University of Alabama in Huntsville
Continuing Education
Modeling and Simulation Certificate Program
Hands-On Simulation

Constructive Battlefield Simulation using VR-Forces

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Outline, part 1 of 1

- Lecture, part 1
  - Background: constructive battlefield simulation
  - Basic VR-Forces: entities and tasks
- VR-Forces exercises, part 1

(1) GUI and map operation
(2) Entity movement
(3) Stealth operation
(4) Entity combat
(5) Aggregates
(6) Battle control

Outline, part 2 of 2

- Lecture, part 2
  - Advanced VR-Forces: plans and other features
- VR-Forces exercises, part 2

(7) Simple entity plans
(8) Plan vs plan
(9) Breaching scenario

Background: constructive battlefield simulation

Live

Live simulation. Simulation involving real people operating real systems. [DOD, 1998]

Live simulation

- As close as possible to real use
- Often involves real equipment or systems
- Instrumentation may replace actual weapon firings or impacts
- Primary goal: useful experience

Example live simulation.

U.S. Army, MILES

- Lasers transmit coded signals, codes identify weapon
- Signals detected by sensors
- User alerted for hits

MILES, Vehicle

MILES, Soldier

Virtual

Virtual simulation. Simulation involving real people operating simulated systems. [DOD, 1998]

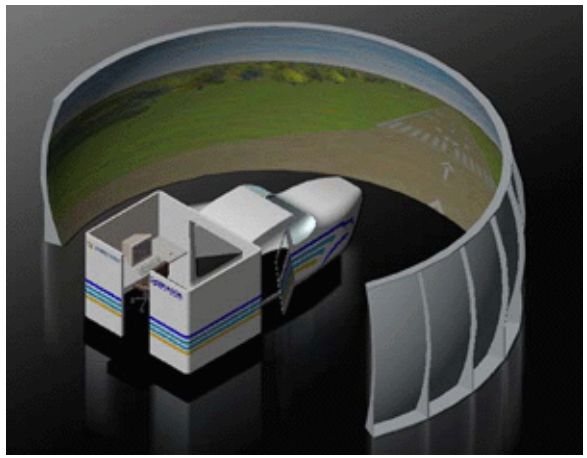
Virtual simulation

- Systems are recreated with simulators
- Systems operated by participants
- Designed to immerse user in a usefully realistic virtual environment
- Primary goal: useful experience

Example virtual simulation

Human-in-the-loop flight simulator

- Physical cockpit
- Computer model of flight dynamics
- Computer generated visuals



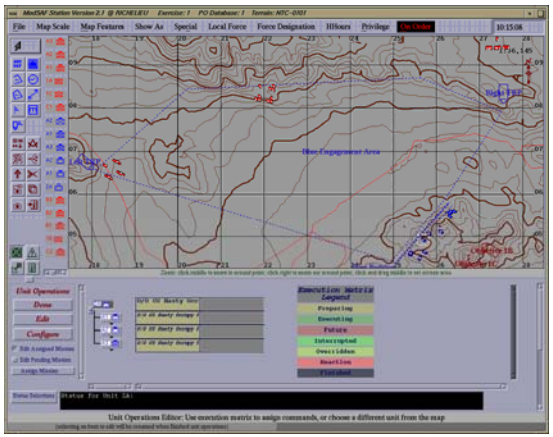
Constructive

Constructive simulation. Simulation involving real people making inputs into a simulation that carries out those inputs by simulated people operating simulated systems. [DOD, 1998]

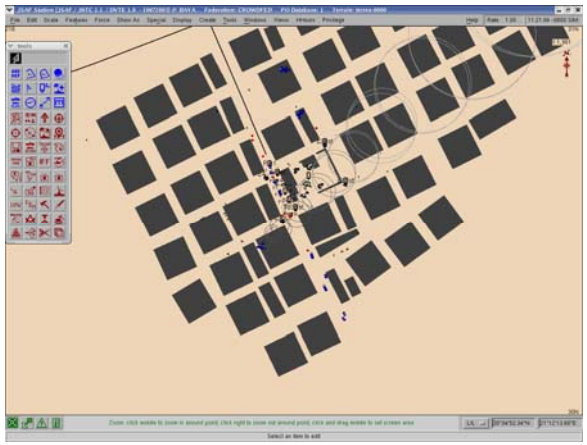
Constructive simulation

- No virtual environment or simulators
- Systems operated by non-participants
- Primary goal: useful result

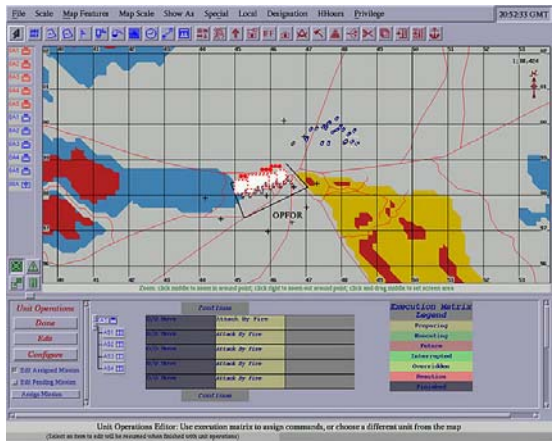
Example constructive simulations.
U.S. Army; ModSAF, JSAF, OneSAF



ModSAF



JSAF



OneSAF

Summary of simulation types

Category	Participants	Systems
Live	Real	Real
Virtual	Real	Simulated
Constructive	Simulated	Simulated

Systems combining the categories exist

- CCTT; virtual and constructive
- BFTT; live and constructive

Models in constructive simulations

- Variety of models and modeling methods
- Depends on fidelity, resolution, application
- Single constructive simulation typically combines several models

Example entity combat model

P_h (probability of hit) for a weapon system

Range (meters)	**Target speed** (meters per second)			
	0 - 6	> 6 - 12	> 12 - 18	> 18 - 24
> 50 - 250	.72	.64	.54	.42
> 250 - 2,000	.55	.47	.37	.25
> 2,000 - 5,000	.40	.32	.22	.10
> 5,000 - 10,000	.22	.14	.04	.01

A simulation using this model would

- Access table with range and target speed
- Retrieve P_h value
- Generate random number, compare to P_h

Example aggregate combat model

Lanchester equations; differential equations for attacker and defender force attrition with respect to time; widely used. [Davis, 1995]

$$\frac{dA}{dt} = -K_d A^r D^s \qquad \frac{dD}{dt} = -K_a D^t A^u$$

A	Attacker strength (abstract, aggregate value)
D	Defender strength (abstract, aggregate value)
K_a, K_d	Lethality (K_a attacker, K_d defender)
r, s, t, u	Free parameters, time independent

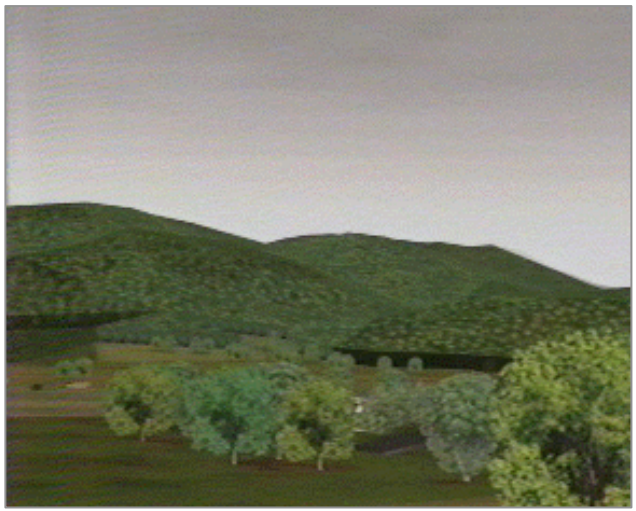
Example sensor model

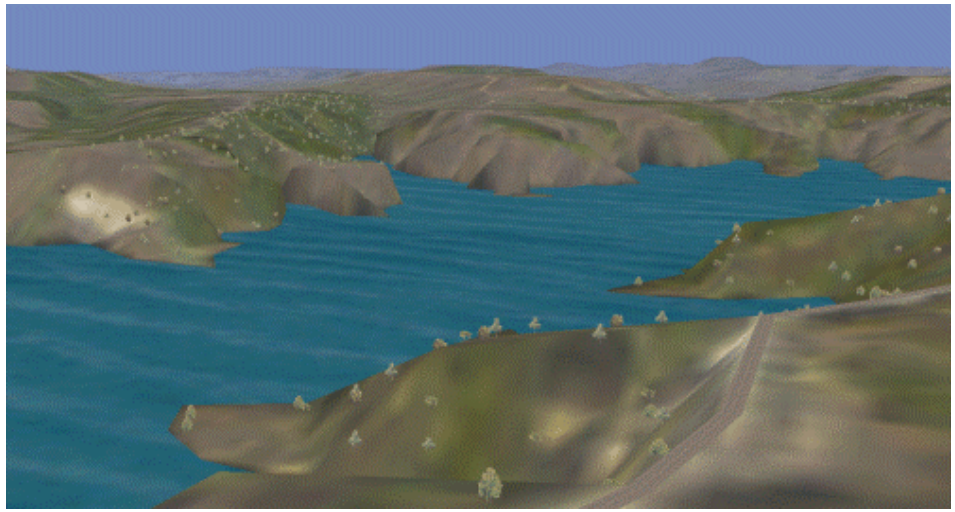
Radar detection range.

$$R = 2.59 \times \sqrt[4]{\sigma \times \left(\frac{\log^{-1}\left(\frac{ERP_t}{10}\right)\log^{-1}\left(\frac{G_r}{10}\right)\log^{-1}\left(\frac{MDS_r}{10}\right)}{\log^{-1}\left(\frac{FEL_r}{10}\right)F_t^2} \right)}$$

R	Radar detection range	Model output
G	Antenna gain	Physical constant
MDS	Minimum discernable signal (dbm)	Physical constant
FEL	Front End Loss (dbm)	Physical constant
F	Frequency (mhz)	Data from table
ERP	Effective Radiated Power (dbm)	Data from table

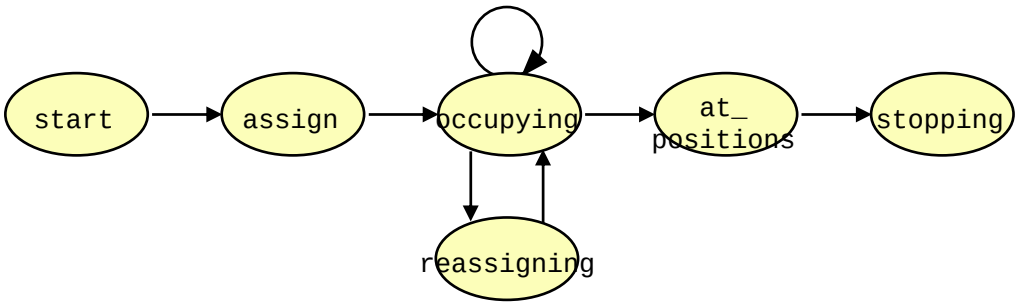
Example terrain model

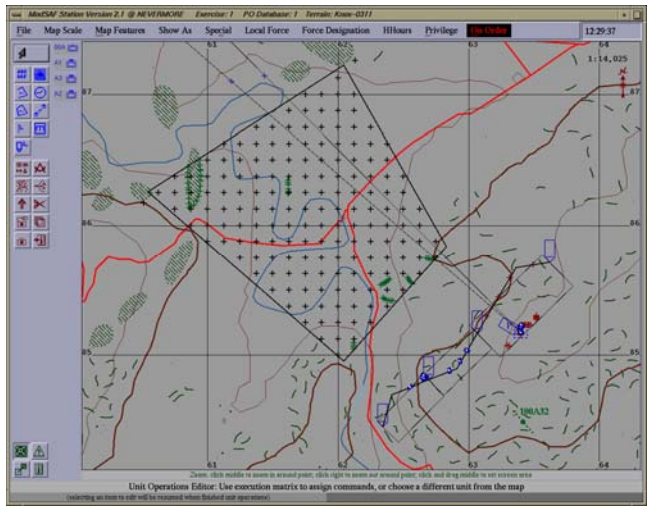




- Surface formed from polygons (triangles)
- Polygons
  - Vertices on 2D grid (elevation posts) or arbitrary (TINs)
  - x, y, z values at vertices
  - Texture associated with each polygon
- Features (trees, buildings) separate

Example behavior generation model





- Low-level behaviors implemented directly
  - e.g., follow route, fire missile, …
- Composite behaviors assembled using FSMs
  - e.g., occupy position
  - States are low-level behaviors
  - Transitions are simulation conditions

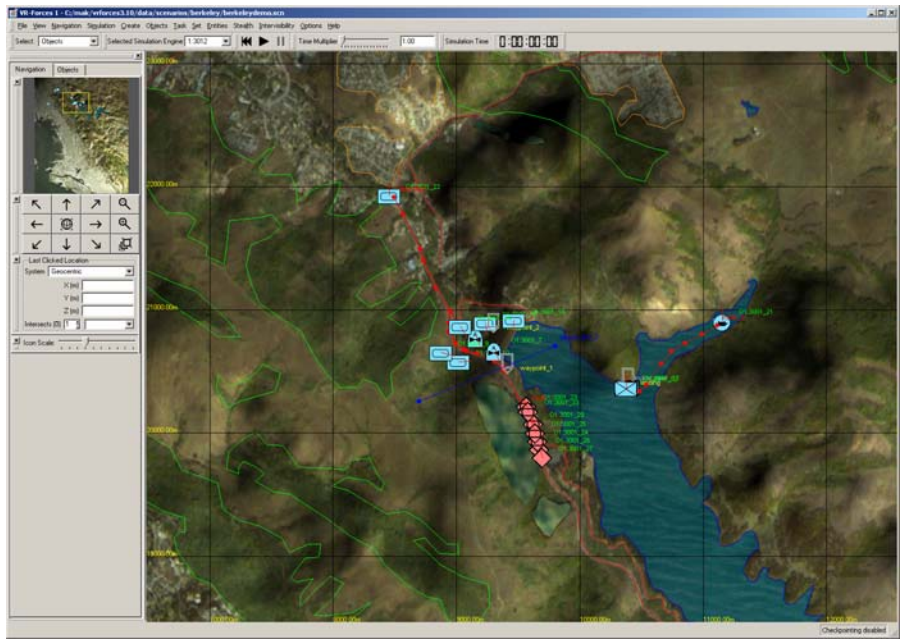
Uses of constructive battlefield simulation

- Training
  - e.g., command post exercises
- Analysis
  - e.g., course of action comparison
- Experimentation
  - e.g., doctrine concept
- Acquisition
  - e.g., requirements analysis
- Engineering
  - None?

Basic VR-Forces: entities and tasks

Introduction

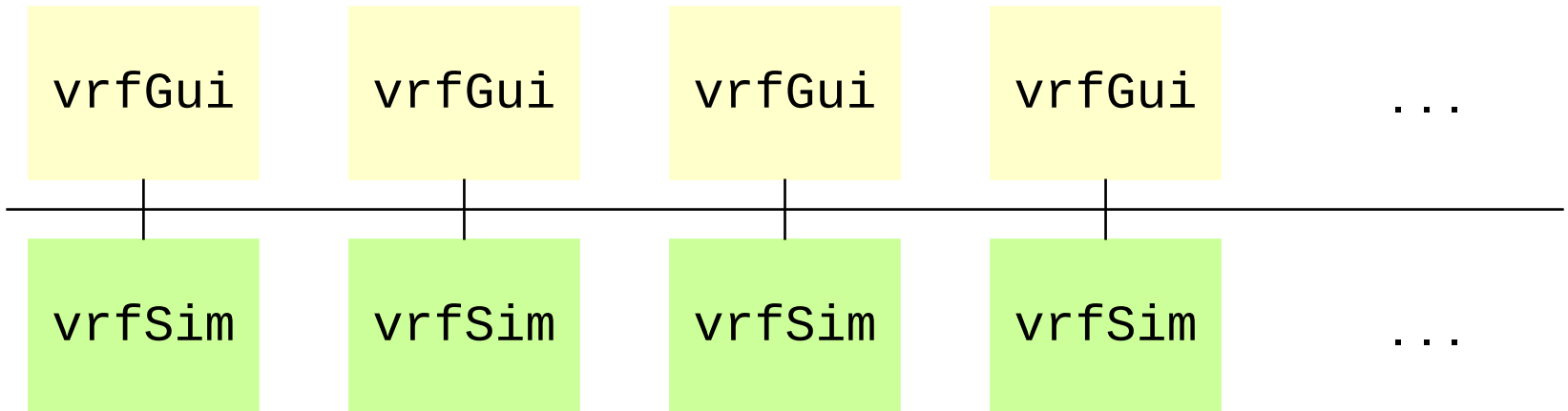
- VR-Forces
  - COTS product of MÄK Technologies
  - Similar in resolution, scale, and feel to ModSAF, JSAF, OneSAF



- Simulation capabilities
  - Semi-automated forces (SAF) system
  - Simulates combat at entity level
  - Ground, sea, and air entities
  - Real-time and non-real-time operation
- Technical characteristics
  - Object oriented C++ implementation
  - User development supported via APIs
  - DIS and HLA interoperability

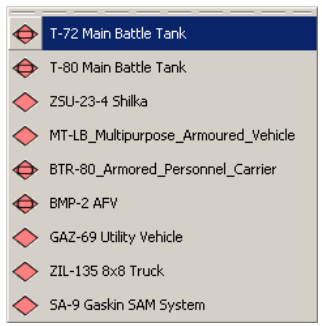
Front-ends and back-ends

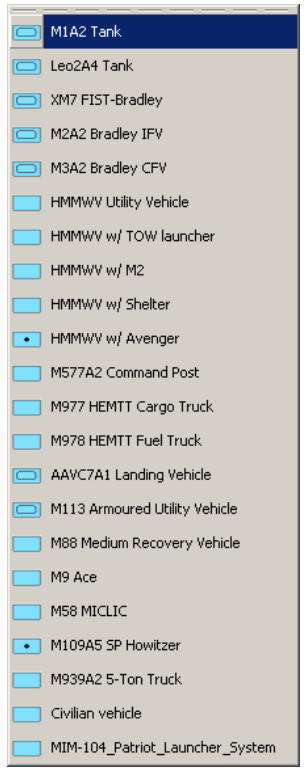
- VR-Forces components
  - Front-end: operator GUI
  - Back-end: simulation engine
- Architecture options
  - Linked many-many, via network
  - Combined on single computer



Objects

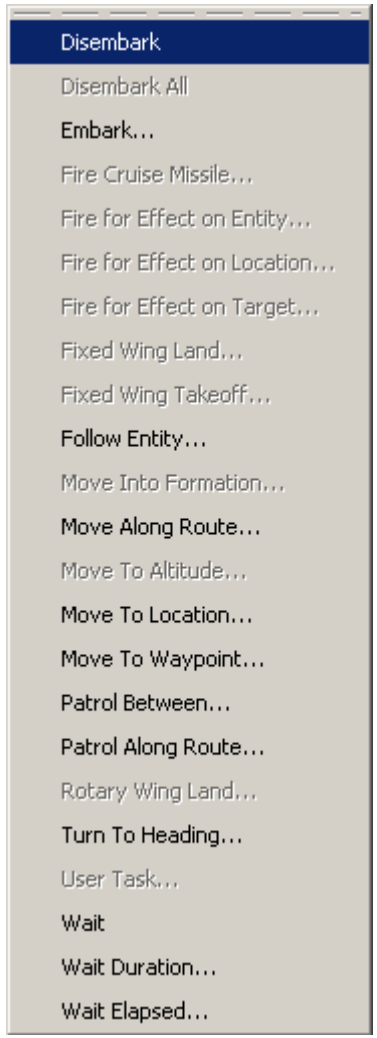
- Entities
  - Individual entities “entities”
    tanks, trucks, helicopters, …
  - Aggregate entities “aggregates”
    platoons, companies, …
- Graphical objects
  - Control objects
    routes, phase lines, areas, …
  - Overlay objects
    shapes, symbols, …





Tasks and sets

- Tasks
  - Actions an entity can execute
- Sets
  - Change entity state or attribute
- Both tasks and sets
  - Individual or aggregate
  - Independent or planned



Aggregates

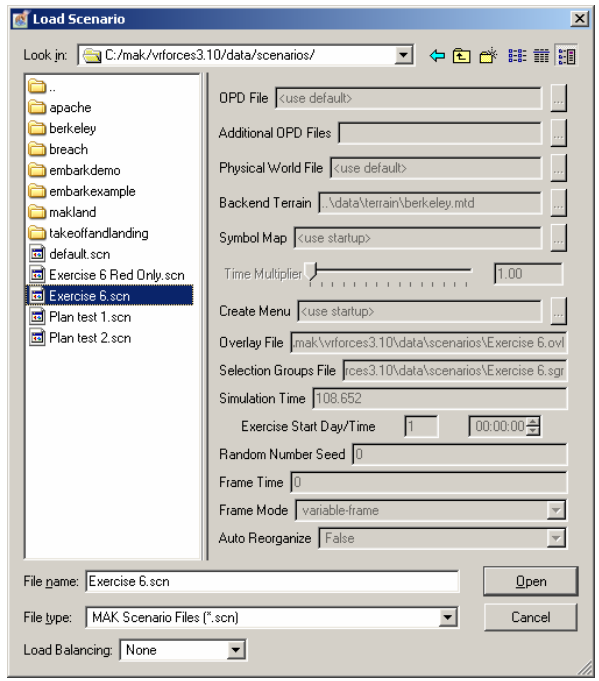
- Concept
  - Military units, e.g., platoon
  - Set of individual entities “pseudo-aggregate”
- Capabilities
  - Most entity tasks/sets work for aggregates
  - Tasks given to aggregate executed by entities

Graphical objects

- Concept
  - Not “real world” entities
  - Used to control entities, communicate to users
- Uses
  - Control objects drawn on map, used in tasks
  - Overlay objects drawn on overlays

Scenarios

- Basic organizing unit of VR-Forces use
- Contents (each a file)
  - Terrain database
  - Entities
  - Plans
  - Graphical objects
  - Overlays
  - Selection groups



VR-Forces exercises, part 1

Advanced VR-Forces: plans and other features

Plans

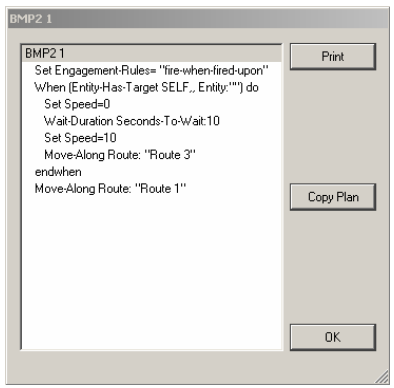
- Concept
  - Prewritten scripts or programs for entities
  - Control behavior without operator attention
  - Useful for large scenarios, repeatability
- Types of plans
  - Entity; individual or aggregate
  - Global; overall scenario

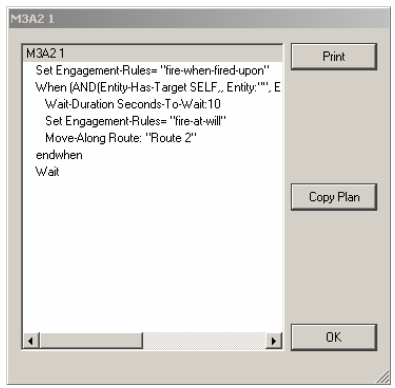
Entity plans

- Structure
  - Associated with entity
  - Execution begins when scenario starts
  - Operator commands override plan
- Contents
  - Tasks and sets for entity
  - Conditionals
  - May refer to control objects, other entities

Plan conditionals

- Concept
  - Plan statements check simulation conditions
  - Allow action selection based on current state
- Conditionals available
  - If/else; select between alternatives
  - While; repeat as long as condition met
  - When; watch for condition, trigger when met





Other VR-Forces features

- Simulation and GUI features
  - Multiple hierarchical levels of aggregates
  - Non-real-time execution, including batch
  - Spot reports and “fog of war”
  - Embarking and debarking
  - Overlays
  - Special effects (hazard clouds, emissions, …)
  - Intervisibility
- Utility and support features
  - Stealth control within plans
  - APIs for user customization

VR-Forces exercises, part 2

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