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ICCRTS
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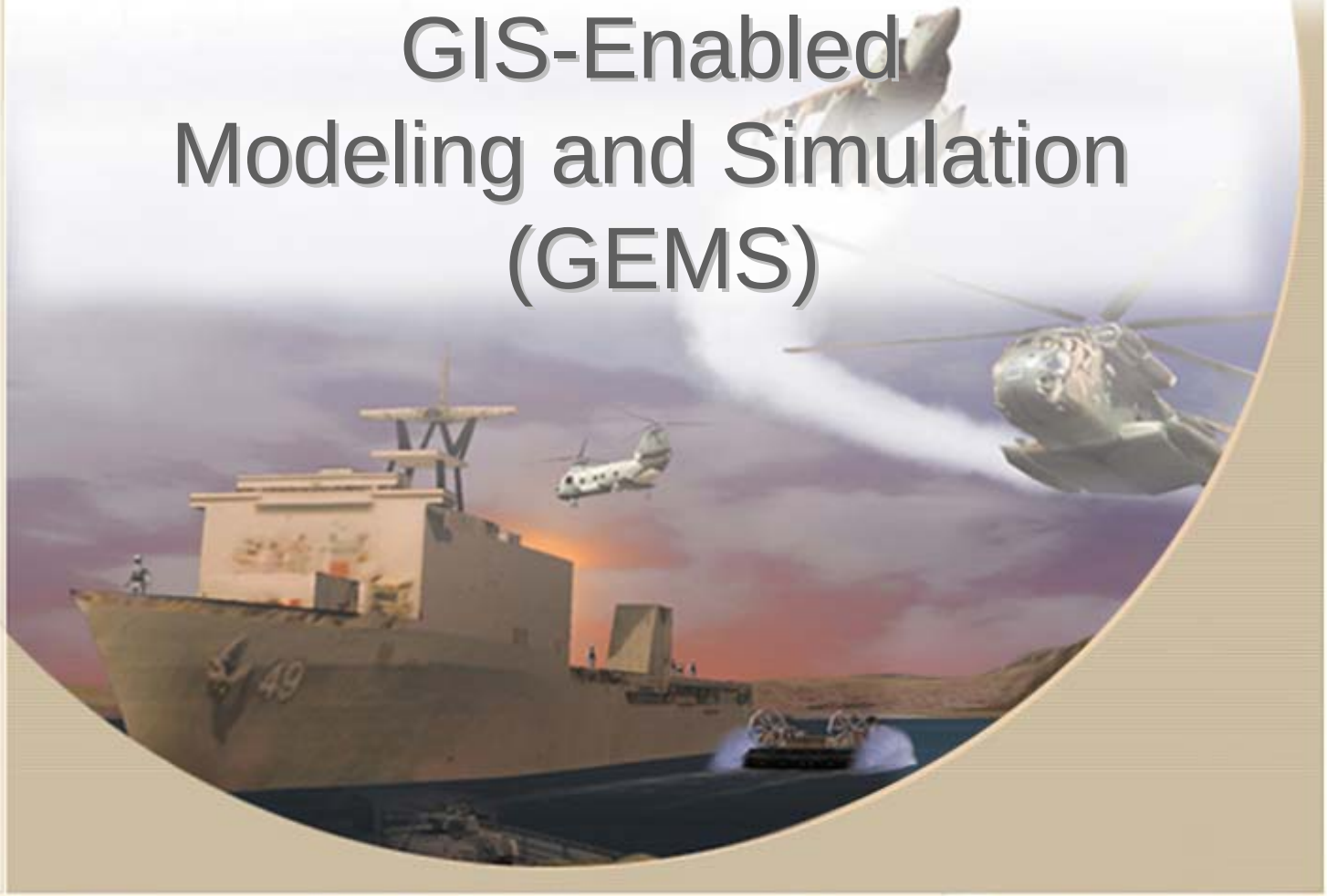
GIS-Enabled Modeling and Simulation (GEMS)



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MÄK TECHNOLOGIES

Sponsor

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- Government POC
  - David Lashlee, Ph.D.
    - Associate Technical Director
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- Contract # W9132V-06-C-0018

Objectives

- Enable modeling, simulation, and visualization systems to operate directly on GIS-based terrain
- Eliminate need to for time-consuming and expensive conversion to specialized formats
- Use same data used in operational C4ISR systems (C/JMTK)
- Enable mission planning, mission rehearsal, and predictive situation awareness

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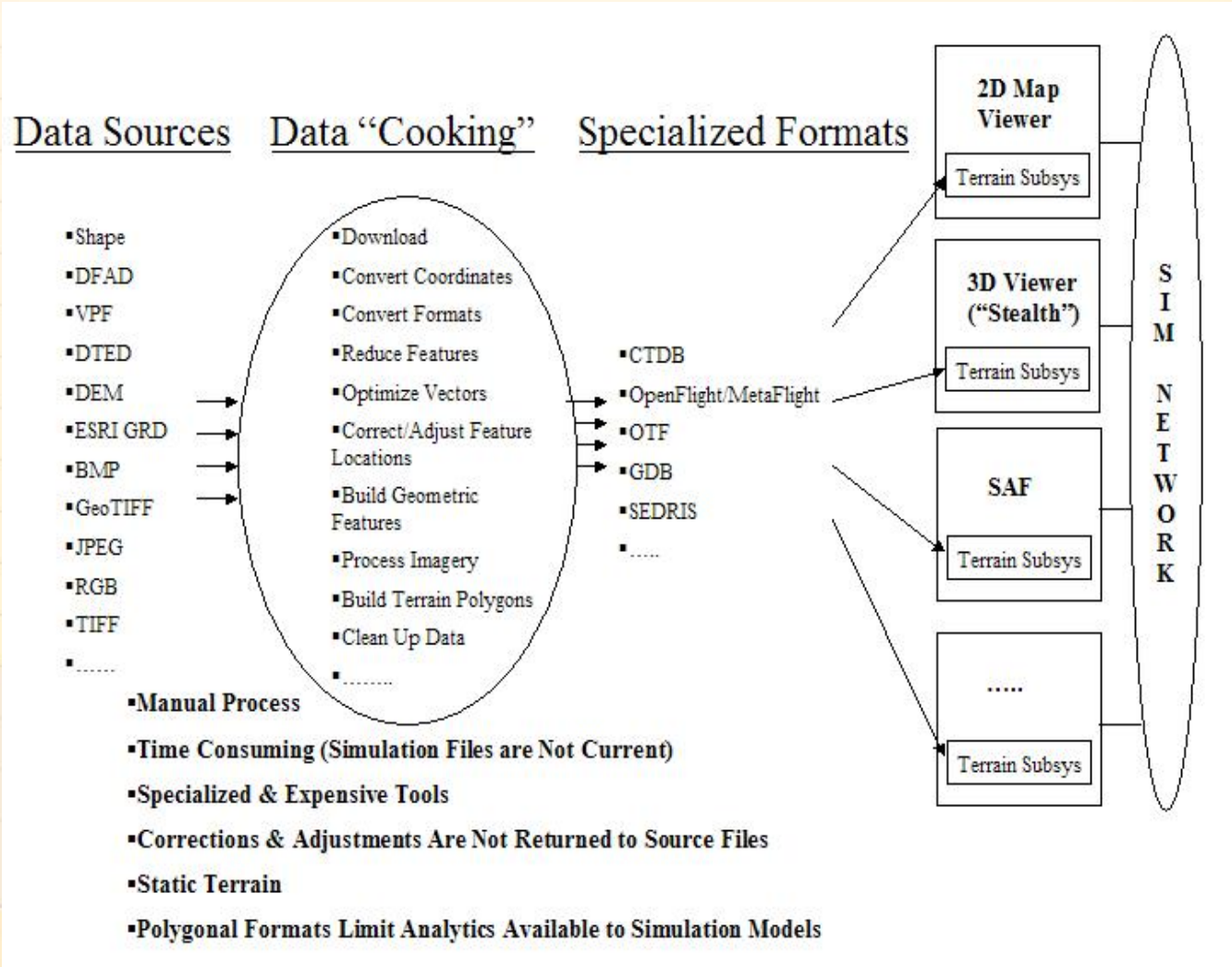
Terrain Generation for M&S Current Practice



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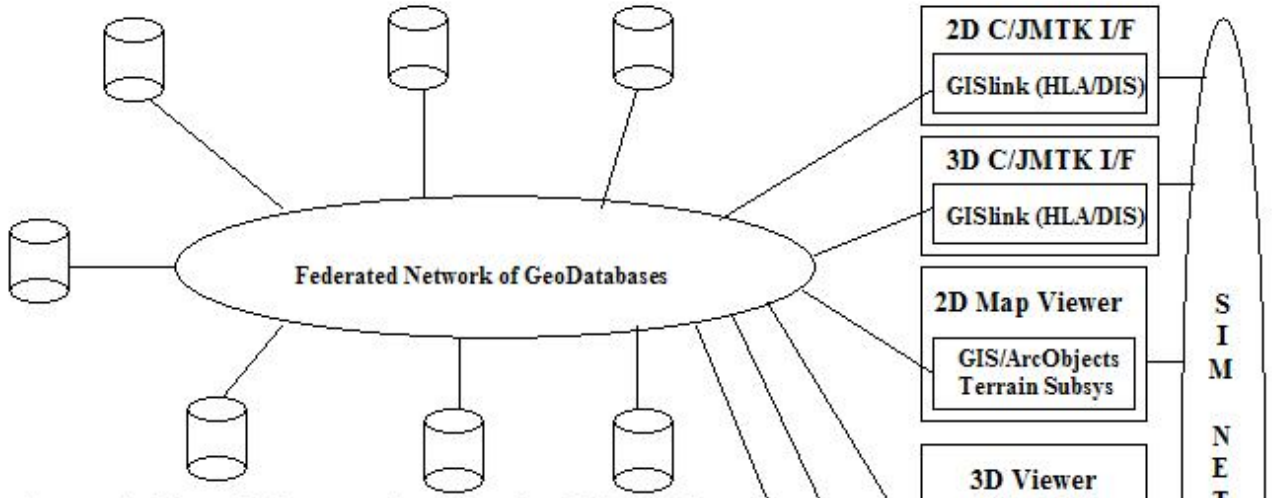
GIS-Enabled M&S



- Automatic, Network Access to Operational and Historic Data
  - Immediate: "Spin the Globe," Zoom, Select Layers, and Go
- The Most Current Data is Always Available
  - Enables Mission Planning, Mission Rehearsal and Predictive Situation Awareness Applications
- Use the Same Tools that are Used for Operational Data
  - Access Simulations from C/JMTK-Based C4I Systems
- Make Corrections & Adjustments to Source Files, and Retain
- Dynamic Terrain
- Simulations can Access GIS-Based Analytics
  - E.g., Network Analysis for Effects Based Operations

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GIS and C4ISR

- Commercial Joint Mapping Toolkit (C/JMTK)
  - Mapping, Charting, Geodesy, and Imagery functionality for C4ISR applications
  - Deployed to support both legacy and new mission applications
  - Components for the management, analysis and visualization of map information
- Includes ESRI ArcGIS components
  - ArcGIS Engine & Desktop
  - Military Analyst extension
    - Direct use of NGA vector and raster products
    - Military Overlay Editor (MOLE) for 2525B symbology
  - Selected for GEMS terrain subsystem because of close ties to C4ISR community

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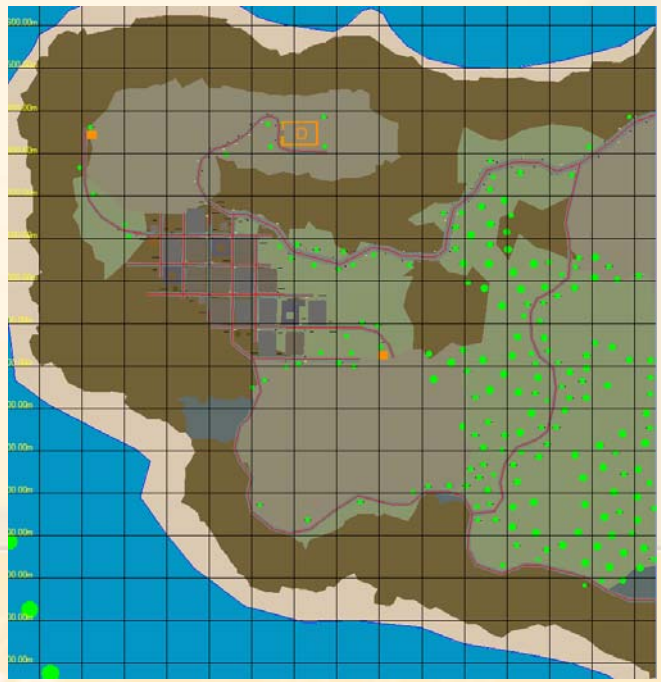
CGF Terrain Databases

- 2D Visualization
  - Abstract representation (maps)
  - Realistic representation (imagery)
- Reasoning
  - Geometry and attribution of elevation and features
    - Data structures in memory
  - Uses:
    - Vehicle placement
    - Movement algorithms
      - Path planning
      - Obstacle avoidance
      - Vehicle dynamics
    - Line of sight
      - Targeting
      - Communications



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CGF Terrain Databases

- Terrain Skin
  - Grid or TIN of elevation values
    - May or may not be stored as polygons
  - Attributes
    - “Soil Type”
      - Water
      - Mobility Characteristics
- Features
  - Point, Lines, Areas
  - Attributes
    - Width, height, type, …
  - 3D Models
    - Typically associated with point features
    - Building models
      - Varied fidelity
      - Overturned shoe boxes to complex structures with interior details
- Spatial organization
  - Find all terrain information around a location quickly
  - Grid-based
  - Hierarchical
    - Quad trees

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Requirements Analysis

- M&S terrain data
  - Elevation
  - Features
- GIS terrain data
  - Existing C4ISR data sets
  - Geodatabase schemas
  - Theater Geospatial Database (TGD)
- Interfaces for M&S data
  - VR-Forces, OneSAF Testbed, Delta 3D

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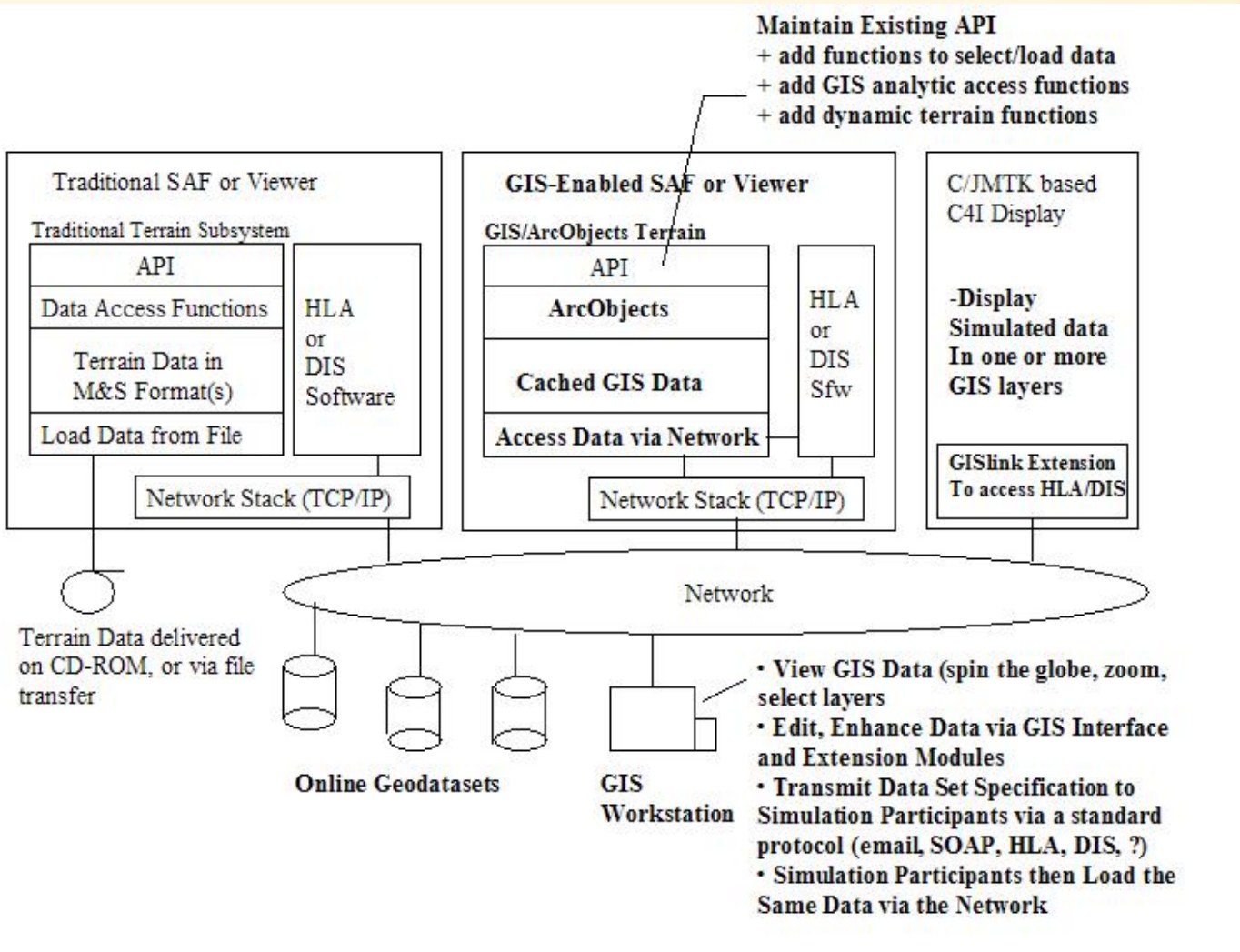
System Components being Developed



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GIS Terrain Data for M&S

- Elevation Data
  - Raster
  - Triangulated Irregular Network (TIN)
  - Terrain Feature Class (GeoDB)
  - Polygon Z Feature Class (GeoDB)
- Feature Data
  - Shape Files
  - Multi Patch (GeoDB)
  - Polygon, Polyline, Point Feature Datasets (GeoDB)
  - Networks (GeoDB)
- Geodatabase
  - Personal
  - File
  - Network

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Geodatabase Design

- TIN for elevation data
- Multipatch datasets for 3D features
- Individual point, polyline, and polygon feature datasets for 2D features
- Everything except TIN in a file geodatabase
  - Faster than personal geodatabase
- Database schema based on the TGB operational terrain schema

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Geoprocessing

- Geoprocessing on GIS data for runtime efficiency
- Convert point buildings to footprints, merge with area buildings, extrude to 3D and store as multipatch features
- Create a unified soil types layer from linear and area features
  - Linear features are expanded by width attribute

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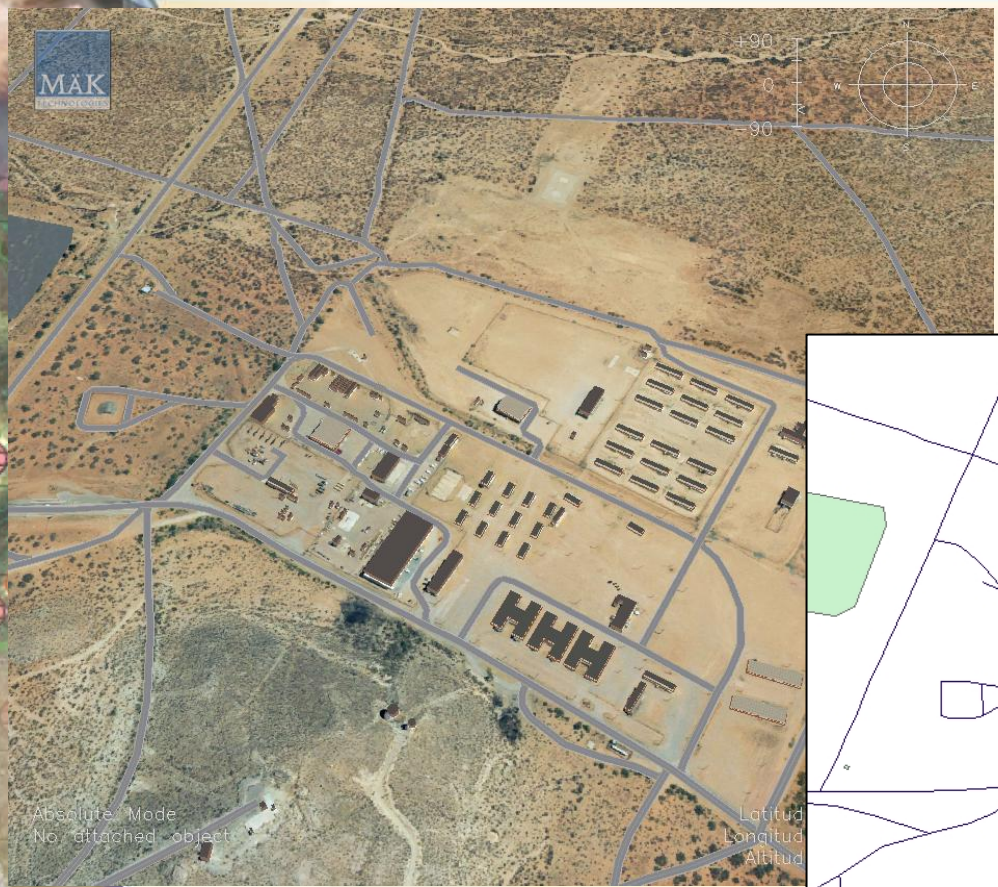
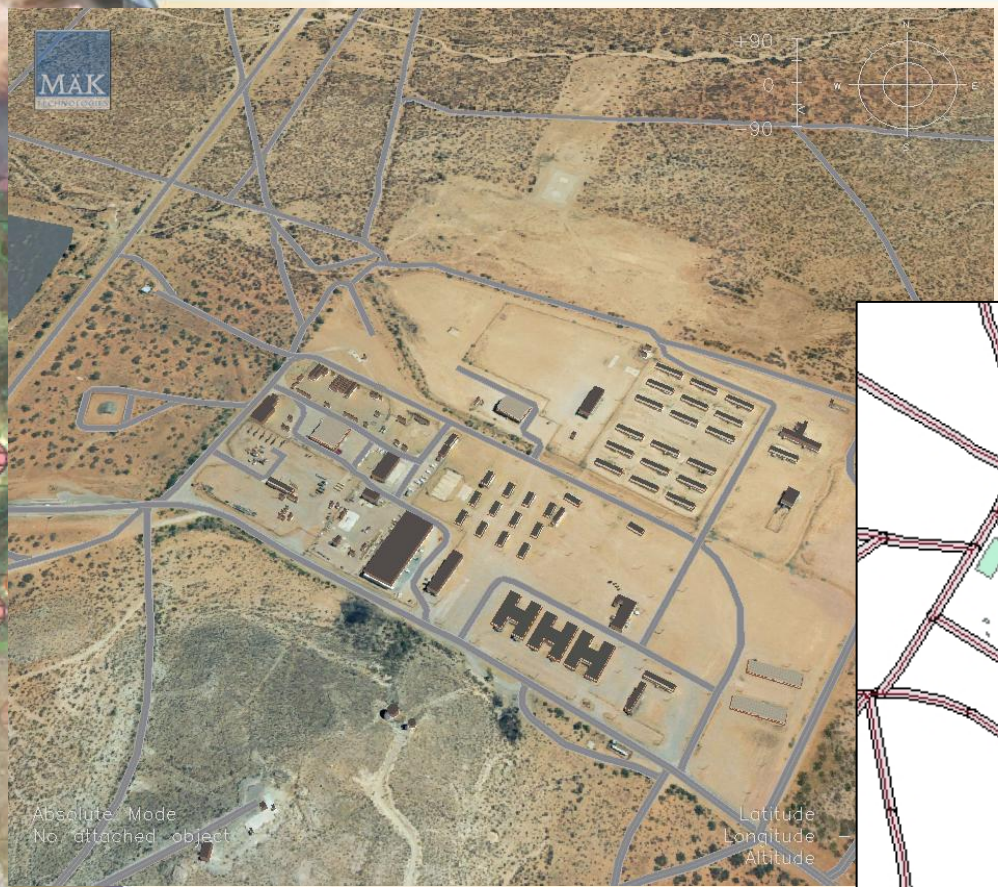
Before Geoprocessing



After Geoprocessing



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Terrain Subsystem Prototype

VR-Forces
Simulation Engine

Physical World

Coordinate System

Terrain

ESRI Coordinate System

ESRI Terrain

GIS Data
TIN
Multi-Patch
Polygon

DIS

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Software Implementation

- Geoprocessing tools to populate a geodatabase for CGFs
- Developing prototype API for CGF
  - Elevation from TIN
  - LOS thru TIN and buildings
- Modifying VR-Forces to use API
  - ESRI Terrain subclass using ArcObjects
  - ESRI Coordinate System subclass using ArcObjects

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GIS vs GDB Performance

- Three main terrain calls:
  - ClosestIntersection – Elevation
  - Intersect (1) – Horizontal LOS
  - Intersect (2) – Vertical surfaces intersection
- Scenario
  - 10 moving ground vehicles, 3 moving amphibious vehicles, 1 moving surface vehicle, 4 moving air vehicles and 16 non moving target vehicles
- Average length of time in each call (microseconds)

	GDB w/ soil type	TIN	Raster	TIN w/ soil type
ClosestIntersection	37	94	25	298
Intersect (1)	54	705	2006	N/A
Intersect (2)	62	407	691	N/A

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Performance Improvements

- Use of geocentric coordinate (GCC) system in ArcGIS
  - Used in DIS and HLA simulation protocols to provide continuous coordinate system anywhere around the world
  - Not yet supported by ESRI, so have to convert in each terrain call
    - GIS data in UTM or geodetic
- Caching algorithms
  - Especially multipatch features, which are stored as compressed data and have to be uncompressed
- Simulation system terrain call optimization

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Performance Improvements

- Using pointers from TIN triangles to attribute table for soil type look up
  - Eliminate separate lookup for soil type and elevation
- Bounding box of buildings added to TIN
  - Expand base of buildings by a few centimeters to avoid vertical polygons
  - Faster LOS
  - Reference to multipatch for more detailed LOS
- Wrote own LOS test that walks TIN topology
  - ESRI test walks whole ray
  - We only need to find first intersection
- Using geographic coordinate routines in ArcSDE SDK
  - Eliminate overhead with each coordinate conversion

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Updated Performance

	GDB w/ soil type	TIN	Raster	**TIN w/ buildings & soil type**
ClosestIntersection	37	94	25	**74**
Intersect (1)	54	705	2006	**234**
Intersect (2)	62	407	691	**79**

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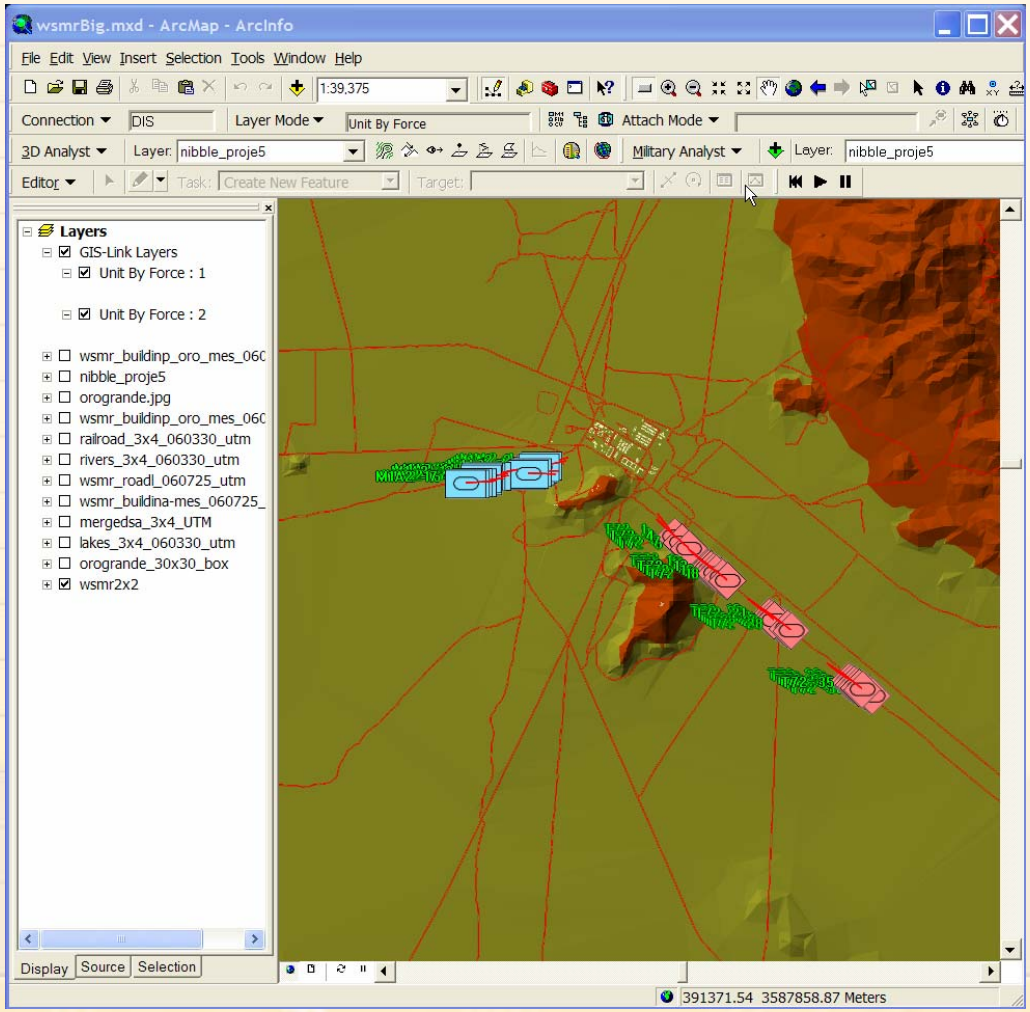
VR-Forces using GIS Terrain Demonstration



Click on image to run demo

Conclusions

- Early prototyping suggests feasibility of GIS terrain for M&S
- M&S using operational data facilitates embedded training in C4ISR systems
- Can still benefit from high fidelity M&S terrain databases
  - Convert to GIS formats as needed
  - Use automated content generation from terrain database generation systems

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Future Work

- GIS Server technology to distribute GIS terrain data
- 3D Visualization Capabilities
  - Extend terrain subsystem
- Access to GIS-based Analytics and Terrain Reasoning
  - Extend terrain subsystem API
  - Develop framework for asynchronous processing
- Dynamic Terrain
  - Extend terrain subsystem and GIS-Link
  - Data management and distribution

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