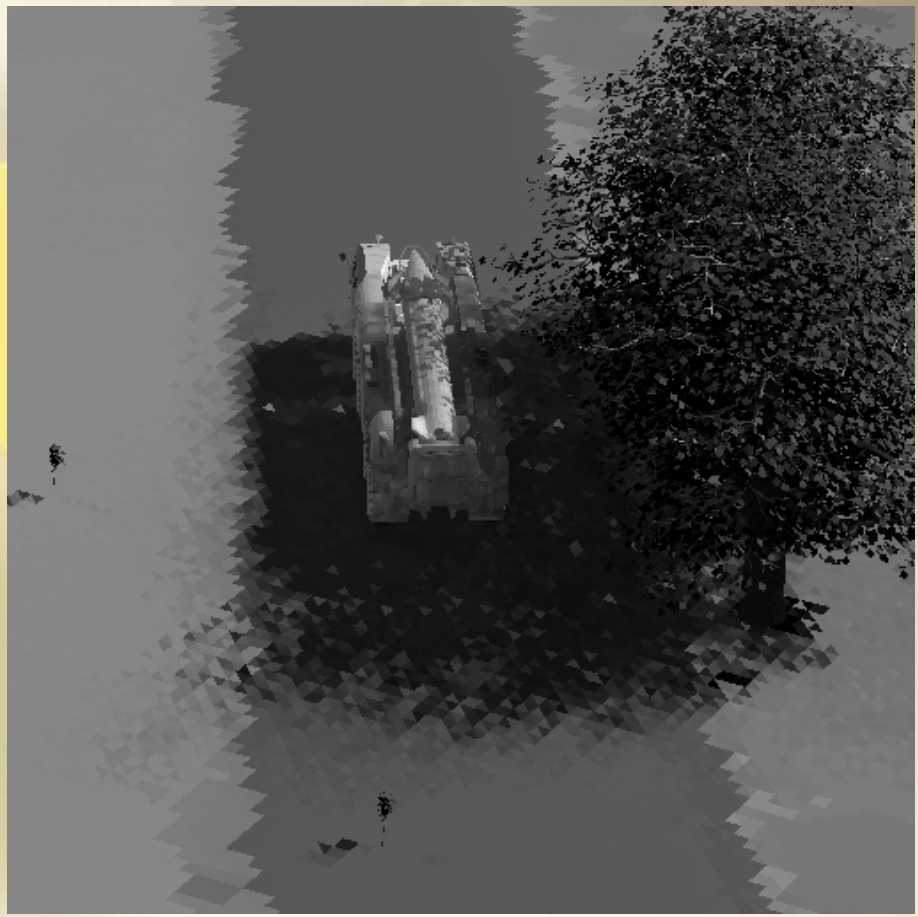
Physical Temperatures

Target
Terrain
Clutter Discretes

CSG Thermal Signature Inputs

FRAD
BIFS

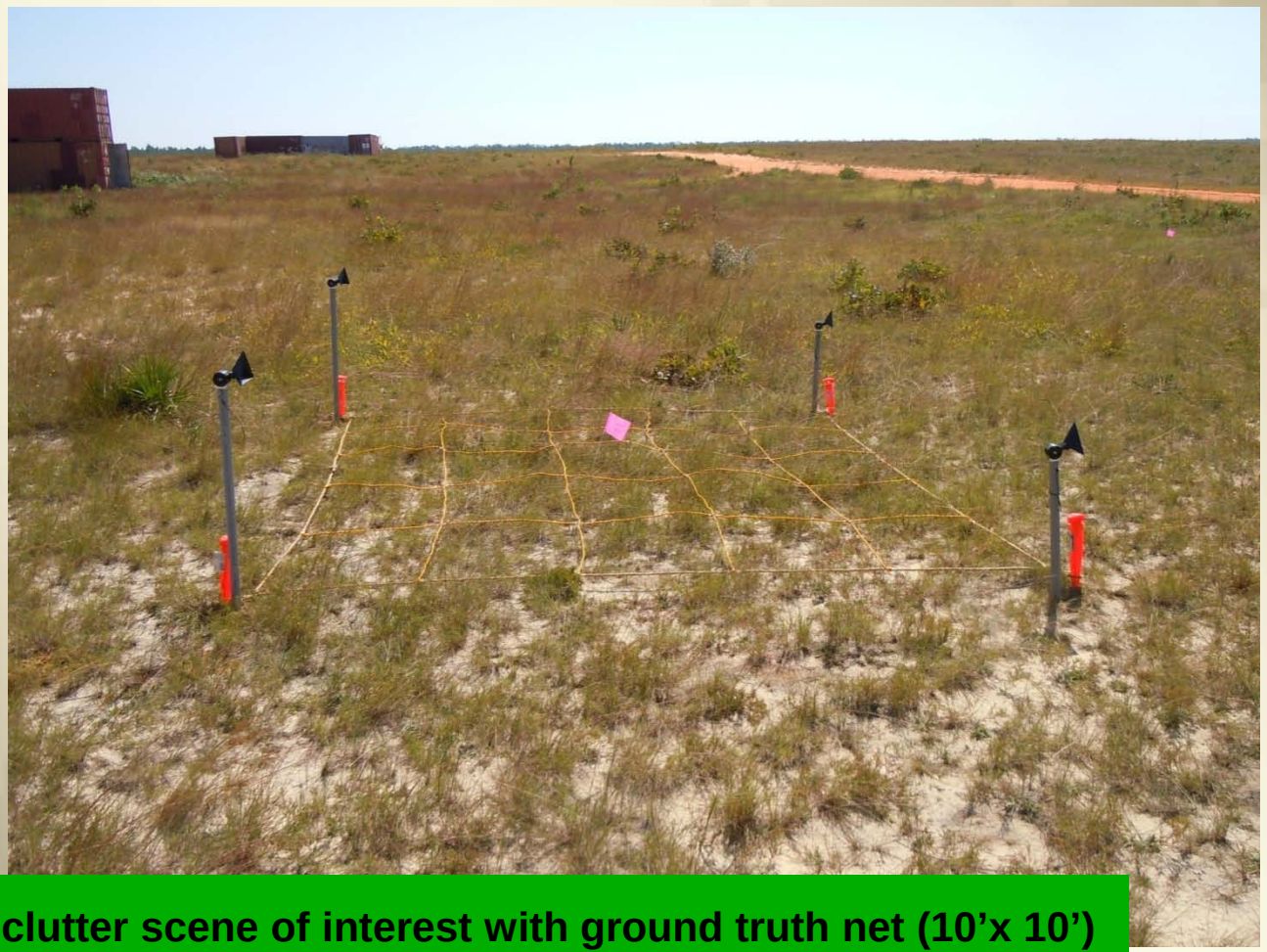
EOView Results - Thermal Interactions with VirtualTarget Model



Radar Signature Data Collection

Portable radar collection asset
Ka-band
2GHz Bandwidth
1.8m rail
~110’ height extension

Radar Measurement Process

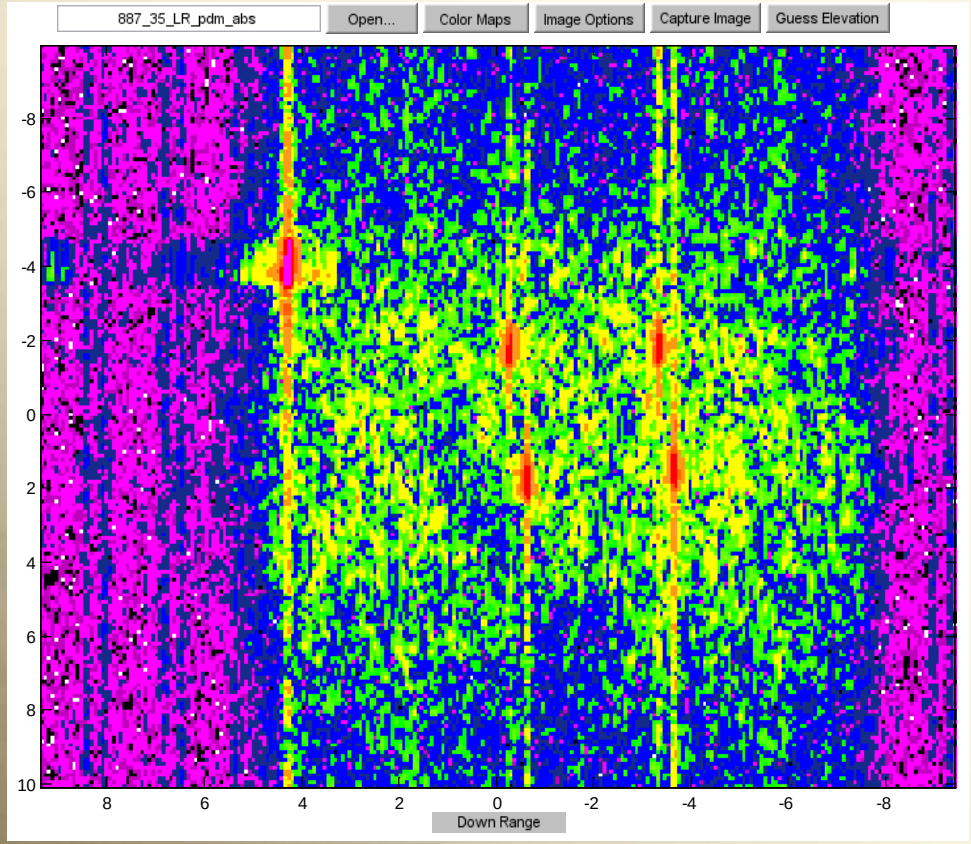


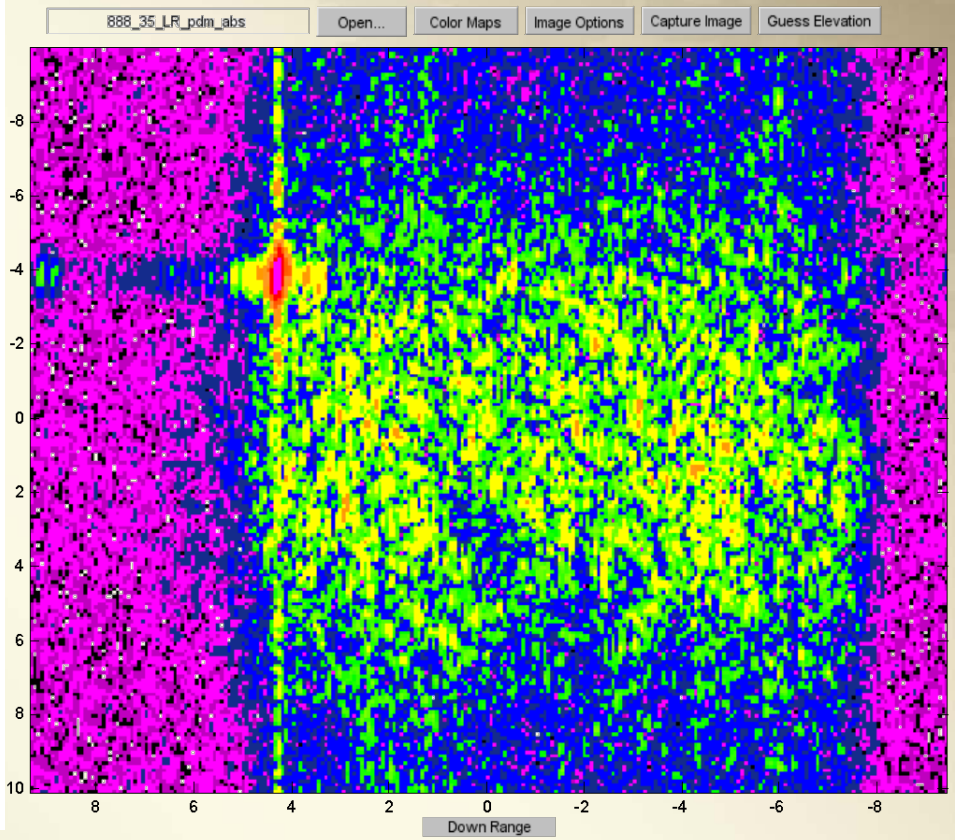
Mark the exact clutter scene of interest with ground truth net (10'x 10')
Set removable trihedral markers at the corners of the net
Remove net

Measure Clutter: with indexing

View from the RAILSAR camera
Index reflectors in-scene
Motion compensation reflector in-scene

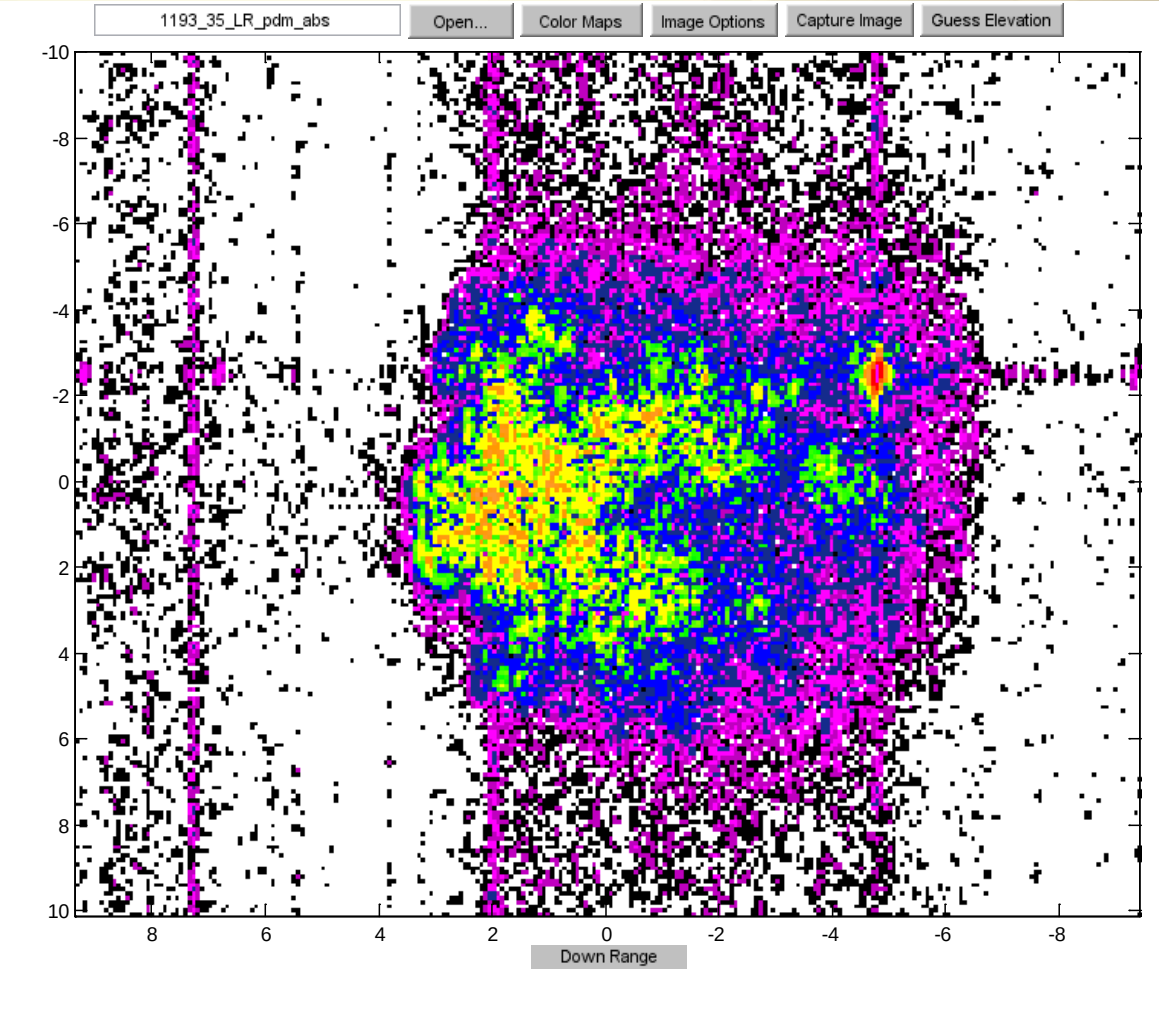
Grass Data:10deg Elevation



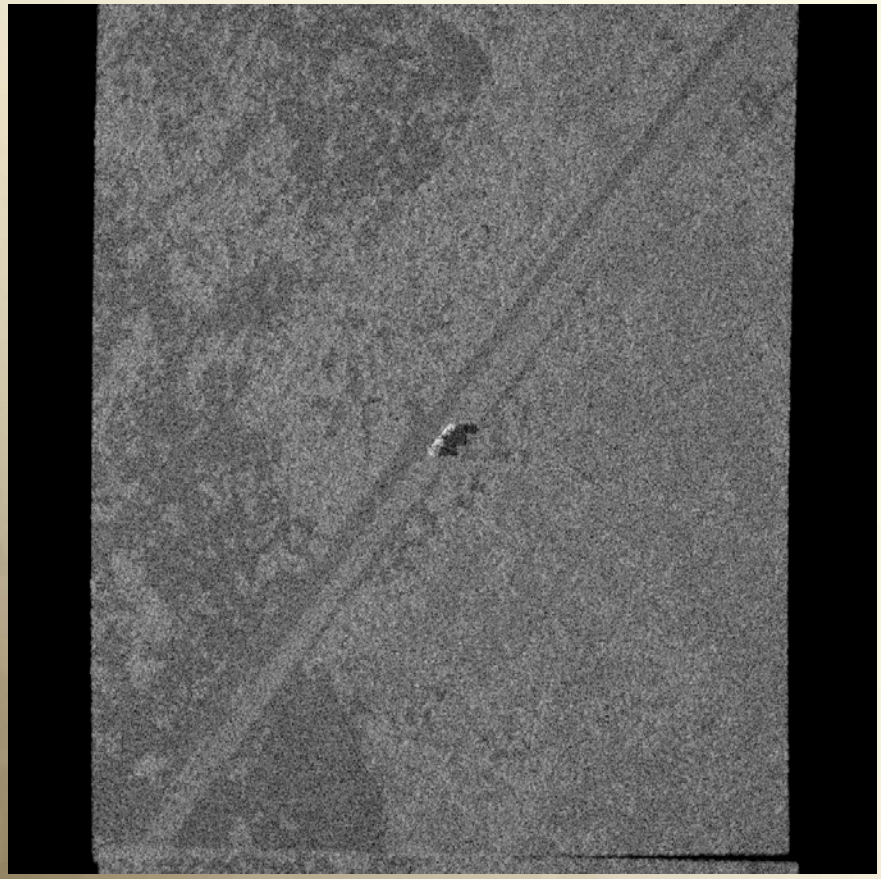


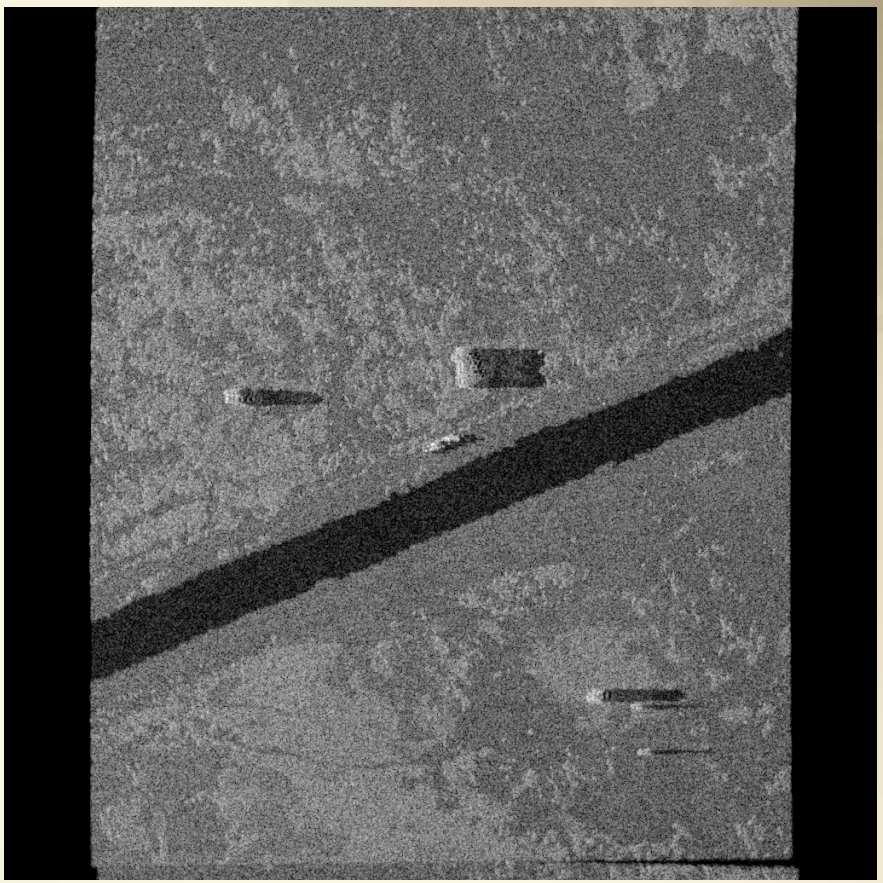
Live Oak, 30 deg Elevation

Live Oak, 30deg Elevation



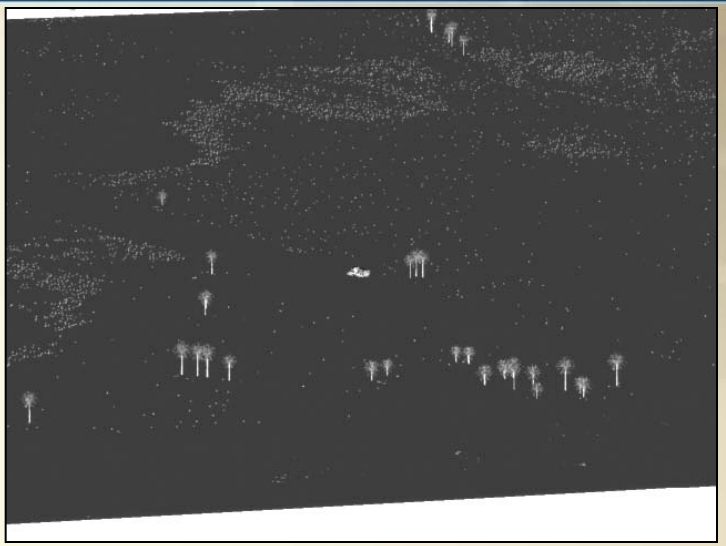
Radar CSG
Demonstration Pictures





Infrared CSG Demonstration Pictures

0500

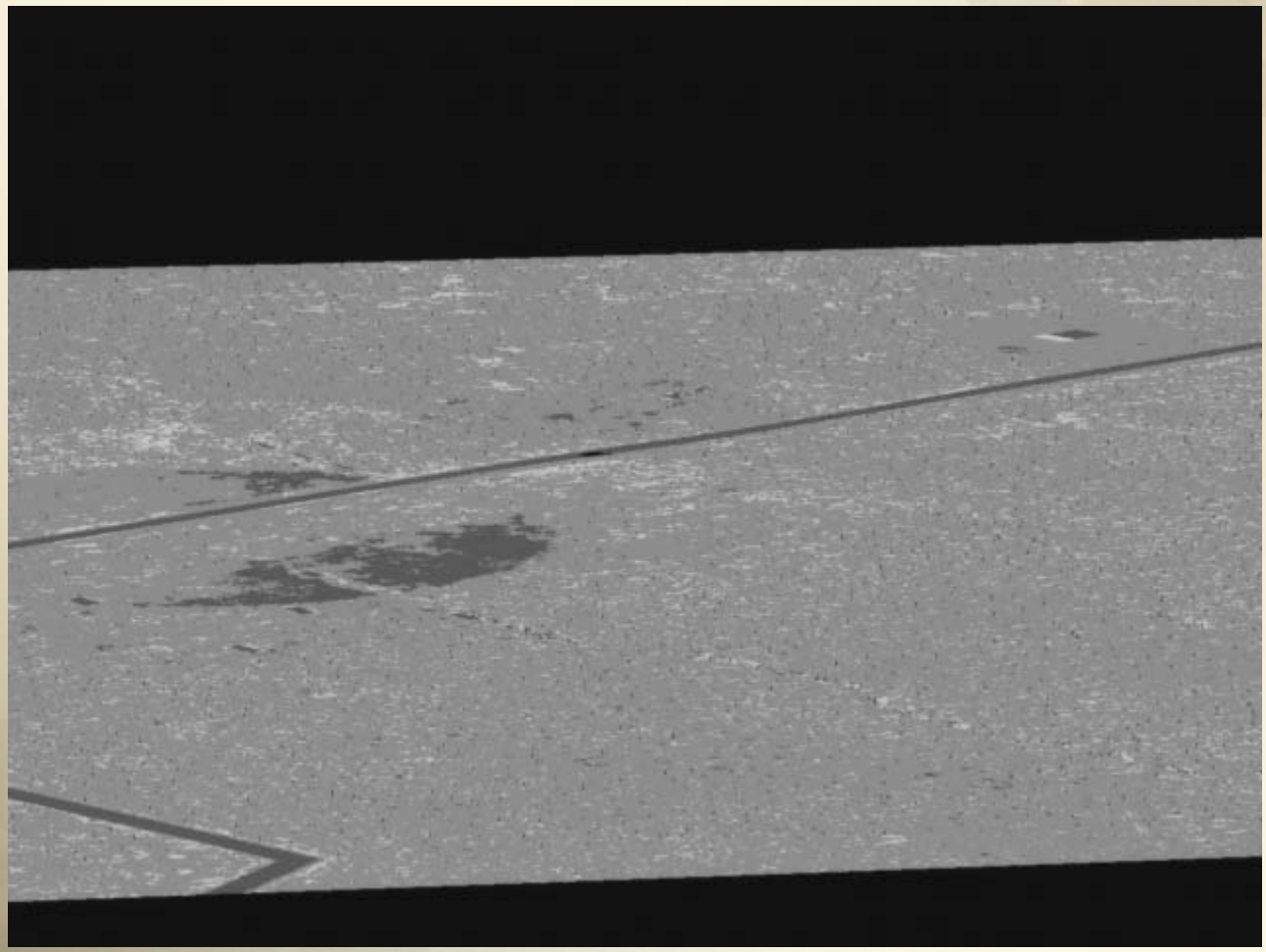


0500

1200

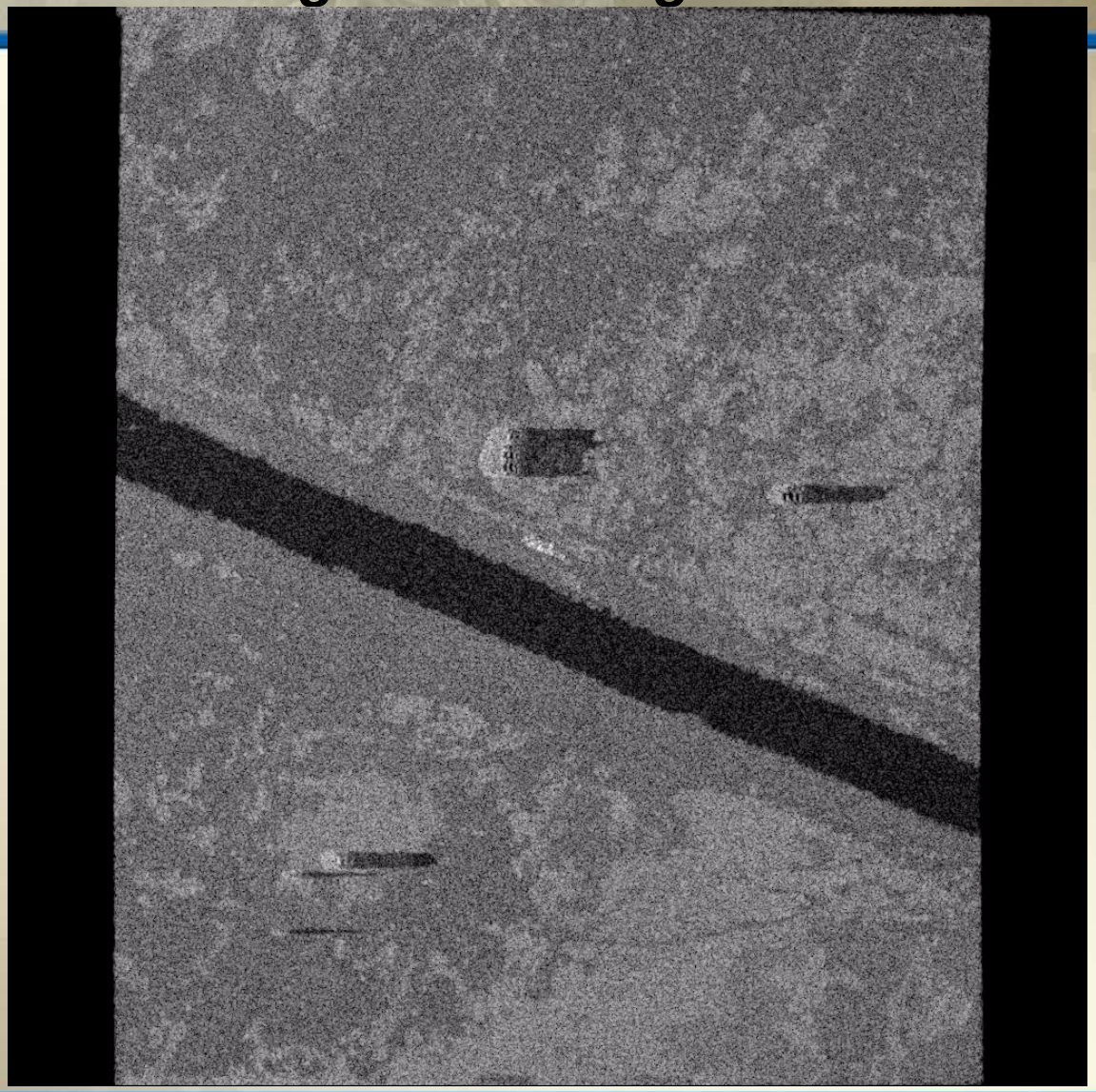
1200

Infrared Demonstration: Moving Virtual Target



Infrared Demonstration: Moving Virtual Target

Radar Demonstration: Moving Virtual Target

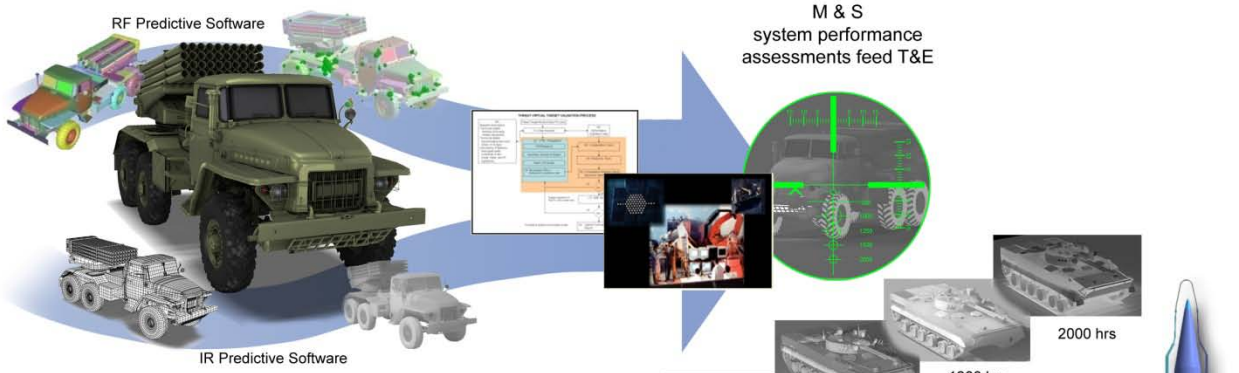


Virtual Targets Center

The VTC is a collaborative effort between the PEO for Simulation, Training, and Instrumentation (STRI), PM ITTS, Targets Management Office and the AMRDEC, System Simulation and Development Directorate that supports Army and other service's major weapon system developers in meeting their Modeling and Simulation (M&S) requirements

The VTC creates:

- Target and clutter models at varying resolutions
- Signature representative simulation inputs such as
- millimeter wave (MMW), infrared (IR), and Semi Active Laser (SAL)
- Spectrally representative hardware surrogates and prototypes



The VTC completes performance assessments of its threat target models in conjunction with the Army's Threat Validation Working Group in order to facilitate model use for DOT&E in accordance with AR 5-11 and PAM 73-1.

The VTC utilizes predictive technologies to add flexibility and robustness to the current simulation target suite.

Summary

https://modelexchange.army.mil