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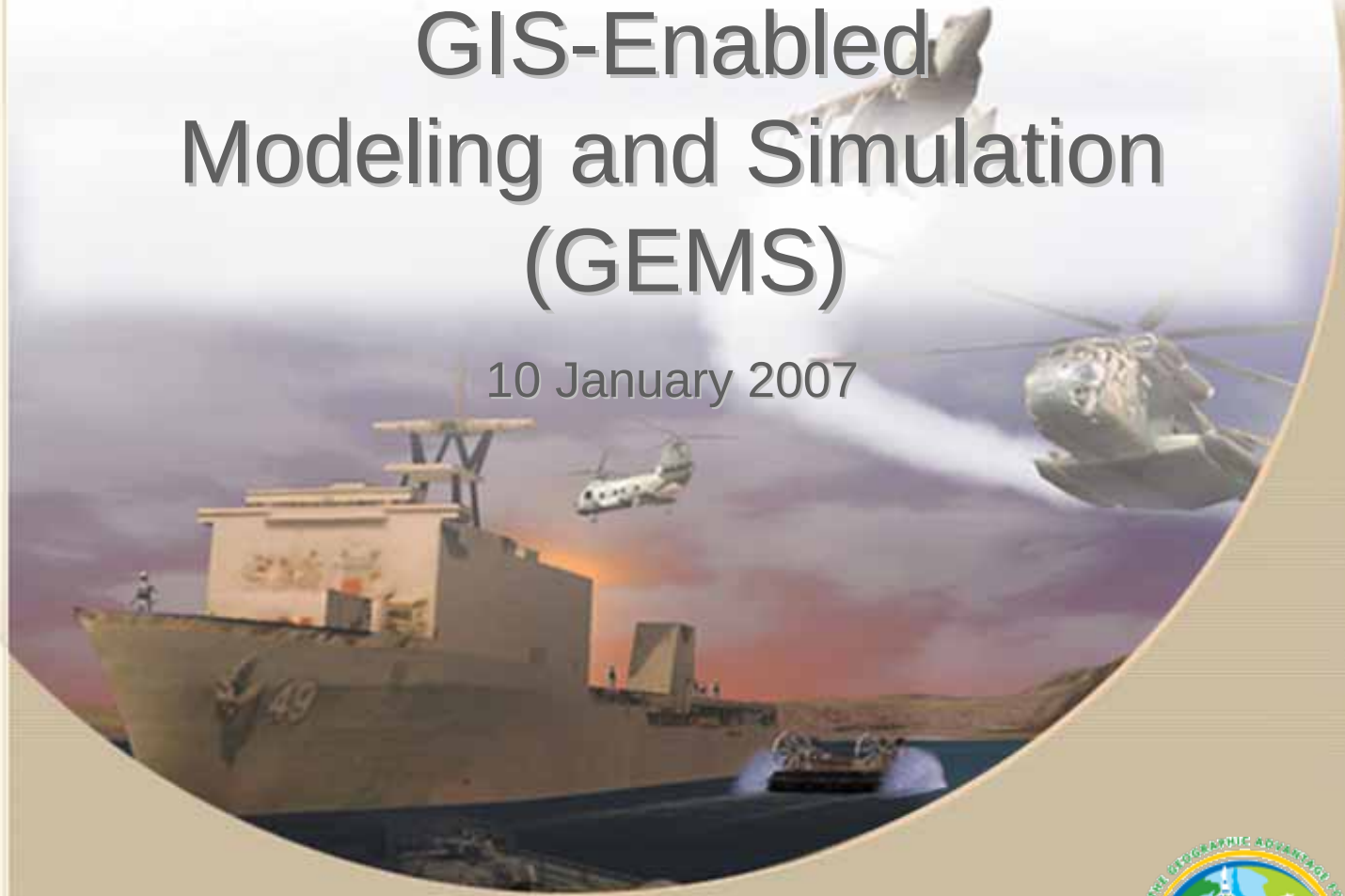
Paper # 1015

GIS-Enabled Modeling and Simulation (GEMS)

10 January 2007



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Overview

- Objectives
- Technical Challenges
- Terrain Subsystem
  - Requirements Analysis
  - Design
  - Prototype
- MÄK GIS-Link
- Conclusions and Future Work

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Sponsor

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- Government POC
  - Dave Lashlee
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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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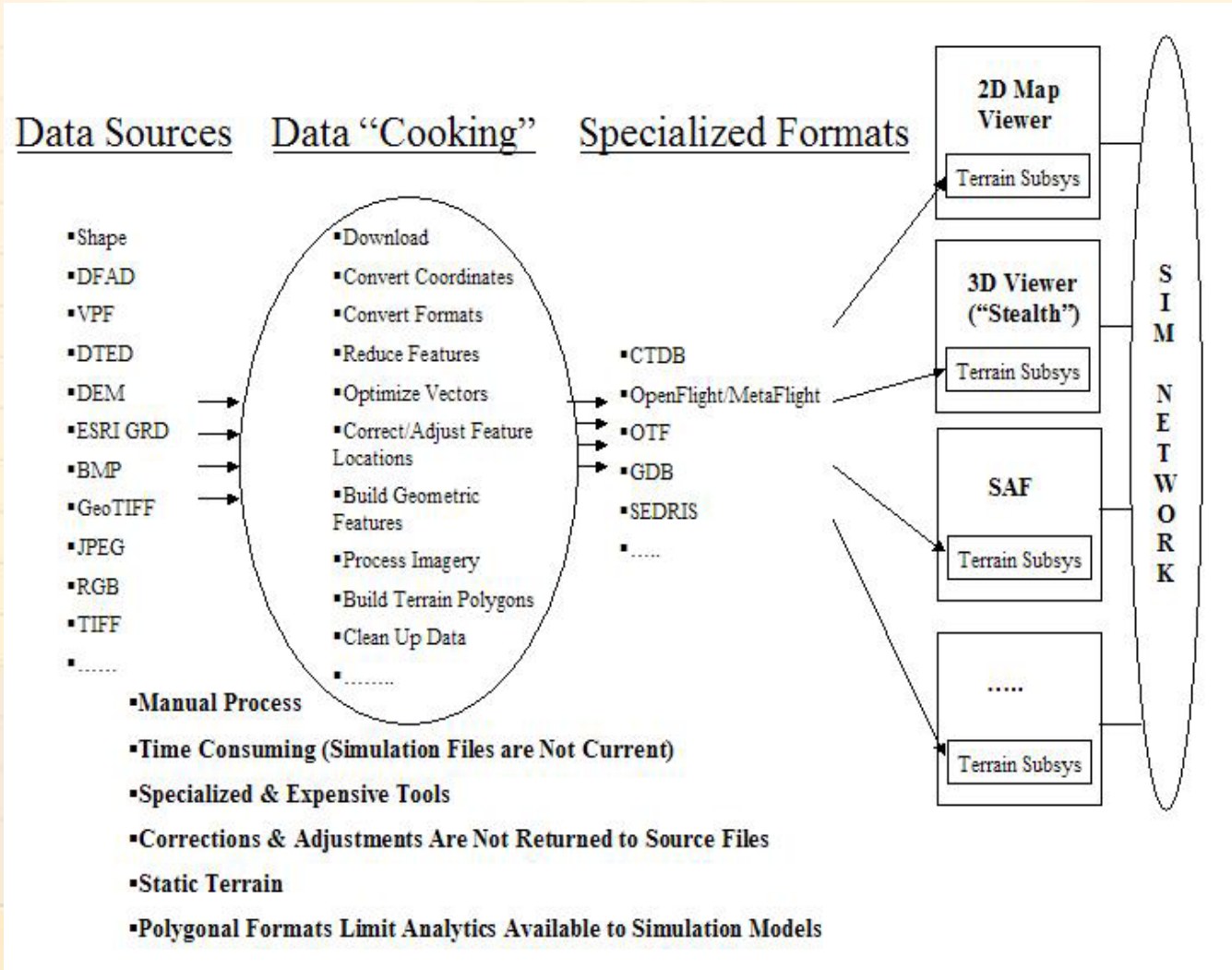
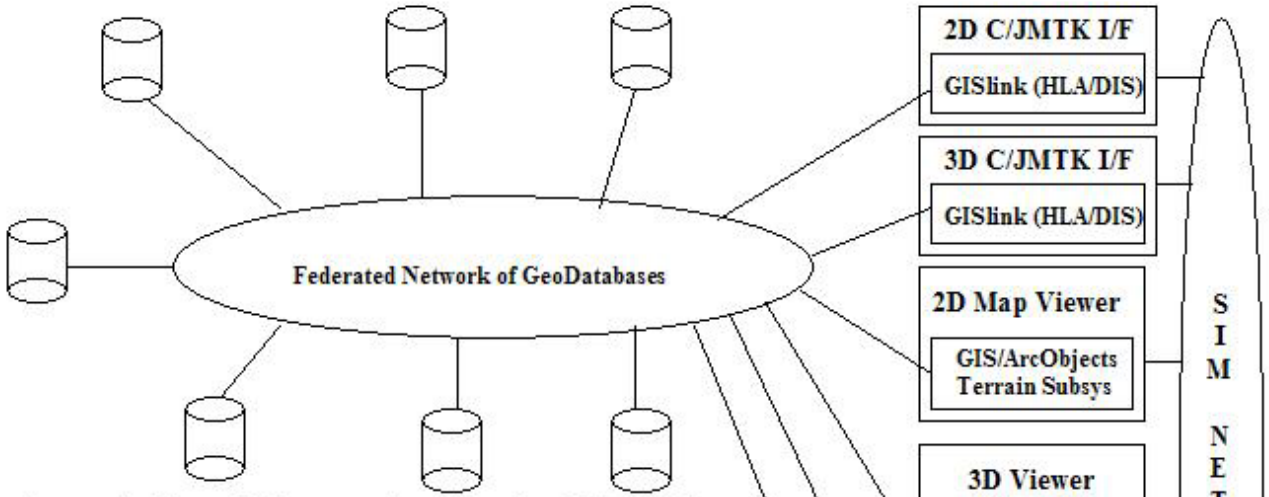
Terrain Generation for M&S Current Practice



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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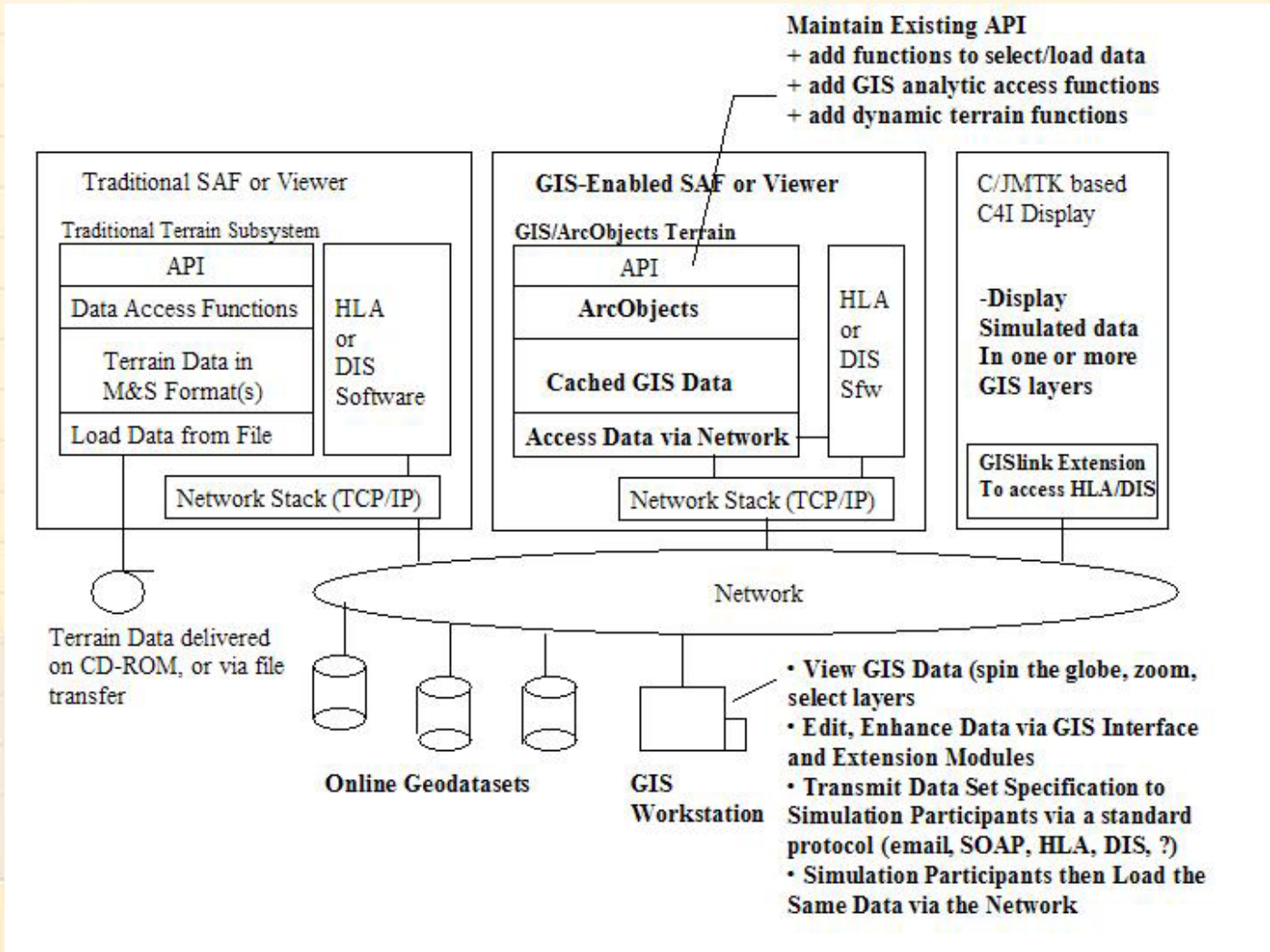
System Components to be Developed



Development Items

- ArcGIS/ArcObjects-based Terrain Subsystem
  - APIs to terrain data for CGF systems
  - Caching mechanisms
  - APIs to terrain data for 3D visualization (Option)
  - APIs to analysis routines (Option)
  - Dynamic terrain capabilities (Option)
- MÄK GIS-Link
  - HLA, DIS, and TENA data display on C/JMTK displays
  - GIS data to simulations
    - Dynamic terrain, analytics, semantic information

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Technical Challenges

- Overcoming performance bottlenecks
  - ESRI ArcGlobe already performs fly-thrus of GIS data
  - Caching
  - More performance enhancements coming
    - ArcGlobe Server
    - ArcGIS Dynamic Display
    - Having ESRI as subcontractor will facilitate this
- Access to analytical routines
  - API definition
  - Time delays that may arise

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Terrain Subsystem Tasks

1. Work with TEC to develop requirements
2. Develop a system and software design for year 1 development
3. Implement terrain subsystem for CGF and 2D viewer applications
4. Integrate and test terrain subsystem with VR-Forces

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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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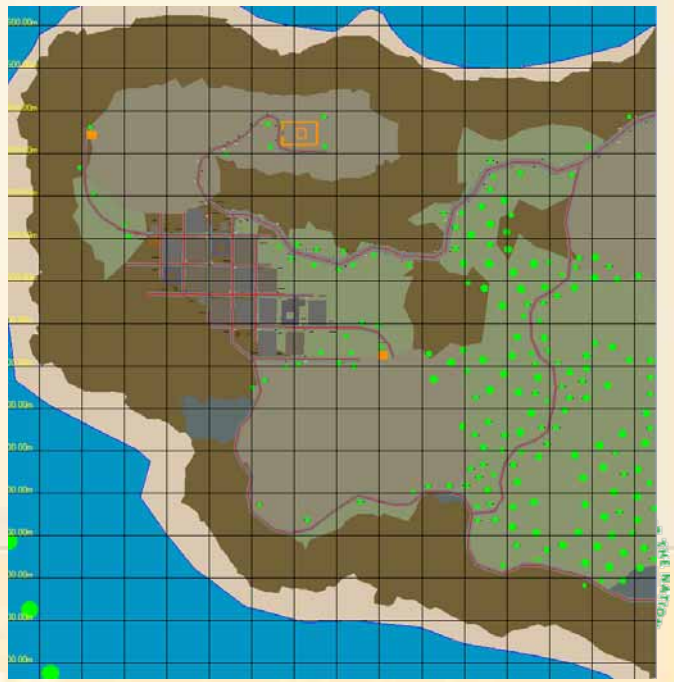
CGF Terrain Databases

- 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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GIS Terrain Data

- 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)
- Geodatabase
  - Personal
  - File

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System and Software Design

- System level component designs
- Interface design
- Functional and performance characteristics
- Performance improvements
- Caching mechanisms

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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

Software Implementation

- 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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VR-Forces using GIS Terrain

MÄK GIS-Link | VRF Toolbar

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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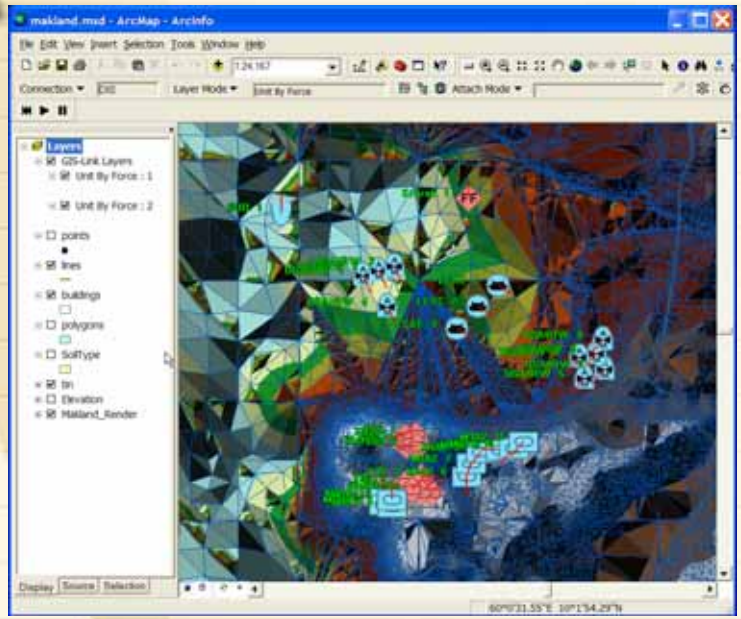
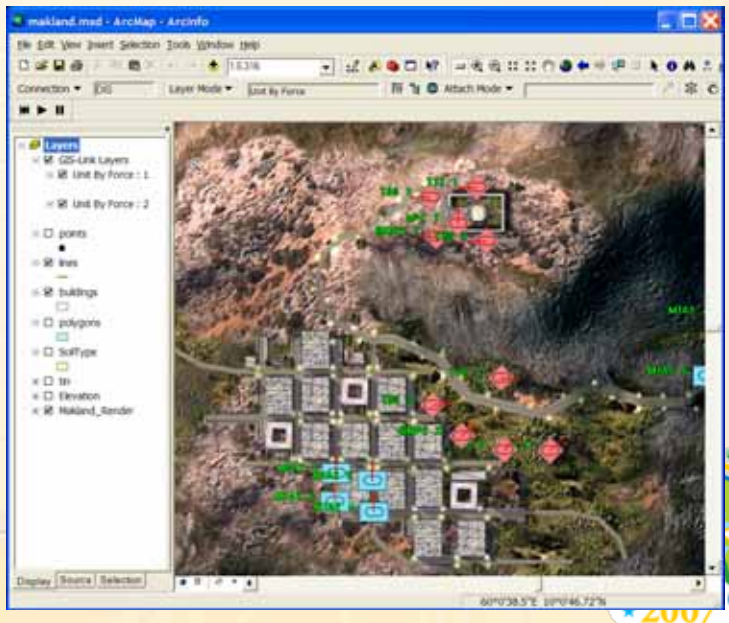
VR-Forces using GIS Terrain Demonstration





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MÄK GIS-Link

- Provides underlying components to enable ArcGIS-based applications to connect to HLA/DIS/TENA exercise & visualize real-time data
  - ArcMap rapidly updating symbology
  - ArcGlobe dynamic 3D models
- Comprised of underlying ArcObjects that easily integrate with other ArcGIS Engine components
- Utilizes dynamic display capabilities in ArcGIS 9.2

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MÄK GIS-Link...Continued

- Supply building blocks to …
  - Support HLA/DIS/TENA simulation interoperability standards
  - Enable visualization of simulation specific objects & interactions
  - Provide higher-level GUI components for viewing & configuring simulation specific functionality
- C/JMTK & ArcGIS conformant way to easily incorporate HLA, DIS, or TENA data

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MÄK GIS-Link Product

- Available in 3 forms
  - Extension for ArcMap (*Map-Link*),
  - Extension for ArcGlobe (*Globe-Link*), &
  - ArcObjects available for use with other ArcGIS Engine components
- Comprised of
  - ArcObjects that wrap VR-Link functionality
  - ArcObjects for GUI components & display capabilities
  - ArcMap & ArcGlobe extension toolbars

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Current Status

- ArcMap release candidate
  - Connect to DIS, HLA 1.3, HLA 1516, or TENA exercise
  - Define layers, either manually or automatically
  - Display entities and aggregates using MOLE symbology
  - Display fire & detonate interactions
  - Display target-to-shooter lines
  - Dialogs for
    - Entities by layer
    - Simulation-specific attributes
    - Entity specific information
    - Aggregate specific information

Current Status

- ArcGlobe release candidate
  - Display entities as OpenFlight models
  - Display fire and detonate interactions as animated sequences
  - Display target-to-shooter lines
  - Support attach modes to entities
    - Compass
    - Mimic
  - Support ArcGlobe “identify” tool

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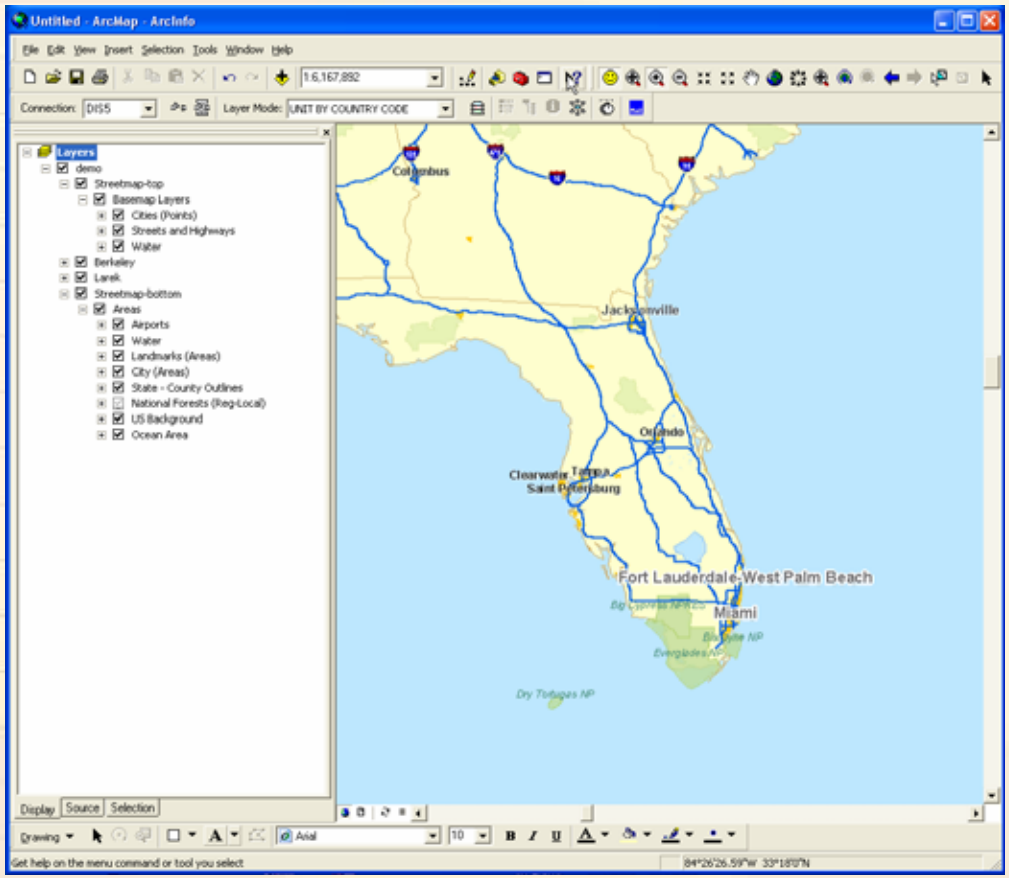
Map-Link Prototype



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
- MÄK GIS-Link provides interoperability between C4ISR and M&S domains

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Future Work

- Complete CGF Terrain Subsystem
- 3D Visualization Capabilities
  - Extend terrain subsystem
- Browser-based Visualization Capabilities
  - Extend GIS-Link for GIS servers
- Access to GIS-based Analytics and Terrain Reasoning
  - Extend terrain subsystem API
  - Develop framework
- Dynamic Terrain
  - Extend terrain subsystem and GIS-Link
  - Data management and distribution

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