CB System Military Worth Assessment Toolkit

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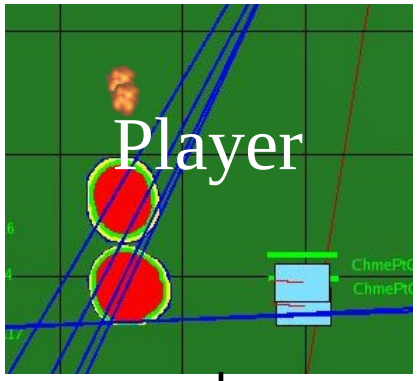
CB Sim Suite

- High Level Architecture (HLA) Compliant Model
- Represents
  - Chem/Bio Threat Propagation/Delivery
  - CB Exposure Effects
  - CB Detection in Constructive and Virtual M&S (OneSAF, Biological Standoff Detection System (BSDS))
  - Radiological Static Grids (FOX trainer)
- TRADOC Battle Lab Collaboration Environment (BLCSE) Model Federate (Interim Approval)
- Modeling Architecture for Technology and Research Experimentation (MATREX) Federate (FY07/08 target)

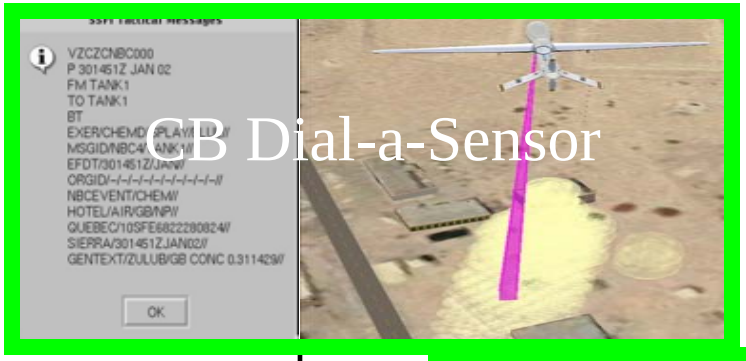
CB Simulation Suite Architecture

Threat Delivery



Hazard Environment

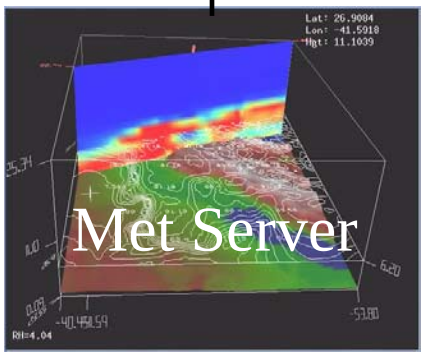
Real-time Sensors



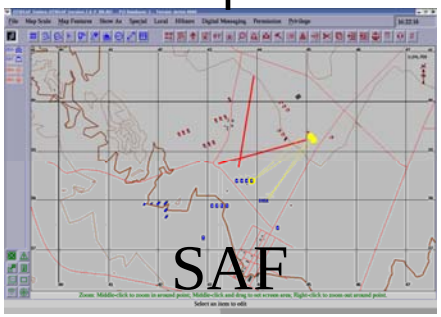
DIS Network / HLA RTI

Exposure Toxicity Server

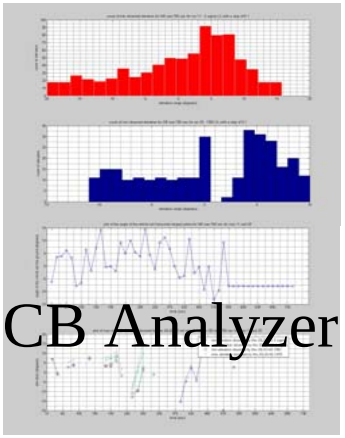
Entity State Tracking



Environment



Platform



AAR

CB Sim Suite is a set of distributed simulation tools designed to represent all aspects of CB passive defense on the tactical battle field for application to analysis, testing, and training.

Uses of the CB Sim Suite

- Supports Army SMART Architecture
  - Development of effective CB defense materiel (requirements analysis)
  - Development of Tactics, Techniques, and Procedures (TTPs)
  - Robust testing over a wide parameter space
  - Broad scenario-based training
  - Simulation-Based Acquisition (SBA)
- Studies ongoing for
  - PM Contamination Avoidance
    - Joint Service Lightweight Standoff Chemical Agent Detector (JSLSCAD)
  - Expeditionary Biological Detection (EBD) Advanced Technology Demonstration
  - JPEO-CBD Future Acquisition Directorate
    - Future Combat Systems (FCS)
- Supports live sensor testing at West Desert Test Center at Dugway Proving Ground

Who Uses the CB Sim Suite?

- ECBC Research & Technology Directorate
  - System R&D, concept evaluation
- JPEO CBD JPM Contamination Avoidance (requirements, R&D)
  - JSLSCAD
  - Artemis
  - Ion Mobility Spectroscopy (IMS)
- JPEO CBD Future Acquisition Directorate
- PM Recon (Fox NBCRV, BIDS, and component trainers)
  - US Army Chemical School
  - Ft. Hood
  - Ft. Polk

Who Uses the CB Sim Suite?

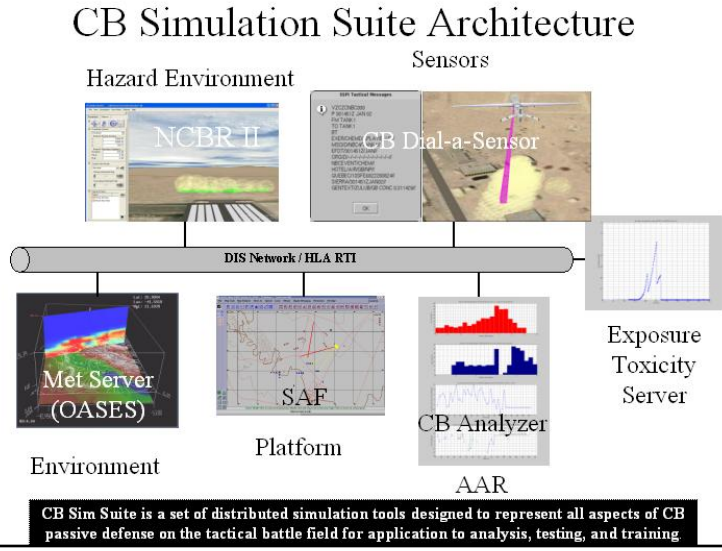
- Army Research Laboratory (ARL)
  - UGV robotics hazard mapping algorithm development
- Army Test and Evaluation Command (ATEC) Developmental Test Center (DTC)
  - Dugway Proving Ground (DPG)
  - Virtual Proving Ground (VPG)
  - Future Combat System (FCS) Combined Test Organization (CTO)
- Army Test and Evaluation Command (ATEC) Army Evaluation Center (AEC)
- Army Maneuver Support Center (MANSCEN)
- Expeditionary Biological Detection ATD (USMC)
- Constructive Simulations

CB System Military Worth Assessment Toolkit, Chris Gaughan, ECBC, BA05MSB030

Objective: Extend the CB Simulation Suite to operate in non-real-time modes using the High Level Architecture's (IEEE 1516) time management capabilities to support military worth assessments at platform through theater levels. The effort will also increase the simulation capabilities of the Sim Suite.

Description of Effort: Modify existing simulations (CB Dial-a-Sensor, CB Exposure Toxicity Server, NCBR) to operate in faster-than-real-time modes

- Add biological toxicological to CB Exposure Toxicity Server
- Add MOPP capability to the Suite, begin preliminary research on implementation of collective protection and decontamination
- Develop interface between CB Sim Suite tools and widely-used constructive simulation



Benefits of Proposed Technology: This capability will provide a more cost effective and timely means of analyzing the impact of CB defense materiel on op tempo, force structure. The capability will also support development better-defined system requirements and development of tactics, techniques, and procedures. The capability will support analyses of fixed sites and mobile forces.

Challenges:

- Development of interfaces between sensor entities and widely-used constructive simulations
- Handling delayed effects of bio exposure through the use of time-management and how that fits into an overall wargame

Maturity of Technology: TRL 4-5. The component models (NCBR Environment Server, CB Dial-a-Sensor, CB Exposure Toxicity Server) are in use for various applications at the CMLS, Dugway Proving Ground, MANSCEN, ECBC, and JPEO CBD.

Capability Area: Modeling&Simulation/Battlespace

Major Goals/Milestones by Fiscal Year

- Final testing of HLA time management in NCBR, ETS, and DAS (FY07)
- Final testing of ETS with biological agent toxicity effects (FY07)
- Complete interface to widely-used constructive level simulation (FY07)
- Update existing user documentation (FY07)

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Project Overview

- Overall goal: extension of the CB Sim Suite to better support military worth assessments
  - Support non-real-time simulations
  - Support widely-used constructive simulations
  - Study phenomenology effects for future implementation

- Benefit to the Warfighter
  - Cost effective and timely means of analyzing the impact of CB defense materiel
    - Fixed sites
    - Mobile forces
  - Development of better-defined
    - System requirements
    - Tactics, techniques, and procedures

Updating the CB Sim Suite

- Develop and integrate time management into CB Sim Suite elements using HLA time management services
- Extend the existing ETS to include biological elements
- Develop an interface to widely-used constructive simulations

Updating the CB Sim Suite

- **Develop and integrate time management into CB Sim Suite elements using HLA time management services**
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Development and Integration of Time Management into the CB Sim Suite

- Updating all major components
  - NCBR
  - ETS
  - DAS
- Provides the ability to
  - Support slower- and faster-than real-time analyses
  - Support theater-level and aggregate-level simulations
  - Continue to support platform-level simulations
- Time management capabilities of HLA runtime infrastructure employed
- The event manager class of each component is updated by utilizing time advance grants from the HLA runtime infrastructure
  - Overhaul of entire code

Time Management Defined

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Time Management Definitions

- Coordination
  - Coordinated
    - Time advance is controlled via an external mechanism
  - Independent
    - Time advance is controlled by federates
- Advance
  - Constrained
    - Time advance rate is uniform (across all federates)
  - Unconstrained
    - Time advance rate is **not** uniform (within a federate and/or across federates)

Time Advance and Process Coordination Types

	Constrained	Unconstrained
Independent	•Real-Time and scaled Real-Time •DIS and non-Time Managed HLA	•**N/A** Meaningless in the Context of distributed simulations
Coordinated	•Not used in practice •Requires an external mechanism to control time	•HLA Time Managed •Federation driven time with non-uniform time advance

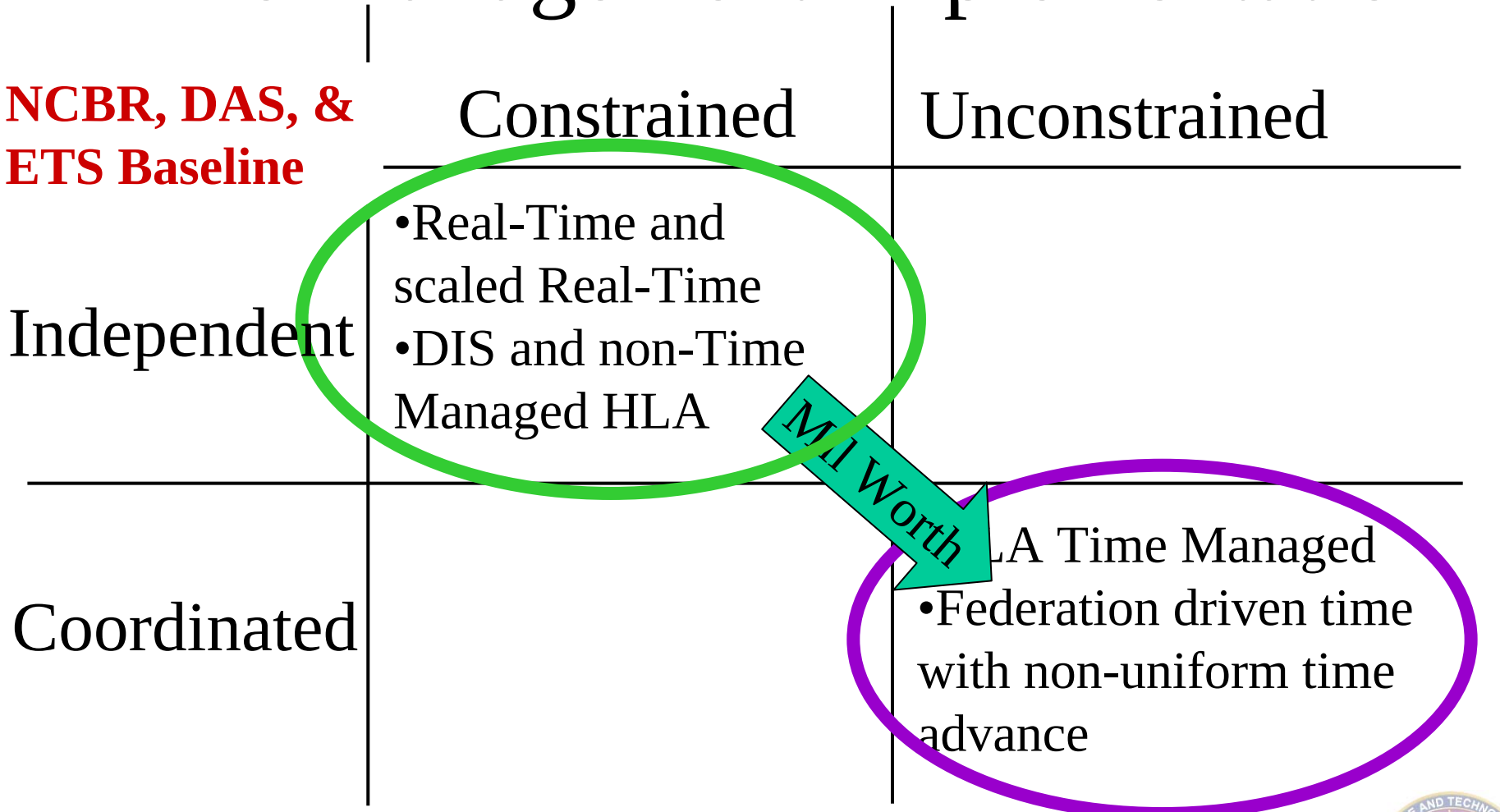
Time Advance and Process Coordination Types

	Constrained	Unconstrained
Independent	•Real-Time and scaled Real-Time •DIS and non-Time Managed HLA	
Coordina		•HLA Time Managed •Federation driven time with non-uniform time advance

All simulations in the exercise advance independently at the same rate using the same time scale (e.g., 1 sec = 1 sec) (constrained)

Each simulation in the exercise advances at its own (unconstrained) time scale as coordinated by an exercise time/event

Time Management Implementation



NCBR, DAS, & ETS Baseline

NCBR, DAS, & ETS End State

How Time Management Works

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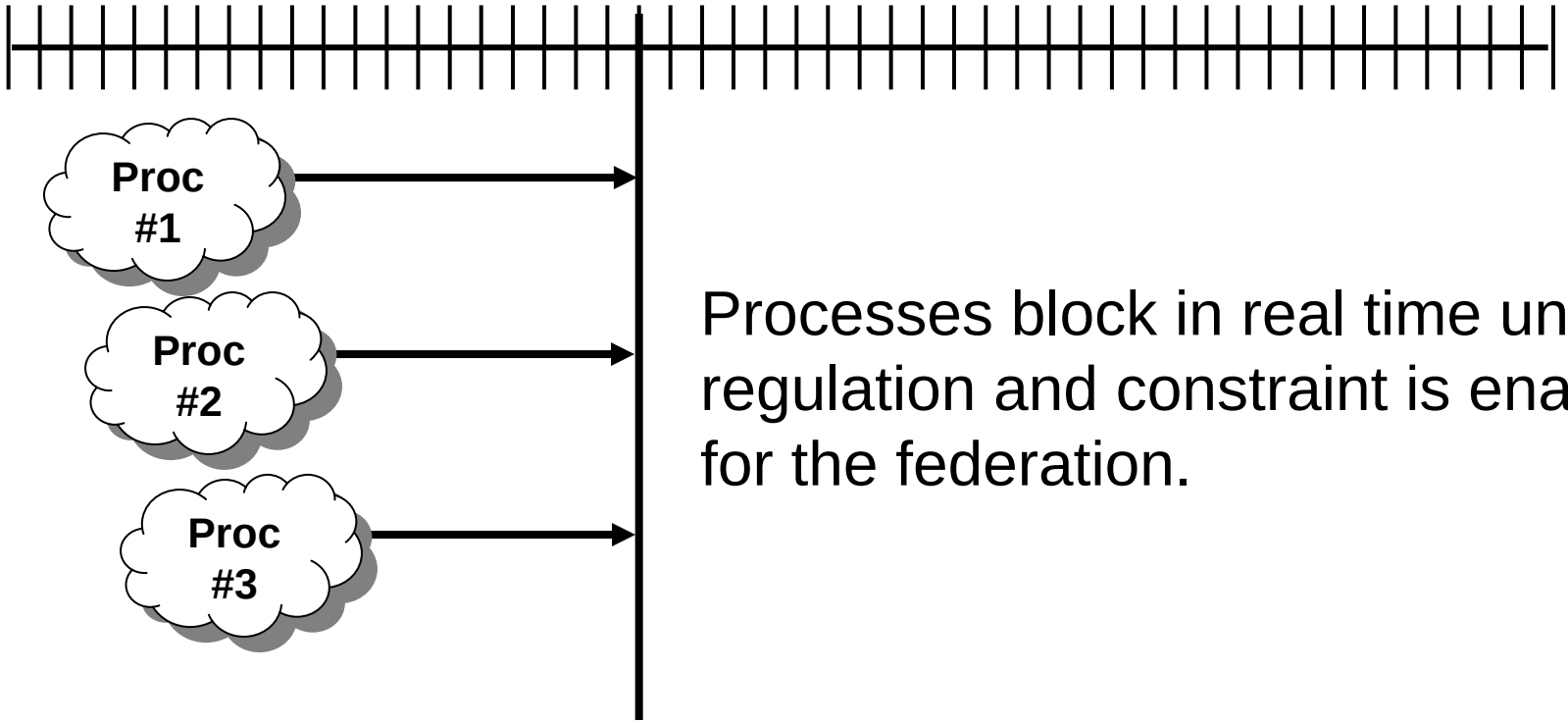
Process Initialization

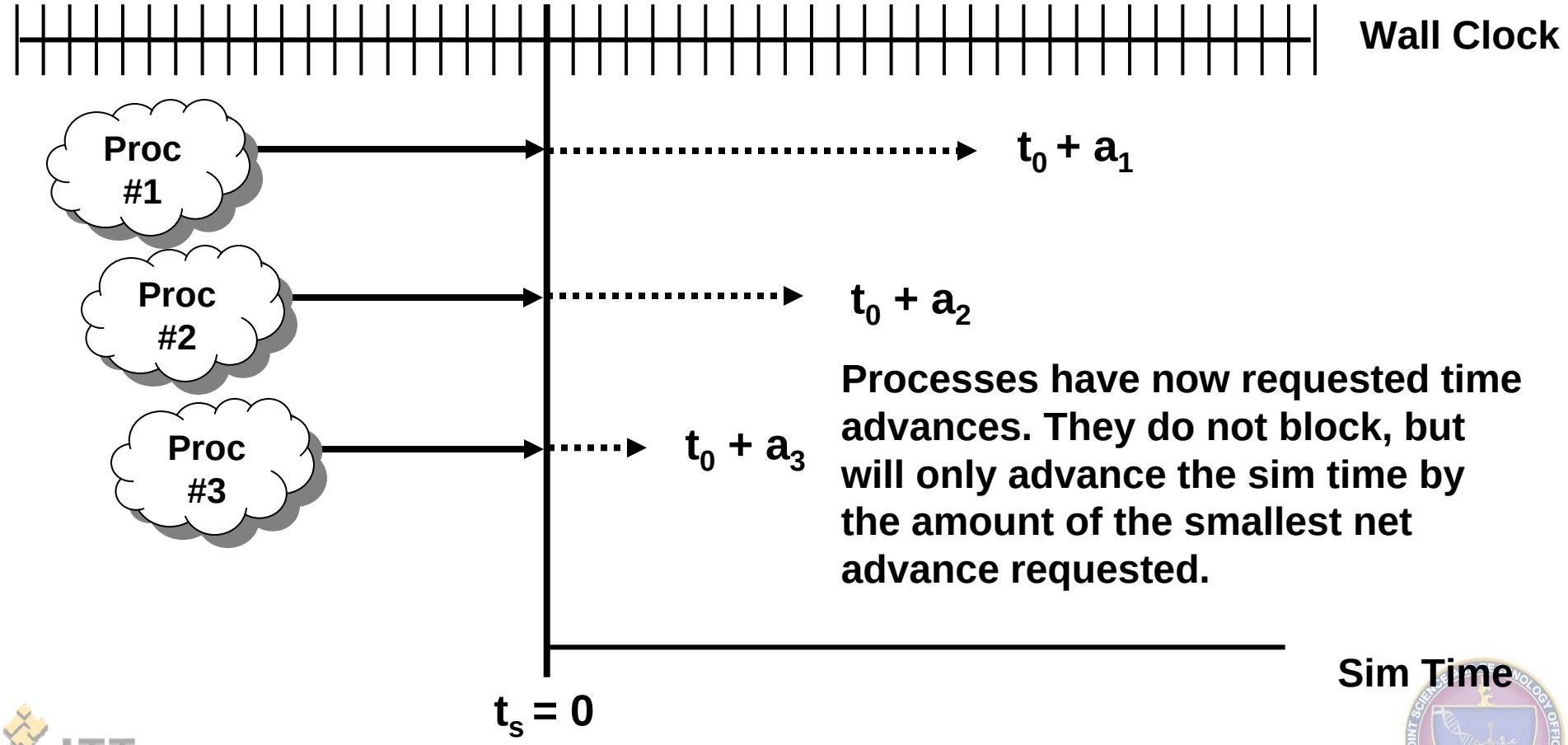
- **Initialize Process**
- **Request Time Regulation/Constraint**



Processes block in real time until time regulation and constraint is enabled for the federation.

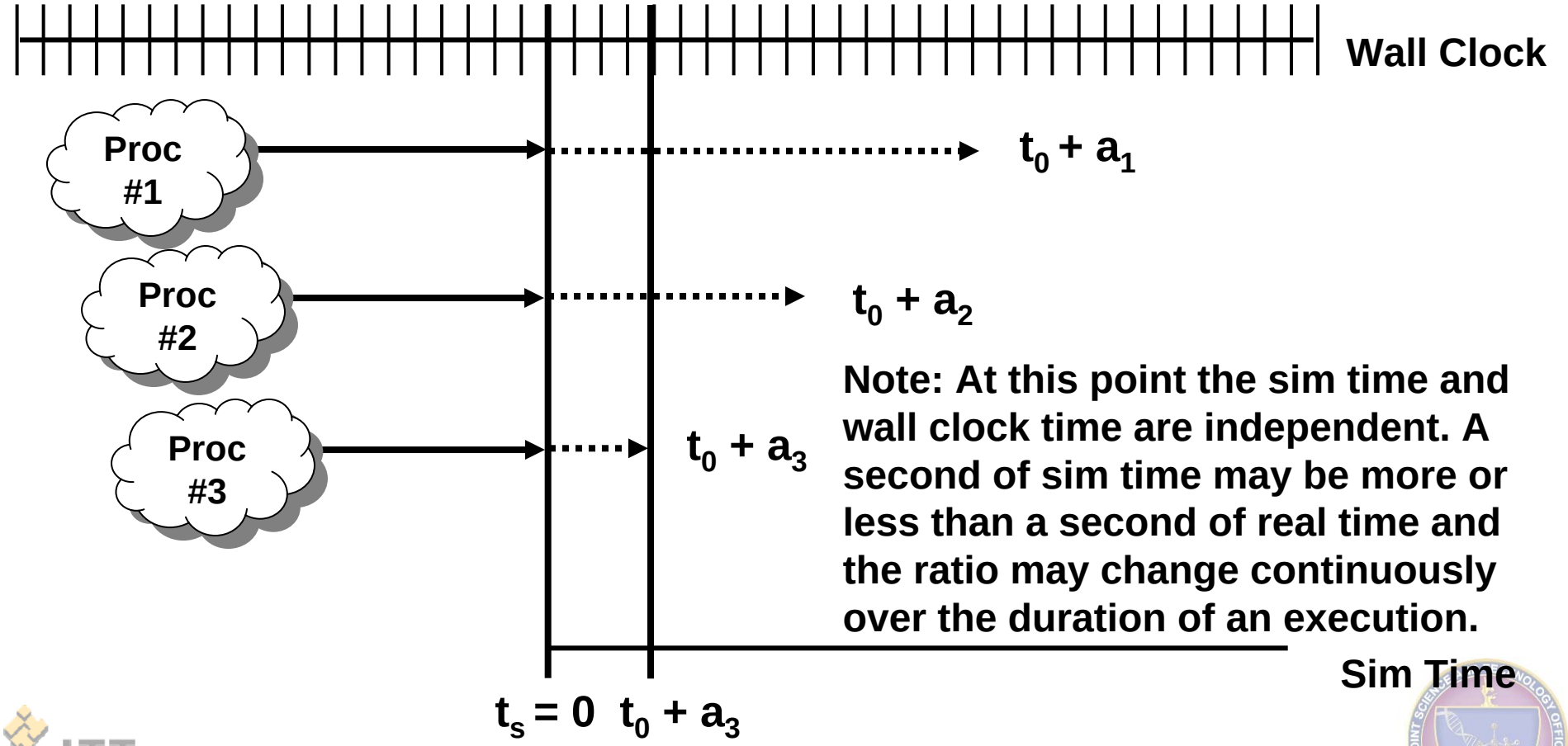
Process Execution

- **Time Regulation/Constraint started**
- **Request Initial Time advance**



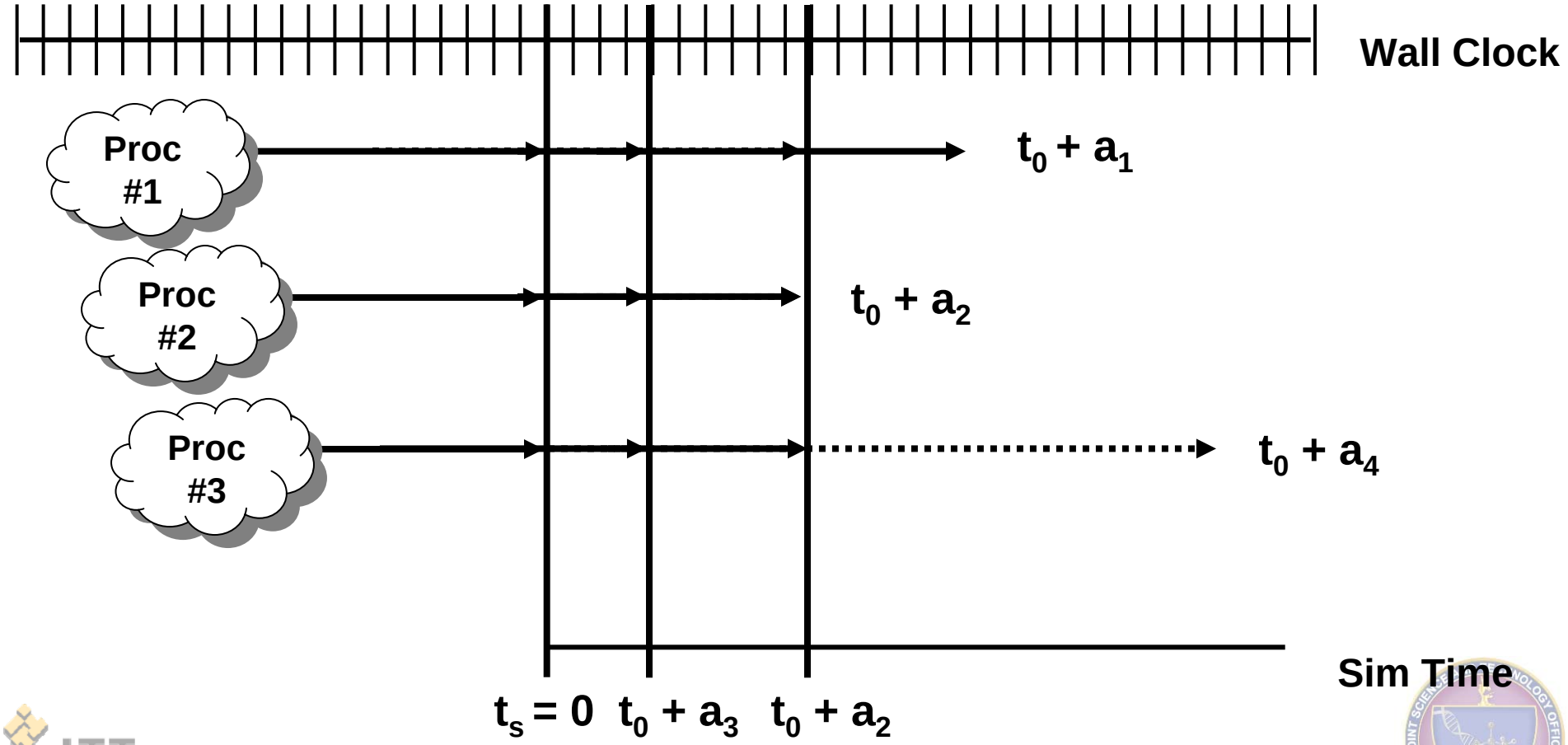
Process Execution

- **All the processes now complete any processing to get to time t0+a3**



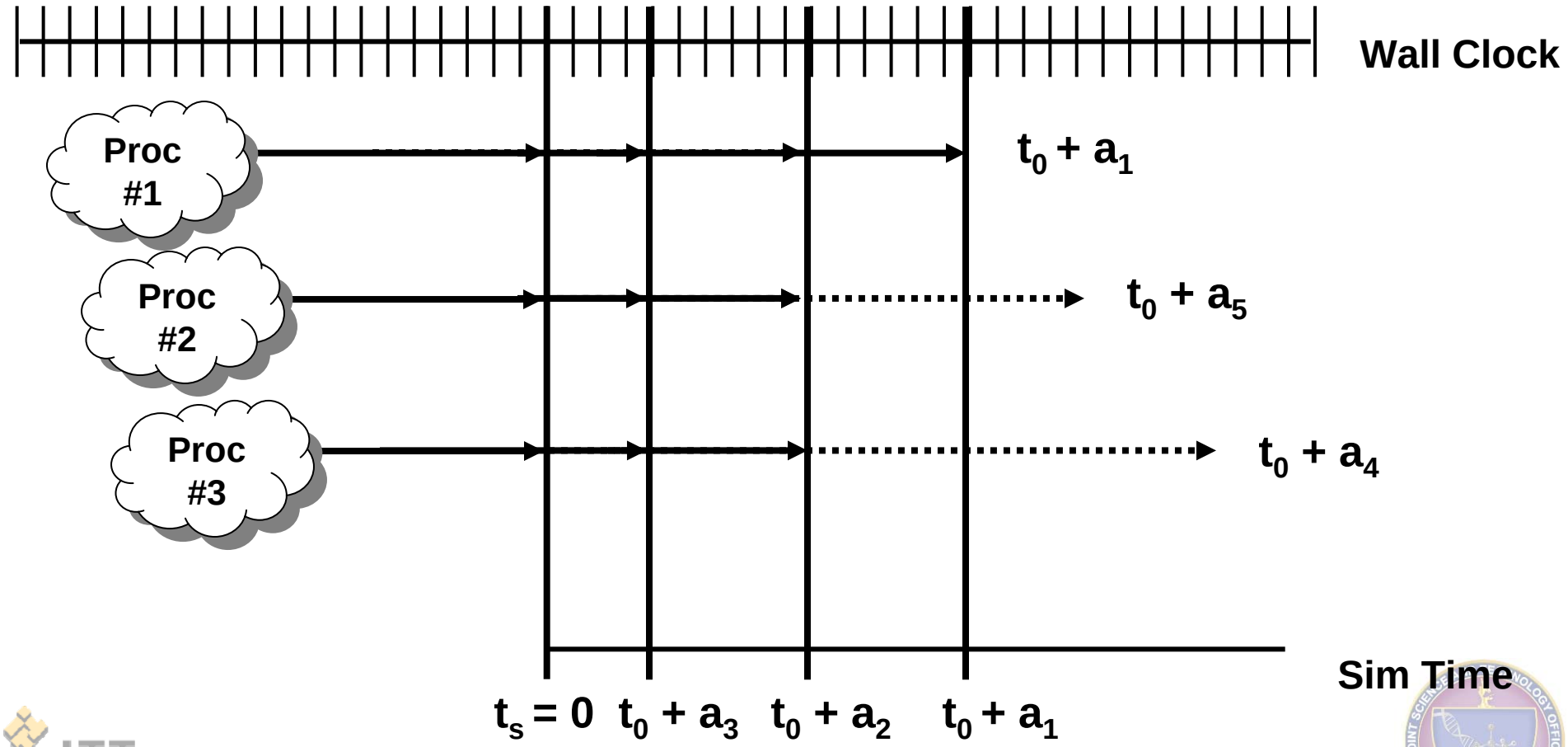
Process Execution

- **Proc #3 then issues another Time Advance Request**



Process Execution

- **Next Iteration**



Updating the CB Sim Suite

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- **Extend the existing ETS to include biological elements**
- Develop an interface to widely-used constructive simulations

Extend the existing ETS to Include Biological Elements

- Use a community-accepted toxicity model
  - LD_{50} and probit slope used
    - Recommendation from senior community
    - Derived from chemical methodology
      - All three algorithms [8-10] selectable
    - Limited agent data available

- Bio considerations for future work
  - Delay between exposure and onset of symptoms/impacts
  - Most simulations do not last long enough for onset of effects
  - Need the capability to work exposure portion then effects portion
    - Predosing
    - "Jump time" during simulation/non-real-time simulation
      - Non-trivial problem
      - Research area

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Develop an Interface to Widely-Used Constructive Simulations

- Happening now (FY06/07): Battle Lab Collaborative Simulation Environment (BLCSE)
- Happening soon (FY07/08): Modeling Architecture for Technology and Research Experimentation (MATREX)
- Modifications required on both sides of the interface
  - Inputs from the SAF drive the Sim Suite
    - Flags need to be added for MOPP, etc.
  - Outputs from the Sim Suite need to affect the behaviors of the SAF
    - Effects of CB insults need to be modeled in the SAF behaviors
      - This is happening in the BLCSE

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Other Current Sim Suite Work

- JSTO MSB (FY06-07)
  - Verification of the CB Sim Suite
  - Robust User Documentation
  - Preliminary GUI development
- ATEC/FCS CTO upgrade of NCBR and DAS for FCS T&E (FY04-FY10)
  - Urban environments
  - Higher fidelity sensor representations in DAS (“ROC” curves)
  - Independent verification
- JSTO T&E (FY06-FY08)
  - Currently defining requirements for M&S architecture to support T&E
    - Collective Protection
    - Individual Protection (FY07)
    - Contamination Avoidance

CB Sim Suite

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- Represents
  - Chem/Bio Threat Propagation/Delivery
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Questions or Comments?

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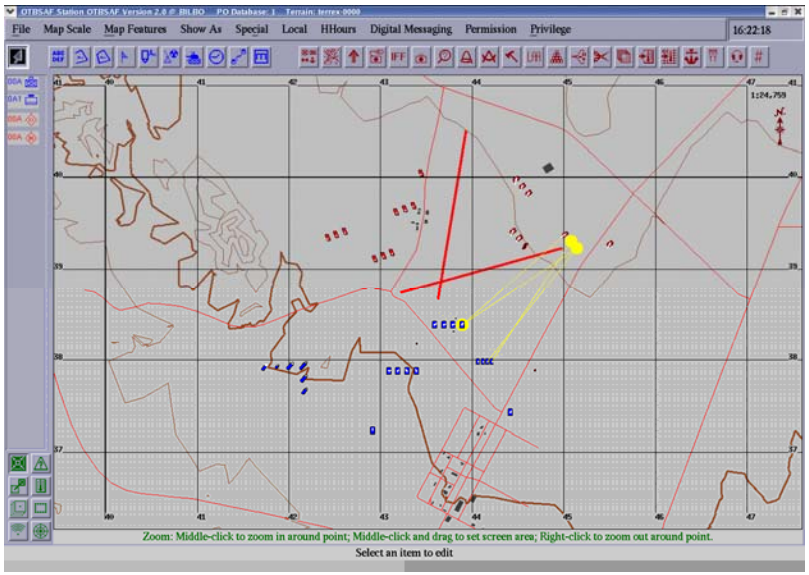
Backup Slides

OneSAF Testbed Baseline

- Managed by PEO STRI
- Entity-level distributed simulation that represents combined arms tactical operations up to the battalion level
- Entities behave semi-autonomously
  - Entity behaviors and tactics generated based on orders to top-level units or subordinate units



NCBR

- Simulates multiple CBR events simultaneously in real time
  - Expanded to include smoke propagation
  - Nuclear support in previous version release
    - No current customers
- Validated physics-based models for hazard propagation
  - DTRA's SCIPUFF
  - NSWC's VLSTRACK
- Terrain and meteorology effects
  - 4D met—external/OASES or scripted feeds
  - 3D terrain (CTDB, ERC)

Medium Range Missile GB release
yellow -> vapor green -> aerosol

NCBR

- Communicates environment information with other simulators
  - DIS, HLA compliant
  - Hazard output (outputs gridded, 3D hazard data)
    - 3D Gaussian puffs (air concentration – vapor and aerosol)
    - 2D conformal grids (concentration, dose, ground deposition)
    - Post processing to XML output
  - Supports
    - Sensor modeling (point, standoff)
    - 2D/3D visualization
    - Exposure modeling (ETS)

CB Simulation Suite Architecture

Player

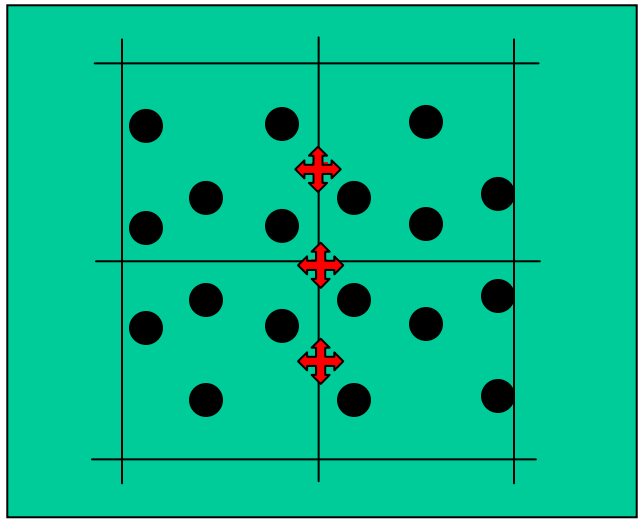
- Performs the hazard delivery

- Detonation
  - Standard munition/agent combination
    - 122 Artillery
    - 152 Artillery
    - Small Rocket
    - Large Rocket
    - 100 kg Bomb
    - 250 kg Bomb
    - 500 kg Bomb
    - 1000 kg Bomb
    - Medium Range Missile
    - Long Range Missile
    - Cruise Missile
  - Chem point sprayer detonation
  - Chem point source detonation

- Laydown
  - Artillery Volley – 6 shells (1 Battery)
  - Small Artillery – 18 shells (1 Battalion)
  - Medium Artillery – 54 shells (3 Battalions)
  - Small Bomb – 2 bombs side by side
  - Medium Bomb – 4 bombs in a square pattern
  - Large 500k Bomb – 8 bombs
  - Large 1000k Bomb – 4 bombs
  - MLRS Battery – 240 Shells
  - MLRS Battalion – 720 Shells

Small Laydowns

- 122 mm Battery, 3 rounds – Equivalent of a 122 mm battery arrayed in a “lazy W”, firing 3 volleys, at aimpoints 50 meters apart in range. See pattern below.
  18 rounds x 2 kg agent/round x 60% dissemination efficiency = 21.6 kg of agent



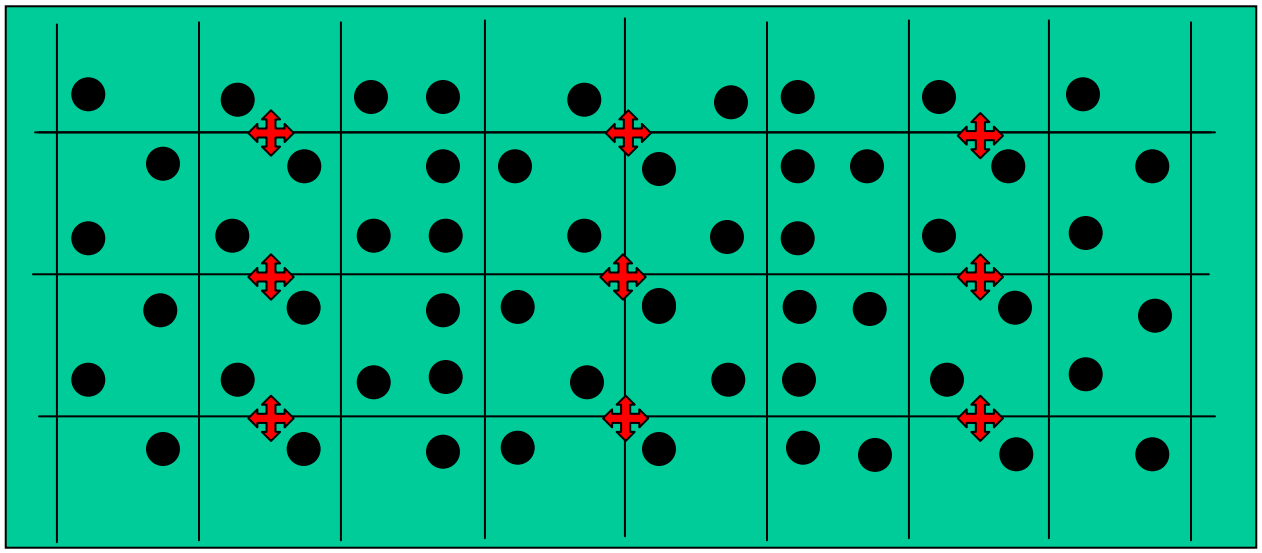
Grid line spacing
= 100 meters

aimpoints

- 2 x 100 kg bombs, simultaneous impact 50 meters apart.
  2 bombs x 25 kg agent/bomb x 60% dissemination efficiency = 30 kg of agent

Medium Laydowns

- 152 mm Battalion, 3 rounds – Equivalent of 3 firing batteries, each firing a volley at aimpoints that are 250 meters apart laterally. Subsequent volleys are at aimpoints 100 meters north and south of initial aimpoints. See pattern below.
  54 rounds x 4 kg agent/round x 60% dissemination efficiency = 129.6 kg of agent



Grid line spacing = 100 meters

aimpoints

- 4 x 250 kg bombs, simultaneous impact in square pattern 50 meters apart.
  4 bombs x 75 kg agent/bomb x 60 % dissemination efficiency = 180 kg of agent

Large Laydowns

• 8 x 500 kg bombs, simultaneous impact in 2 rows of 4 bombs each, 100 meters between rows and between bombs. 8 bombs x 125 kg/bomb x 60% dissemination efficiency = 600 kg of agent

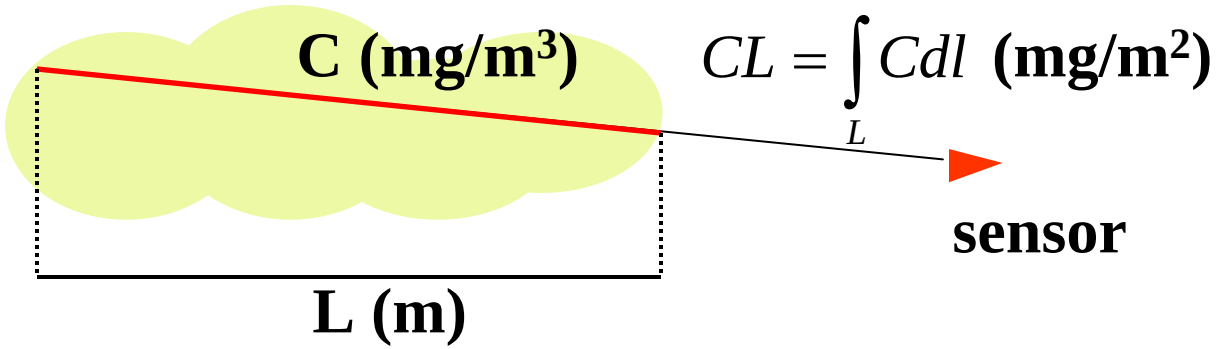
• 4 x 1000 kg bombs, simultaneous impact in square pattern, 150 meters apart. 4 bombs x 300 kg/bomb x 60% dissemination efficiency = 720 kg of agent

CB Analyzer

- CB Analyzer processes logged data at time stamps with both vehicle data and hazard data
- A polar stepped scan pattern is executed for every vehicle time stamp
- Reported data
  - The Maximum CL
  - Elevation/Azimuth of the Max CL Detection
  - Extents of the cloud in Elevation and Azimuth
  - CL at Elevation/Azimuths of interest

What is CL (in simulation)

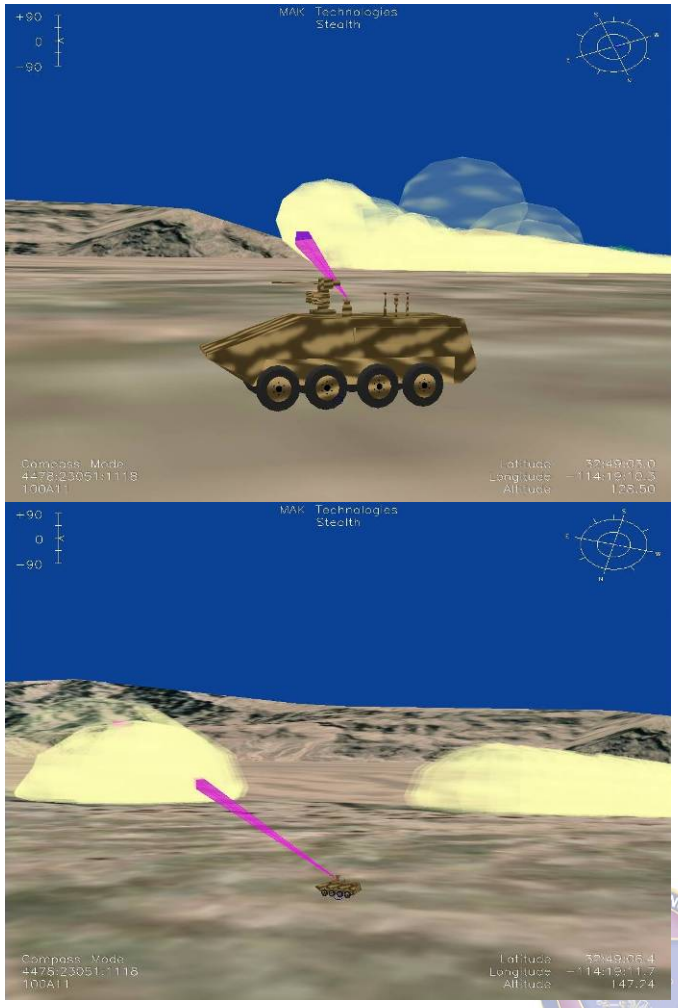
- Path integrated concentration aka concentration pathlength (CL)
- C – average concentration along pathlength
- L – length along the sensor field of view that represents the distance across the cloud



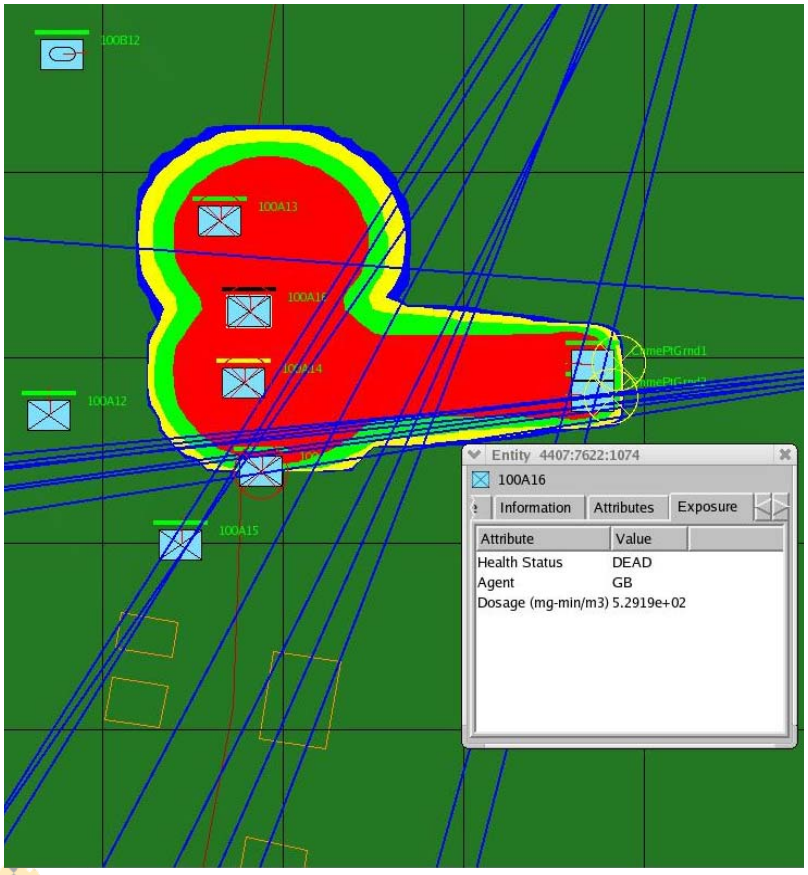
Reference: Visualization of Foreign Gases in Atmospheric Air, Gruber Jr. , *et al.*, 11th International Symposium of Flow Visualization

CB Dial-A-Sensor

- Simulation tool (architecture) for representing any general technology class of CB particle and vapor sensors
  - Point and stand-off
  - Active and passive systems
- Capability to “dial” parameters to set performance characteristics for a known set of detector technology families
- Multiple data output mechanisms
  - Provide data to constructive simulations via DIS/HLA
  - Write data to a local file for analysis
  - Stimulate other system/operator software
    - Sensor user I/F
    - C2 messages



Exposure Toxicity Server



- Scalable methodology/tool for contamination and exposure tracking to support constructive simulation entity level simulation
- Selectable fidelity/methodology for human effects/lethality modeling
- Track effects status of entities in simulation

Exposure Toxicity Server

- Design Approach
  - Uses community accepted toxicity/lethality methodologies
    - Grotte/Yang
  - Allows user to select specific implementation (equation)

$$Y = b_o + b_1 \log(C) + b_2 \log(t) \quad [8]$$

$$Y = b_o + b_2 \log(C^n t) = b_0 + b_2 \log(L1) \quad [9]$$

$$Y = b_o + b_1 \log(C t^{1/n}) = b_0 + b_1 \log(L2) \quad [10]$$

- Leverages/reuses CB Dial-A-Sensor infrastructure for exposure calculation, entity tracking and subscription

ETS Exposure Calculations