Geospatial Data Use in Modeling and Simulation

Tom Stanzione
VT MÄK
VP Advanced Technologies Division
(617) 876-8085 x109
tstanzione@mak.com
Overview

Traditional Terrain Database Generation Process for M&S
GIS-Enabled Modeling and Simulation (GEMS)
Terrain Server Approach
M&S Terrain Database Generation Process

Digital Elevation Model (DEM)

Creation of a Triangulated Irregular Network (TIN) from the elevation data.

Application of Imagery onto the surface of the TIN

Collection and creation of Geospatial features (i.e. roads and buildings)

Completed database featuring elevation data, with overlaid imagery, and integrated GIS features compiled together into a synthetic environment.
Terrain Generation for M&S
Current Practice

Takes Time – Costs Money
Continuum of Terrain Database Approaches
Each Approach Has Merits

Hand Modeled

Direct from Source

Built with Terrain Tools

Streaming from ‘the Cloud’
Geospatial Interoperability between M&S and Battle Command

Geospatial representations are quite different
- BC uses GIS-based geospatial data and mapping components
  - Raster elevation, imagery, vector features
- M&S uses proprietary, highly optimized run time terrain database formats
  - Specialized for each application

The GEMS project was started to address BC and M&S interoperability

Army Geospatial Center bringing these domains closer together through use of common geospatial data, geospatial enterprise, and terrain analysis capabilities
- Leveraging GIS capabilities in Commercial Joint Mapping Toolkit (CJMTK)
GEMS - GIS Enabled M&S

GEMS is a technical architecture and set of functional components that allow M&S systems to run directly on operational geospatial data.

Started by TEC (now AGC) in 2006
  ► Developed initial prototype using MÄK VR-Forces as simulation

Continued with funding from US Army Simulation to C4I Interoperability (SIMCI) program in 2008
  ► Added GIS enterprise capabilities

Continued with funded by SIMCI and Army Modeling and Simulation Office (AMSO) in 2009 and 2010
  ► Integrating GEMS capabilities into OneSAF

Current SIMCI project to perform formal testing of OneSAF GEMS
GEMS Architecture

GIS-Enabled VR-Forces Front End

Full VRF Control ArcMap & ArcGlobe Capabilities

VR-Link

Geoprocessing Model

ESRI Geodatabase

VR-Forces Simulation Engine

Other Models

Vehicle Dynamics

Behaviors

GEMS API

VRF Terrain I/F

ArcObjects

VR-Link

HLA / DIS
GEMS Performance

GIS vs MAK GDB Performance

Microseconds

Vertical Intersection

Horizontal Intersection

- Original Geodatabase
- Optimized Geodatabase
- MÄK GDB

Microseconds
GEMS API

Designed with integration into more than just VR-Forces in mind

Two layers

- ESRI (ArcObjects) specific layer for access to geodatabase
- Simulation application specific layer
  - Backward compatible to existing terrain APIs
  - Packages up result of queries for applications
GEMS Enterprise Capabilities

Used ArcServer to move from static, file geodatabase to distributed geodatabase
  ► Dynamic geodatabase
    ► Changes to layers used by GEMS API as simulation is running
    ► Content and extents
  ► Shared geodatabase between different simulation applications
    ► Still using only VR-Forces back ends and front ends for prototype

Remote geoprocessing capabilities
  ► Terrain analysis queries that can be run on GIS server
  ► Demonstrated use of Web services in enterprise GIS environment

Enhanced the GEMS API to work in distributed environment
  ► Remote geoprocessing infrastructure
    ► Asynchronous queries and results
  ► Modified VR-Forces models to demonstrate enterprise capabilities
GEMS in OneSAF

Examined OneSAF terrain API and determined design for GEMS API and geodatabase changes to support OneSAF

Integrated GEMS API into OneSAF
  ► Developed a OneSAF specific layer (plus)

Modified the OneSAF MCT (GUI) and behaviors to use GIS environment
GEMS in OneSAF PLAF

<table>
<thead>
<tr>
<th>Architectural Applications (OneSAF System Compositions)</th>
<th>Leader and Staff Training System Composition</th>
<th>Seamless Training System Composition</th>
<th>Force and Organizations Analysis Tool System Composition</th>
<th>Test and Evaluation System Composition</th>
<th>Other System Compositions</th>
</tr>
</thead>
<tbody>
<tr>
<td>OneSAF Product Layer</td>
<td>System Composer</td>
<td>Model Composer</td>
<td>Simulation Generator</td>
<td>Simulation Core</td>
<td>Simulation Controller</td>
</tr>
<tr>
<td></td>
<td>Knowledge Eng. Env.</td>
<td>Event Planner</td>
<td>Technical Manager</td>
<td>Simulation Core</td>
<td>CI Adapter</td>
</tr>
<tr>
<td></td>
<td>Event Planner</td>
<td>Model Composer</td>
<td>Simulation Generator</td>
<td>Simulation Core</td>
<td>CI Adapter</td>
</tr>
<tr>
<td></td>
<td>Model Composer</td>
<td>Simulation Generator</td>
<td>Technical Manager</td>
<td>Simulation Core</td>
<td>CI Adapter</td>
</tr>
<tr>
<td></td>
<td>Simulation Generator</td>
<td>Technical Manager</td>
<td>Simulation Core</td>
<td>Simulation Controller</td>
<td>CI Adapter</td>
</tr>
<tr>
<td></td>
<td>Technical Manager</td>
<td>Simulation Core</td>
<td>Simulation Controller</td>
<td>CI Adapter</td>
<td>CI Adapter</td>
</tr>
<tr>
<td>OneSAF Component Layer</td>
<td>System Composer</td>
<td>Unit Composer</td>
<td>Management &amp; Control Tool (SSDE)</td>
<td>Unit Models</td>
<td>Management &amp; Control Tool</td>
</tr>
<tr>
<td></td>
<td>KA/KE Tools</td>
<td>Entity Composer</td>
<td>Federation Develop. Tool</td>
<td>Entity Models</td>
<td>Management &amp; Control Tool</td>
</tr>
<tr>
<td></td>
<td>Military Scenario Development Environment</td>
<td>Behavior Composer</td>
<td>Performance Modeling Tool</td>
<td>Behavior Models</td>
<td>Management &amp; Control Tool</td>
</tr>
<tr>
<td></td>
<td>ENvironment</td>
<td>Icon Tool</td>
<td>Sim. Config. &amp; Asset Mgmt. Tool</td>
<td>Physical Models</td>
<td>Management &amp; Control Tool</td>
</tr>
<tr>
<td></td>
<td>Battlefield Enum. Tool</td>
<td>Benchmark Tool</td>
<td>Sim. Config. &amp; Asset Mgmt. Tool</td>
<td>Physical Models</td>
<td>Management &amp; Control Tool</td>
</tr>
<tr>
<td></td>
<td>K/AKE Tools</td>
<td>Benchmark Tool</td>
<td>Sim. Config. &amp; Asset Mgmt. Tool</td>
<td>Physical Models</td>
<td>Management &amp; Control Tool</td>
</tr>
<tr>
<td>GEMS API Simulation I/F</td>
<td>GIS Interface</td>
<td>Environment Models</td>
<td>Sim. Config. &amp; Asset Mgmt. Tool</td>
<td>Physical Models</td>
<td>Management &amp; Control Tool</td>
</tr>
<tr>
<td>ESRI Geodatabase (Local or Server)</td>
<td>Geoprocessing Model</td>
<td>Environment Models</td>
<td>Sim. Config. &amp; Asset Mgmt. Tool</td>
<td>Physical Models</td>
<td>Management &amp; Control Tool</td>
</tr>
<tr>
<td>Geoprocessing Model</td>
<td>Environment Models</td>
<td>GUI Services</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
</tr>
<tr>
<td>Geoprocessing Model</td>
<td>Environment Models</td>
<td>GUI Services</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
</tr>
<tr>
<td>Geoprocessing Model</td>
<td>Environment Models</td>
<td>GUI Services</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
</tr>
<tr>
<td>OneSAF Component Support Layer</td>
<td>Environment Models</td>
<td>GUI Services</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
</tr>
<tr>
<td>K/AKE Repository</td>
<td>Environment Models</td>
<td>GUI Services</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
</tr>
<tr>
<td>Environment Repository</td>
<td>Environment Models</td>
<td>GUI Services</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
</tr>
<tr>
<td>Software Repository</td>
<td>Environment Models</td>
<td>GUI Services</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
</tr>
<tr>
<td>System Composition Repository</td>
<td>Environment Models</td>
<td>GUI Services</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
</tr>
<tr>
<td>Military Scenario Repository</td>
<td>Environment Models</td>
<td>GUI Services</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
</tr>
<tr>
<td>Local Exercise Environment Repository</td>
<td>Environment Models</td>
<td>GUI Services</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
</tr>
<tr>
<td>Parametric &amp; Initialization Repository</td>
<td>Environment Models</td>
<td>GUI Services</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
</tr>
<tr>
<td>Simulation Output Repository</td>
<td>Environment Models</td>
<td>GUI Services</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
</tr>
<tr>
<td>Middleware Services</td>
<td>Environment Models</td>
<td>GUI Services</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
</tr>
<tr>
<td>OneSAF Common Services Layer</td>
<td>Environment Models</td>
<td>GUI Services</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
</tr>
<tr>
<td>Monitor Services</td>
<td>Environment Models</td>
<td>GUI Services</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
</tr>
<tr>
<td>Time Services</td>
<td>Environment Models</td>
<td>GUI Services</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
</tr>
<tr>
<td>Name Directory Services</td>
<td>Environment Models</td>
<td>GUI Services</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
</tr>
<tr>
<td>Messaging Services</td>
<td>Environment Models</td>
<td>GUI Services</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
</tr>
<tr>
<td>Coordinate Services</td>
<td>Environment Models</td>
<td>GUI Services</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
</tr>
<tr>
<td>Interchange Services</td>
<td>Environment Models</td>
<td>GUI Services</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
</tr>
<tr>
<td>Middleware Services</td>
<td>Environment Models</td>
<td>GUI Services</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
<td>Plan View Display</td>
</tr>
</tbody>
</table>

**Notes:**
- GEMS in OneSAF PLAF is a diagram showing the integration of GEMS with the OneSAF platform.
- The diagram illustrates the layers and components involved in the integration, including Architectural Applications, OneSAF Product Layer, OneSAF Component Layer, OneSAF Component Support Layer, and OneSAF Common Services Layer.
- Key components include System Composer, Knowledge Eng. Env., Event Planner, Model Composer, Simulation Generator, Technical Manager, and Simulation Core.
- The diagram also highlights the integration with ESRI Geodatabase (Local or Server) and the GEMS API Simulation I/F.
GEMS in OneSAF

Running OneSAF models and behaviors on GIS data either locally or from server
  ► Incremental loading of geospatial data into simulation
  ► Caching and background loading of data

Same operational data as used in C4I systems
  ► Augmented with high resolution for simulation-specific purposes

Can change geospatial data while simulation is running

Can use GIS for remote terrain reasoning using operational algorithms

Use GIS functions for geospatial data management and control in user interface
Design and Implementation Approach

Java

OneSAF Models and Behaviors

JNI

GEMS API

C++

Environmental Runtime Component (ERC)

Terrain API

Terrain Cache API

OneSAF Terrain Format

ESRI Geodatabase
GIS Pane in MCT

GIS Layer Table of Contents
Mil Std 2525B Symbology
Control Measures
Routes
Target/Shooter Lines
Detonations
GIS Pane in MCT
OneSAF Behaviors using GIS

Route Generation in GIS
Movement and LOS using GIS terrain
Covered and concealed locations in movement behaviors
SIMCI FY 10 Project
Formal Testing of GEMS in OneSAF

More formal testing of GEMS OneSAF
► In cooperation with PM OneSAF
► Three test cycles
  ► Increase complexity of scenarios and terrain

Updated GEMS API to work with OneSAF 4.0
► Came out in Spring 2010

Using standard ERC test routines for first test phase
► Instrumented to collect performance metrics
Benefits of GEMS Approach

Use operational geospatial data and terrain reasoning algorithms
Reduce need for compiled run time simulation formats
Dynamic geospatial data supported by server technology
Enterprise GIS allows large area coverages of variable spatial resolution
Limitations of GEMS Approach

Run time performance close to optimized terrain databases but not exceeded

- Supports medium size scenarios, 80% of entities per simulation engine vs optimized TDB

Some initial geoprocessing currently needed to obtain meet performance requirements

- Working to move these to run time function as part of terrain paging
- Convert elevation grids to TINs
  - This step no longer necessary – can generate terrain surface on the fly as portions are brought into the simulation
- Expansion of linear and point features to areas
Terrain Server Approach (VR-TheWorld)
Correlated Streaming Terrain Through Open Standards

Browser-based Configuration Interface

Elevation
Imagery
Digital Maps

Other TMS or WMS Compliant Applications

VR-Forces CGF
VR-Vantage IG
VR-Vantage XR
Google Earth Client
Web Apps
VR-TheWorld

Open-standards-based streaming terrain server
► WMS (OGC’s Web Mapping Service)
► TMS (OSGeo’s Tile Map Service)

VR-TheWorld Server
► Host terrain locally

VR-TheWorld Online
http://www.vr-theworld.com/
► 4TB of elevation and imagery
Summary

More options now for geospatial data in M&S
GIS tools in CJMTK and geospatial products from the AGC provide a powerful capability for improving M&S and BC interoperability

► Reduction in time and cost for geospatial data
► Increased currency and data correlation
► Facilitating embedded training in BC systems

Simulations decisions now based on same geospatial data and information as human decision makers
Questions?