



Modeling and Simulation of a System of Systems: Incorporating Electromagnetic and Radiation Effects into the Army's Future Combat Systems

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Background

- Army's Future Combat Systems (FCS)
 - FCS operates as a system-of-systems
 - Whole greater than sum of parts
- Net-centric
 - Enables soldiers to perceive, comprehend, shape, and dominate the future battlefield
 - Network provides the synergistic glue for FCS
 - Performance not dependent on single element, but on success of the system-of-systems (SoS)



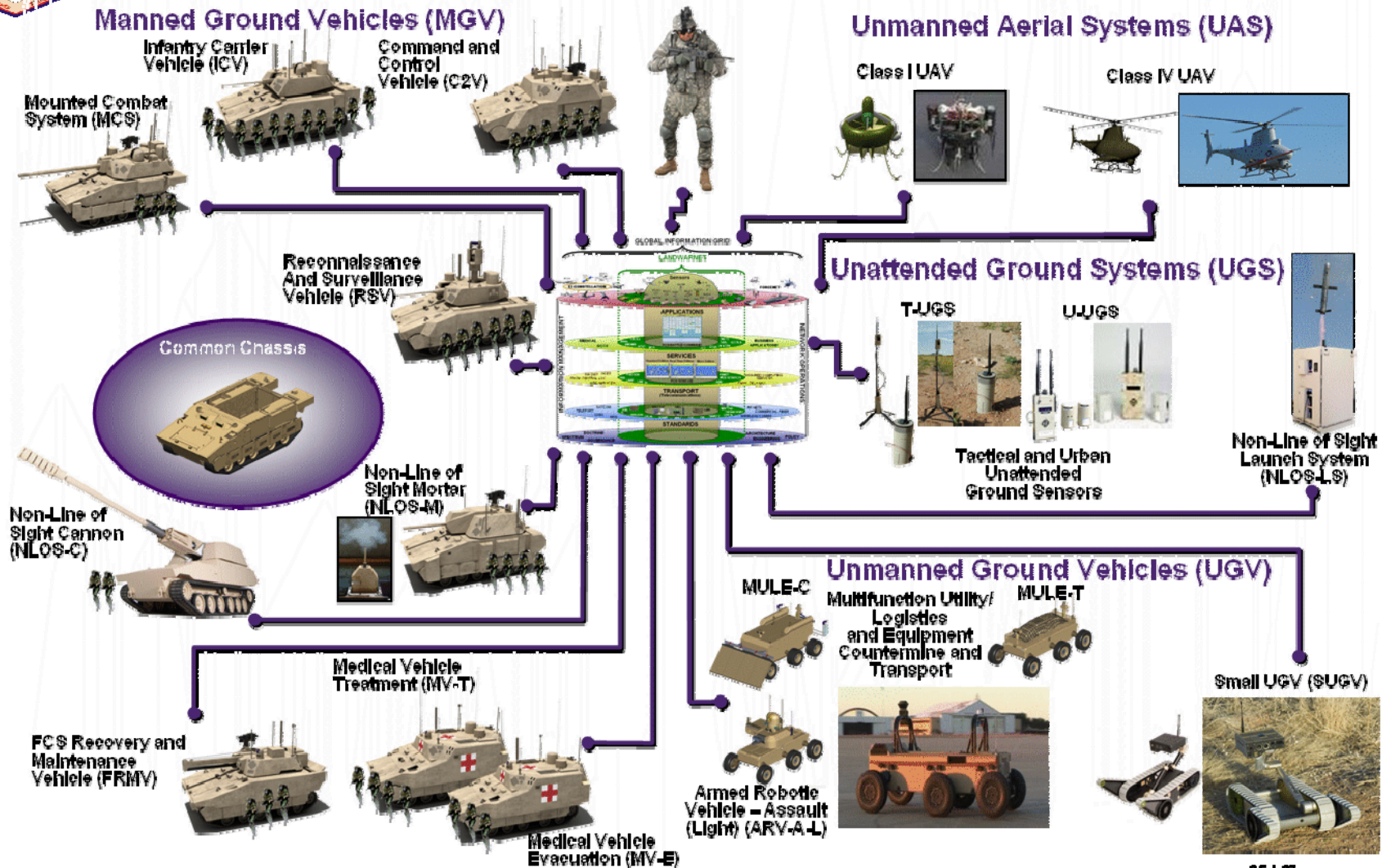
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FCS Brigade Combat Team...



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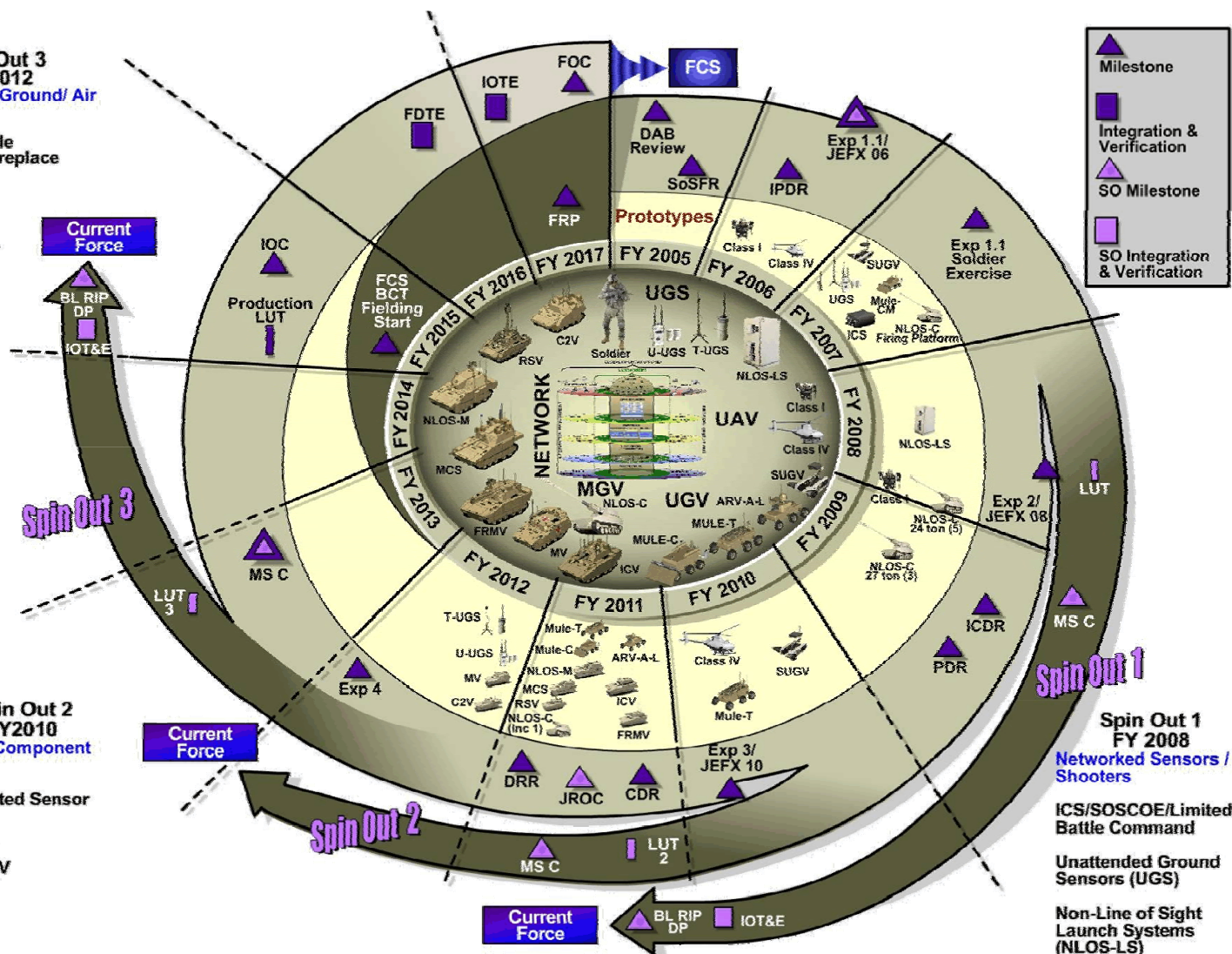


FCS (BCT) System-of-Systems Schedule

Spin Out 3
FY 2012
Network and Ground/ Air
Sensors

Full FCS Battle
command to replace
ABCS

ARV-A-L
Small UGV
Class I UAV
Class IV UAV
CC/DCD



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System-of-Systems Qualification

- Challenge
 - Performance measured at SoS level
 - Can SoS complete mission?
 - Many new platforms
 - Platforms developed in parallel
 - Platforms must work together
- Solution
 - Rely on wargaming
 - Mix live elements with simulated battlefield and weapon effects
 - Modeling and simulation V&V'd
 - Models tethered to data



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NETS and DETES

- Nuclear Effects Threat Simulator (NETS)
 - Models effects from ground and near ground bursts
 - Gammas, neutrons, overpressure,...
 - Two main components
 - Platform model: *Testable Hardware Toolkit (THTk)*
 - Real-time wargame simulation: *SurVNETS*
- Directed Energy Threat Environment Simulator (DETES)
 - Models EM environment effects
 - HEMP, HPM, lightning,...
 - Two components
 - Platform model: *Unified Electromagnetic Design (UEM)*
 - Real-time wargame simulation: *DETES*



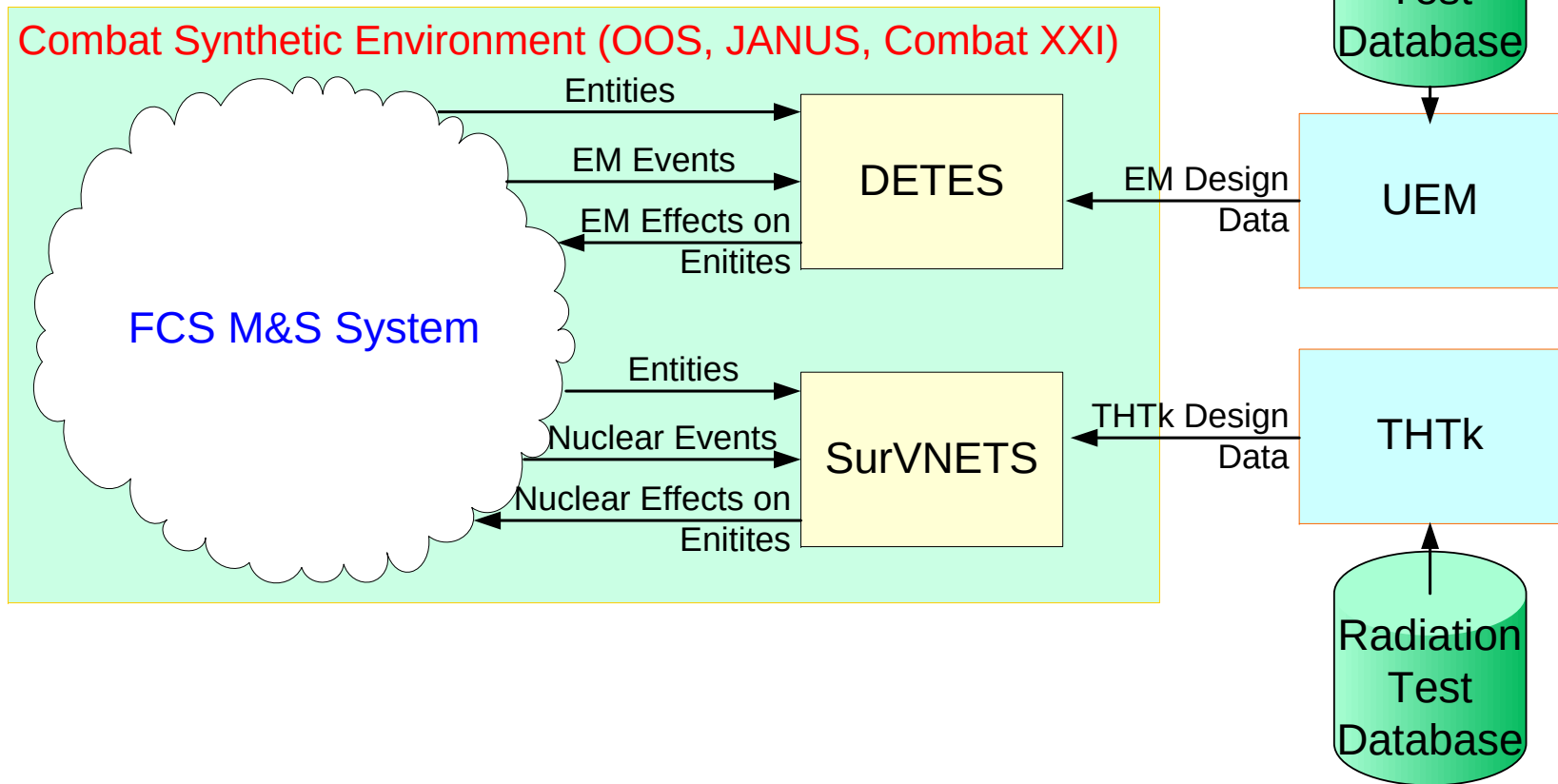
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NETS / DETES Operational Diagram





NETS

- NETS Tools
 - Build platform models with *THTk Workbook*
 - *SurVNETS* operates in near real-time Combat Synthetic Environment
- SurVNETS
 - Effects threshold data
 - High-speed nuclear environments
 - Conveys functional impact on all battlefield entities to combat synthetic environment



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NETS: Effects Thresholds

SurVNETS Properties Editor

File Edit Help

All Categories

- Other
- Platform
 - Other
 - Land
 - Air
 - Other
 - Fighter/Air Defense
 - Attack/Strike
 - Bomber
 - Cargo/Tanker
 - ASW/Patrol/Observation
 - Electronic Warfare (EW)
 - Reconnaissance
 - Surveillance/C2 (Airborne Early Warning)
 - Attack Helicopter
 - Utility Helicopter
 - Antisubmarine Warfare/Patrol Helicopter
 - Cargo Helicopter
 - Observation Helicopter
 - Special Operations Helicopter
 - Trainer
 - Unmanned
 - Non-Combatant Commercial Aircraft
- Surface
- Subsurface
- Space
 - Other
 - Manned
 - Unmanned
 - Booster
- Munition
- Life form
- Environmental
- Cultural feature
- Supply

Air

☐ Inherit from parent

Susceptibility Properties

Overpressure:

Mobility Threshold: 1.5

Firepower Threshold: 1.5

Destroyed Threshold: 3

Reference: JMJ estimates

Gamma Dose Rate:

Mobility Threshold: 1000000000

Firepower Threshold: 100000000

Destroyed Threshold: 10000000000

Reference: JMJ estimates

Gamma Dose:

Mobility Threshold: 10000

Firepower Threshold: 10000

Destroyed Threshold: 100000

Reference: JMJ estimates

Display Properties

Image File: GenericAirPlatform.png



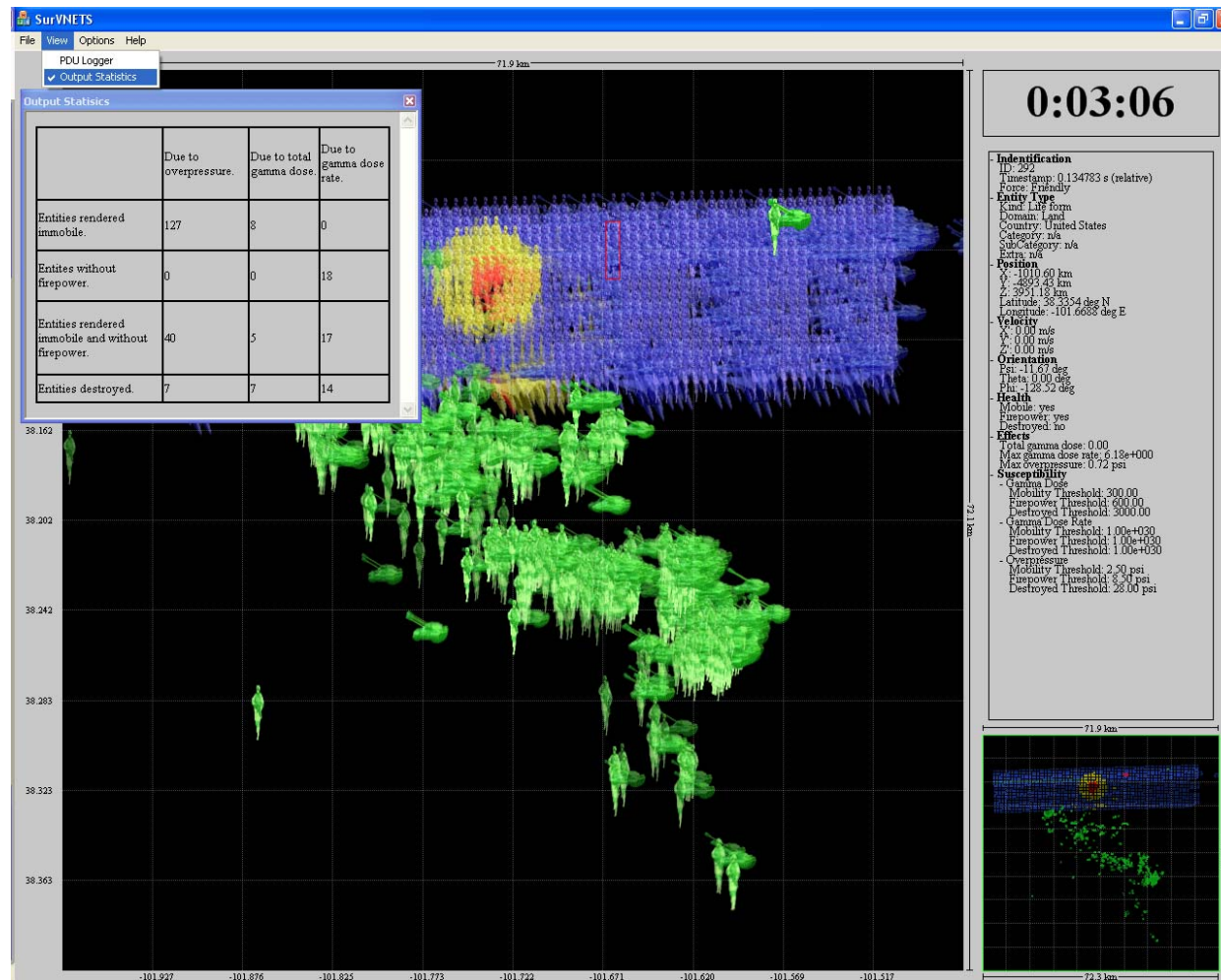
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NETS Tools: SurVNETS Interface



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DETES

- DETES Tools
 - Build platform models with *UEM Design*
 - *DETES* operates in near real-time Combat Synthetic Environment
- *DETES*
 - Probability of effect models
 - High-speed EM environments
 - Conveys functional impact on all battlefield entities to combat synthetic environment



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DETES User Interface

Exercise Runtime Mode

DETES Version 1.0 Main Control Form

Setup UDP
 ☒ Byte Swap Received Data ☒ Byte Swap Send Data

Remote Host Receive Port Send Port

Data Base
Path and Name

DETES Processing

Entity State
Janus Site
Janus Host or Application
Global Entity State
☒ Static ☐ Learn

Fire
☐ Log Fire PDUs

Nuclear Effects
☒ Do Statistical Upset/Damage
☒ Log Nuclear Effects PDUs
☐ Send Nuclear Effects PDUs
PDU Rate

Detonation
☐ Log DETES Detonation PDUs
☐ Log all Detonation PDUs
Global Detonation
☒ Static ☐ Learn
HEMP HOB
☒ Detonation PDU ☐ HEMP Form
Environment Parameters
☒ Static (Forms) ☐ Dynamic (PDU/Data Base)

PDU Status
Number of PDUs
PDUs Received
PDUs Not Processed

☐ Display Next PDU

Protocol Version 5
Exercise Identifier 1
PDU Type 1
Protocol Family 1
Time Stamp 0
PDU Length 104
Site 1
Host 1
Entity 1
Force ID 225

Self Test
Entity State
☒ Single PDU ☐ Multiple PDUs
PDU Rate

Repeat #
Detonation - Extra (Byte80)
☐ HEMP ☐ HPM ☒ Static

Nuclear Effects

HPM Environment

Source
Power (MW) Frequency (GHz)
Antenna Aperture (m²)

Environment
Peak Field @ 1 m (V/m) Maximum Range (m)
Upset Threshold (V/m)

HEMP Environment

Weapon Information
Height of Burst (50 to 400 km)
Gamma Ray Yield (0.001 to 10.0 KT)

Earth
Radius (km)
Tangent (km)

HEMP Environment Levels

Maximum Field (kV/m) Tangent Field (kV/m)

Scaling

Scaling Exponent Range (km) Environment (kV/m)

Diagram: A circle representing Earth with a radius line and a tangent line. Labels include "Tangent", "HOB", "Radius", and "Earth".



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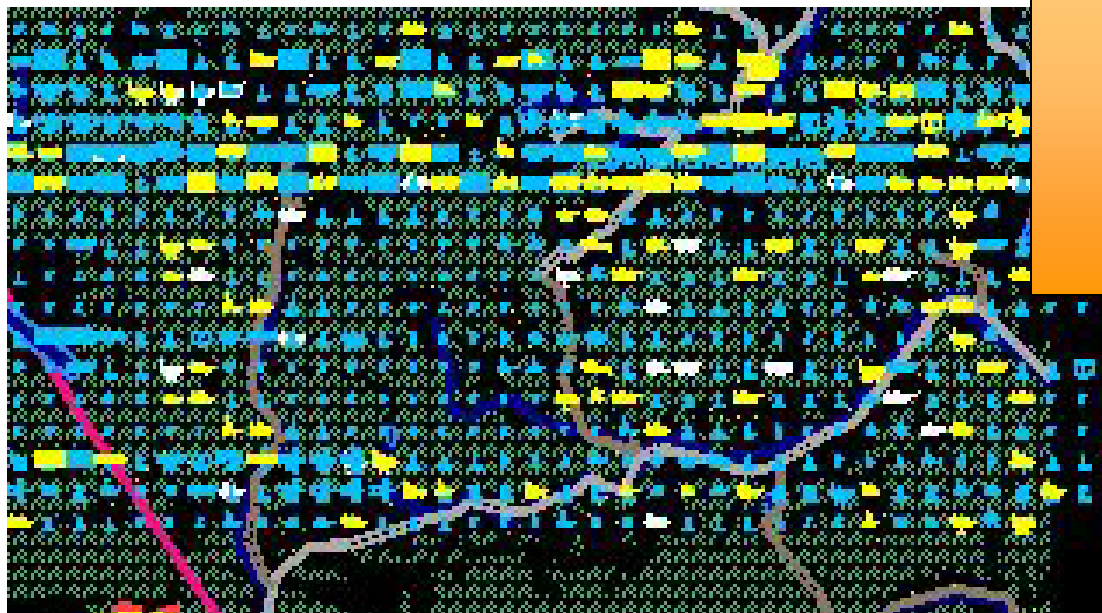
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EM Effects Results for a Hypothetical HEMP Event

- Hardness levels arbitrarily set by type of equipment
- 5,624 entities processed for upset and damage effects
- Percentages consistent with P_e for each class



Color Code:
No Effect
Upset
Damaged



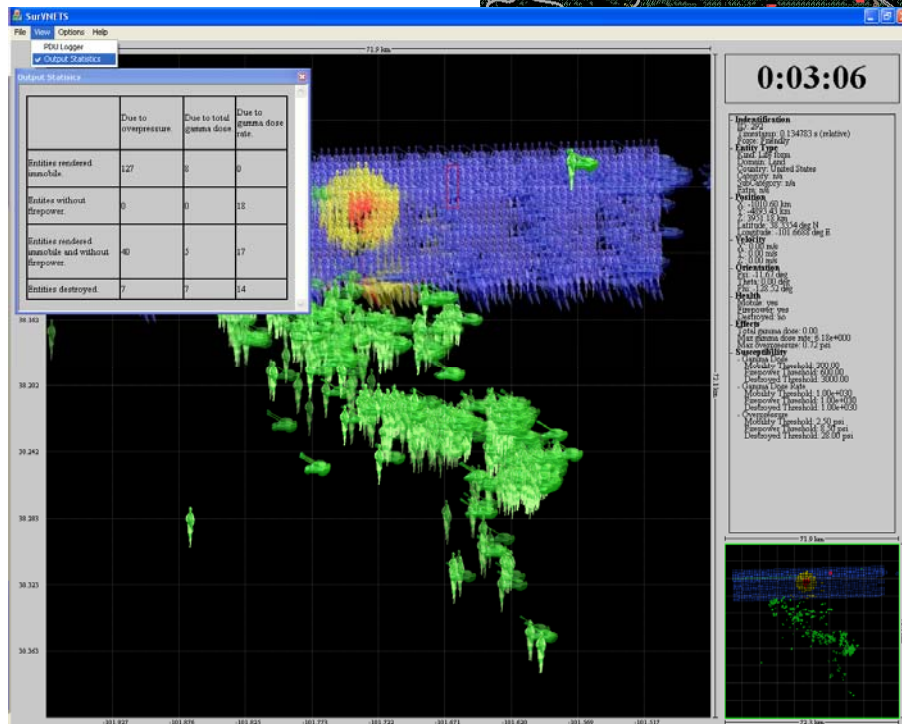
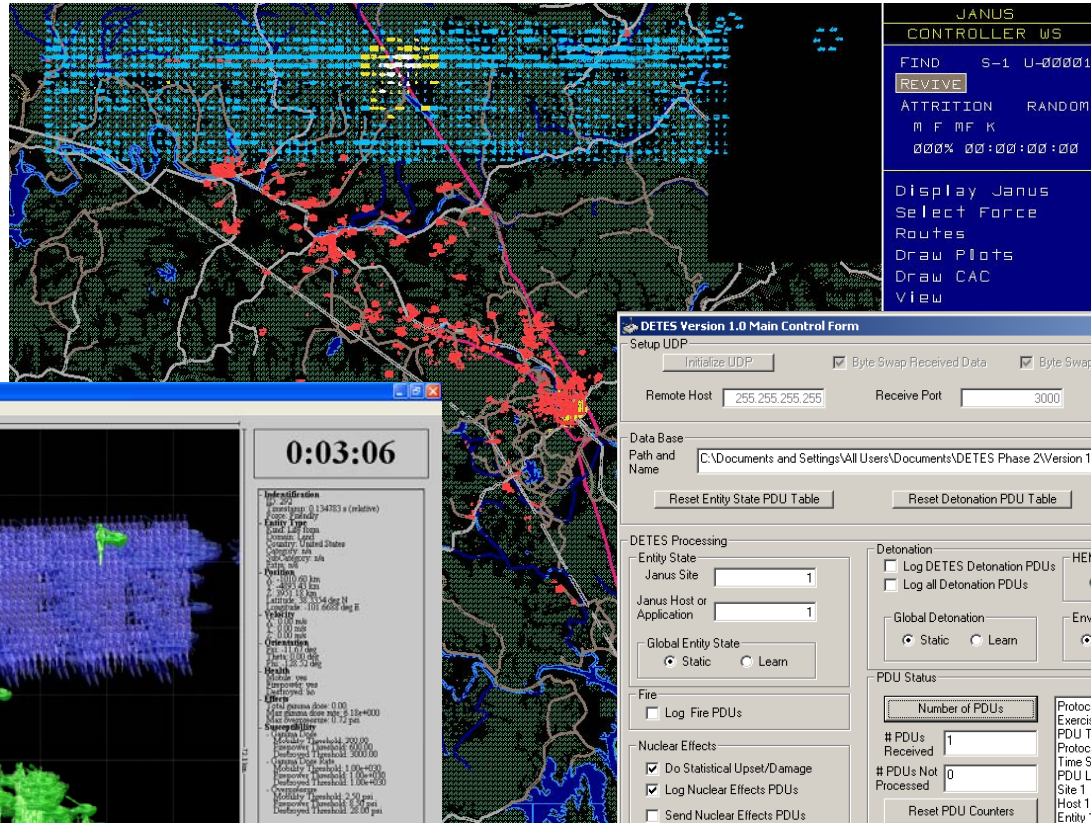
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JANUS Battlefield Simulation



DETES Version 1.0 Main Control Form

Setup UDP

Initialize UDP ☒ Byte Swap Received Data ☒ Byte Swap Send Data Disconnect UDP

Remote Host: 255.255.255.255 Receive Port: 3000 Send Port: 3000

Data Base Path and Name: C:\Documents and Settings\All Users\Documents\DETES Phase 2\Version 1.0\Version 1 w new db\Test Data Bases\DETES Da

Reset Entity State PDU Table Reset Detonation PDU Table Reset Nuclear Effects PDU Table

DETES Processing

Entity State: Janus Site 1

Janus Host or Application: 1

Global Entity State: Static Learn

Fire: ☐ Log Fire PDUs

Nuclear Effects: ☒ Do Statistical Upset/Damage ☒ Log Nuclear Effects PDUs ☐ Send Nuclear Effects PDUs

PDU Rate: 1.000

Detonation: ☐ Log DETES Detonation PDUs ☐ Log all Detonation PDUs

Global Detonation: Static Learn

Environment Parameters: Static (Forms) Dynamic (PDU/Data Base)

PDU Status: Number of PDUs: 1

PDUs Received: 1

PDUs Not Processed: 0

Reset PDU Counters

Display Next PDU

Protocol Version 5

Exercise Identifier 1

PDU Type 1

Protocol Family 1

Time Stamp 0

PDU Length 104

Site 1

Host 1

Entity 1

Force ID 225

Self Test: Entity State: Single PDU PDU Rate: 1.000 Repeat #: 1

Detonation - Extra (Byte80): HEMP HPM Static

Nuclear Effects: Send Detonation PDU Send Nuclear Effects PDU



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Conclusion

- NETS and DETES Version 1.0 development complete
- Software development included Verification and Validation
- Capability demonstration with *JANUS*
- Future development will include interface with other M&S applications



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