Simulation Team

Distributed and Interoperable Modeling & Simulation

M&SNet

DIME University of Genoa
via Opera Pia 15
16145 Genova, Italy
www.itim.unige.it

Agostino G. BRUZZONE
agostino@itim.unige.it

Riccardo DI MATTEO
riccardo.dimatteo@simulationteam.com

SIlENI
SImulation LEarning iNItiative

Simulation Team
www.simulationteam.com

Liophant Simulation ***www.liophant.org/downloads/st_dims_4cw.pdf***

Simulation Team

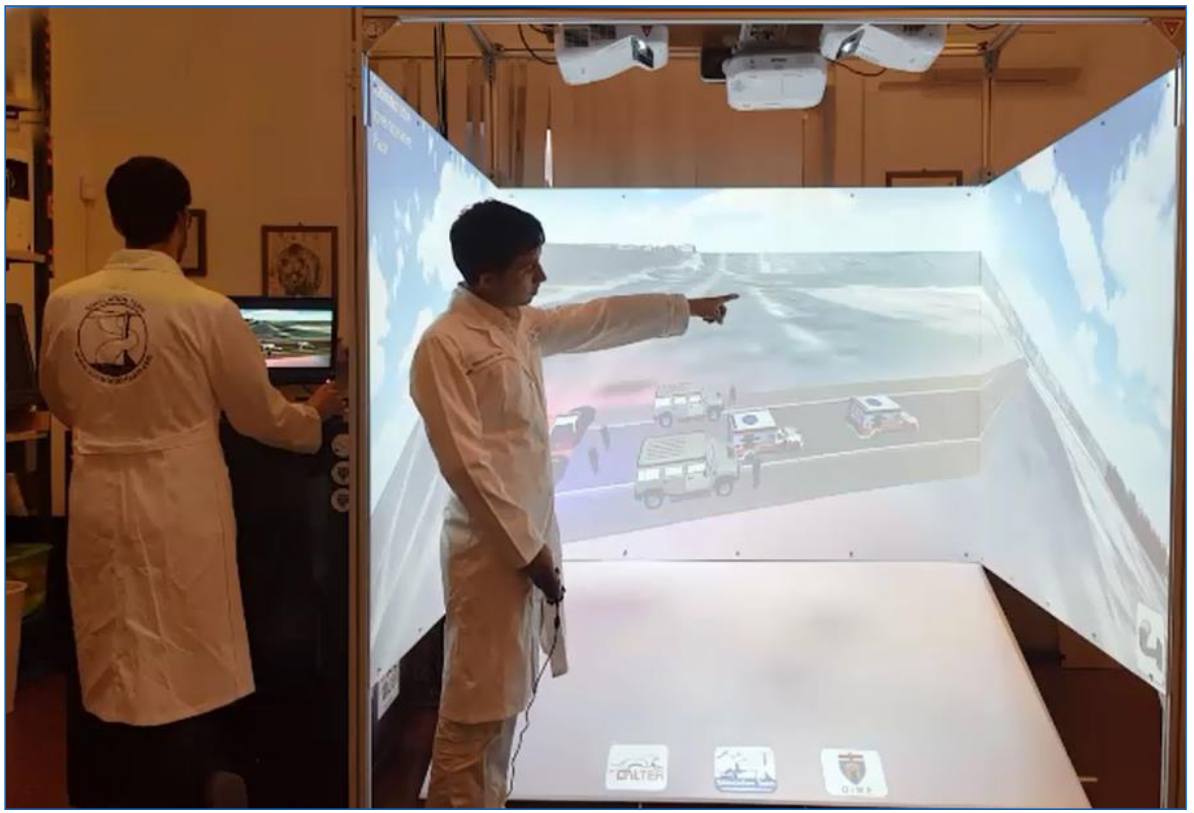
Who's Who
Agostino G.Bruzzone

- Basic Engineering Studies in Italian Naval Academy, Pisa and Genoa University
- Mechanical Engineer
- Expert in Modelling & Simulation, Project Management, Operation Management, Industrial Plants &Logistics
- Expertise as Consultant and in Industry, Military Service and Academia
- Experience in Projects with Major Companies (e.g.IBM, ABB, Dupont, Boeing, FCA Group, COOP, CAE, Solvay) and Agencies (e.g. NASA, NATO, DoD, EDA, DGA, etc.).
- Served as M&S Project Leader for NATO STO CMRE in Extended Maritime Framework
- Full Professor in DIME , University of Genoa
- Visiting Professor in Several Universities in North & Latin America, Europe, Australia, Africa and Asia
- President of Simulation Team
- World Director of the M&S Net (34 Centers worldwide)
- Director of McLeod Institute of Simulation Science Genoa
- Project and Program Manager in R&D Projects and Joint Ventures with Industries and Agencies for several USD millions
- Founder and President of Liophant
- Director of the International Master Program in Industrial Plants ("Impiantistica Industriale") of Genoa University.

Simulation Team

Who's Who
Riccardo di Matteo

- First Class of Douhet Aeronautical Military College and Naval Academy
- Bachelor in Engineering in La Spezia, Master in Mechanical Engineering by Genoa University
- Thesis on Simulation for the Protection of Off-Shore Critical Infrastructures at NATO Science and Technology Organization, Center for Maritime Research & Experimentation
- Member of Simulation Exploratory Experience, lead by NASA, active in creating an HLA Evolved Simulator for a Space Guard System against Debris and Asteroids
- Developer in MAST of advanced interoperable Solutions within the Simulation of Multi Coalition Joint Operations involving Human Modeling
- Developer of Simulation Team SPIDER: an Innovative Immersive Interactive CAVE used in multiple M&S applications
- Member of NATO Modeling and Simulation Group 128 on Human Behavior Modeling
- Speaker at major M&S conferences in Europe, Asia & United States including I3M, CAX Forum, Summer Sim, DHSS, since 2015
- Team Leader in ICAMES2016 organized by Engineering Society in Istanbul
- Track Chair for Serious Games in the International Workshop on Applied Modeling
- Member of the Simulation Team



Simulation Team

University of Genoa

The University of Genoa is one of the oldest in Italy and in the World (founded in 1471 AD), it is located in middle of Italian Riviera.
The students are about 40,000 (about 8,000 new entries), and the engineering departments has about 7,500 students (12% in Savona Branch Departments); in effect the Savona Campus Savona holds about 1,000 Engineering Students.
That campus is located about 2 km from Savona Downtown, in an old complex of barracks recently converted into new University Buildings (over an area of 200,000 m^2).

For further Information about the University of Genoa:

www.itim.unige.it
www.unige.it

Simulation Team

What Department?
DIME - University of Genoa

DIME was established in spring 2012 as DIPTEM adding; the DIPTEM was originally founded in 1997 as evolution of the Institute of Technology and Industrial Management (ITIM) that was operative from '60.

DIME is composed by about 85 faculty members, 15 technicians and administrative, plus several PhD Students, external Researchers and Consultants. DIME teachers are involved in Undergraduate, Postgraduate and Professional activities in Engineering, Management. DIME is active in R&D Projects for major Institutions, Companies and Governmental Organisations. DIME co-operates actively with major Excellence Centers World-Wide.

Simulation Team

McLeod Inst. Simulation Science
M&S Net Genoa Center

Email: agostino.bruzzone@m-s-net.org
URL: www.m-s-net.org
www.mcleodinstitute.org

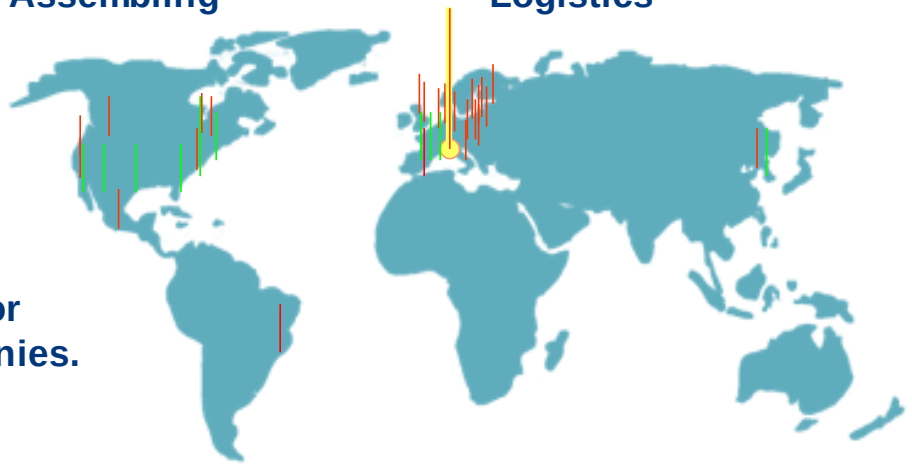
MITIM Simulation Team Genoa Center

The research group of DIPTEM of *Genoa University* is active from '60 in Simulation applied to Industrial Engineering and is part of McLeod Institute and M&S Net

The activities involve modeling, simulation, VV&A and analysis of Industrial Applications and Services (design, re-engineering, management, training etc.) as:

- Power
- Harbor Terminals
- Manufacturing
- Transportation
- Defense
- Public Services
- Assembling
- Project Management
- Environment
- Logistics

The Department staff is in touch world-wide with the simulation community and is present actively to conferences, exhibitions and working meetings with the major Associations, Agencies and Companies.



McLeod: 28 Institutes and 34 M&S Net Centers World-Wide

Simulation Team

Simulation Team

Universities, Research Centers and Companies operating worldwide in synergy for developing Innovative Solutions with a particular focus in Modelling and Simulation

DIME
Università
di Genova

Genoa

Liophant
Simulation

CentraLabs
Cagliari

CSU
Australia

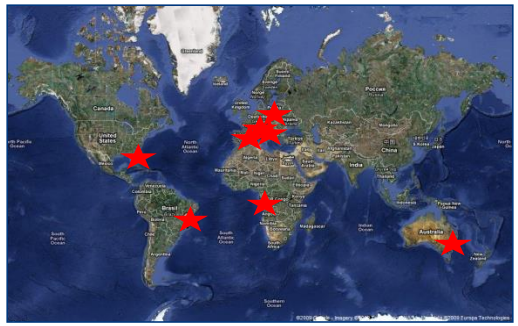
CIREM
Università di Cagliari

MSC-LES

Mik
Riga TU

DIPMEC
Università Calabria

SimCenter Universitat
Autonoma de Barcelona



Università di Perugia

LSIS
Marseille

Rio de Janeiro
Brazil

Simulation Team
Genoa Center

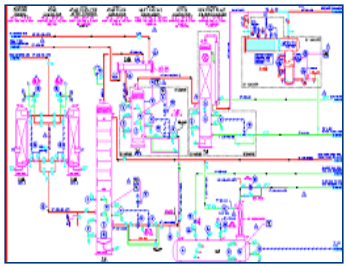
McLeod Institute of
Technology & Interopeable
Modeling Simulation Genoa

IMS-LAPS
Univ.Bordeaux

DIPTEM
Università di Genova

M&S Concepts applicable to interoperability in HLA & DIS

Why Modeling & Simulation?



Internal Complexity → Complex Behaviors

↓

Simulation:
More Efforts
More Capabilities
Reusable Model

←

Not Linear Systems
Not valid Simplification Hypotheses
Boundary Conditions are Critical
No Generalization

↑

External Complexity → Many Interaction

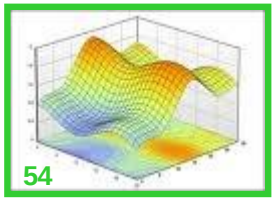
Classification Criteria for M&S in Military Applications

Classification of Simulation for Military Applications:

- **Live Simulation**
  - *A Simulation where real people are operating real systems*

- **Virtual Simulation**
  - A simulation involving real people operating simulated systems (MIL)

- **Constructive Simulation**
  - A simulation involving Simulated people operating simulated systems



Simulation Team

Simulation Types

- Interoperable
- Distributed
- Parallel
- M&S as a Service
- Deterministic
- Stochastic
- Man-in-the-Loop
- HW-in-the-Loop

SIMULATION

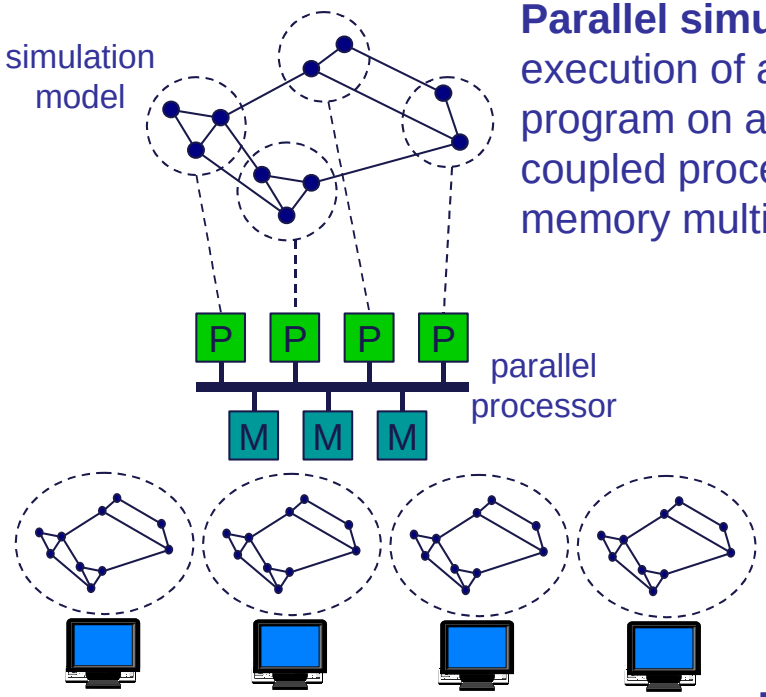
- Discrete Event
- Continuous
- Combined
- Hybrid
- Real-Time
- Slow-Time
- Quasi-Real Time
- Fast-Time Reality

Simulation Team

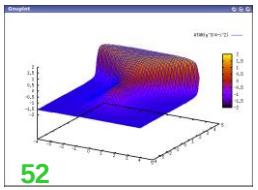
Interoperable Simulation and Distributed Interactive Simulation

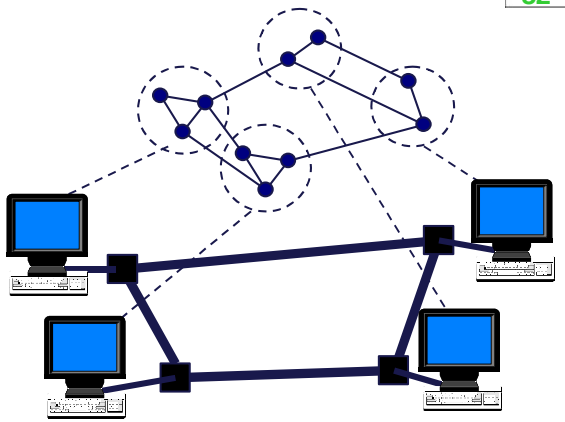
DIPTEM
Università di Genova

Parallel and Distributed Simulation



Parallel simulation involves the execution of a *single* simulation program on a collection of *tightly* coupled processors (e.g., a shared memory multiprocessor).





Distributed simulation involves the execution of a *single* simulation program on a collection of *loosely* coupled processors (e.g., PCs interconnected by a LAN or WAN).

Replicated trials involves the execution of *several*, independent simulations concurrently on different processors

Reasons to Use Parallel / Distributed Simulation

Enable the execution of time consuming simulations that could not otherwise be performed (e.g., simulation of the Internet)

- Reduce model execution time (proportional to # processors)
- Ability to run larger models (more memory)

Enable simulation to be used as a forecasting tool in time critical decision making processes (e.g., air traffic control)

- Initialize simulation to current system state
- Faster than real time execution for what-if experimentation
- Simulation results may be needed in seconds

Create distributed virtual environments, possibly including users at distant geographical locations (e.g., training, entertainment)

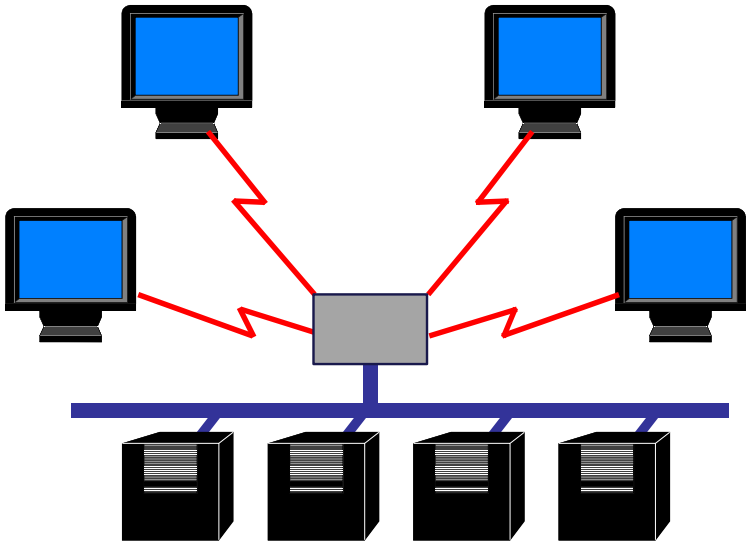
- Real-time execution capability
- Scalable performance for many users & simulated entities

Geographically Distributed Users/Resources

Geographically distributed users and/or resources are sometime needed

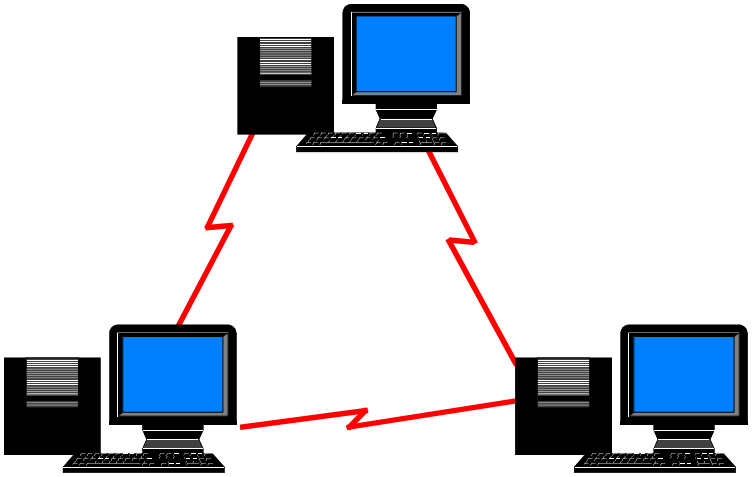
- Interactive games over the Internet
- Specialized hardware or databases

Server architecture



Cluster of workstations on LAN

Distributed architecture



Distributed computers

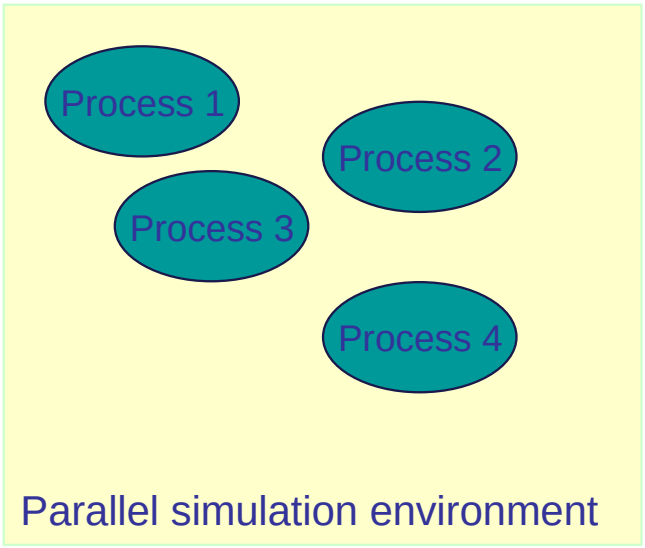
WAN interconnect

LAN interconnect

Simulation Team

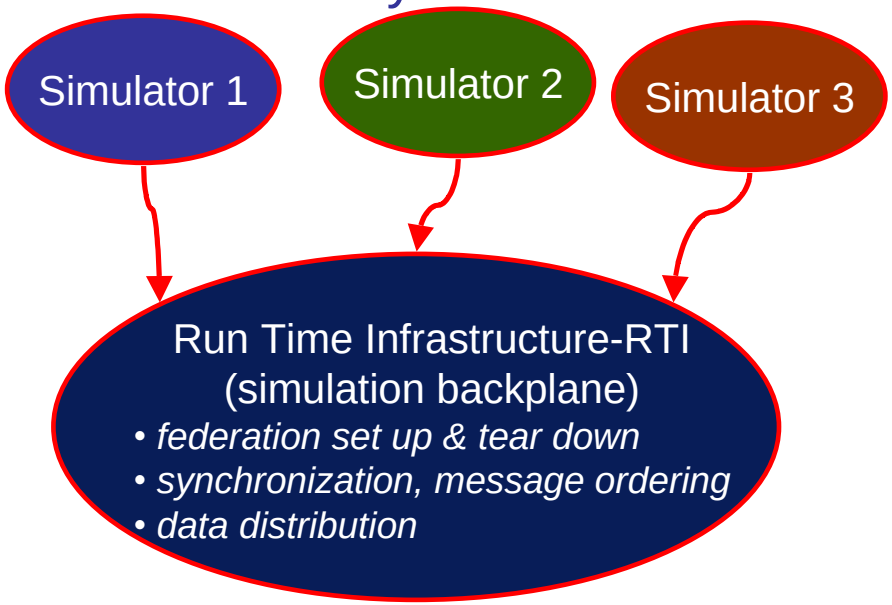
Stand-Alone vs. Federated Simulation Systems

Stand-Alone Simulation System



Homogeneous programming environment
- *simulation language*

Federated Simulation Systems



Interconnect autonomous, heterogeneous simulators
- *interface to RTI software*

Simulation Team

Principal Application Domains

Parallel Discrete Event Simulation (PDES)

- Discrete event simulation to analyze systems
- Fast model execution (as-fast-as-possible)
- Produce same results as a sequential execution
- Typical applications
  - Telecommunication networks
  - Computer systems
  - Transportation systems
  - Military strategy and tactics

Distributed Virtual Environments (DVEs)

- Networked interactive, immersive environments
- Scalable, real-time performance
- Create virtual worlds that appear realistic
- Typical applications
  - Training
  - Entertainment
  - Social interaction

Simulation Team

Historical Perspective

High Performance Computing Community

Chandy/Misra/Bryant algorithm

Time Warp algorithm

early experimental data

second generation algorithms

making it fast and easy to use

1975 1980 1985 1990 1995 2000 2005 2010

SIMulator NETworking (SIMNET) (1983-1990)

High Level Architecture (1996 - today)

HLA1516

HLA Evolved

Defense Community

Distributed Interactive Simulation (DIS)

Aggregate Level Simulation Protocol (ALSP) (1990 - 1997ish)

Dungeons and Dragons Board Games

Adventure (Xerox PARC)

Multi-User Dungeon (MUD) Games

MMOG

Multi-User Video Games

Mobile MMOG

MMORPG

Internet & Gaming Community

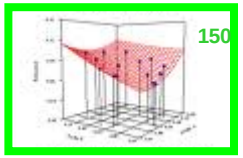
Concept of Interoperability

- Interoperability is a property referring to the ability of diverse systems and organizations to work together (inter-operate).

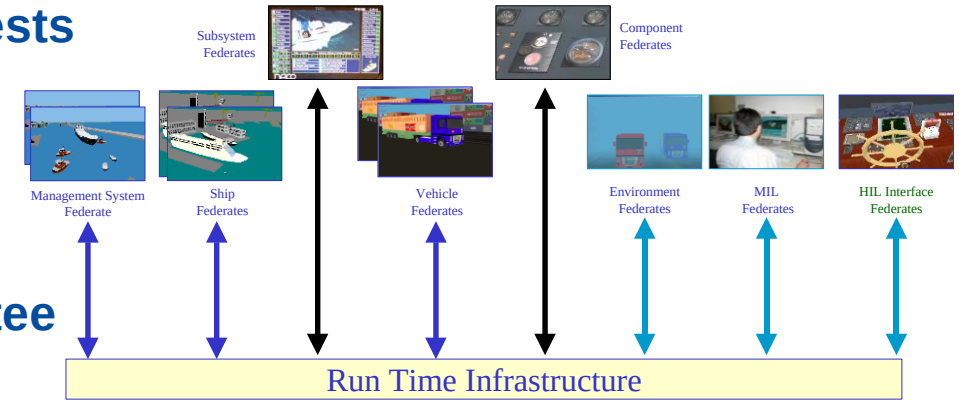
Composability & Interoperability

- **Software Interoperability: the ability of two or more systems or components to exchange information and to use the information that has been exchanged. IEEE Standard Computer Dictionary**
- **Simulation Composability: the capability to select and assemble simulation components in various combinations into valid simulation systems to satisfy specific user requirements. Somewhere on the scale of integration effort, the problem changes from the composition of components to one of component interoperability when a "substantial effort" is required, Petty & Weisel**
- **Interoperability: The Capability, promoted, but not guaranteed by joint conformance with a given set of standards, that enables heterogeneous equipment, generally built by various vendors, to work together in a network environment. IEEE 1278.2**
- **DIS Interoperable: Two or more simulations/simulators that, for a give exercise, are DIS compliant and DIS Compatible and whose performance characteristics support the fidelity required for the exercise IEEE 1278.4**
- **Simulation Interoperability: The ability of a model or simulation to provide services to and accept services from other models and simulations, and to use the services so exchanged to enable them to operate effectively together. DMSO**

V&V for Complex Systems



- It is critical to understand, that due to the high not linear nature of most of simulation models it is not possible to apply superposition principle.
- Due to this reason it even more evident that even if all the sub models, objects or federates are able to pass VV&T (Validation, Verification and Testing) this fact don't allows to conclude that the overall simulator is validated and verified
- It is necessary to conduct tests and experiments and to complete specific VV&A (Verification Validation and Accreditation) even on the whole Federation to guarantee this results



Origins: SIMNET

- In the beginning there was SIMNET.
  - Prior to 1983, military training simulations existed as stand alone units that were developed to fit a specific purpose. If a simulation did not meet a certain objective, a new one was developed.
  - In the late 1970's, the military began considering linking simulators together.
  - As a result, the Defense Advanced Research Projects Agency (DARPA) developed Simulator Networking (SIMNET).

    This effort linked tank trainers together to support collective unit training for tank companies

Next: Distributed Interactive Simulation (DIS)

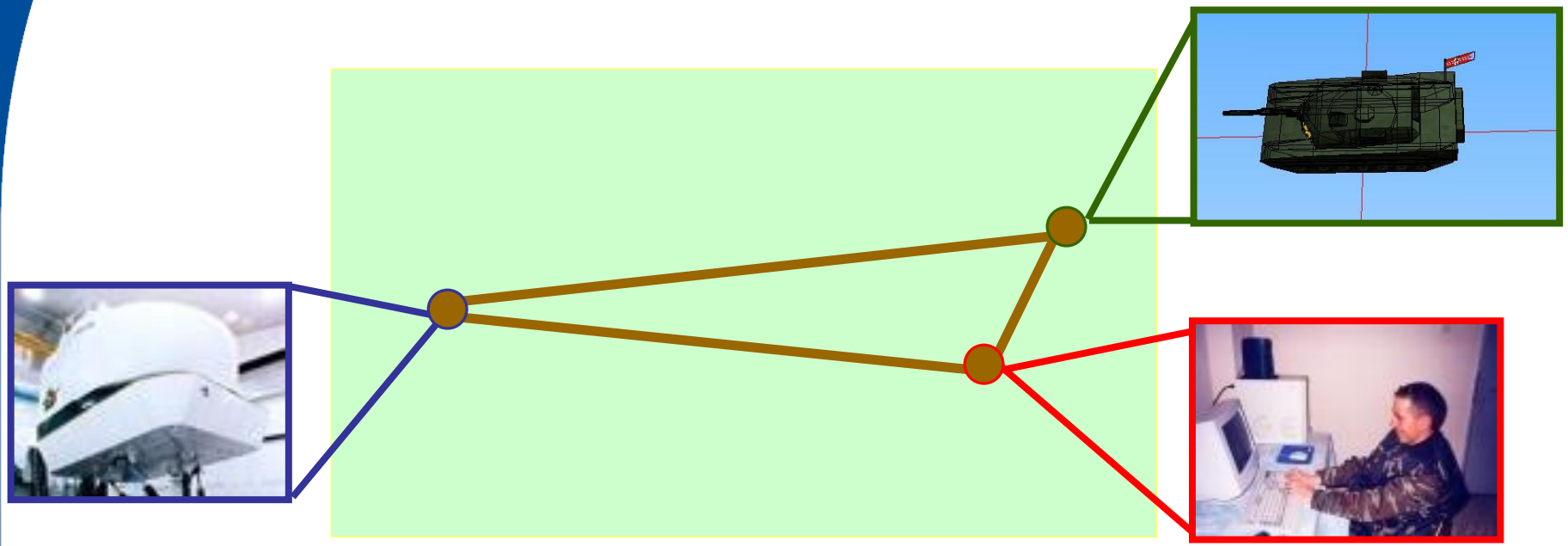
- ***SIMNET's success spawned a desire to develop general purpose protocols to support all types of network-based training applications.***

- ***The Distributed Interactive Simulation (DIS) protocol appeared in 1993 to "…create synthetic, virtual environments by systematically connecting separate subcomponents of simulations which reside at distributed, multiple locations."***

- **Generally real time, entity-level simulations that communicate via a Protocol Data Unit (PDU).**
- **PDUs are bit-encoded packets that report entity states and simulation events, e.g. weapon fire event.**
- **DIS-based simulations employ dead reckoning to reduce the number of entity state PDUs that must be passed among simulations.**

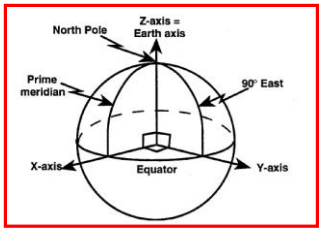
Example: Distributed Interactive Simulation (DIS)

"The primary mission of DIS is to define an infrastructure for linking simulations of various types at multiple locations to create realistic, complex, virtual 'worlds' for the simulation of highly interactive activities"



developed in U.S. Department of Defense, initially for training
distributed virtual environments widely used in DoD; growing use in other areas (entertainment, emergency planning, air traffic control)

DIS Design Principles



Autonomy of simulation nodes
- simulations broadcast events of interest to other simulations; need not determine which others need information
- receivers determine if information is relevant to it, and model local effects of new information
- simulations may join or leave exercises in progress

Transmission of "ground truth" information
- each simulation transmits absolute truth about state of its objects
- receiver is responsible for appropriately "degrading" information (e.g., due to environment, sensor characteristics)

Transmission of state change information only
- if behavior "stays the same" (e.g., straight and level flight), state updates drop to a predetermined rate (e.g., every five seconds)

"Dead Reckoning" algorithms
- extrapolate current position of moving objects based on last reported position

Simulation time constraints
- many simulations are human-in-the-loop
- humans cannot distinguish temporal difference < 100 milliseconds
- places constraints on communication latency of simulation platform

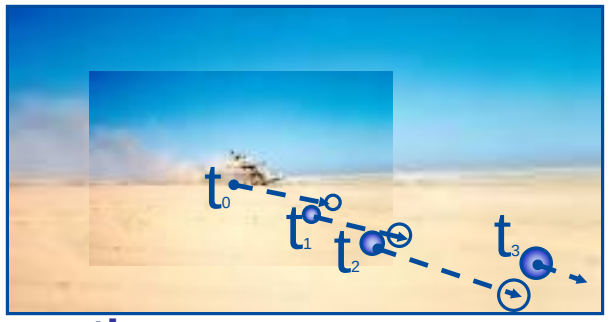
Distributed Simulation Example & Limitations

- Virtual environment simulation containing two moving vehicles
- One vehicle per federate (simulator)
- Each vehicle simulator must track location of other vehicle and produce local display (as seen from the local vehicle)
- Approach 1: Every 1/60th of a second:
  - Each vehicle sends a message to other vehicle indicating its current position
  - Each vehicle receives message from other vehicle, updates its local display

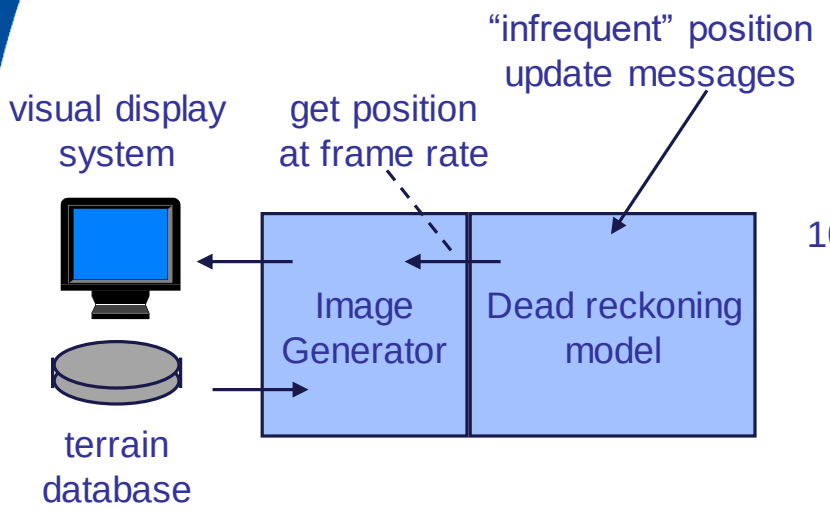
- *Position information corresponds to location when the message was sent; doesn't take into account delays in sending message over the network*
- *Requires generating many messages if there are many vehicles*

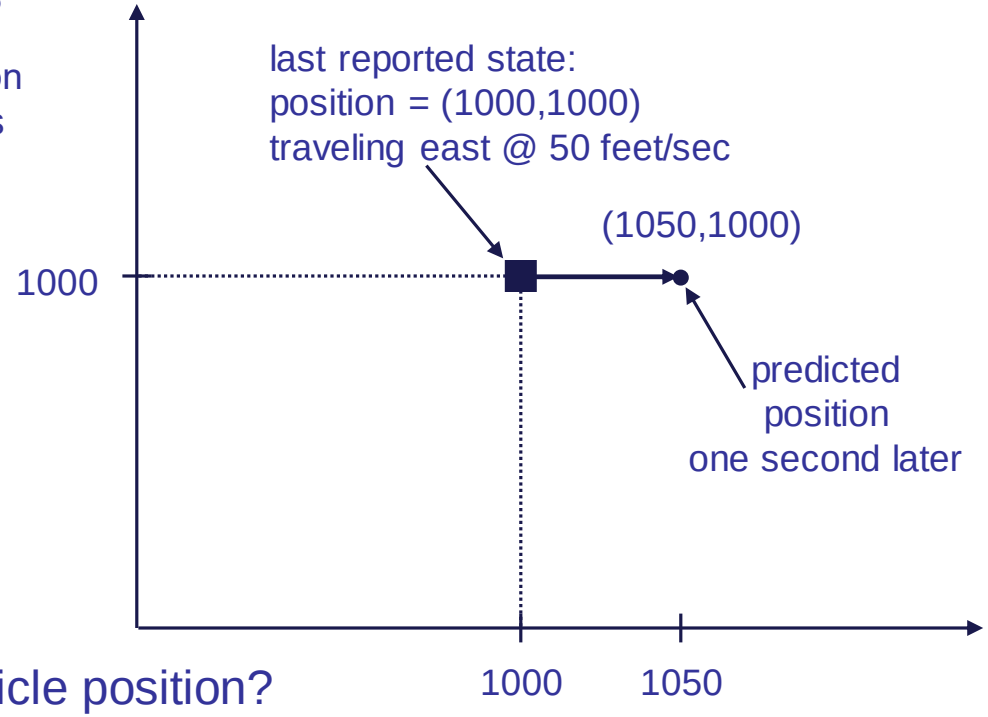
Simulation Team

Dead Reckoning



- **Send position update messages less frequently**
- **local dead reckoning model predicts the position of remote entities between updates**





When are updates sent?

How does the DRM predict vehicle position?

Dead Reckoning Models (DRM)

1728.1995 B.1.4

DRM are defined based on 3 parameters:

- **Rotation: fixed (F) or rotating (R).**
- **DR rate: constant rate of position (P) or rate of velocity (V)**
- **Coordinate system: world (W) or body axis coord. (B)**

DRM Parameters include:

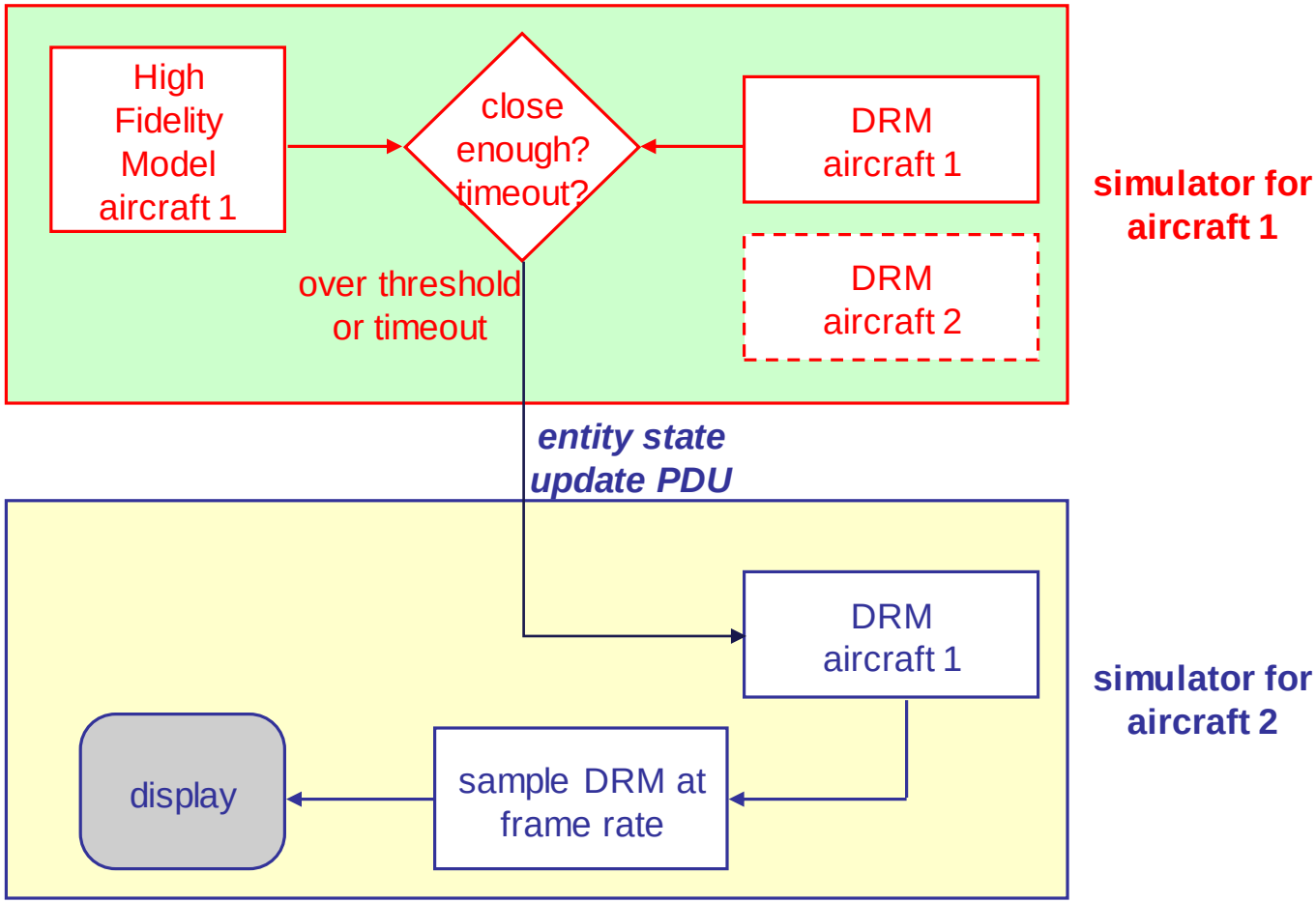
- **Dead Reckoning Algorithm Field (8 bit length)**
- **Dead Reckoning Other Parameters Field (120)**
- **Entity Linear Acceleration Record (96)**
- **Entity Angular Velocity Record (96)**

Simulation Team

Re-synchronizing the DRM

When are position update messages generated?

- **Compare DRM position with exact position, and generate an update message if error is too large**
- **Generate updates at some minimum rate, e.g., 5 seconds (heart beats)**



Dead Reckoning Models (DRM)

1728.1995 B.1.4

DRM are defined based on 3 parameters:

- **Rotation: fixed (F) or rotating (R).**
- **DR rate: constant rate of position (P) or rate of velocity (V)**
- **Coordinate system: world (W) or body axis coord. (B)**

DRM Parameters include:

- **Dead Reckoning Algorithm Field (8 bit length)**
- **Dead Reckoning Other Parameters Field (120)**
- **Entity Linear Acceleration Record (96)**
- **Entity Angular Velocity Record (96)**

Simulation Team

$$\omega = (\omega_x^2 + \omega_y^2 + \omega_z^2)^{\frac{1}{2}}$$

DRM

$$[DR] = \frac{(1-\cos(|\omega|\Delta t))}{|\omega|^2}\omega\omega^T + \cos(|\omega|\Delta t)I - \frac{\sin|\omega|\Delta t}{|\omega|}\Omega$$

Field	Model	Formula
1	STATIC	N/A
2	DRM (FPW)	$P = P_o + V_o\Delta t$
3	DRM (RPW)	1) $P = P_o + V_o\Delta t$ 2) $[R]_{w->b} = [DR][R_o]_{w->b}$
4	DRM (RVW)	1) $P = P_o + V_o\Delta t + \frac{1}{2}A_o\Delta t^2$ 2) $[R]_{w->b} = [DR][R_o]_{w->b}$
8	DRM (RVB)	1) $P = P_o + [R]^{-1}_{w->b}(R1V_b + R2A_b)$ 2) $[R]_{w->b} = [DR][R_o]_{w->b}$
9	DRM (FVB)	1) $P = P_o + [R]^{-1}_{w->b}(R1V_b + R2A_b)$

1728.1995 B.1.5 & B1.6

P Position
V Speed
t time
[DR] DR Matrix
$[R_0]_{w->b}$ Entity Initial World to body orientation Matrix

Field	Model	Formula
10	DRM (RPW)	1) $P = P_o + V_o\Delta t$ 2) $\theta = \theta_o + (d\theta_o/dt)\Delta t$ (see [B6]) where θ in equation 2) represents any of the three Euler angles (θ, Φ, Ψ)
11	DRM (RVW)	(1) $P = P_o + V_o\Delta t + 1/2\ A\ \Delta t^2$ (2) $\theta = \theta_o + (d\theta_o/dt)\Delta t$ (see [B6]) where θ in equation 2) represents any of the three Euler angles (θ, Φ, Ψ)

1728.1995 B.1.7 Additional DMR

$$[R_o] = \begin{vmatrix} \cos\theta\cos\psi & \cos\theta\sin\psi & -\sin\theta \\ \sin\phi\sin\theta\cos\psi - \cos\phi\sin\psi & \sin\phi\sin\theta\sin\psi + \cos\phi\cos\psi & \sin\phi\cos\theta \\ \cos\phi\sin\theta\cos\psi + \sin\phi\sin\psi & \cos\phi\sin\theta\sin\psi - \sin\phi\cos\psi & \cos\phi\cos\theta \end{vmatrix}$$

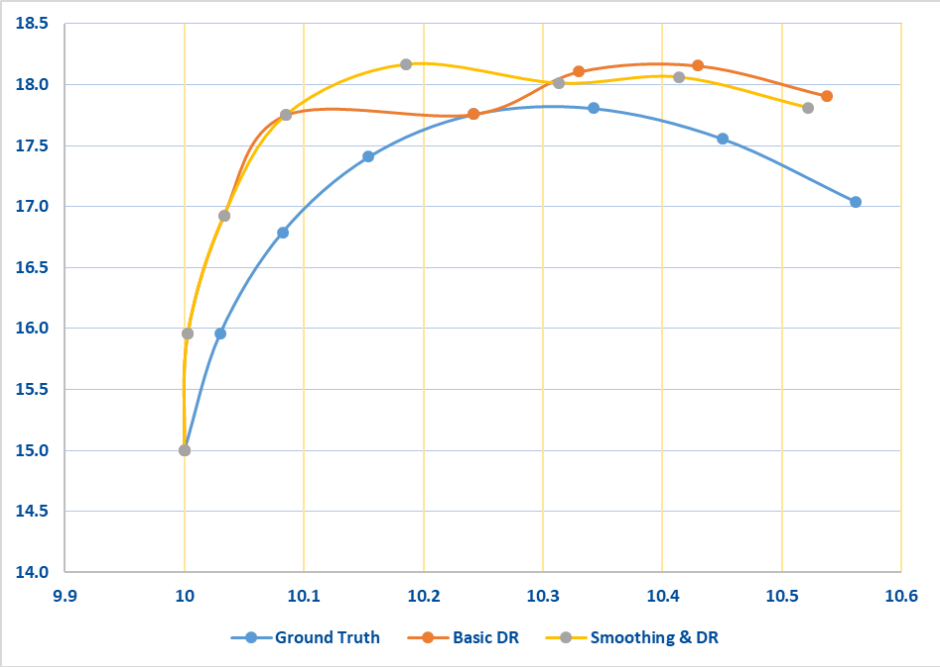
$$[R1] = \frac{|\omega|\Delta t - \sin(|\omega|\Delta t)}{|\omega|^3}\omega\omega^T + \frac{\sin(|\omega|\Delta t)}{|\omega|}I + 1 - \frac{\cos(|\omega|\Delta t)}{|\omega|^2}\Omega$$

$$[R2] = \frac{\frac{1}{2}|\omega|^2\Delta t^2 - \cos(|\omega|\Delta t) - |\omega|\Delta t\sin(|\omega|\Delta t) + 1}{|\omega|^4}\omega\omega^T + \frac{\cos(|\omega|\Delta t) + |\omega|\Delta t\sin(|\omega|\Delta t) - 1}{|\omega|^2}I + \frac{\sin(|\omega|\Delta t) - |\omega|\Delta t\cos(|\omega|\Delta t)}{|\omega|^3}\Omega$$

Simulation Team

Smoothing in DR

Smoothing techniques allows to reduce jumps during synchronization among two units in a DIS Exercise



1728.1995 B.1.8

$$x_i = x_o + (x_f - x_o) i / p$$

- x_f Smoothing Position
- x_f initial position before update
- x_f DR position
- i progressive number
- p number of smoothing points

Valid for i<=p

DIPTEM
Università di Genova

Dead Reckoning Exercise

T	[s]	222.2	Speed	[km/h]	18760	X	[km]	286	Y	[m]	632422	Mass	[kg]	1608	Stage	4
T	[s]	222.3	Speed	[km/h]	18758	X	[km]	286	Y	[m]	632878	Mass	[kg]	1608	Stage	4
T	[s]	222.4	Speed	[km/h]	18755	X	[km]	286	Y	[m]	633335	Mass	[kg]	1608	Stage	4
T	[s]	222.5	Speed	[km/h]	18753	X	[km]	287	Y	[m]	633791	Mass	[kg]	1608	Stage	4
T	[s]	222.6	Speed	[km/h]	18751	X	[km]	287	Y	[m]	634247	Mass	[kg]	1608	Stage	4
T	[s]	222.7	Speed	[km/h]	18748	X	[km]	287	Y	[m]	634704	Mass	[kg]	1608	Stage	4
T	[s]	222.8	Speed	[km/h]	18746	X	[km]	287	Y	[m]	635160	Mass	[kg]	1608	Stage	4
T	[s]	222.9	Speed	[km/h]	18744	X	[km]	288	Y	[m]	635616	Mass	[kg]	1608	Stage	4
T	[s]	223	Speed	[km/h]	18742	X	[km]	288	Y	[m]	636072	Mass	[kg]	1608	Stage	4
T	[s]	223.1	Speed	[km/h]	18739	X	[km]	288	Y	[m]	636528	Mass	[kg]	1608	Stage	4
T	[s]	223.2	Speed	[km/h]	18737	X	[km]	288	Y	[m]	636984	Mass	[kg]	1608	Stage	4
T	[s]	223.3	Speed	[km/h]	18735	X	[km]	289	Y	[m]	637439	Mass	[kg]	1608	Stage	4
T	[s]	223.4	Speed	[km/h]	18732	X	[km]	289	Y	[m]	637895	Mass	[kg]	1608	Stage	4
T	[s]	223.5	Speed	[km/h]	18730	X	[km]	289	Y	[m]	638351	Mass	[kg]	1608	Stage	4
											638806	Mass	[kg]	1608	Stage	4
											639262	Mass	[kg]	1608	Stage	4
											639717	Mass	[kg]	1608	Stage	4
											640173	Mass	[kg]	1608	Stage	4
											640628	Mass	[kg]	1608	Stage	4

Bursting - Ballistic Unified Rocket Simulation Testing and Interactive...

Bursting 1.1

	1st Stage	2nd Stage	3rd Stage	Final Part
Mass [kg]	22500	7075	3649	1620
Fuel [kg]	22000	6575	3150	420
Trust [kgf/s]	97000	27500	15820	479
Time [s]	60	56	59.6	120

Run

Quit

Angle [°] 10 20 30 Enable Target [km] 5500

Integration Mode: Euler

Integration Interval [s]: 0.1

Random Seed: 0

Turbolences: 10

Simulation Team
www.simulationteam.com

Target [km] 4884.41910

Vel Max [km/h] 21539.6103

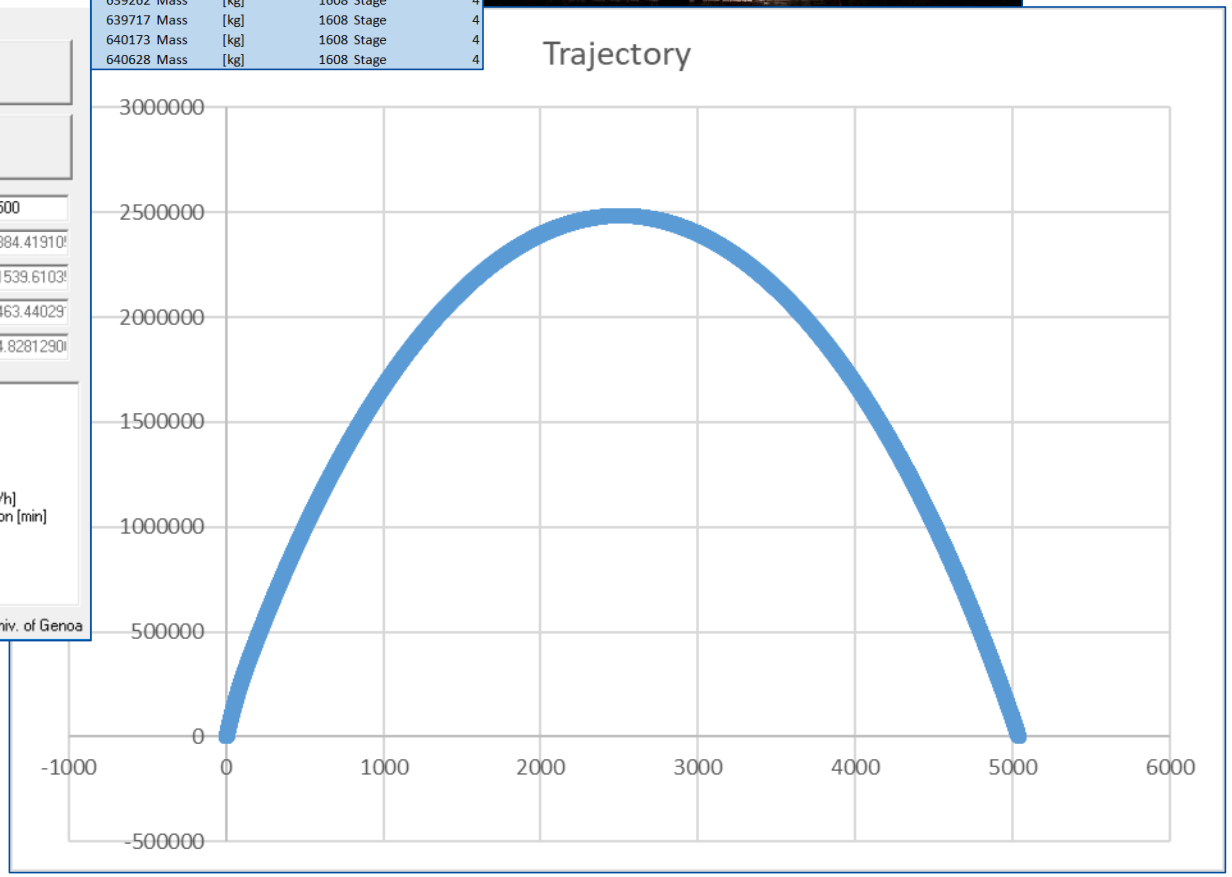
H Max [km] 2463.44029

Flight Time [min] 34.8281290

```
T [s] 2049.64 Speed [km/h] 20545 X [km] 4785 Y [m] 260262 Mass [kg] 1608 Stage 4
T [s] 2059.65 Speed [km/h] 20812 X [km] 4810 Y [m] 208375 Mass [kg] 1608 Stage 4
T [s] 2069.66 Speed [km/h] 21085 X [km] 4835 Y [m] 155661 Mass [kg] 1608 Stage 4
T [s] 2079.67 Speed [km/h] 21363 X [km] 4859 Y [m] 102103 Mass [kg] 1608 Stage 4
T [s] 2089.68 Speed [km/h] 21531 X [km] 4884 Y [m] 47698 Mass [kg] 1608 Stage 4

T [s] 2098.39 Speed [km/h] 20655 X [km] 4903 Y [m] 0 Mass [kg] 1608 Stage 4  Speed max [km/h]
21539.6103515625 Hmax [km] 2463.44029171235 Finalx [km] 4903.46978078569 Travel Duration [min]
34.9732706705729
==========
```

Temporal Evolution ☑ Final Results ☑ Append ☐ Copyright (c) 2009 MISS DIPTEM Univ. of Genoa



Simulation Team
www.simulationteam.com

Simulation Team

Protocol Data Units

- The heart of DIS. A PDU is a package containing information about an entity.
- Standard set of PDUs and definitions must exist on all hosts.
- Common PDUs are:

Entity state
Fire PDU
Detonation PDU
Signal PDU
Collision PDU
Action request PDU
Action response PDU

- PDU fields:
  - Header. DIS exercise ID number, protocol version, type of PDU, time stamp, length.
  - Data Structure Follows C format of structures.
    - Object oriented.
    - Declared variables → state data.

DIS PDUs

DIS standard defines the following 27 PDUs organized into 6 protocol families:

a) Entity Information/Interaction
1) Entity State PDU
2) Collision PDU

b) Warfare
1) Fire PDU
2) Detonation PDU

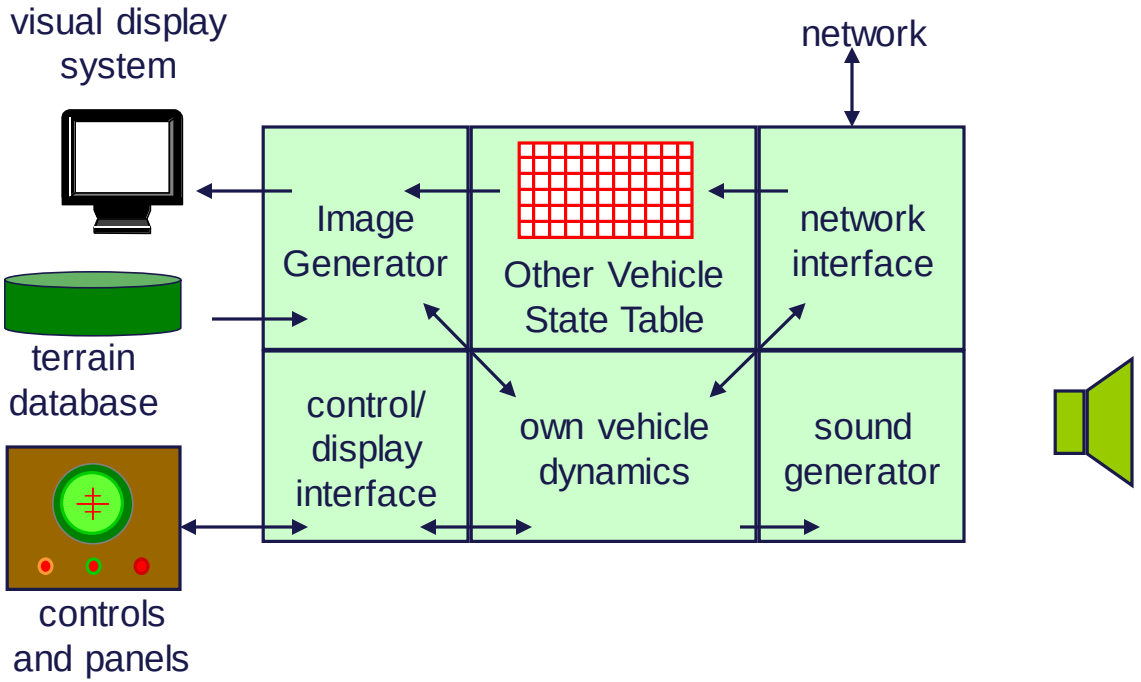
c) Logistics
1) Service Request PDU
2) Resupply Offer PDU
3) Resupply Received PDU
4) Resupply Cancel PDU
5) Repair Complete PDU
6) Repair Response PDU

d) Simulation Management
1) Start/Resume PDU
2) Stop/Freeze PDU
3) Acknowledge PDU
4) Action Request PDU
5) Action Response PDU
6) Data Query PDU
7) Set Data PDU
8) Data PDU
9) Event Report PDU
10) Comment PDU
11) Create Entity PDU
12) Remove Entity PDU

e) Distributed Emission Regeneration
1) Electromagnetic Emission PDU
2) Designator PDU

f) Radio Communications
1) Transmitter PDU
2) Signal PDU
3) Receiver PDU

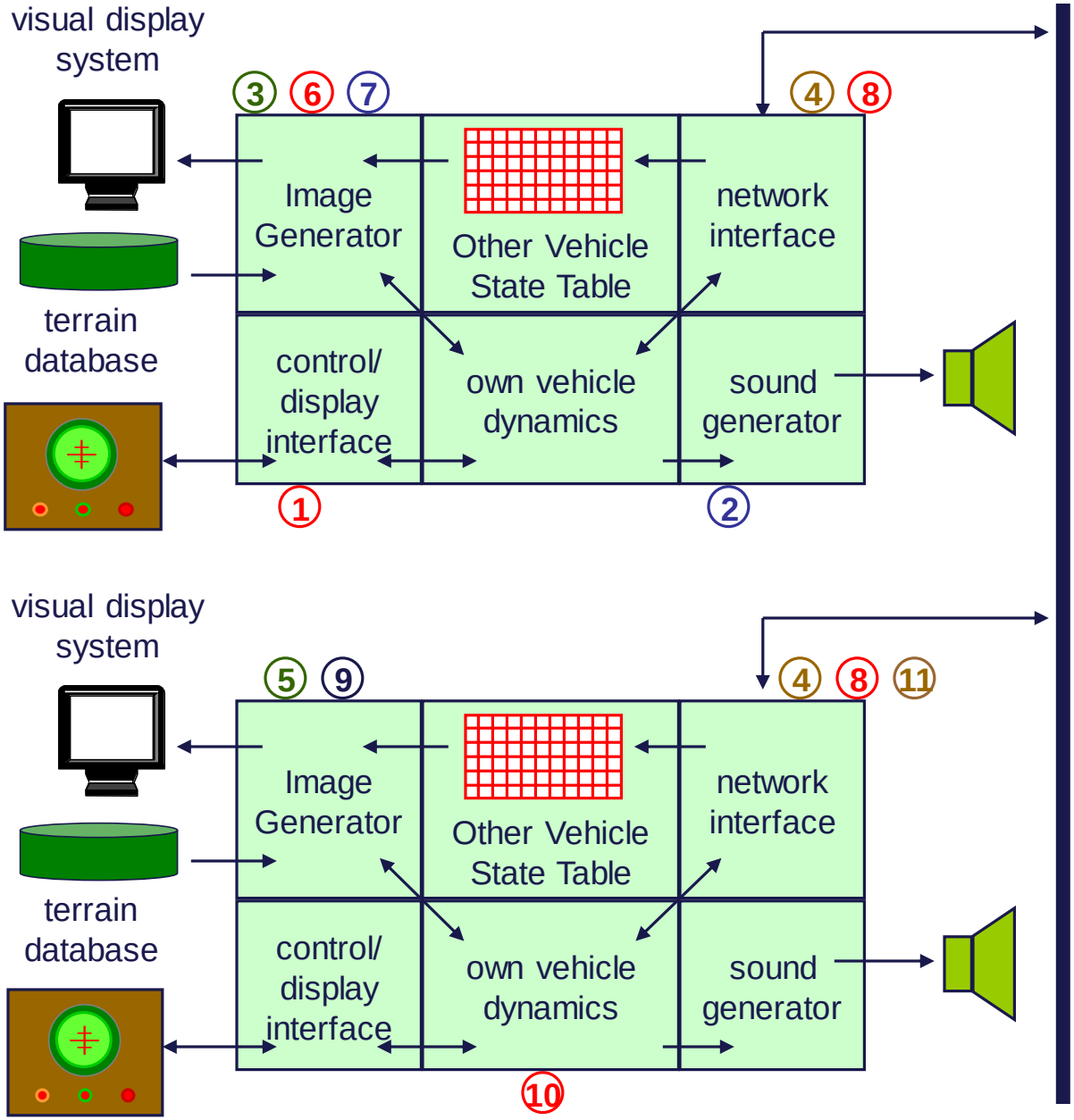
A Typical Distributed Virtual Environment Node Simulator



Execute every 1/30th of a second:

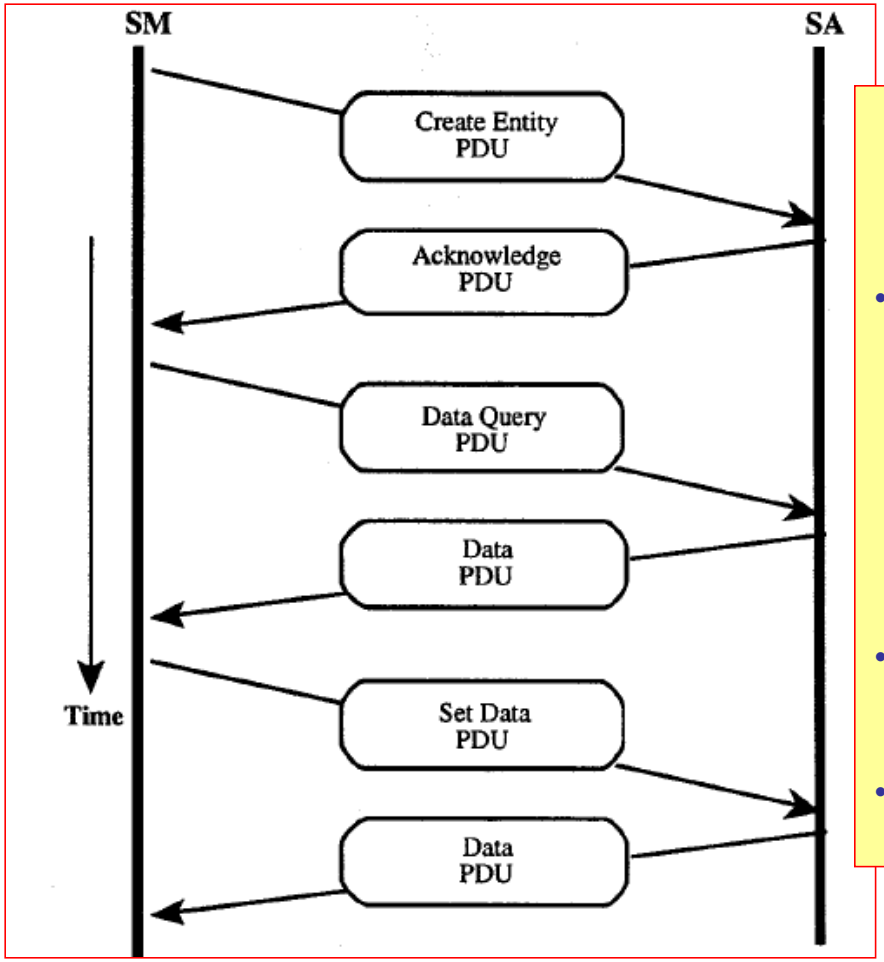
- **receive incoming messages & user inputs, update state of remote vehicles**
- **update local display**
- **for each local vehicle**
  - **compute (integrate) new state over current time period**
  - **send messages (e.g., broadcast) indicating new state**

Typical Sequence



1. Detect trigger press
2. Audio “fire” sound
3. Display muzzel flash
4. Send fire PDU
5. Display muzzel flash
6. Compute trajectory, display tracer
7. Display shell impact
8. Send detonation PDU
9. Display shell impact
10. Compute damage
11. Send Entity state PDU indicating damage

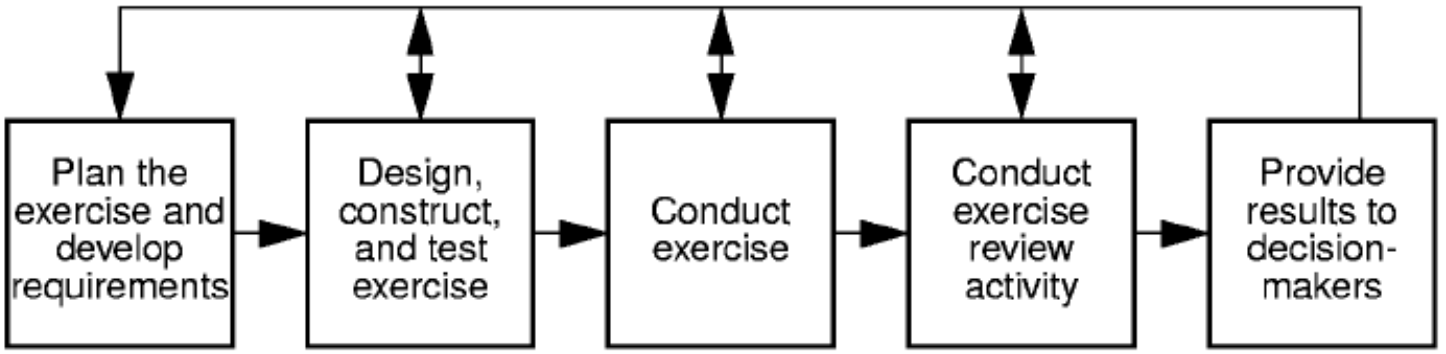
Entity Creation, Query, Initialization



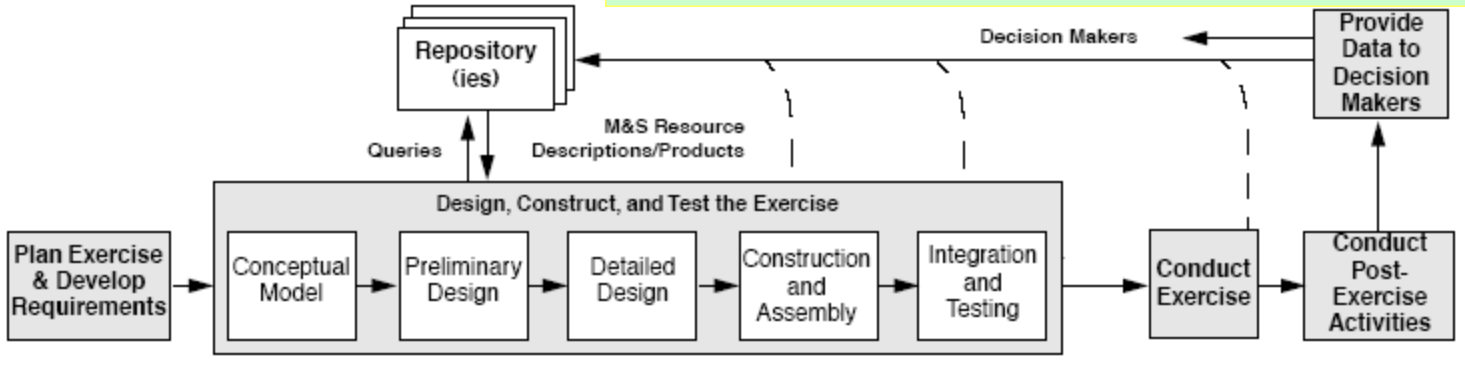
The Simulation Management protocol provides three ways to create a new entity.

- The SM to establish the identification (using Create Entity PDU) of the new entity, query for data about the new entity (using Data Query PDU), and set initial parameters for the new entity (using Set Data PDU).
- The SM operates as in the previous case except the SM does not query for data.
- The SM only creates Entity PDU.

DIS Exercise Life Cycle

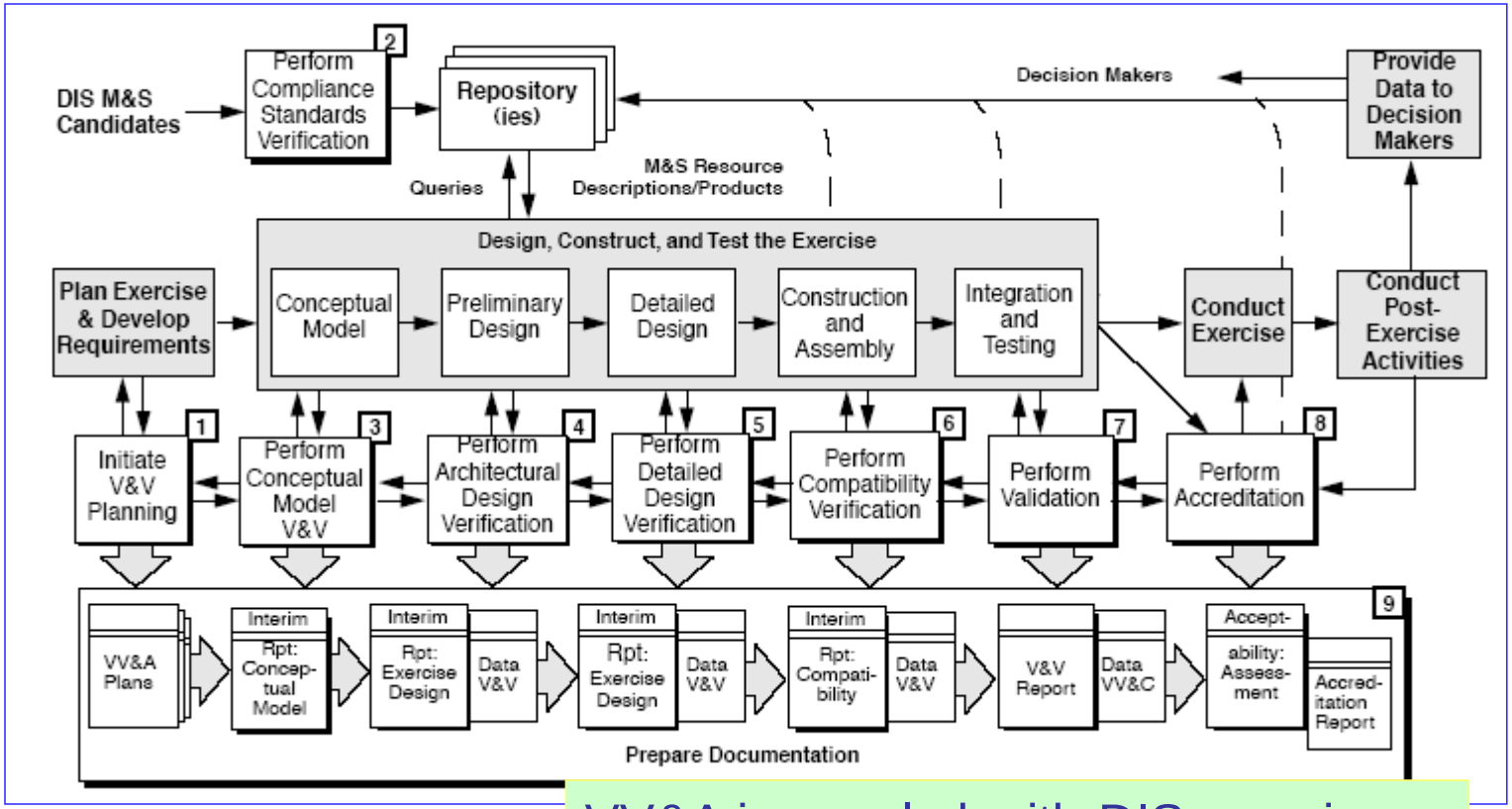


Distributed interactive Simulation is based on Exercise Life Cycle



Simulation Team

Exercise Life Cycle & VV&A

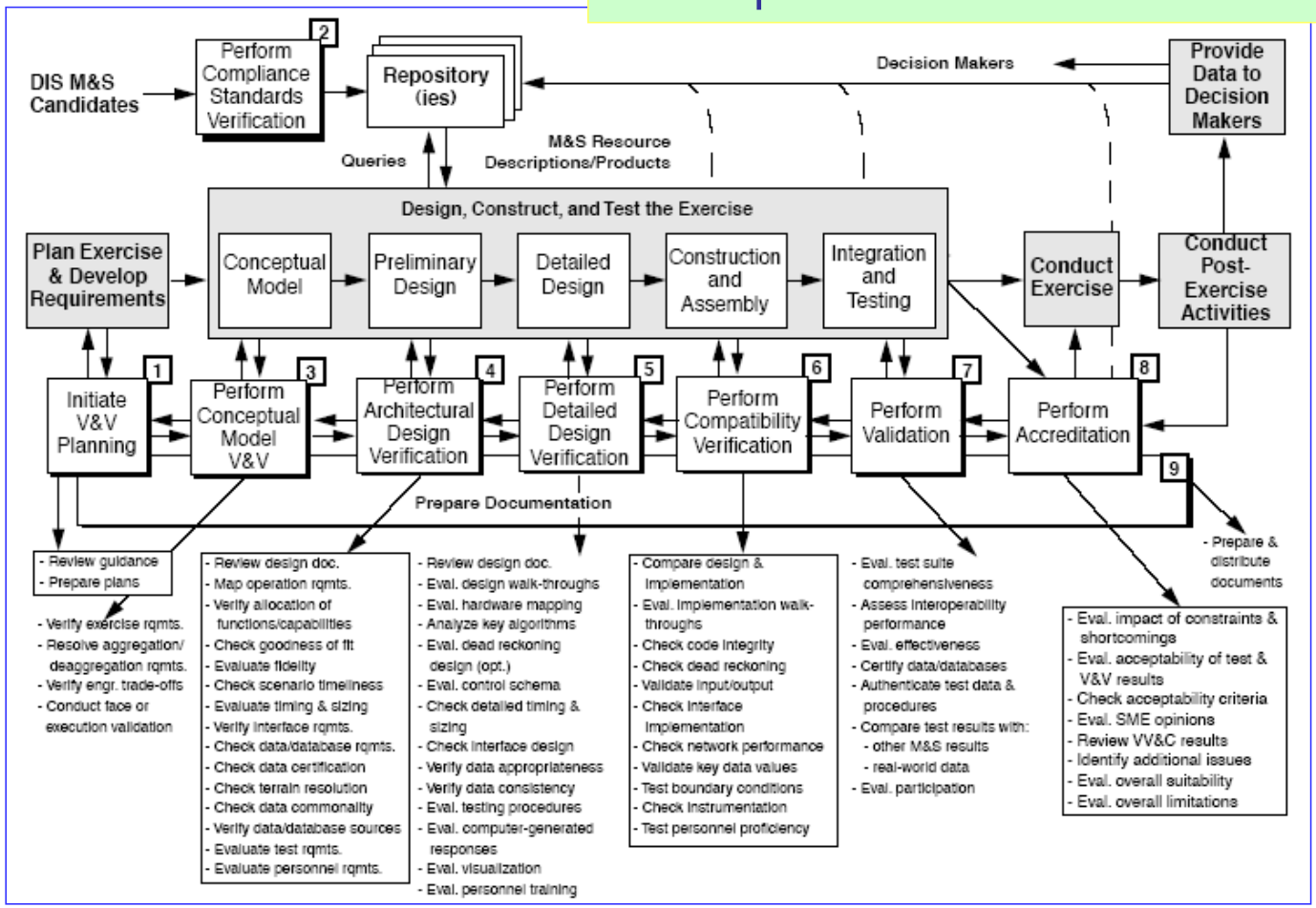


VV&A is coupled with DIS exercises

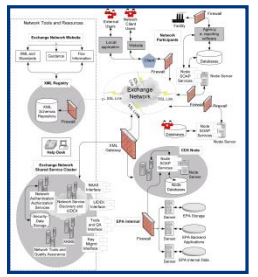
Simulation Team

VV&A Plan in DIS

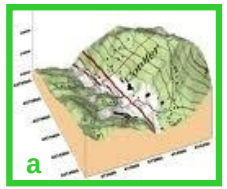
VV&A processes in DIS exercises



HLA High Level Architecture



- The High Level Architecture (HLA) has been designed to facilitate interoperability among simulations and to promote reuse of simulations and their components. The HLA is composed of three major components:
- HLA rules: a set of ten basic rules that together describe the general principles defining the HLA.
- HLA interface specification: a description of the functional interface between simulations (federates) and the HLA runtime infrastructure (RTI).
- HLA Object Model Template (OMT): a specification of the common format and structure for documenting HLA object models.



Example of an HLA Federation

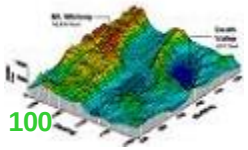
Federates

It is possible to execute Federations both on a Networks or on a single computer

Passive Data Viewers

Simulations

Interfaces to Live Components



Interface Specification

Run-Time Infrastructure (RTI)

OMDT and HLA

OMDT (Object Model Development Tool) supports documentation of HLA object models:

- **Compliance with HLA Object Model Template**
- **Electronic data entry/modification**
- **Syntax/Consistency checking**
- **Automated Object Model Library (OML) access**
- **Automated FED file generation**
- **Management Object Model (MOM) support–**
- **Man Power reduction in preparing FOM/SOM**
- **Improved FOM/SOM maintainability**

```
  <attribute> <name>y_Latitude</name>
<dataType>HLAfloat64LE</dataType>
<updateType>Conditional</updateType>
<updateCondition>when
changes</updateCondition>
<ownership>NoTransfer</ownership>
<sharing>PublishSubscribe</sharing>
<transportation>
HLAbestEffort</transportation>
<order>Receive</order>
<semantics>Latitude, [decimal]</semantics>
</attribute>
  <attribute> <name>x_Longitude</name>
<dataType>HLAfloat64LE</dataType>
<updateType>Conditional</updateType>
<updateCondition>when
changes</updateCondition>
<ownership>NoTransfer</ownership>
<sharing>PublishSubscribe</sharing>
<transportation>
```

It has been originally available for free by DMSO (currently MSCO)

High Level Architecture (HLA)

- HLA is based on a composable “system of systems” approach
  - no single simulation can satisfy all user needs
  - support interoperability and reuse among DoD simulations
- *federations* of simulations (*federates*)
  - pure software simulations
  - human-in-the-loop simulations (virtual simulators)
  - live components (e.g., instrumented weapon systems)

The HLA consists of

- **Rules** that simulations (federates) must follow to achieve proper interaction during a federation execution
- **Object Model Template (OMT)** defines the format for specifying the set of common objects used by a federation (federation object model), their attributes, and relationships among them
- **Interface Specification (IFSpec)** provides interface to the *Run-Time Infrastructure* (*RTI*), that ties together federates during model execution

Interface Specification

Category	Functionality
Federation Management	Create and delete federation executions join and resign federation executions control checkpoint, pause, resume, restart
Declaration Management	Establish intent to publish and subscribe to object attributes and interactions
Object Management	Create and delete object instances Control attribute and interaction publication Create and delete object reflections
Ownership Management	Transfer ownership of object attributes
Time Management	Coordinate the advance of logical time and its relationship to real time
Data Distribution Management	Supports efficient routing of data

DIS/HLA Comparison on an Example

A tank join an exercise, comparing DIS vs. HLA

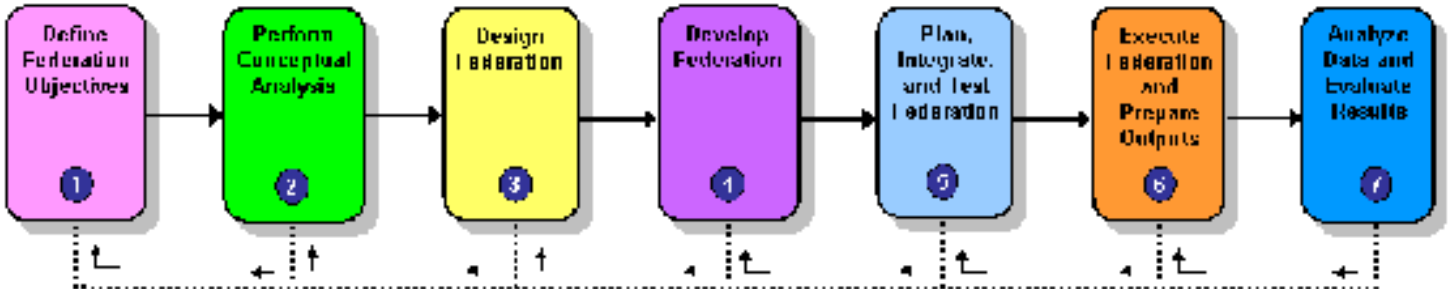
Action	DIS	HLA/RTI	Comments
Create an Scenario	Define (or use) an Exercise ID	Create Federation execution	
Join the Scenario	Listen and send PDUs as appropriate	Join Federation Execution	Implicit vs Explicit
Get an object ID (entity)	Application creates a unique ID	Request object ID(s) from the RTI	
Create an object (entity)	Start sending ESPDUs	Instantiate Object	
Discover new object (entity)	ESPDU from unknown entity arrives	Instantiate Discovered Object	Call from RTI to federate software
Tank moves forward	send entity state PDU	Update Attribute Value (position)	RTI sends only the changed data (position)
Tank moves turret	send entity state PDU	Update Attribute Value (turret orientation)	RTI sends only the changed data (turret orientation)
Tank fires a tank	send fire PDU	Send interaction (direct fire)	virtually identical
Delete object (entity)	Stop sending ESPDUs	Delete Object	Implicit vs Explicit
Leave the Scenario	Stop listening and sending PDUs	Resign Federation Execution	Implicit vs Explicit
Terminate Scenario	All simulations stopped	Destroy Federation Execution	Implicit vs Explicit

Tank joining Exercise and Federation

Simulation Team

FEDEP Model

Federation Development and Execution Process



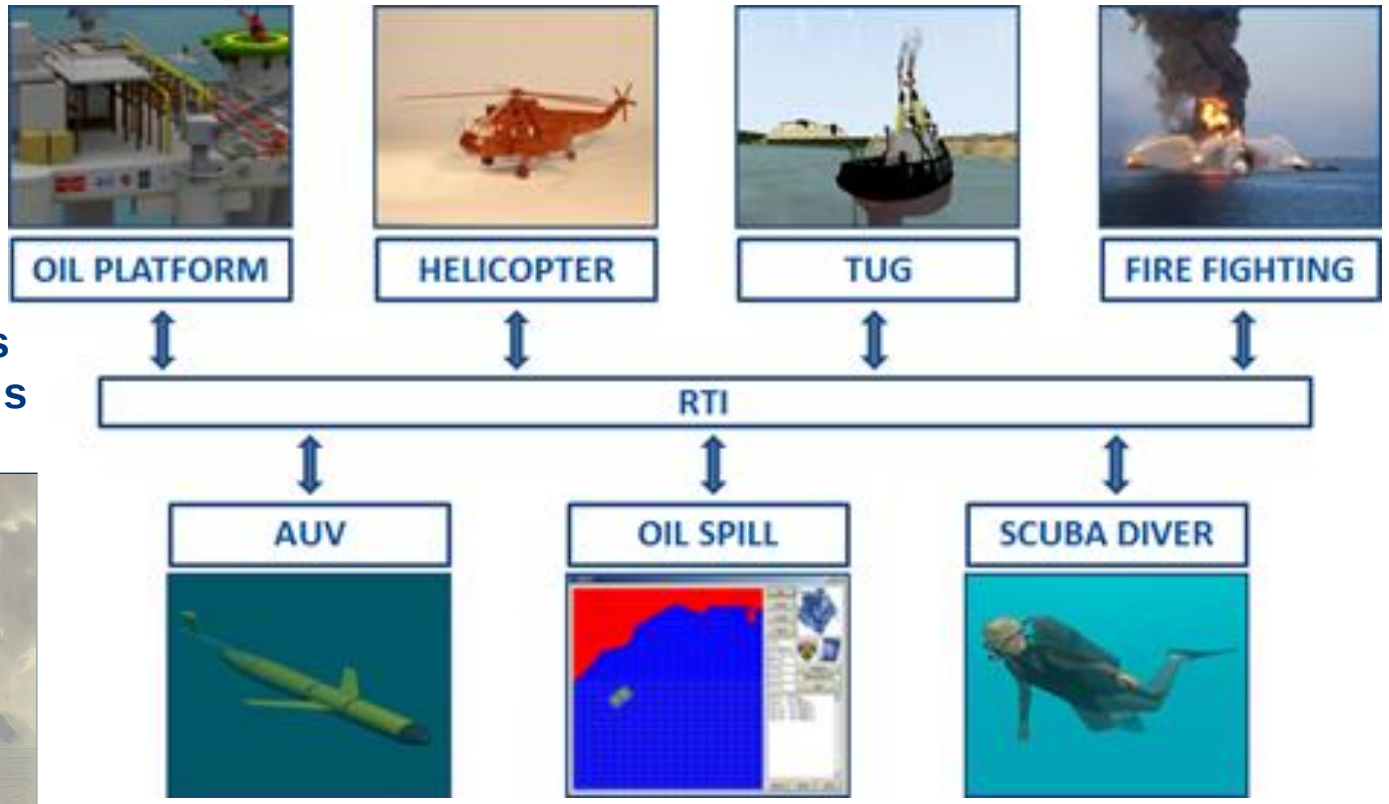
Step 1: Define federation objectives	Step 2: Perform conceptual analysis	Step 3: Design federation	Step 4: Develop federation	Step 5: Plan, integrate, and test federation	Step 6: Execute federation and prepare outputs	Step 7: Analyze data and evaluate results
Identify user/ sponsor needs Develop objectives	Develop scenario Develop federation conceptual model Develop federation requirements	Select federates Prepare federation design Prepare plan	Develop FOM Establish federation agreements Implement federate designs Implement federation infrastructure	Plan execution Integrate federation Test federation	Execute federation Prepare federation outputs	Analyze data Evaluate and feedback results

Simulation Team

Interoperable Simulation to Address Real Challenges

All these Models were available, therefore no joint simulation was existing to address Deep Horizon Crisis in Mexican Gulf

The Criticalities in Safety and Security is related to the Interoperation among Systems!



HLA OVERVIEW

FEDEP & DSEEP

Simulation Projects vs.Fedep

SOM: Simulation Object Model
FOM: FederationObject Model
FR: Federation Requirement
FED: Federation Execution Data
FDD: FOM Document Data
RTI.ID: Run time Infra Structure Interchange Data

Overall Plans
Existing Domain Description
Info on Available Resource
Existing Scenarios
Authoritative Domain Information
Federate Documents
Supporting Resources
Object Model Data Dictionary Elements
Existing FOMs & BOMs

Define Federation Object 1

Perform Conceptual Analysis 2

Design Federation 3

Develop Federation 4

Plan, Integrate & Test Federation 5

Execute Federation & Prepare Output 6

Analyze Date and Evaluation Results 7

Initial Planning Documents
Federation Scenarios
SOM
Federation Development & Execution Plan
List of Selected Federation
•Modified/New Federates
•Implemented Federation Infrastructure
•RTI Initialization Data
•FOM
•FED/FDD
•Scenario Instances
•Supporting DBase
Tested Federation
Execution Environment Description
Derived Output

Federation Objective Statement
Federation Requirements
Federation Test Criterial
Federation Conceptual Model
Federation & Federate Design
Federation Agreements

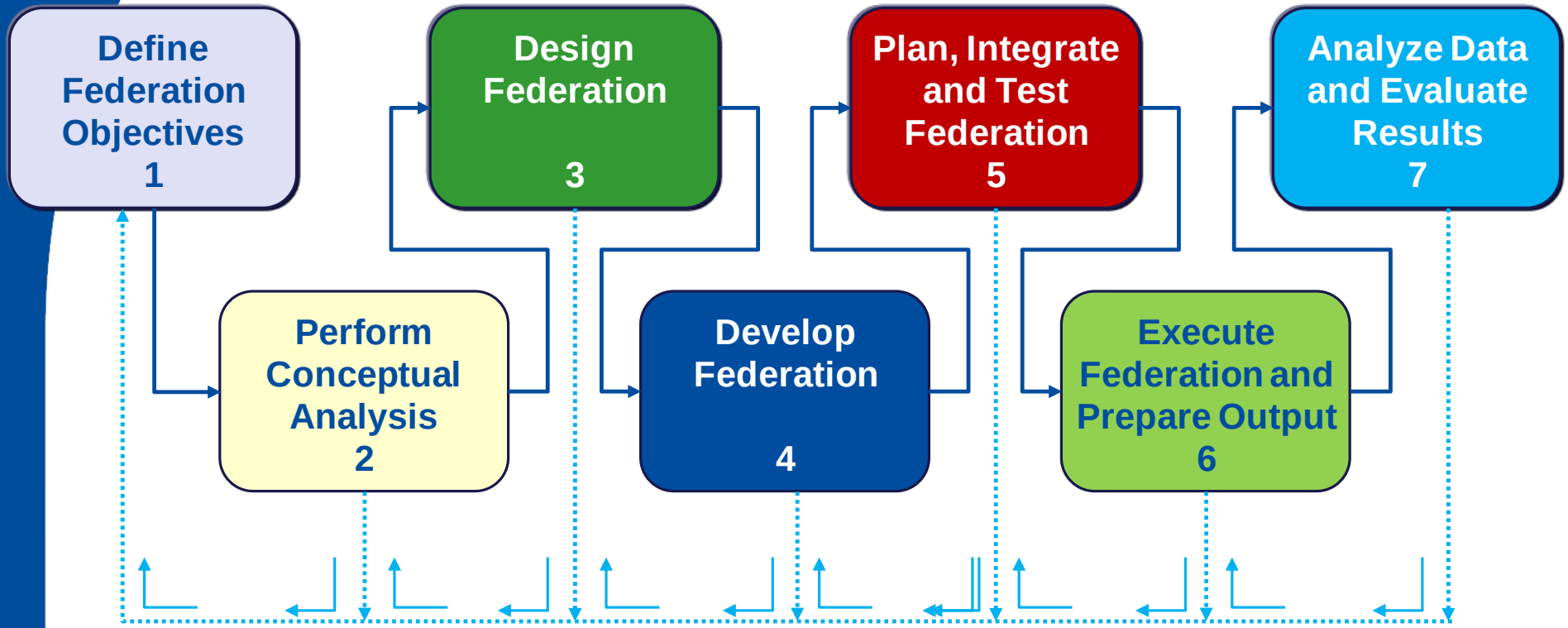
Final Report
Lessons Learned
Reusable Products

Simulation Team

131

FEDEP Model

Federation Development and Execution Process

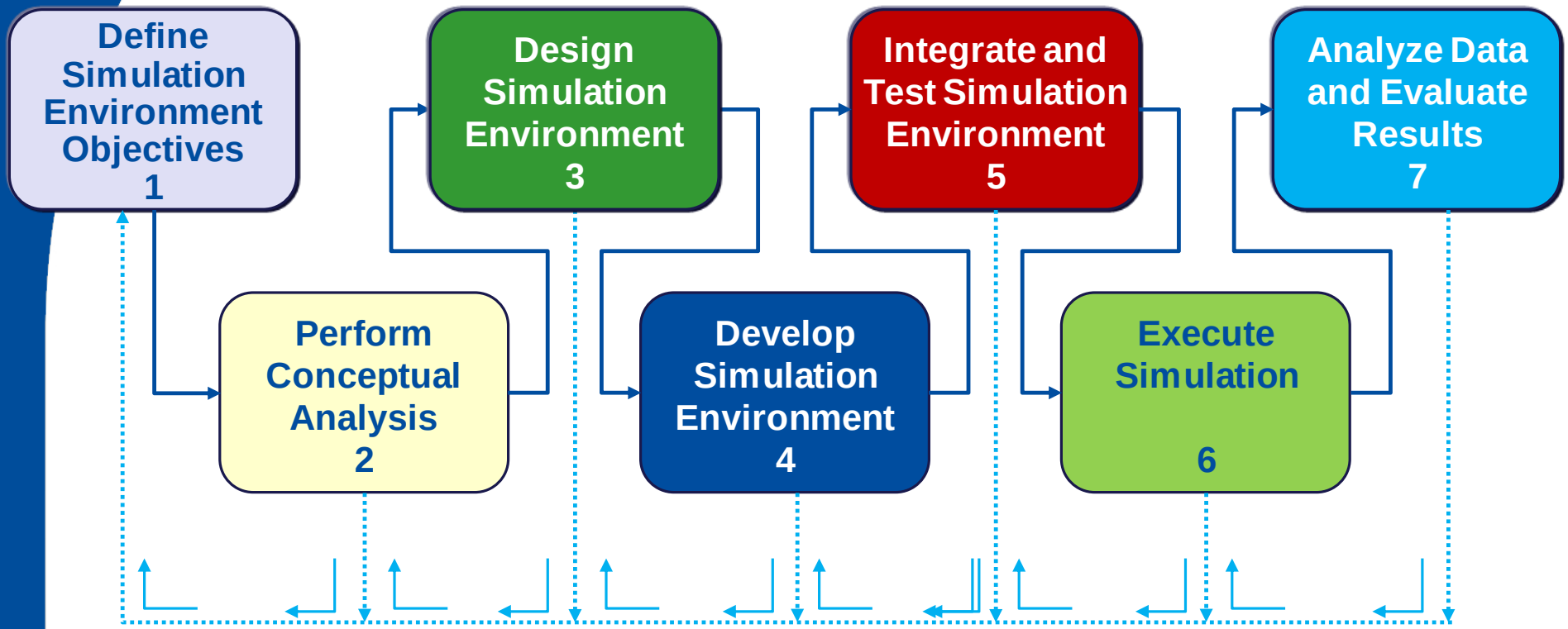


Simulation Team

131

DSEEP Model

Distributed Simulation Engineering and Execution Process



IEEE 1730-2010 (1516.3-2003)

DSEEP

Distributed Simulation Engineering and Execution Process

DSEEP provides recommended practice with the purpose to present a generalized process for building and executing distributed simulation environments.

DSEEP is not devoted to replace the existing management and methodologies of user organizations, but just to provide a high-level framework

DSEEP is not prescriptive and just defines a generic, systems engineering methodology that have to be tailored on specific projects

IEEE 1730-2010 (1516.3-2003)

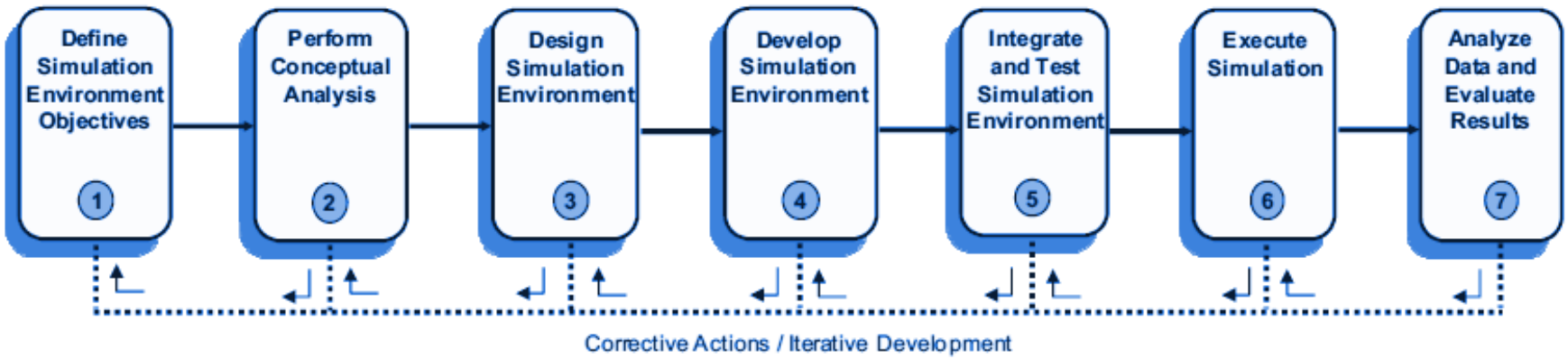
DSEEP Steps

Distributed Simulation Engineering and Execution Process

FEDEP evolves into DSEEP by generalizing:

Federation → ***Simulation Environment***

Federates → ***Members***

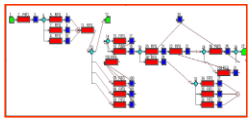


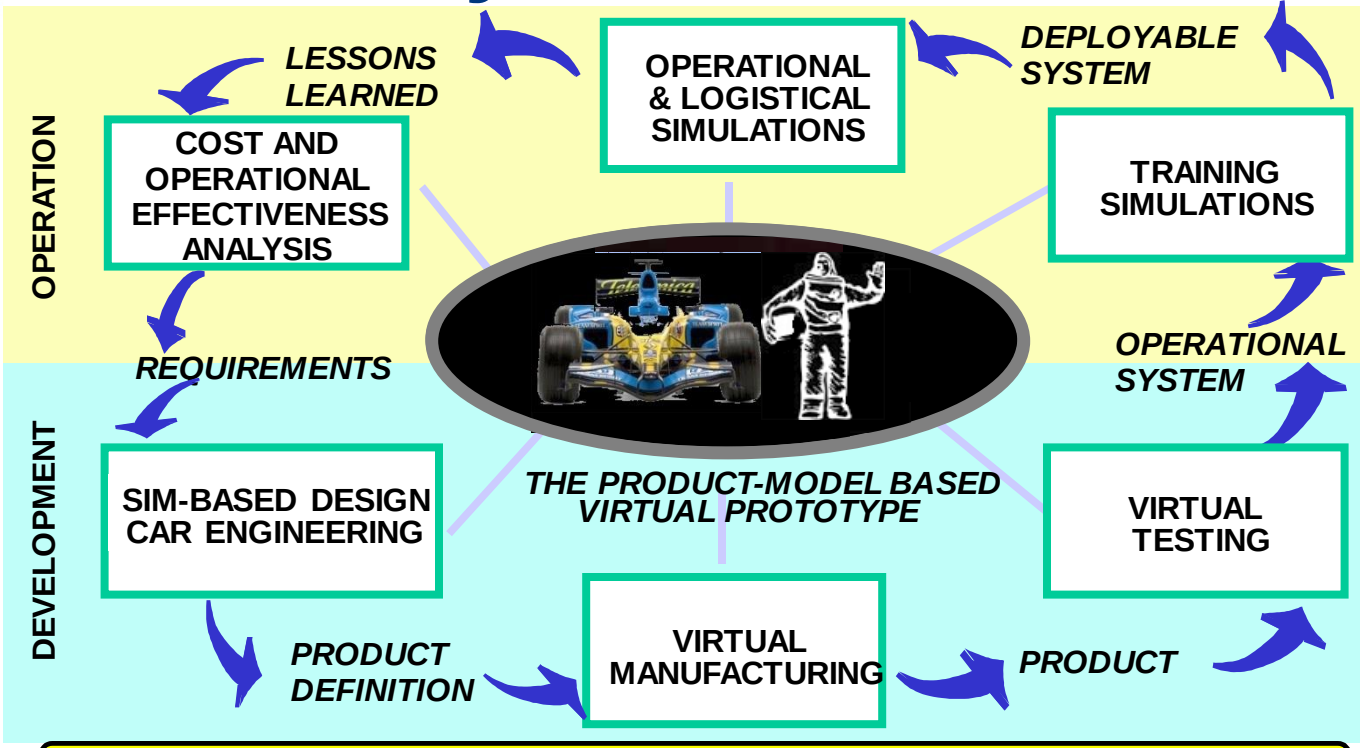
from HLA pure Native… to Mapping also DIS and TENA

Simulation Team

Life Cycle: How many Models?

The Virtual Product Life Cycle





GOAL: CONCEIVE, DESIGN, BUILD, TEST, TRAIN, AND OPERATE A NEW PRODUCT IN A COMPUTER BEFORE CUTTING METAL

Very Few Systems are "No Man in the Loop"
But Where/When we need to Model the "Man in The Loop" ?

HLA EVOLVED

HLA Evolution

- High-Level Architecture (HLA) was presented by DMSO in 1996 and supported by US DoD
- HLA 1.3 was updated in 1998 as major consolidation step
- HLA turned into International Standard, IEEE 1516 in 2000
- NATO finalized HLA issues in its 1st ed. of Standardization Agreement (STANAG 4603) in 2003
- HLA IEEE was revised in 2010 turning to be called HLA Evolved

HLA Performance & Reliability

Along the years HLA evolved non only in terms of standards but also of reliability and performance of its Run Time Infrastructure (RTI).

There have been around 25 implementations of different RTI including:

- **GOTS (Governmental Off the Shelf)**
  - **such as DMSO RTI 1.3**
- **COTS (Commercial Off the Shelf)**
  - **such as Pitch or Mäk**
- **Open Source**
  - **such as Portico**

Example of Actual RTI Performance

New COTS RTI are expected to achieve significant performance such as (i.e. LAN case):

- ***Update rate: ~50,000-100,000 updates of 64 bytes/s between 2 hosts on a LAN***
- ***Latency: ~130 microseconds in updates between 2 Computers***
- ***Scalability***
  - ***Federations with over 100 Federates or Computers.***
  - ***Scenarios with over 100,000 simulated entities are supported (with limited update rate)***

Obviously these issues are not all concurrent

Federation Performance

Federation Performance depends on many components affecting its execution such as :

- ***Federate Speed to acquire and elaborate updates***
- ***Federate Frequency on processing acquired information***
- ***Computational Speed before to request time advances***
- ***Network Latency***

Obviously Performance is not only speed by Robustness, Usability, Security Issues, and Compatibility are examples of other key factors.

HLA Evolved Improvement Area

The new functionality has been divided into different improvement activities:

- Develop: improvements making easier, faster, and less error-prone to develop federates and federations
- Deploy: improvements how and where federates and federations can be deployed.
- Net-centric: facilitation for federations to be used in net-centric environments.
- Quality: improvements addressing quality and reducing ambiguities in the standard

FOM Challenge

Federation Object Models (FOMs) and Simulation Object Models (SOMs) were hard to be reused and developed due to their monolithic approach.
It is difficult to update FOMs due to their block structure making and it is very hard to separate local elements.

So in HLA Evolved it is introduced the concept of Modularity

Modular FOM the Major Advance

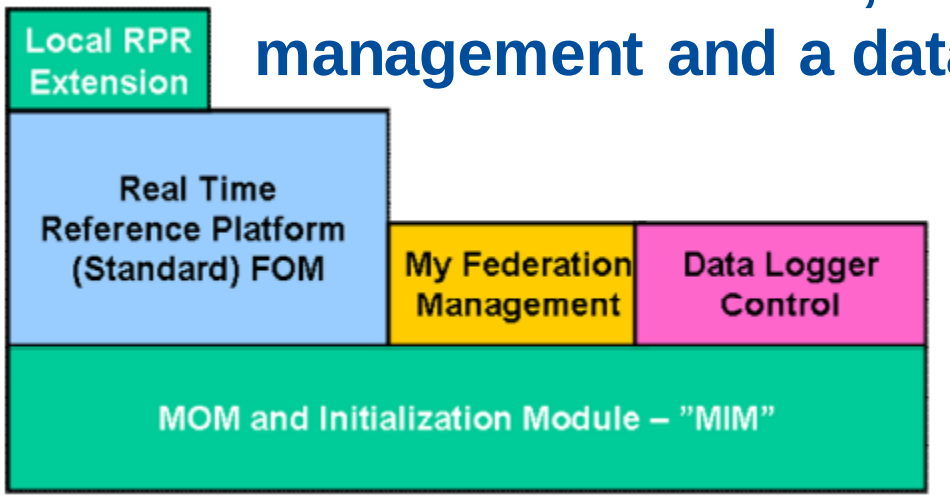
- The FOM is now provided as modules
- FOM contain a subset of the FOMs, for example, selected object classes or data types
- Different assets such as platforms, sensors and communications and reusable data types, can be developed and described in different modules. Locally developed modules can extend standardized modules
- It is easier to support concurrent development by different Partners on different components
- A new set of services makes it possible for a federate to inspect loaded FOM modules have been loaded and to their content

New Hierarchy

- Pre-defined concepts in the HLA FOM, such as management object model (MOM) and predefined data types, have been moved to a separate module called the MOM and Initialization Module (MIM)
- So modules are smaller and easier to handle by developers
- It become possible to act just on its own part of the FOM

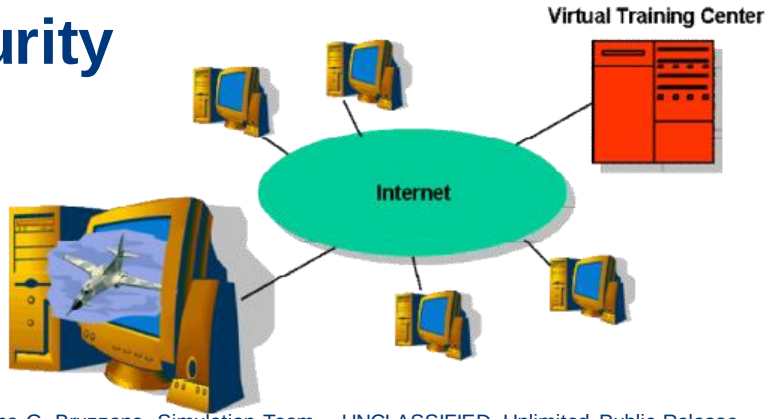
New Hierarchical Scheme

- Example of how Real-time Platform-level Reference (RPR) FOM Hierarchy evolve
- The FOM is composed by standard MIM, a standardized reference FOM, an extension to the reference FOM, a module for federation management and a data logger control module



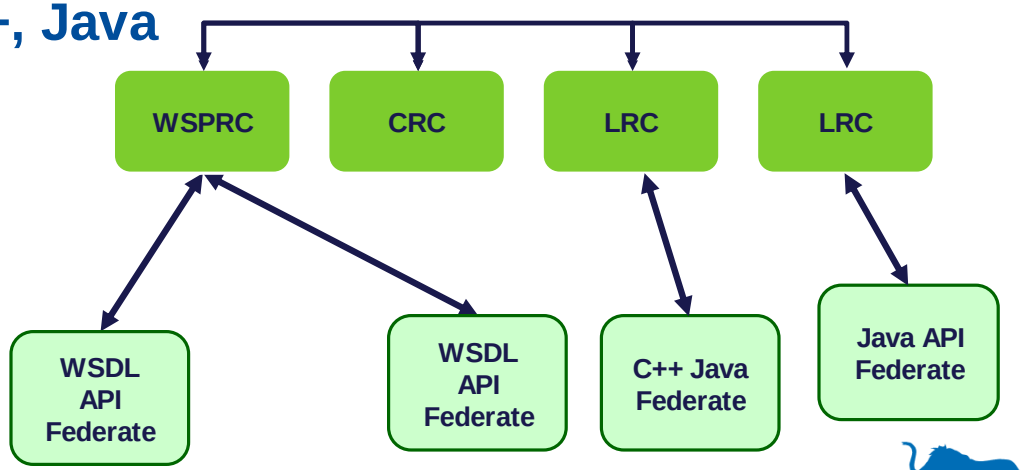
Web Service API: WSDL

- Web Service Distribution Library has been provided as a protocol description with functionalities equivalent to C++ and Java APIs.
- A federate could connect using Web Services across LANs and WANs, optionally using https-based encryption and authentication and to guarantee security



Web Service API: WSDL

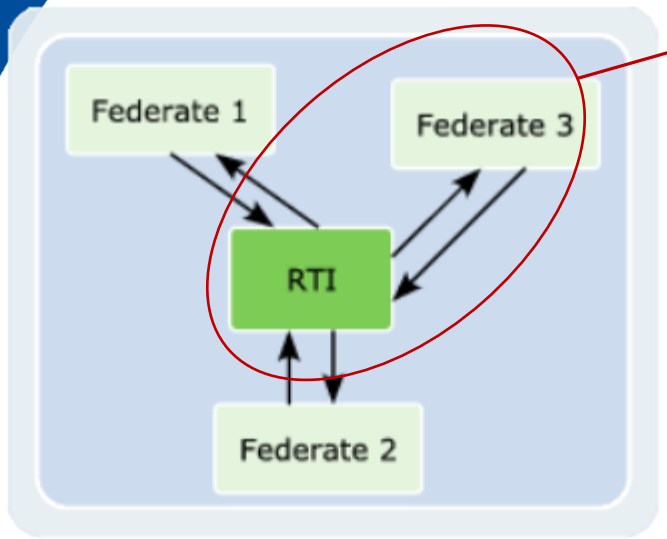
- WSDL supports HLA-based interoperability with clients in many different locations by a principle basically equivalent to a web server and a web browser
- To support the Web Services API, an RTI needs to provide a Web Services Provider RTI Component (WSPRC) that one or more WSDL federates can connect to using a URL
- WSDL is supported for a wide range of programming languages, such as C++, Java

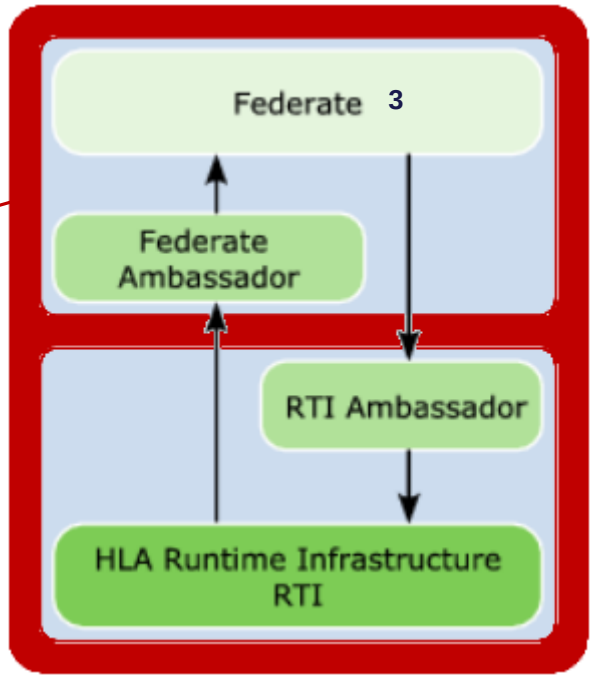


- LRC Local RTI Component
- CRC Central RTI Component
- WSRPR Web Service Provider RTI Component
- WSDL Web Service Distribution Library

DIPTEM
Università di Genova

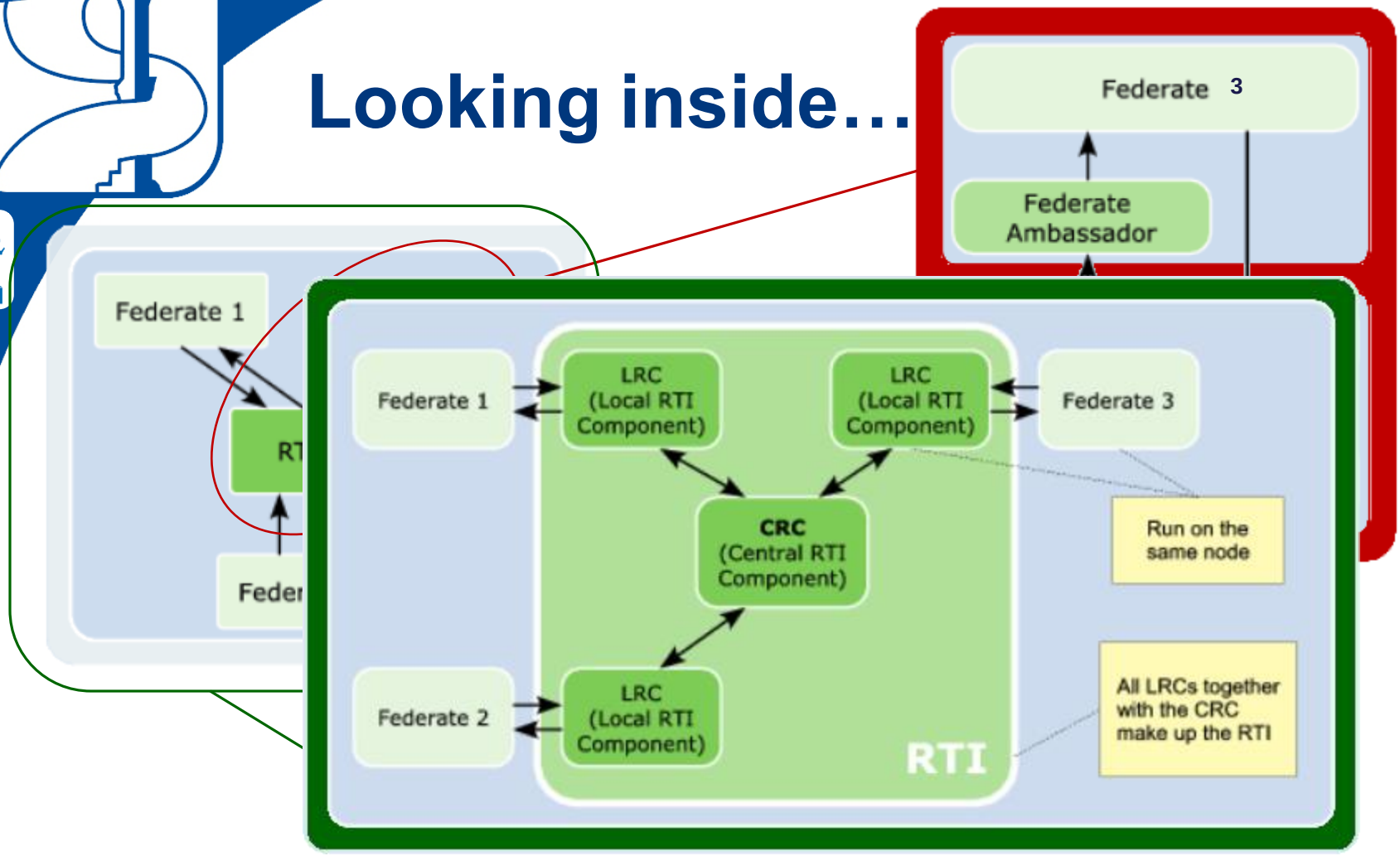
Looking inside





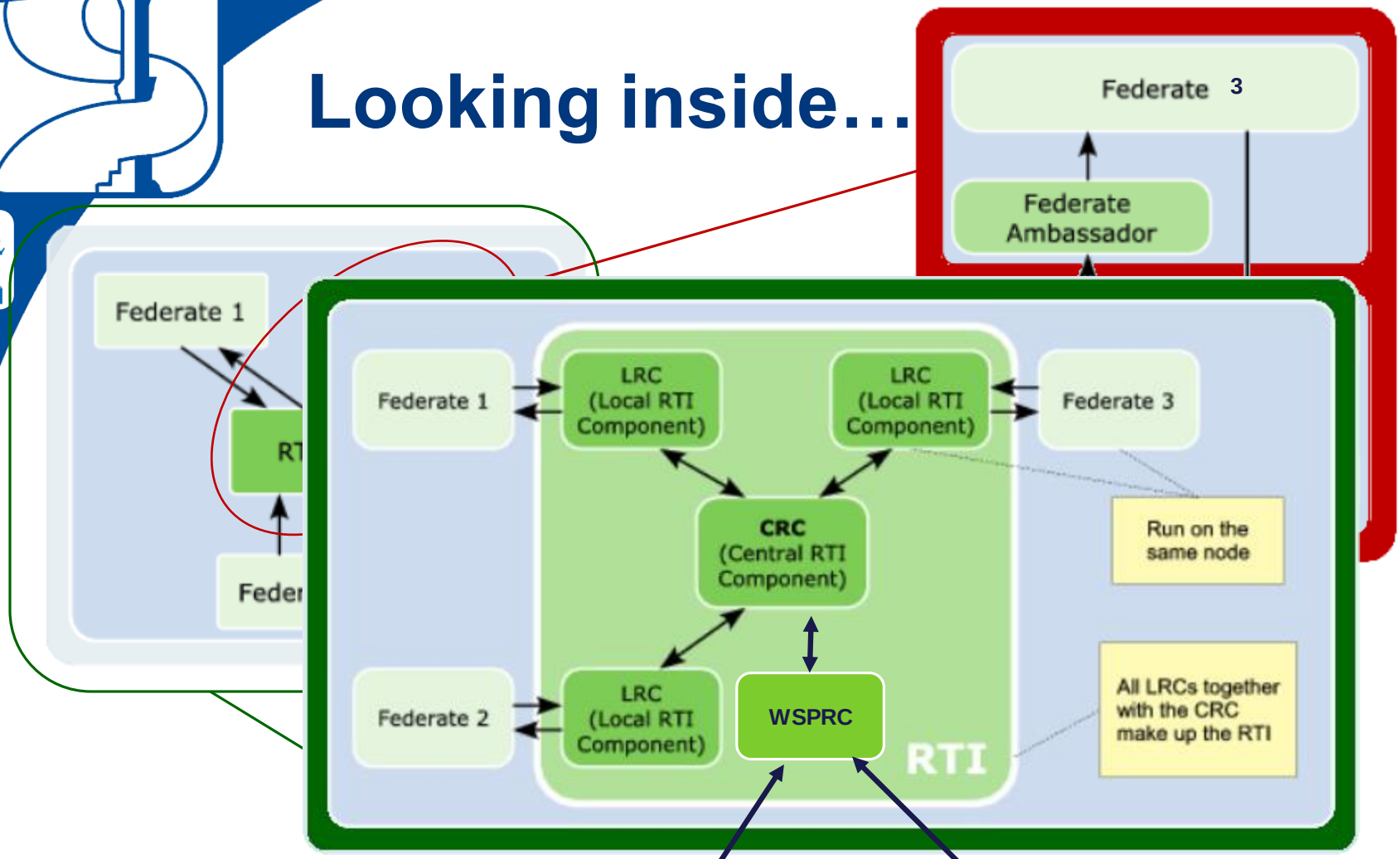
- LRC Local RTI Component
- CRC Central RTI Component
- WSRPR Web Service Provider RTI Component
- WSDL Web Service Distribution Library

Looking inside…



- LRC Local RTI Component
- CRC Central RTI Component
- WSRPR Web Service Provider RTI Component
- WSDL Web Service Distribution Library

Looking inside…



- LRC Local RTI Component
- CRC Central RTI Component
- WSRPR Web Service Provider RTI Component
- WSDL Web Service Distribution Library

Simulation Team

Introduction on Validation and Verification of Simulation Models

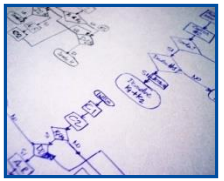
DIPTEM
Università di Genova

V&V Outline

- Introduction
- Definitions of validation and verification
- Techniques for verification of simulation models
- Techniques for validation of simulation models
- Statistical Methods for Comparing real-world observations with simulation output data
  - Inspection Approach
  - Confidence-Interval Approach
- Summary

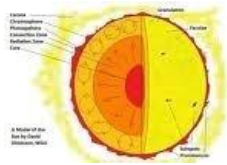
Verification and Validation in M&S

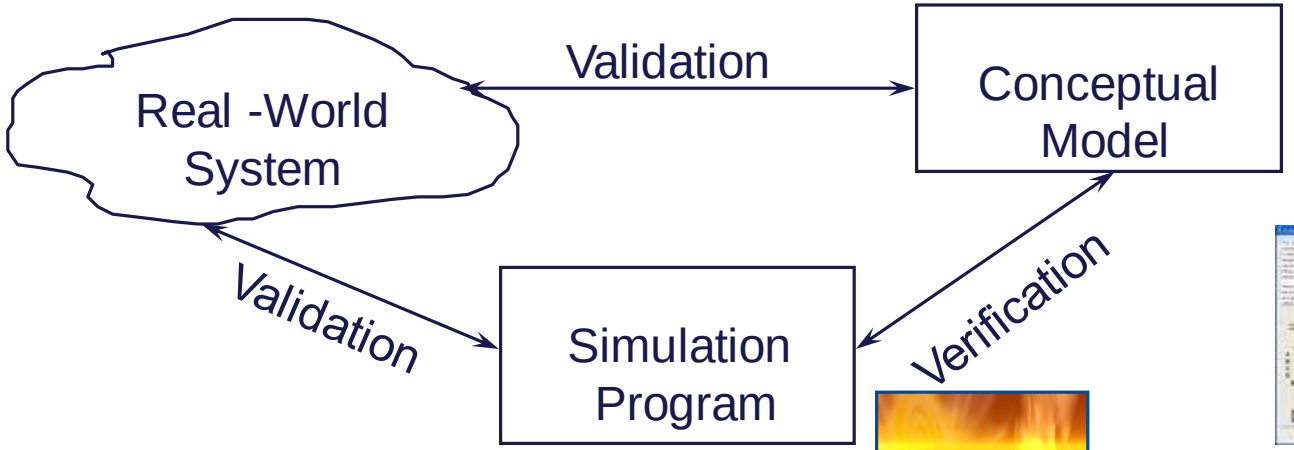
- One of the most difficult problems facing the simulation analyst is determining whether a simulation model is an accurate representation of the actual system being studied (i.e., whether the model is valid).
- If the simulation model is not valid, then any conclusions derived from it is of virtually no value.
- Validation and verification are two of the most important steps in any simulation project.



What are Validation and Verification?

- Validation is the process of determining whether the conceptual model is an accurate representation of the actual system being analyzed. Validation deals with building the right model.
- Verification is the process of determining whether a simulation computer program works as intended (i.e., debugging the computer program). Verification deals with building the model right.





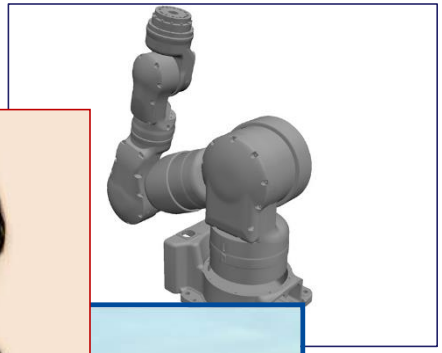
VV&A Criticalities

Respect traditional Software Projects, Simulation requires to create a realistic solution and not just a running program. This requires to conduct multiple Validation and Verification activities and to support the accreditation process

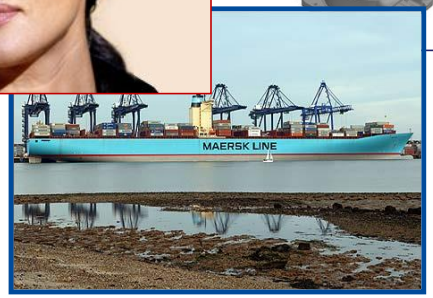
Simulation

Monica Bellucci

Reality



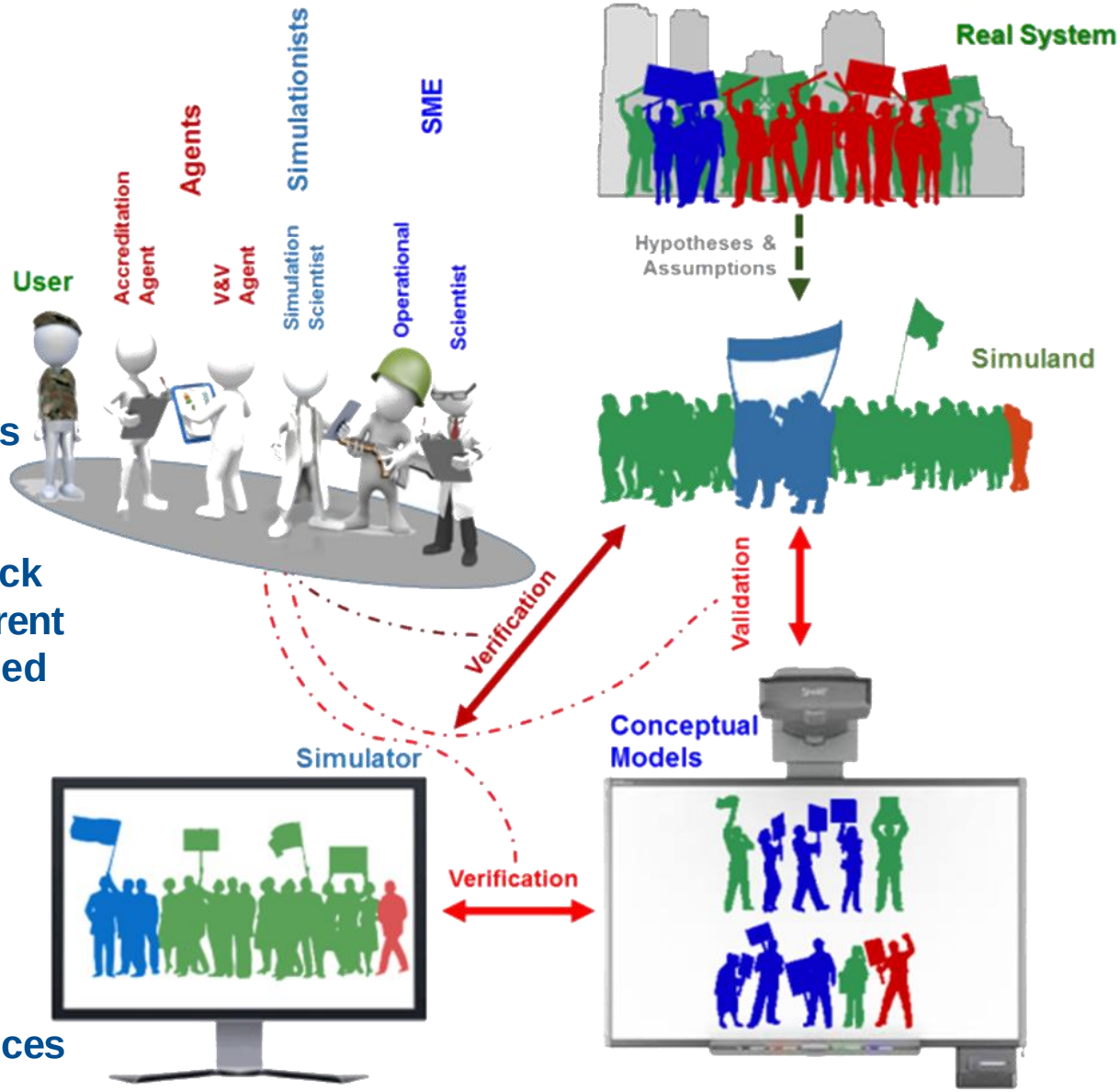
SIAM20D



Emma Maersk

Simulation Team

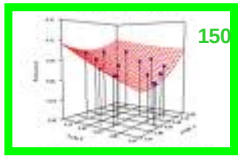
V&V



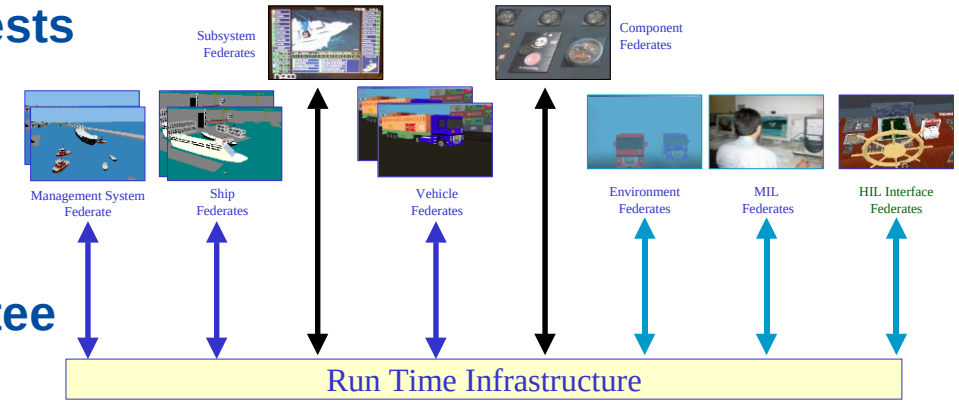
Interoperable Simulators running into an HLA Federation is even more complex requiring to check consistency among different federates and issues raised by the interoperability among models

VV&A (Verification, Validation and Accreditation) results critical and requires different SME and resources

V&V for Complex Systems



- It is critical to understand, that due to the high not linear nature of most of simulation models it is not possible to apply superposition principle.
- Due to this reason it even more evident that even if all the sub models, objects or federates are able to pass VV&T (Validation, Verification and Testing) this fact don't allows to conclude that the overall simulator is validated and verified
- It is necessary to conduct tests and experiments and to complete specific VV&A (Verification Validation and Accreditation) even on the whole Federation to guarantee this results



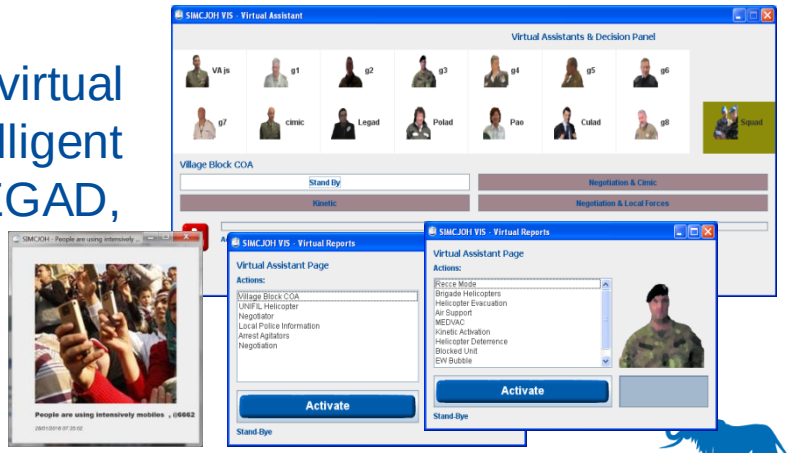
HLA EXAMPLE

SIMCJOH VIS & VIC

Simulation Team
www.simulationteam.com

The SIMCJOH Strongholds

- SIMCJOH combines Interoperable Simulation and Serious Game
- It results user friendly and intuitive moving from Desktop Stand Alone Simulator to HLA Federation available for CAX.
- SIMCJOH VIS includes Human Behavior and Intelligent Agents reproducing dynamic MEL/MIL in Complex Scenarios and the evolution respect possible COAs and contingency
- SIMCJOH VIC reproduce the Virtual Environment allowing to get an immersive representation of the situation.
- It could be easily used in SPIDER Interactive Virtual CAVE and/or Virtual Reality Helmet or from a laptop
- The Commander interacts with his virtual staff (several avatars driven by Intelligent Agents e.g. J1, J2, J3, POLAD, LEGAD, CULAD, etc.)

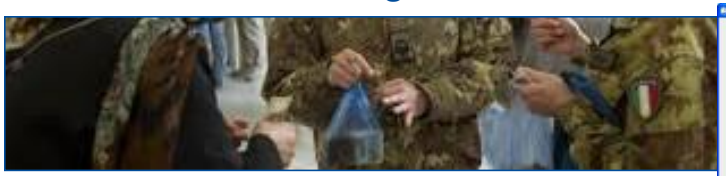


Simulation Team

SIMCJOH VIS & VIC

Simulation of Multi Coalition Joint Operations involving Human Modeling
Virtual Interoperable Simulator & Virtual Interoperable Commander

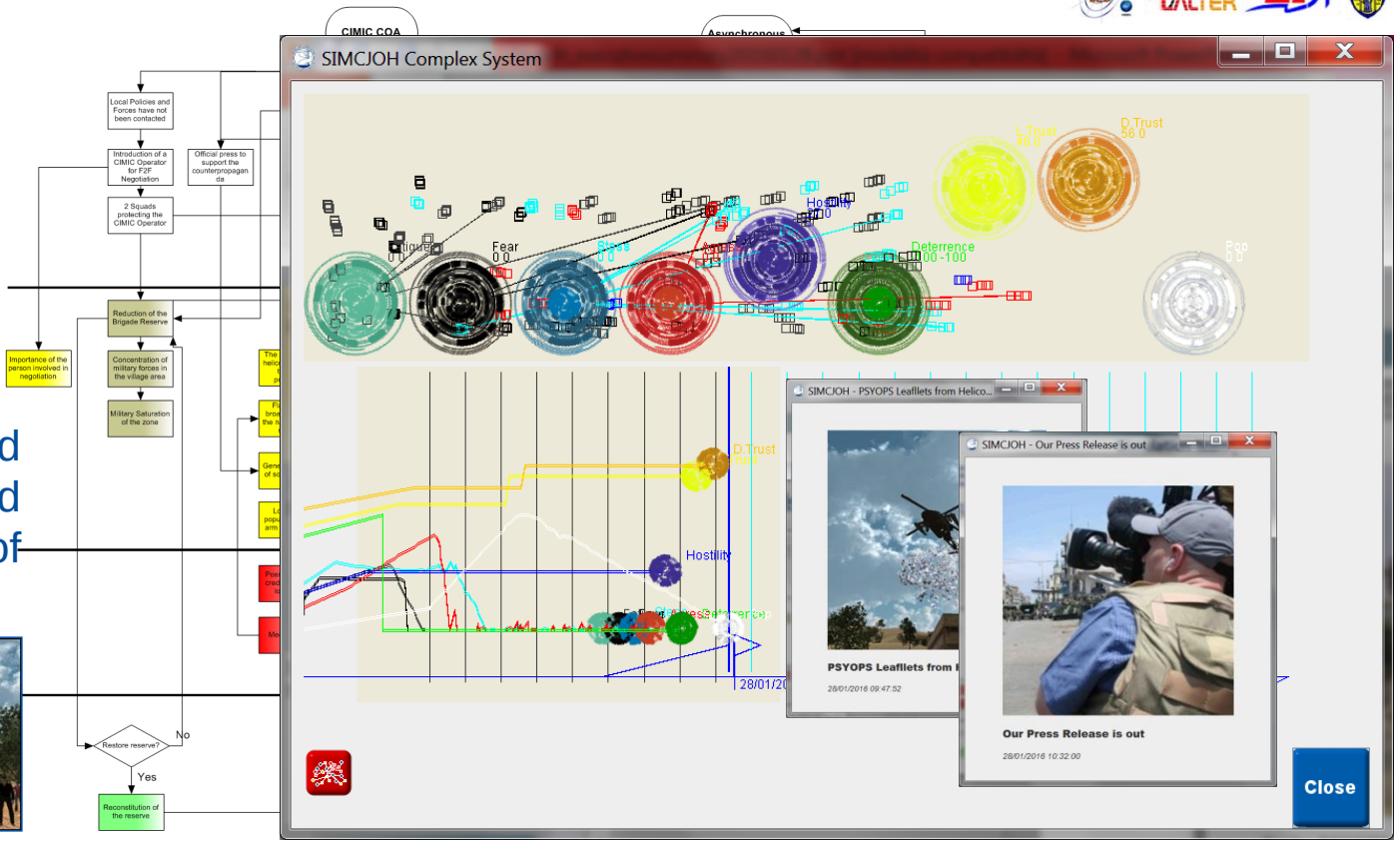
SIMCJOH VIS includes stochastic Population Model, HBM as well as IA-CGF and Virtual Assistants.
SIMCJOH VIS generates dynamically the reports and analyzes the situation, suggesting decisions and assign high level tasks. The simulator includes multiple interface able to deal with complex scenario.s
SIMCJOH VIC provides a virtual framework able to evolve during the scenario.

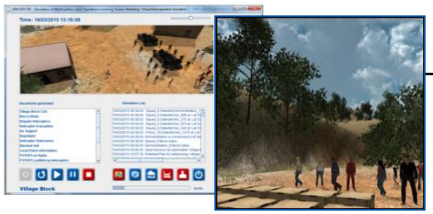


Simulation Team

The MEL/MIL and Human Behavior Models

The Conceptual Models and Human Behavior Models (HBM) are implemented in *SIMCJOH VIS* and SIMCJOH *VIC* and represent the core of the simulation





SIMCJOH VIS Simulation of Multi Coalition Joint Operations involving Human Modeling Virtual Interoperable Simulator
SIMCJOH VIC Simulation of Multi Coalition Joint Operations involving Human Modeling Virtual Interoperable Commander
MEL/MIL *Master Event List, Master Incident List*

Conceptual Models for MEL/MIL, COAs

- SIMCJOH includes Conceptual Dynamic Stochastic Models of MEL/MIL and COAs
- SIMCJOH allowed to investigate MEL/MIL with strategic impact on the Coalition such as the case of a Squad of soldiers under United Nation hat, that is blocked into a village by population.
- SIMCJOH simulate the demonstration in terms of attitude, composition and dynamics growing based on human factors, boundary conditions and decision taken by the Commander
- The squad Commander and forces are driven by IA-CGF based on decisions of the Commanders and affected by Human factors.
- The Virtual Staff analyze the situation and activates procedures to support the situation preparing proposals and COAs
- Three COAs, named CIMIC, KINETIC, LOCAL FORCES respectively, are generated dynamically based on the MEL/MIL specific status of the simulation
- The COA description are generated including Military Effects, Secondary Effects on Population, Risks deriving from COA, possible Mitigation Actions.

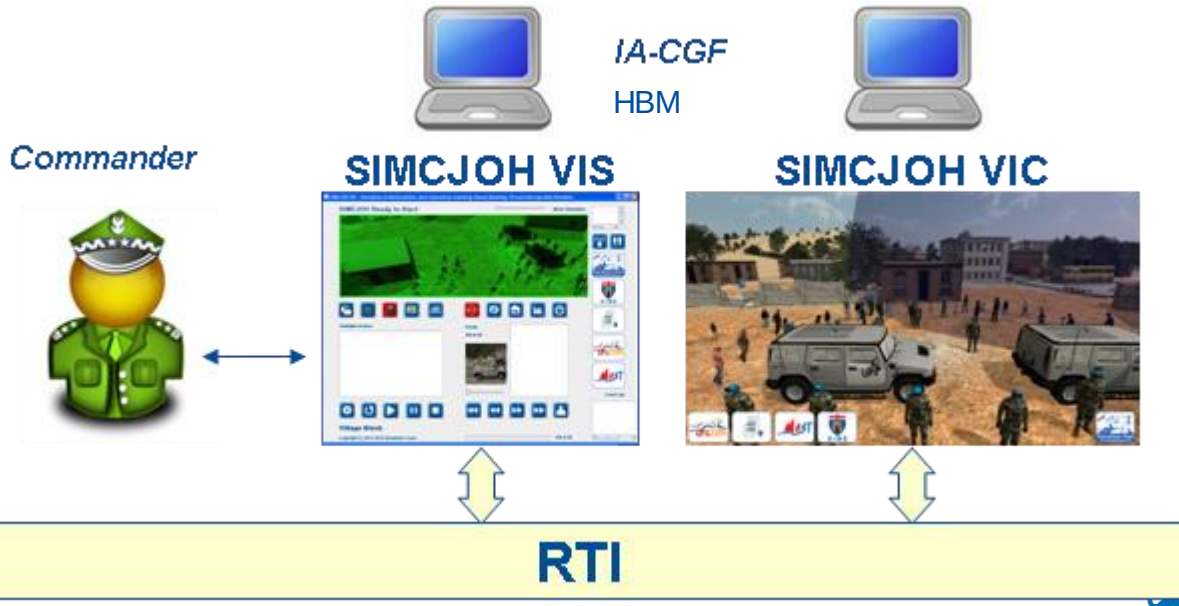
MEL/MIL: Master Event List, Master Incident List
COA: Course of Action
UNIFLI United Nation Force for Large Improvement of Eblanon

CIMIC: Civil Military Cooperation

Simulation Team

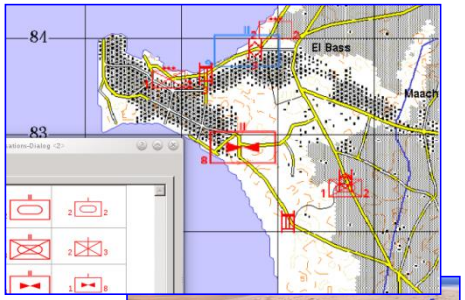
SIMCJOH Stand-Alone Mode using RTI

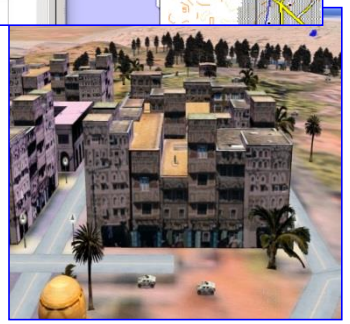
SIMCJOH could operate in Stand-Alone mode on a single PC, or a couple, with & without RTI. In these cases Discrete Event and Virtual Simulations operates managing Events, Actions, Virtual Assistants, COA as well as 3D Immersive Representation



Simulation Team

SIMCJOH VIS, VIC & SGA, NCS & GESI

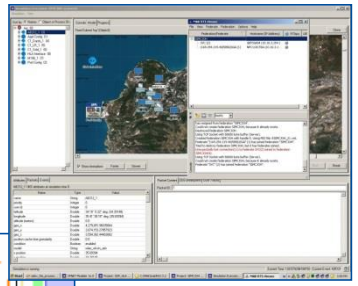


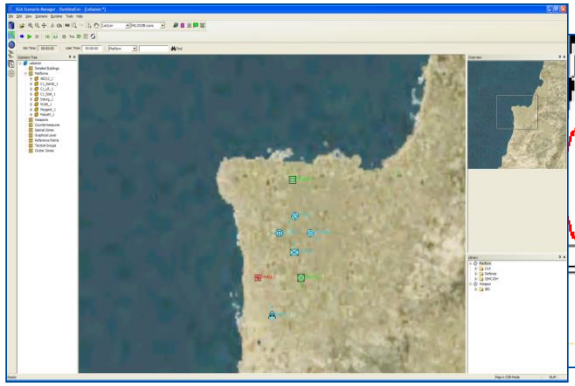


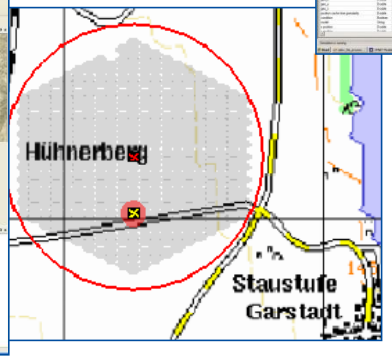
VIS & VIC are the core Simulators of SIMCJOH Project. In this case it was possible to create a partnership, under the leadership of Genoa University, with other industries and to federate VIS & VIC with other Simulators.

Indeed Leonardo contributed by upgrading *SGA & NCS* to be federated in SIMCJOH for simulating platforms interacting with other models and for providing detailed ICT Models

CAE was active in integrating *GESI* to reproduce entity level operations and detailed tactical actions







SGA	Scenario Generator and Animator
NCS	Network Communication Simulator
GESI	GEfechts-SImulation System
ICT	Information &Communication Technology

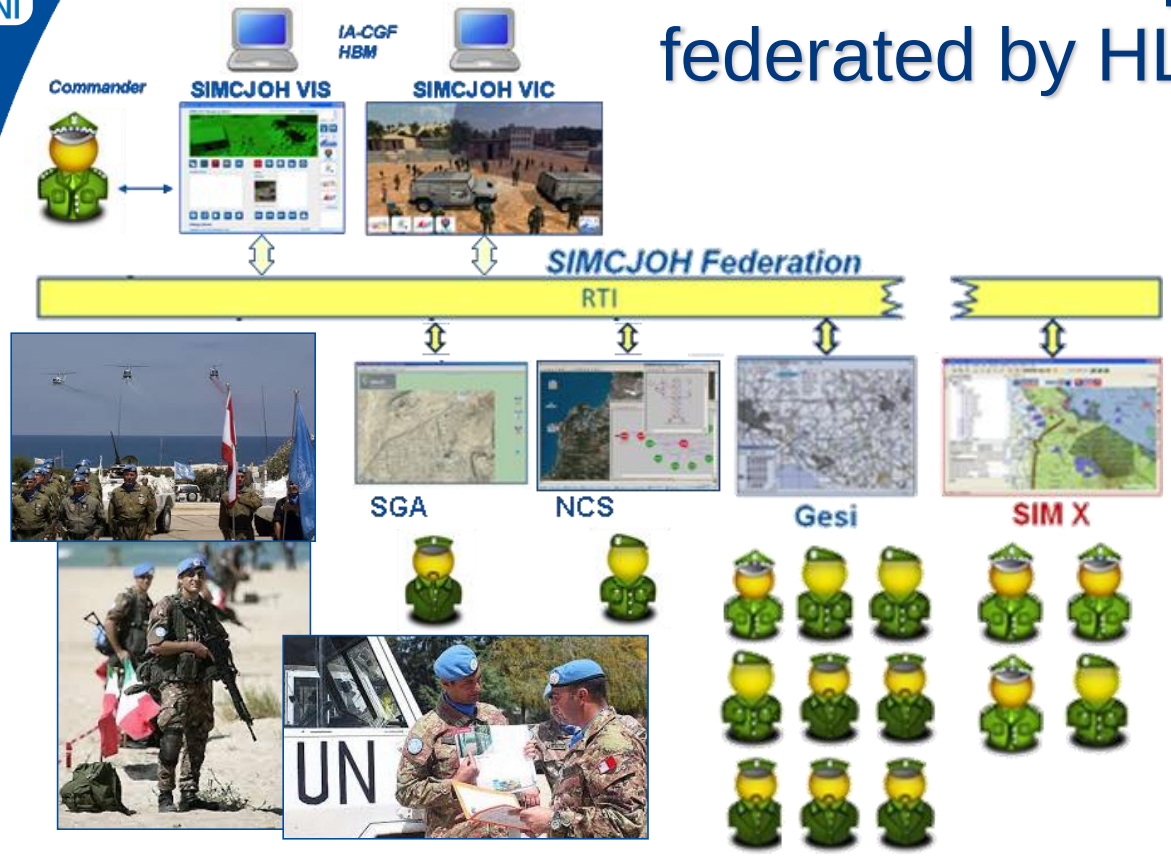
LEONARDO
LAND & NAVAL DEFENCE ELECTRONICS DIVISION

CAE

DIPTEM
Università di Genova

SIMCJOH as Open Framework

SIMCJOH Architecture is open to be fully federated by HLA



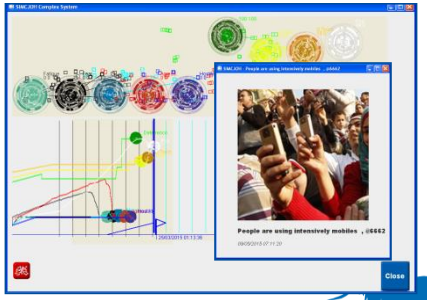
SIMCJOH adopts HLA standard for distributed simulation enabling the possibility to integrate as new federates other models and/or different kind of real systems.

SIMCJOH nteroperatility guarantees to be able to use it as element of a complex CAX for simulating critical issues and human behaviors

SIMCJOH VIS & VIC: HBM and IA-CGF

IA-CGF Federate SIMCJOH_VIS

- Thanks to the Intelligent Agents (IA-CGF), SIMCJOH is able to let the Commander experience with cross cultural awareness and therefore understanding that the human environment goes through the awareness of cultural differences.
- The IA-CGF federate is incapsulated within SIMCJOH VIS (Virtual Interoperable Simulator; this represents an IA-CGF NCS (Non Conventional Framework) using the IA-CGF previously developed by Simulation Team University of Genoa as an innovative family of Intelligent Agents Computer Generated Forces and able to operate in HLA distributed federation of simulators.
- IA-CGF includes the SIMCJOH models of the entities and the HBM (Human Behavior Models) in order to represent population, interest groups, opposite forces as well as consequence of Commander Actions and to direct the dynamic evolution of the secondary effects on the local population, the military effects and the collateral damages.



SIMCJOH Virtual Simulation

SIMCJOH_VIC Federate

- Virtual Simulation is based on an evolution of the Simulator CTRAIN, that was customized for SIMCJOH and became SIMCJOH_VIS (Virtual Interoperable Commander) Federate is in charge of providing 3D Virtual Environments in which the Commander can feel the sensation to be directly involved in the military operations. The 3D Virtual Environments is used only at certain points in time (e.g. at the beginning before running the simulation to provide initial information, after selecting the COA to show military and secondary effects of the COA, etc.).
- CTRAIN is a serious game originally developed by MSC-LES UNICAL and CAL-TEK (under the umbrella of the Simulation Team) to train Operators into Military Logistics for Overseas Operations.
- CTRAIN includes the SIMCJOH conceptual models and therefore it has been used to recreate (at certain points in time during the simulation) the 3D representation of the MEL/MIL and its evolution.

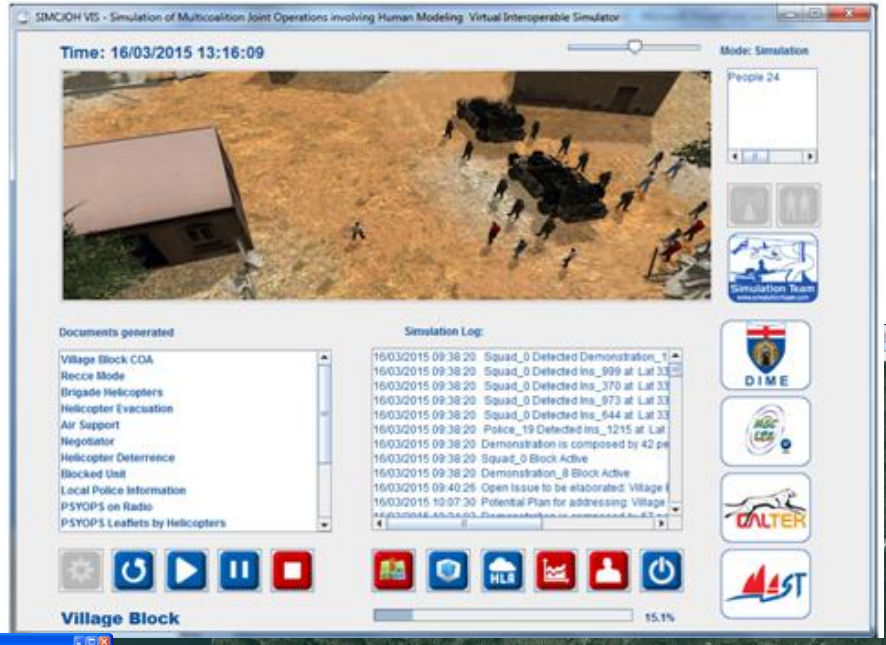
Simulation Team

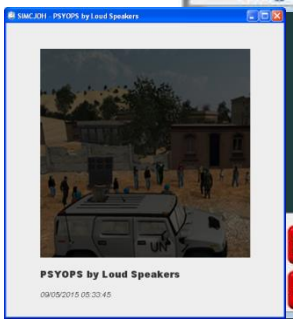
SIMCJOH_VIS

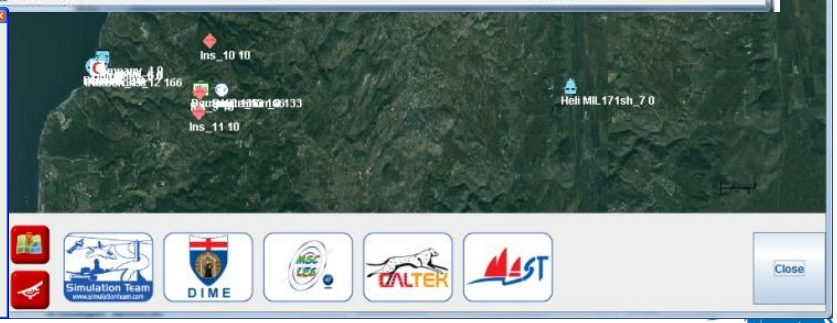
Simulation of Multi Coalition Joint Operations involving Human Modeling Virtual Interoperable Simulator

SIMCJOH VIS includes Population Model, HBM as well as CGF and Virtual Assistants and provides the interactive framework to receive reports, analyze situation, select decisions and assign high level tasks.

The simulator includes multiple interface able to deal with complex scenario. The demonstration is focused on Village Block into a complex framework.





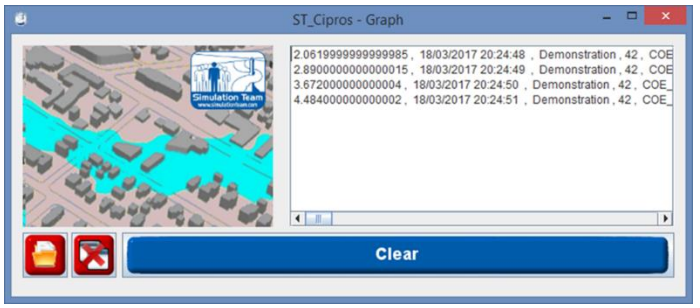


SIMCJOH_VIC MEL/MIL and COAs

SIMCJOH_VIC is a dedicated framework in which the commander observes the evolution over the time of specific scenarios (MEL/MIL) and Course of Actions (COAs). The current virtual environment includes two small towns, one village and one refugees camp in which the different MEL/MIL and COAs could be applied. This framework was finalized based on MEL/MIL and COAs defined within the SIMCJOH project framework, but could be further extended

ST_CIPROS Exercise

Simulation Team
www.simulationteam.com



ST_CIPROS VIS

Simulation Team Civil Protection Simulator

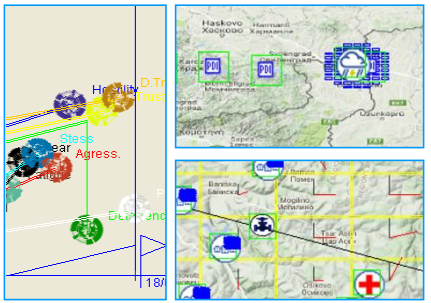
Virtual Interoperable Simulation

ST_CIPROS (Simulation Team Civil Protection Simulator) VIS (Virtual Interoperable Commander) is a MS2G (Modeling, interoperable Simulation and Serious Game) project for supporting Commander and Staff in addressing a Crisis within a Civil Protection Scenario.

ST_CIPROS provides an HLA interoperable immersive framework for the supporting critical decision making over a complex situation respect different kinds of crisis (e.g. flooding, hazardous material spill, CBRN, fires). ST_CIPROS includes models of Population and Human Behaviors developed by Simulation Team based on IA-CGF. CIPROS could support training and operate stand alone or federated in HLA with CRISOM and/or other simulators

DIPTEM
Università di Genova

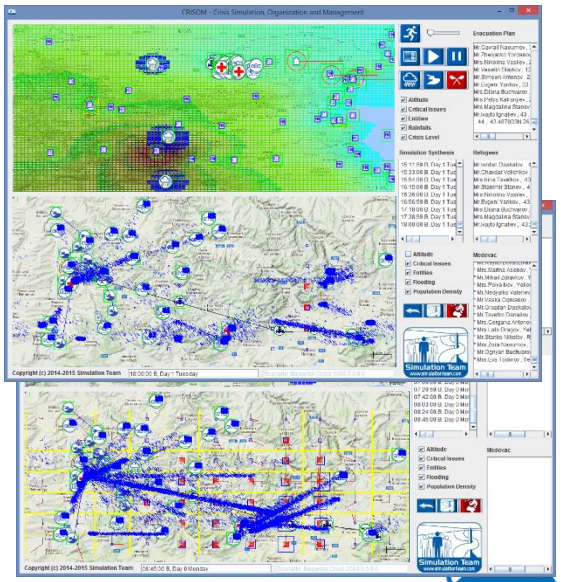
Simulation Team



ST_CRISOM

Simulation Team Crisis Simulation, Organization and Management

ST_CRISOM (Simulation Team Crisis Simulation, Organization and Management) reproduces the dynamics of a complex scenario where a crisis evolves. CRISOM considers the human behavior of the population in terms of evacuations, reactions due to the emergency as well as to human factors such as fear, stress, fatigue and aggressiveness. CRISOM uses the IA-CGF (Intelligent Agent Computer Generated Forces) to reproduce both civilian Populations as well as First Responders and Military Units, Health Care, Civil Protection Agents & Public Infrastructures CRISOM acts as a NCF (Non Conventional Framework) for IA-CGF. CRISOM simulates Flooding Scenario over regional areas and impact on Town, Industrial Facilities and Critical Infrastructures.
It could be federated in HLA with other Simulators.

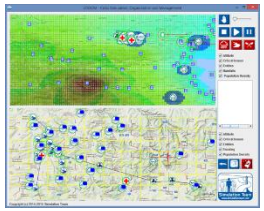


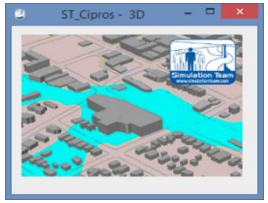
DIPTEM
Università di Genova

Simulation Team

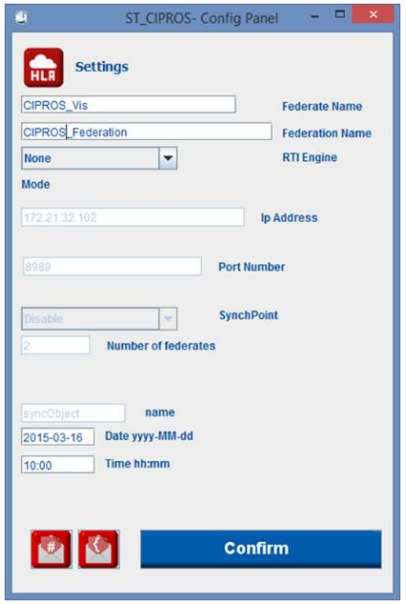
DT Federation for Security Simulation

Decision Theater VIS





Decision Theater VIC

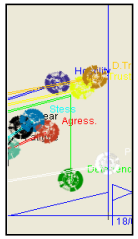


RTI

DT PLatform

Open Data

GIS



HBM IA-CGF

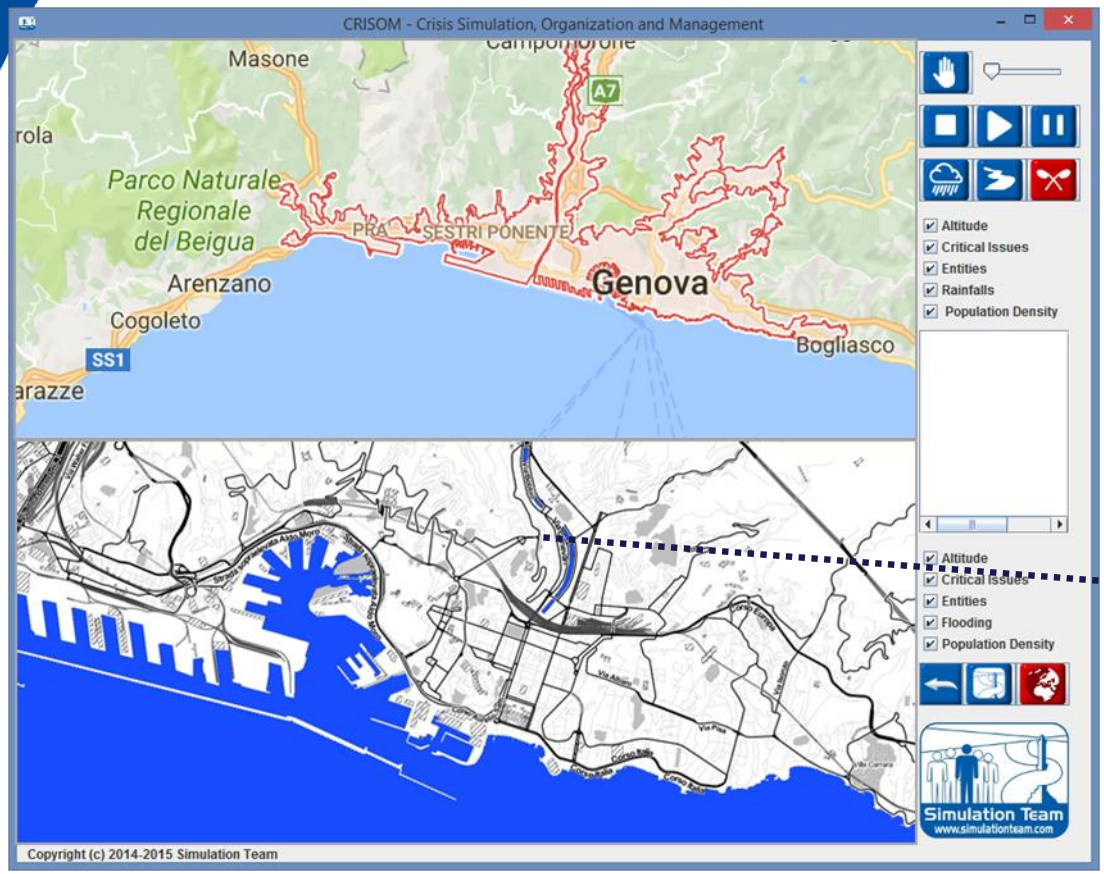
Other Simulator

Decision Theater Federation:
- *HBM & IA-CGF Federate*
- Decision Theater *VIS*
- Decision Theater *VIC*
- *GIS*
- *Human Behaviour – IA-CGF*

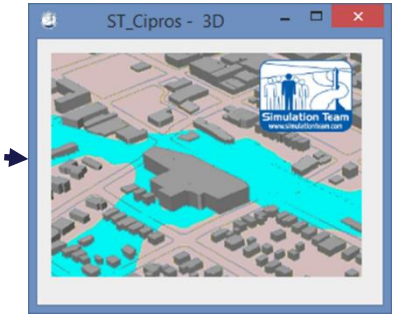
VIS	Virtual Inrteropeable Simulator
VIC	V irtual Interoperable Commander
HBM	Human Behavior Models
IA-CGF	Intelligent Agent Computer Generated Forces

HLA High Level Architecture, IEEE Standard

One Simulator… Multiple Resolutions



Decision Theater intuitive interface with multiple resolution . It is Suitable for the different command levels (Strategical, Tactical & Operative)

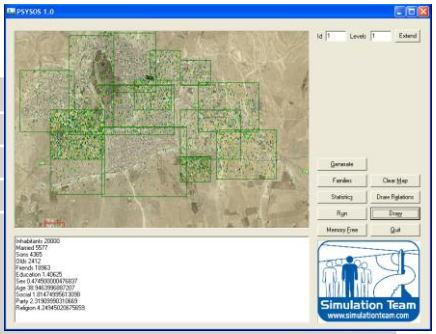


Simulation Team

Modeling Urbanized Areas

Urbanized areas are result of natural and urbanized subsystem

- Natural system reproduces the natural landscape of the city : the sky, the ground, the sea, the rivers
- Urbanized System reproduces all the aspect connected with human activities: location of households, Industries, point of interest and mobility

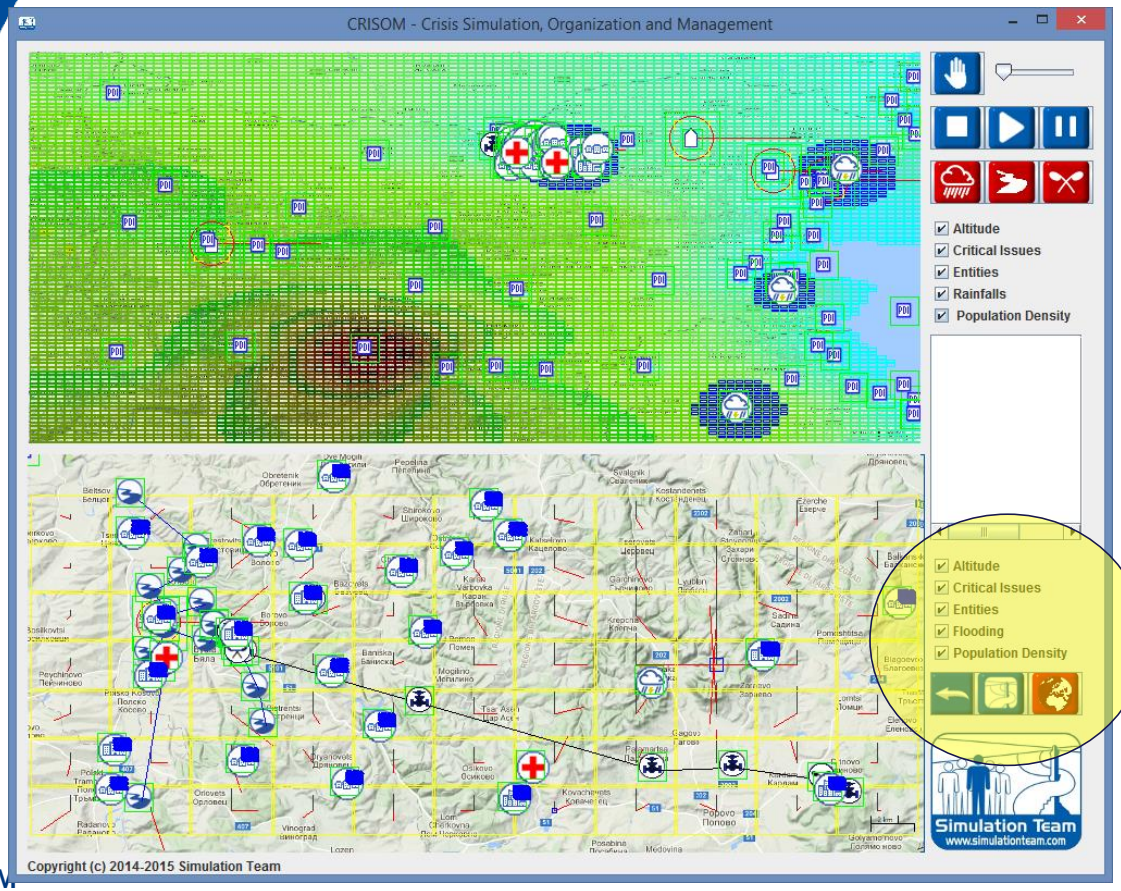


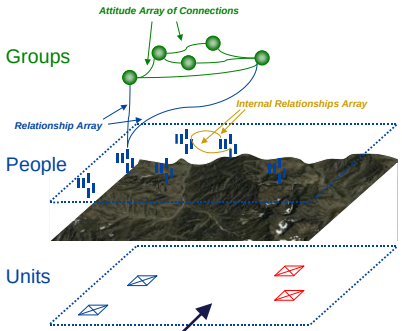
System	Elements	Effect for the simulation
Natural System	Sky	Rain reproduction in the different zone of the city
	Ground	Simulating different ground permeability characteristics
	Sea	Simulating sea level fluctuation, and tsunamis
	Rivers	Simulating the overflowing due to high level of the water: Two different watercourses should be considered: –Fluvial –Torrential
Urbanized system	Location of households	Simulating the more populated zones during the night
	Location of industries	Simulating the more populated zones during the day
	Mobility	Simulating the effect of natural events near the Hydrographic Basin of the river to roads, rail, and highways
	Location of points of interest	Schools, hospitals, stadiums are points of interest where there is a greater probability of high population density during certain hours of the day

The interoperable approach allow to add the simulation specific additional model based on the phenomena to be produced

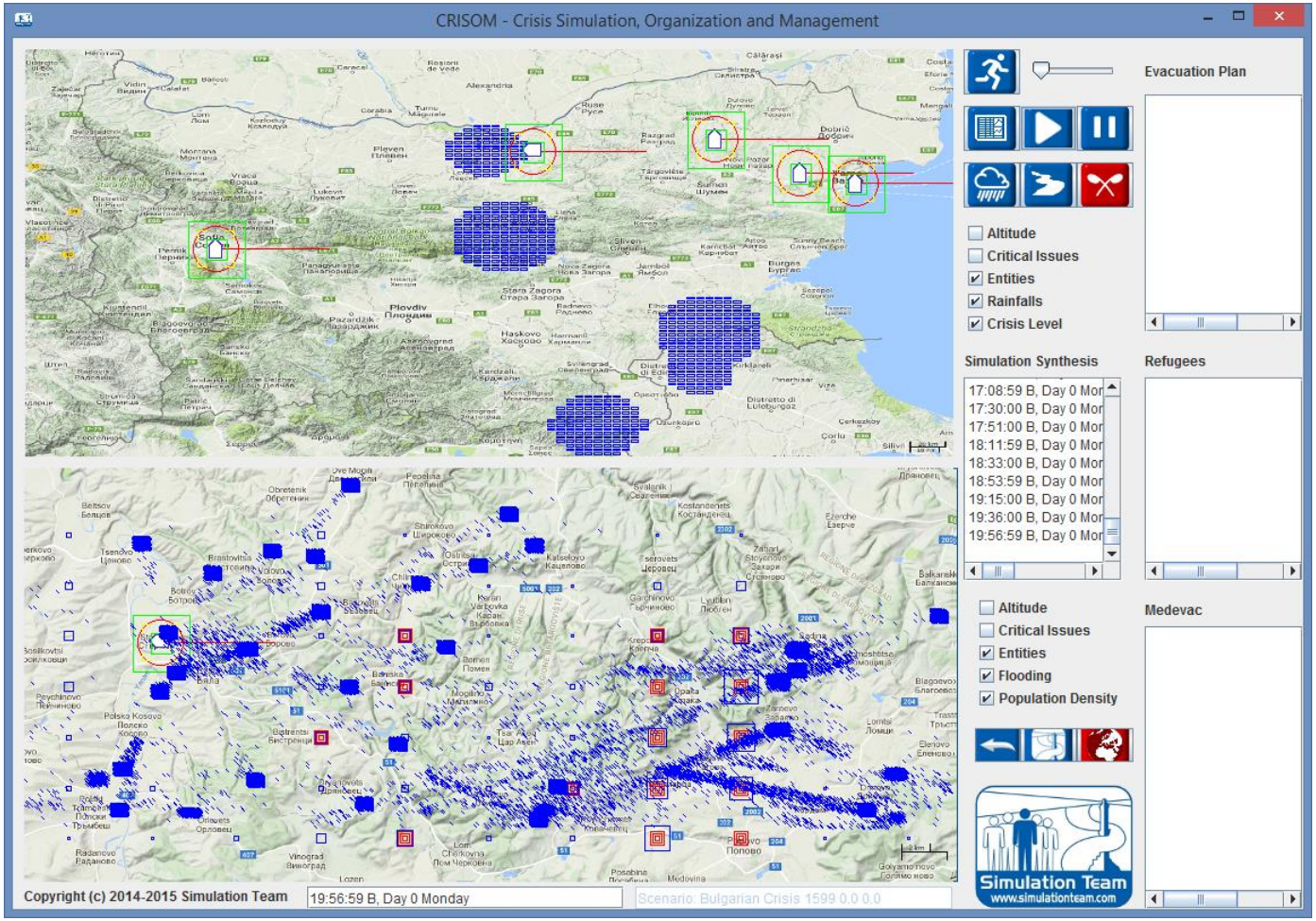
Modeling Urbanized Areas

The interoperable layer approach allow to increase flexibility for input data



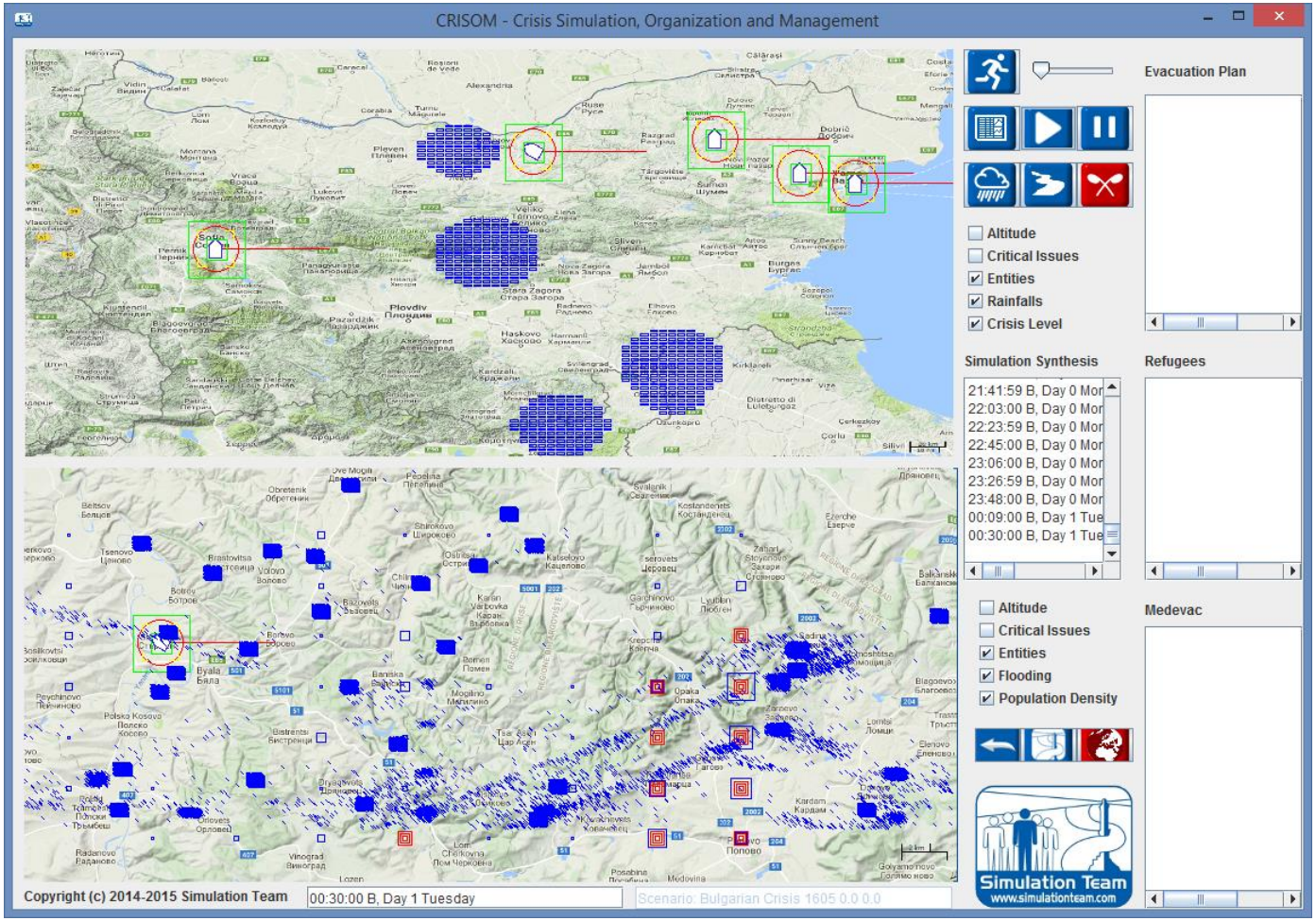


… or Simulation based on Historical Data

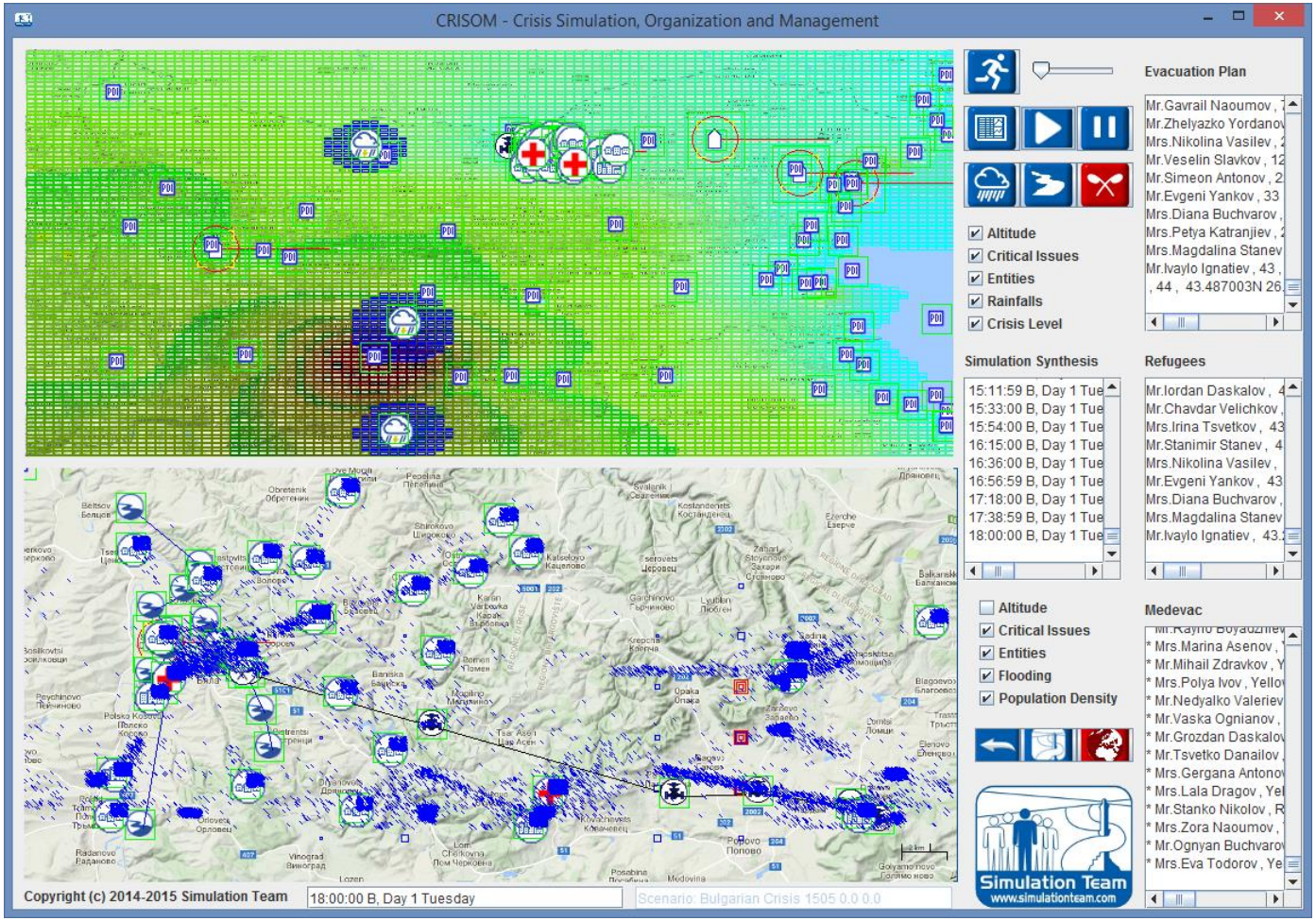


Simulation Team

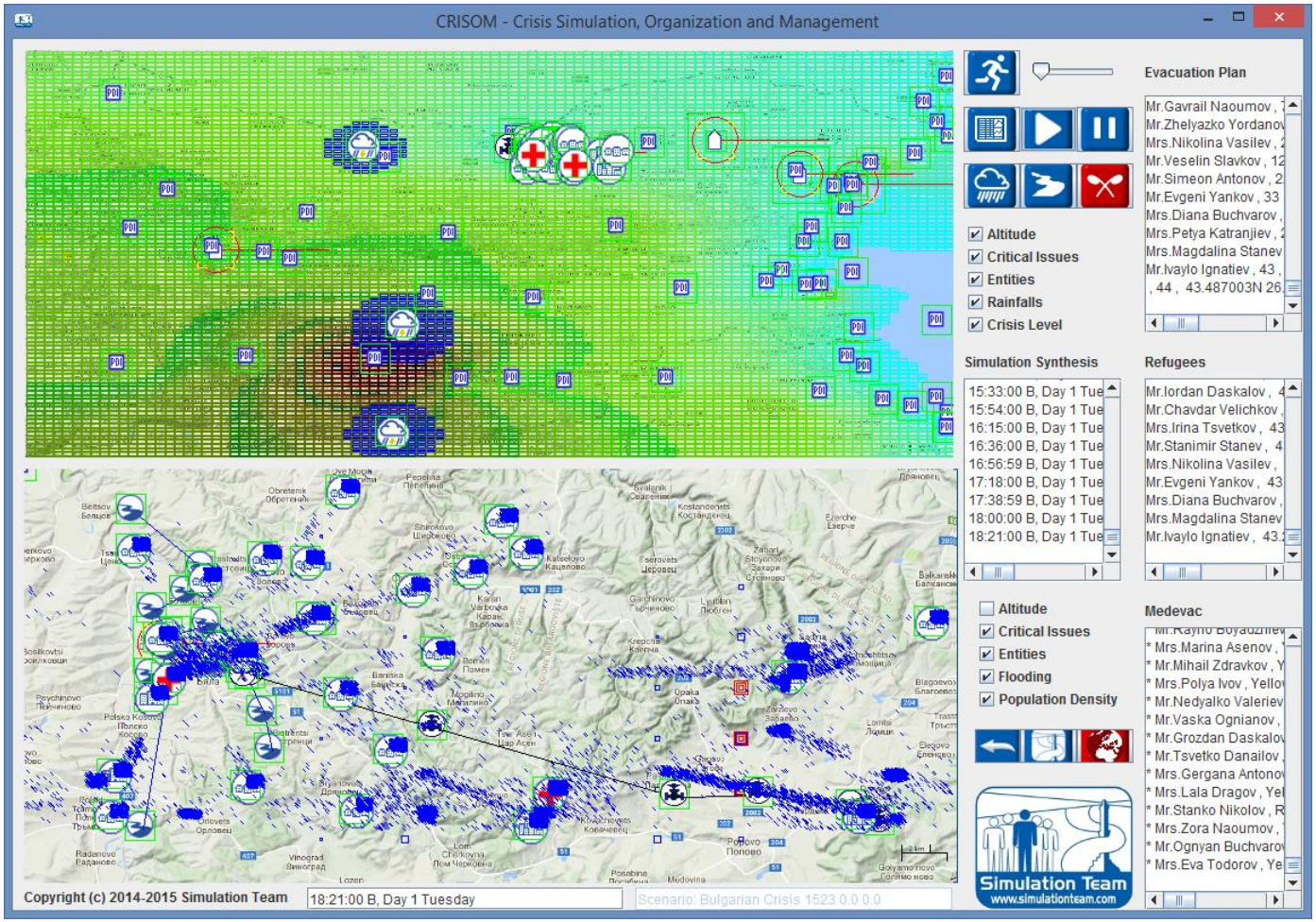
Impact of the Crisis on People and Infrastructures



Dynamics of the Crisis



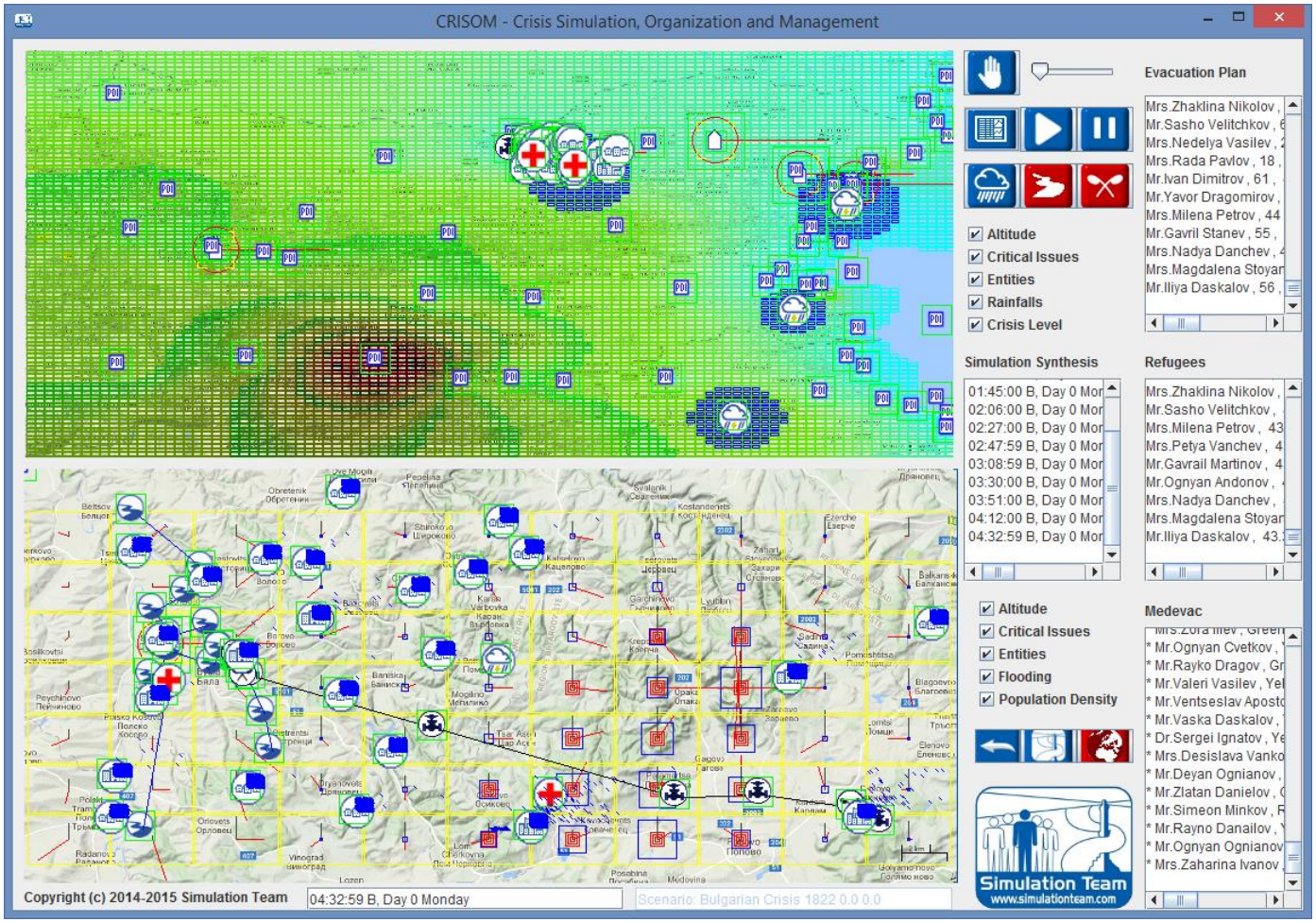
Local Hot Spot and General Situation combined Simulation



DIPTEM
Università di Genova

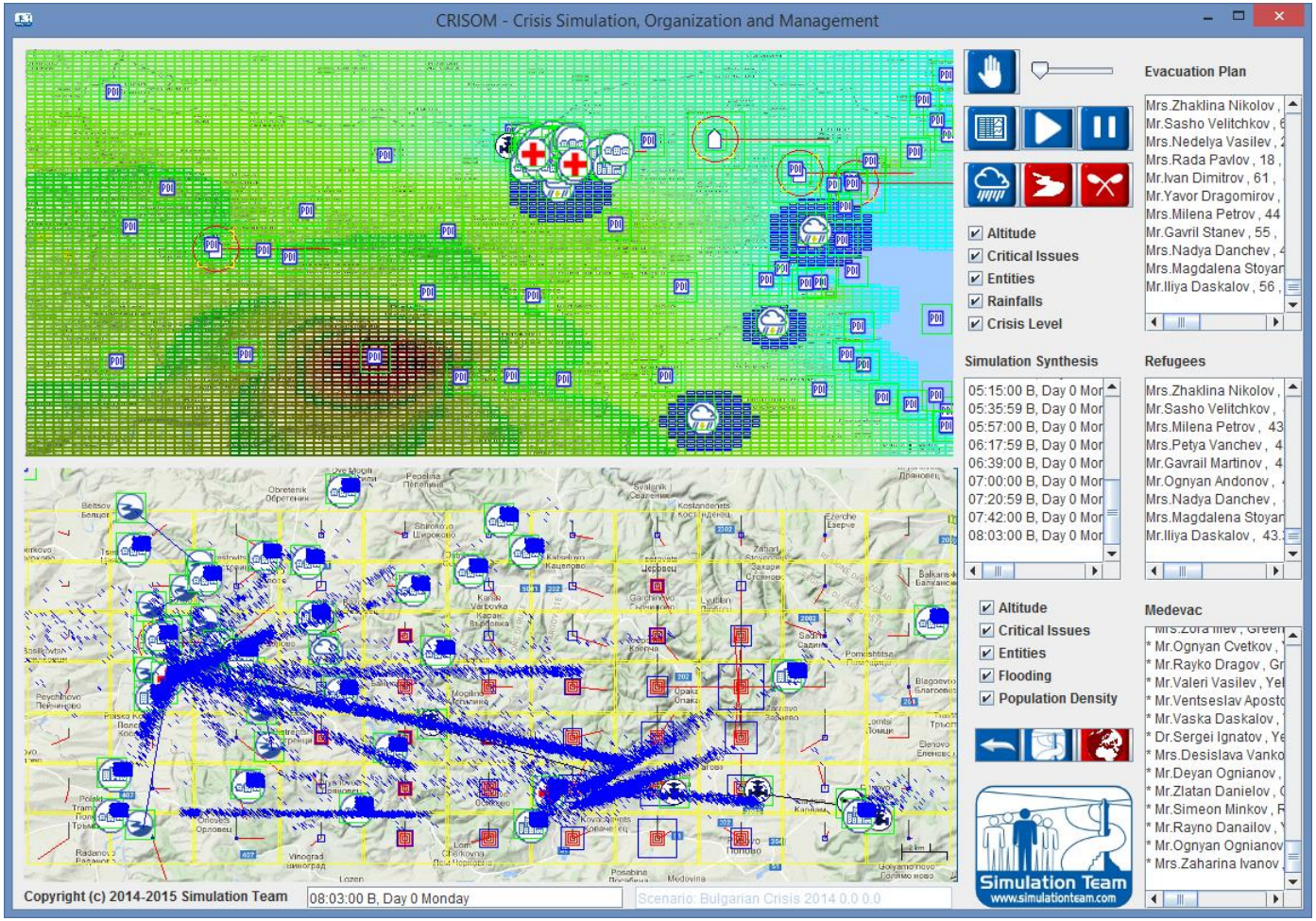
Simulation Team

Critical Infrastructures and Seveso Plants Hit by the Crisis



DIPTEM
Università di Genova

Data About Impact on Population

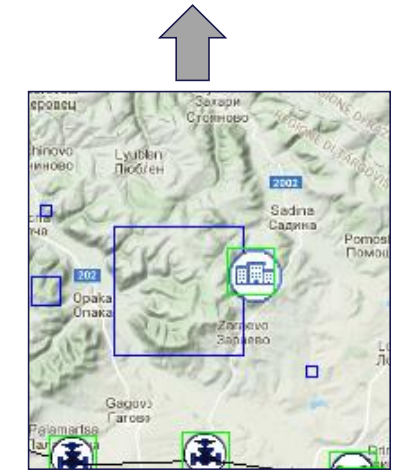


Simulation Team

Report Creation

The Decision Theater provide report of People to be evacuated

- men
- female
- children
- disabled
- wounded
- health status (green code, yellow code, red code)
- Casualities: People moving in the affected area



==========
Casualties: 2
*** Mr.Krastyo Dragomirov M Age 31 Etnich Bulgarian Religion Orthodox**
*** Mrs.Denica Todorov F Age 43 Etnich Turk Religion Atheist**
==========
Wounded: 283
*** Mr.Nikola Dimitrov , Yellow Code , 43.36N 25.990002E**
*** Mrs.Lyubov Velitchkov , Yellow Code , 43.437N 25.828001E**
*** Mrs.Silva Chilikov , Green Code , 43.359N 25.990002E**
*** Mr.Svetomir Aleksandrov , Green Code , 43.334003N 25.976002E**
*** Mr.Filip Petrov , Yellow Code , 43.34N 25.970001E**
*** Mr.Penko Tsvetkov , Red Code , 43.337N 25.976002E**
*** Mrs.Ivka Katranjiev , Yellow Code , 43.341003N 25.983002E**
*** Mr.Milan Katranjiev , Green Code , 43.336002N 25.981E**
*** Mrs.Eva Danchev , Yellow Code , 43.338N 25.983002E**
*** Mrs.Borislava Zlatkov , Yellow Code , 43.343002N 25.978E**
*** Mrs.Galina Viktorov , Red Code , 43.341003N 25.982E**
*** Mrs.Zaharinka Genkov , Yellow Code , 43.342003N 25.980001E**
*** Mrs.Rada Velichkov , Yellow Code , 43.317N 25.821001E**
*** Mr.Zhivko Antonov , Green Code , 43.335003N 25.973001E**
*** Mrs.Svetlana Boyadzhiev , Yellow Code , 43.338N 25.978E**
*** Mr.Zdravko Haralampiev , Green Code , 43.268N 25.79E**
*** Mrs.Ivet Goranov , Yellow Code , 43.334003N 25.978E**
*** Mrs.Zhivka Kaloyanchev , Yellow Code , 43.337N 25.971E**

DIPTEM
Università di Genova

Simulation Team

Decision Theater_VIC & Decision Theater_VIS

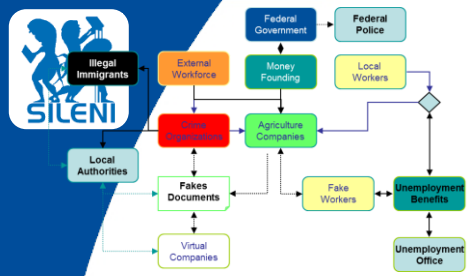
The Decision Maker has the possibility to interact with the virtual environment within the Serious Game observing the effects of his actions and the influence of different preventive measures.

However, it should be noted that within the Decision Theater federation, the Decision Maker is allowed to take decision through the Simulator embedded within Decision Theater_VIS (Virtual Interoperable Simulator) and therefore to observe virtually the effects of his decisions and event evolution within Decision Theater_VIC.

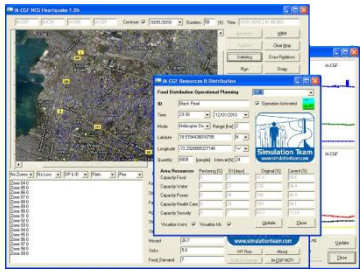
Modeling & Simulation: Examples in Defense and Industry

Simulation Team

Different Experiences



Indastria

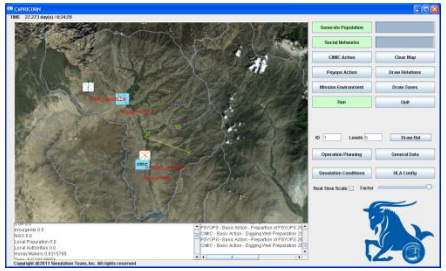


Haiti IA-CGF NCF

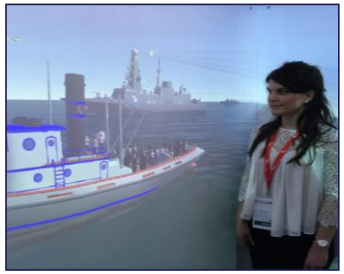
SPIDER

SIMCJOH

RIOT

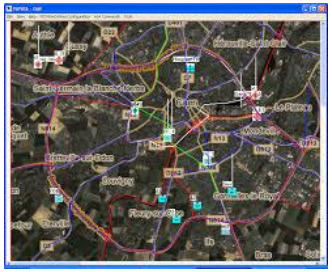


CAPRICORN

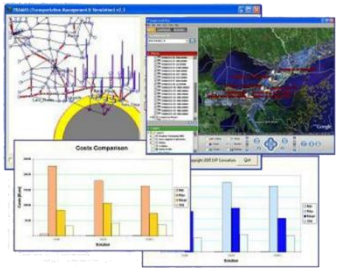


JESSI Immigrants

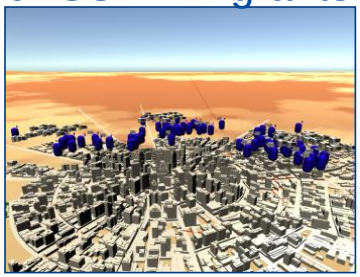
DIES-IRAE



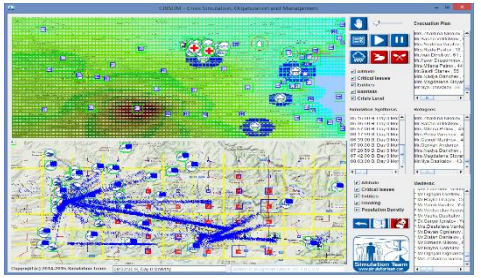
PIOVRA



Katrina Like Tramas



T-REX

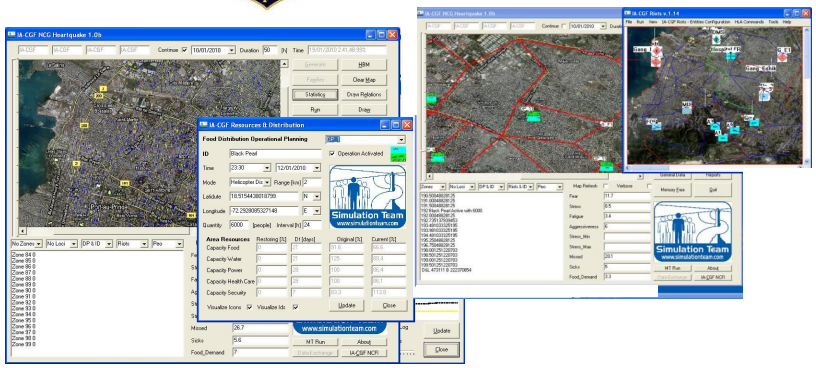


CRISOM

Simulation Team

Haiti Case

IA-CGF NCF Riots & IA-CGF NCF EQ



The Demonstration was based Haiti Earthquake 2010 and presented by USJFCOM at ITEC within 2 months.

The demonstration was devoted to show the potential of interoperability in combining different simulators for full coverage of a complex problem such as that one of Haiti.

Simulation Team was involved by using his interoperable IA-CGF reproducing Population Behavior, Human Factors (famine, stress, diseases, fear, aggressiveness), Riots and Gang Activities as well as the impact of the Simulation Earthquake

New IA-CGF MODULES

The *IA-CGF* Modules were developed by Simulation Team in a wide spectrum of application and are devoted to simulate complex scenarios include the following modules:

IA-CGF Units

IA-CGF Human Behaviors

IA-CGF Non-Conventional Frameworks

IA-CGF Units

***IA-CGF Units* are a set of interoperable units with capability to be integrated in constructive simulation**

- Police
- Gangs
- Local Population
- Rioters
- Insurgents
- Terrorist
- Local Authorities
- Warlord
- Criminal Organizations
- NGOs (CIMIC ops.)
- Civil Personnel (CIMIC ops.)
- Domestic/National Situation (for instance for troops moral)
  - Population
  - Media
  - Lobbies
- International Public Opinion
- International Diplomacy
- New Threats (i.e. 2nd Generation Terrorists)

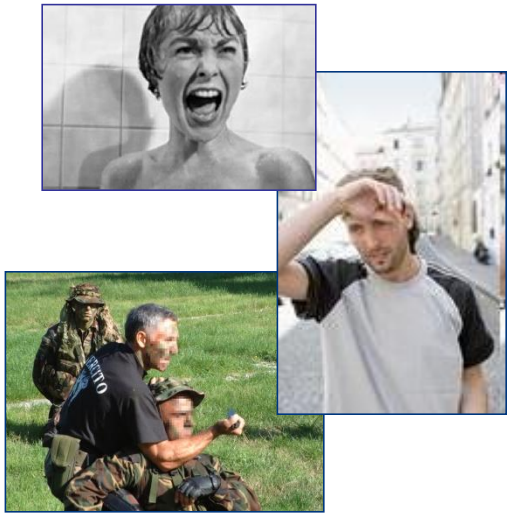
These are examples of non-conventional units controlled by IA-CGF

Simulation Team

IA-CGF Human Behaviors

Specific modules with *IA-CGF Human Behaviors*:

- Fear
- Stress
- Fatigue
- Training Level
- Aggressiveness
- Ethnic Factors
- Religious Factors
- Combat Skills/Experience



IA-CGF Human Behaviors operate as a set of further characteristics to be added to each unit in constructive simulation.

i.e. now in constructive simulation every unit in the scenario have infos about status and type of ammo, by IA-CGF dynamic information are added related to level of fear, fatigue and stress and the Units performing according to it

Simulation Team

IA-CGF Non-Conventional Frameworks

It is important to consider the integration in a scenario of the *IA-CGF-Non-Conventional Frameworks (IA-CGF-NCF)*, each simulating specific events:

IA-CGF CIMIC/HUMANITARIAN FRAMEWORKS

- Food Distribution
- Reconstruction

IA-CGF Homeland Security and Civil Protection FRAMEWORKS

- Natural Disaster (i.e. Hurricanes, Earthquakes)
- Man Made Disasters (i.e. Explosion, Hazardous Material Spills)
- Evacuation

IA-CGF PSYOPS and INTELLIGENCE FRAMEWORKS

- Possible integration with *Sibilla*© Serious Game for Intelligence Officers training

In non conventional scenarios for particular training purposes.

We can imagine to have active different non conventional Frameworks, in different locations, with different level of detail inside the simulated theater.

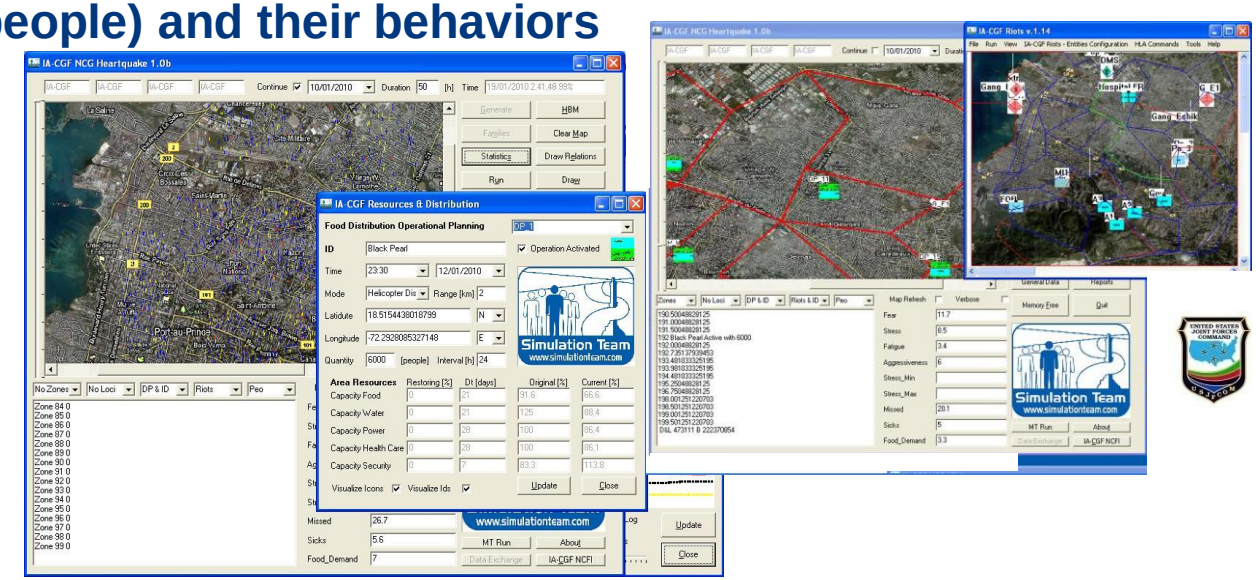
Simulation Team

IA-CGF NCF Riots
IA-CGF NCF Haiti Earthquake & Humanitarian Support

The Simulation is based on IA-CGF and focuses on food distribution and tactical operations impact on population, modeling human factors such as aggressiveness, fear, fatigue, stress, famine, etc.

The IA-CGF are reproducing the population and different groups and networks (~2 million people) and their behaviors as well as crime organizations, gangs and riots.

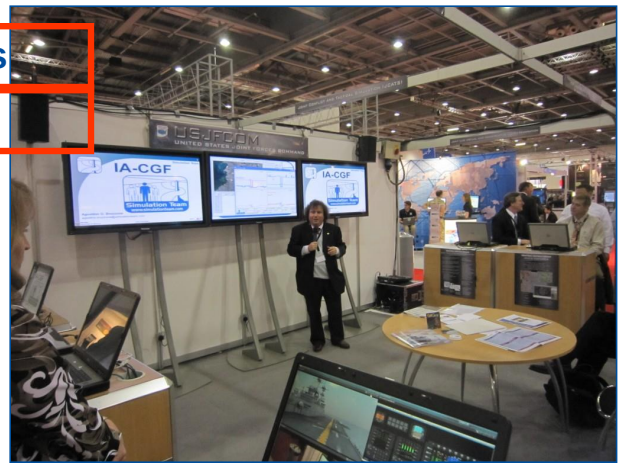
These two IA-CGF NCF are federated in HLA and interact dynamically



Simulation Team

Haiti Humanitarian Support Demonstration





- JTLS
- JCATS
- IA-CGF Riots
- IA-CGF EQ
- VBS2
- DI-GUI
- PLEXSYS

Simulation Team
www.simulationteam.com

Simulation Team

IA-CGF NCF Riots
IA-CGF NCF Haiti Earthquake & Humanitarian Support

The Simulation is based on IA-CGF and focuses on food distribution and tactical operations impact on population, modeling human factors such as aggressiveness, fear, fatigue, stress, famine, etc.

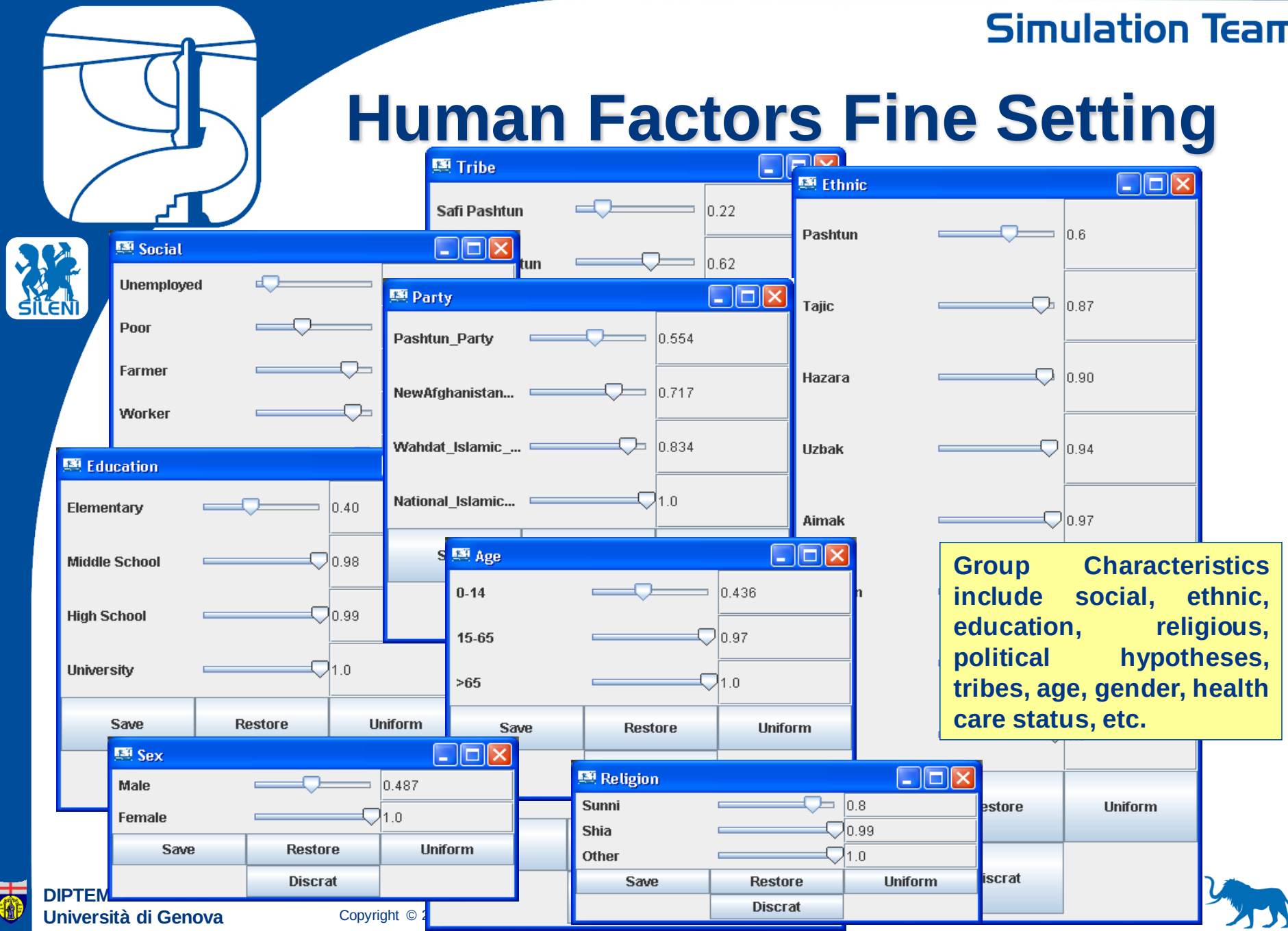
The IA-CGF are reproducing the population and different groups and networks (~2 million people) and their behaviors as well as crime organizations, gangs and riots.

These two IA-CGF NCF are federated in HLA and interact dynamically

DIPTEM
Università di Genova

Simulation Team

Human Factors Fine Setting

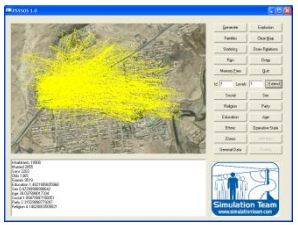


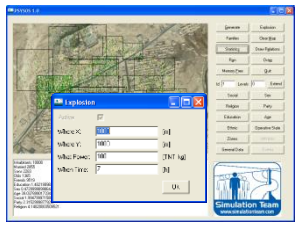
Group Characteristics include social, ethnic, education, religious, political hypotheses, tribes, age, gender, health care status, etc.

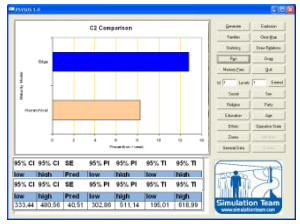
Simulation Team

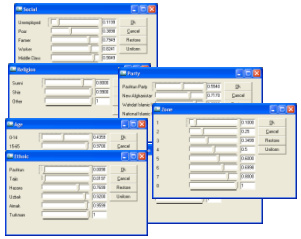
IA_CGF: Modules and Use Mode Example


Specific Mission Environment

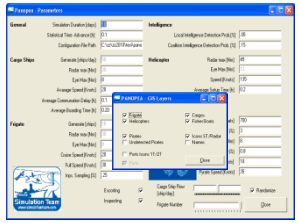

Generate Social Networks CAPSON


DefineCOAs, Metamodels Actors of Threat

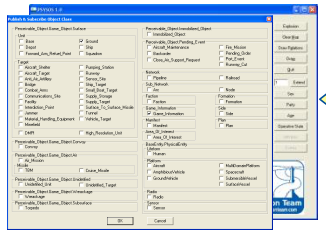

Comparative Analysis & Result Synthesis


Population & Social Network Configuration


Generate Population CAPPOP


Setting Simulation Parameters


Simulation Execution

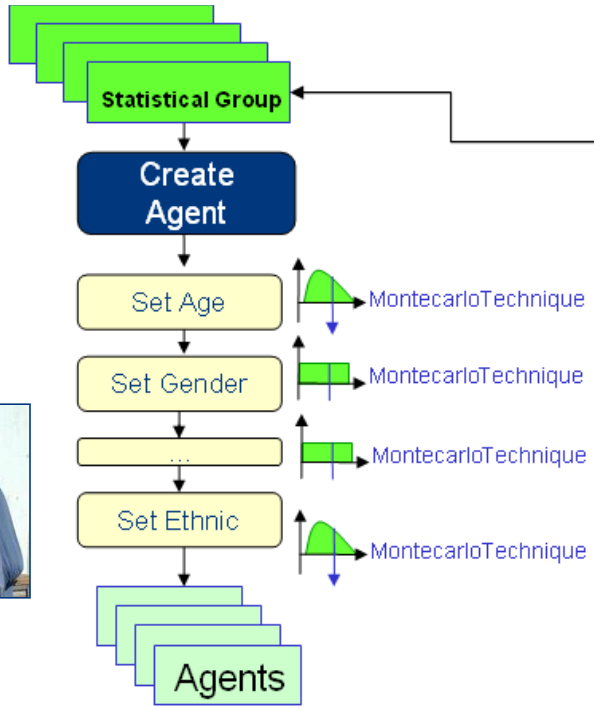

Setting Interoperability Mode

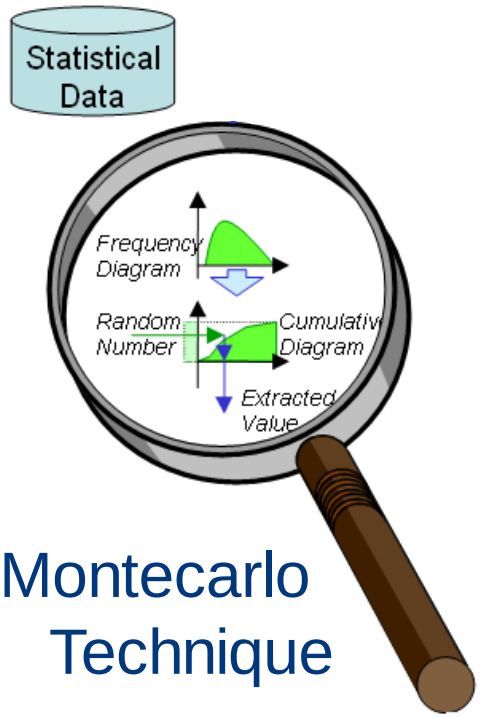
On/Off


Other Federates

Simulation Team

Population Generation by Montecarlo Techniques





Montecarlo Technique

Example of Scenario Operation Planning

Training in Operation Planning, at tactical and strategic level, requires to consider human behavior of the population

Example of Scenario Population Modelling

The Population Model allows to dynamically support scenario evolution to train people on operation planning

Example of Scenario Different Simulations

Urban areas requires capillary presence, detailed control, security service for civilians, support to fundamental needs and could need multiple models

Example of Scenario IA-CGF Interoperating

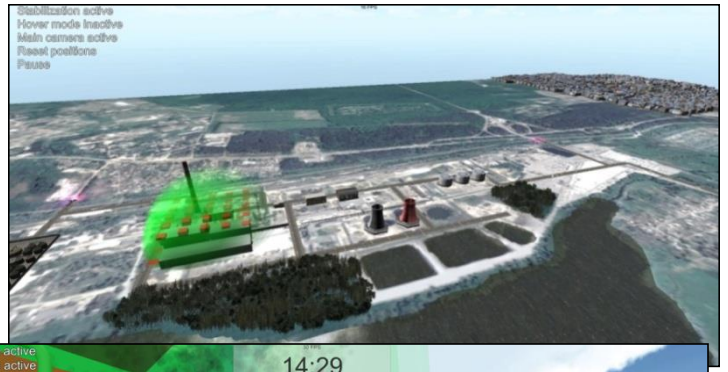
The interoperability among models dealing with different planning aspects allows to create realistic solutions for training

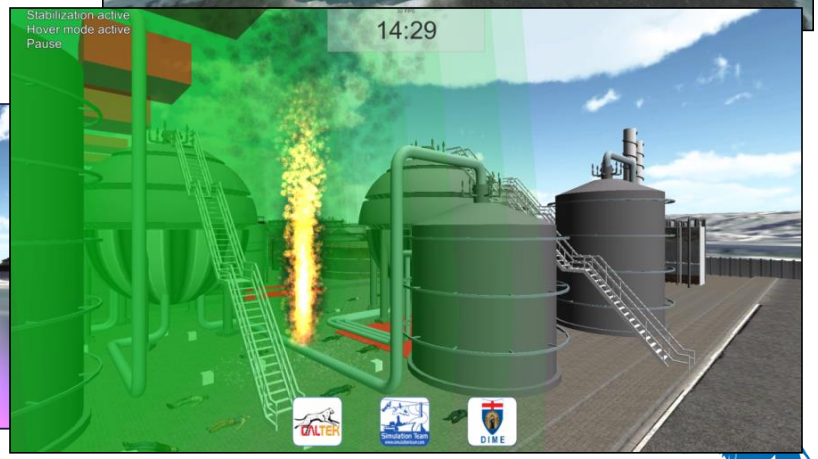
IDRASS

Immersive Disaster Relief and Autonomous System Simulation

IDRASS (*Immersive Disaster Relief and Autonomous System Simulation*) is a MS2G (Modeling, interoperable Simulation & Serious Game) operating in multiple modes: standalone, federated in HLA, integrated through IoT (Internet of Things) to support Education and Training.

IDRASS has been applied to different cases including Accidents in Industrial Facilties, Nuclear Plants, CBRN attacks, anti-Terrorism, CWA and RDD. IDRASS is an interoperable real and fast time simulator.





RDD Radiological Dispersal Device
CWA Chemical Weapon Agent
HLA High Level Architecture

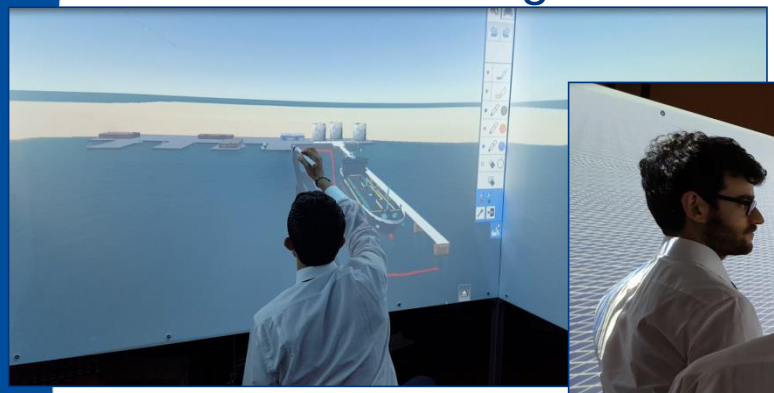
DIPTEM
Università di Genova

Simulation Team

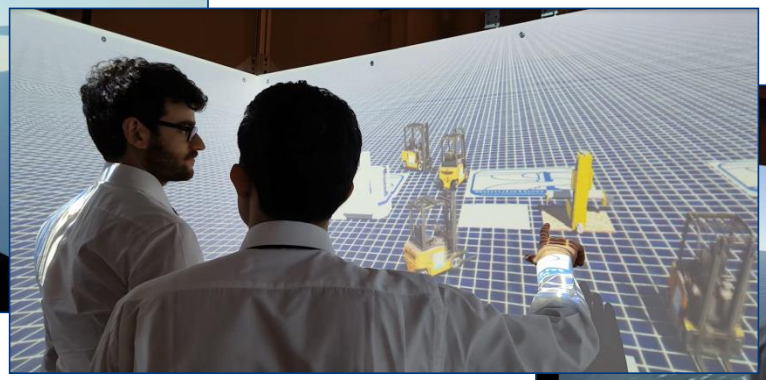
SPIDER

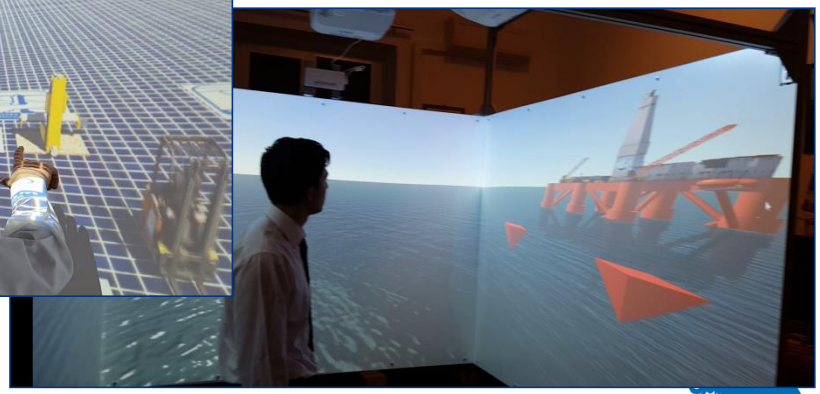
Simulation Practical Immersive Dynamic Environment for Reengineering

The SPIDER (Simulation Practical Immersive Dynamic Environment for Reengineering) is an innovative Interactive and Interoperable CAVE (Cave Automatic Virtual Environment) developed by Simulation Team. The basic configuration is compact (just 2m x 2m x 2.6m) and could be embedded within a standard Container and integrated in any interoperable simulator.



The SPIDER is interactive through touch screen technology.



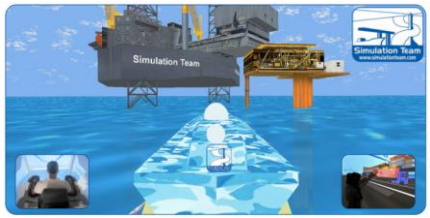


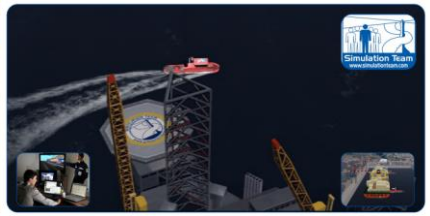
The SPIDER is fully Immersive including sound and motion.

DIPTEM
Università di Genova

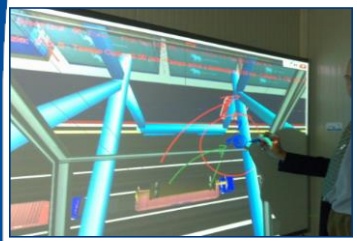
Simulation Team

ST_VM: Virtual Marine





The ST-VM is the ultimate Marine Simulator developed by Simulation Team and includes many different Marine components, equipment and platforms as well as New Solutions for Terminal Design, Operator Training, Safety and Security, Procedure Definition, Equipment Design and Virtual Prototyping



ST-VM is fully containerized real-time distributed HLA Simulator reproducing Port Operations. ST-VM is integrated in a 40' High Cube Container ready to be used on site immediately after arrival.

ST-VM Simulator allows to operate all the different Marine Devices in a Virtual World by an immersive Cave (270 ° Horizontal and 150° Vertical), reproducing Sounds, Vibrations, Motion in all weather conditions

ST-VM includes a Full-Scope Simulation for Training Operations & Procedures, an Integrated Class Room, the Instructor Debriefing Room, and secondary Interoperable Simulators of different Marine equipment with other modules (i.e. Biomedical Module for Safety, Ergonomic and Posture Enhancement).

ST-VM World is customizable for each Platform, Port, Crane, Procedure and Equipment.

DIPTEM
Università di Genova

Simulation Team

ST_VP: Virtual Port Simulation

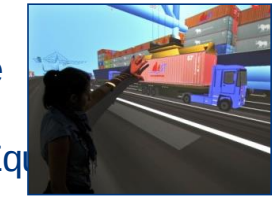
The ST-VP is the ultimate Port Crane Simulator developed by Simulation Team and includes all the different crane types and New Solutions for Operator Training, Safety and Security, Procedure Definition, Equipment Design and Virtual Prototyping

ST-VP is fully containerized real-time distributed HLA Simulator reproducing Port Operations. ST-VP is integrated in a 40' High Cube Container ready to be used on site immediately after arrival.

ST-VP Simulator allows to operate all the different Port Cranes in a Virtual World by an immersive Cave (270 ° Horizontal and 150° Vertical), reproducing Sounds, Vibrations, Motion in all weather conditions

ST-VP includes a Full-Scope Simulation for Training Operations & Procedures, an Integrated Class Room, the Instructor Debriefing Room, and secondary Interoperable Simulators of all the Port Cranes and a Biomedical Module for Safety, Ergonomic and Posture Enhancement.

ST-VP World is customizable for each Port, Crane & Procedure and Eq

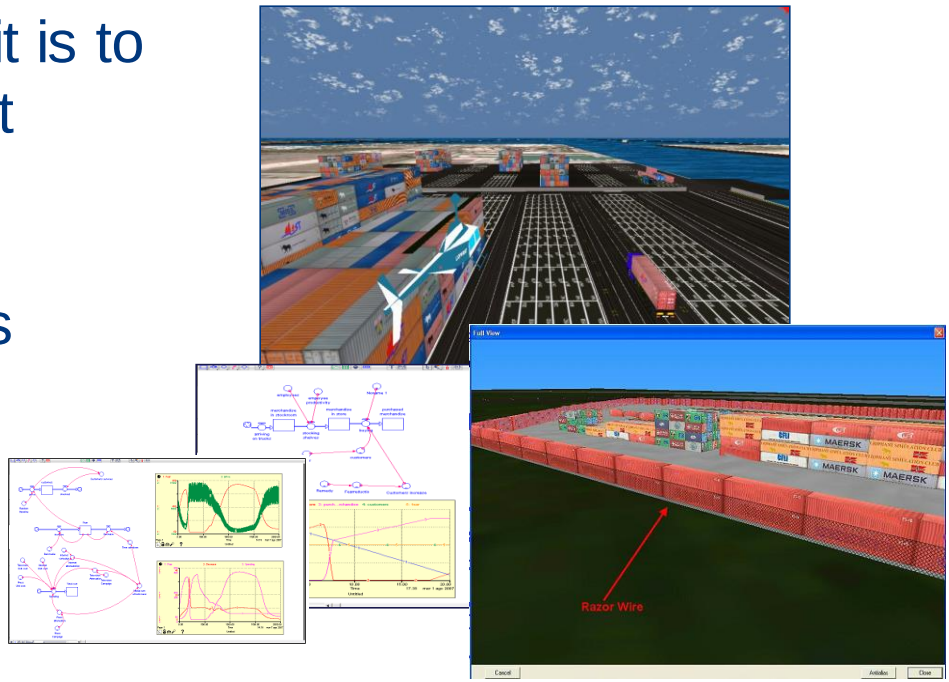


Simulation Team

Port/Terminal Security Simulation

Simulation Team is active in Modelling & Simulation for Guaranteeing Security in Maritime Environment especially in reference to Ports and Terminals

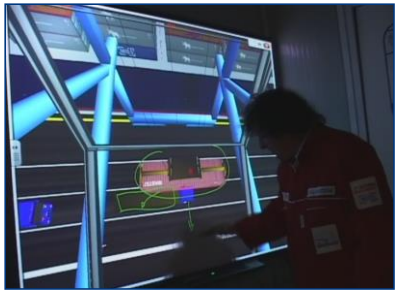
A major goal in this context it is to create solutions that support the Definition of operative and training procedures for security and safety harbours operations with strong emphasis on common standards and multi user framework



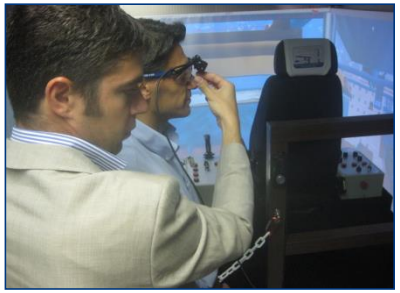
Simulation Team

ST_PT & ST_RS Simulators








Shelter & Facilities | ST_PT Crane Sim | ST_PT Truck Sim

This new generation of simulator is mobile, real-time, scalable and interoperable and compliant with state of art technology and standards

Simulation Team

Atout of our Virtual Simulation

Simulation Team

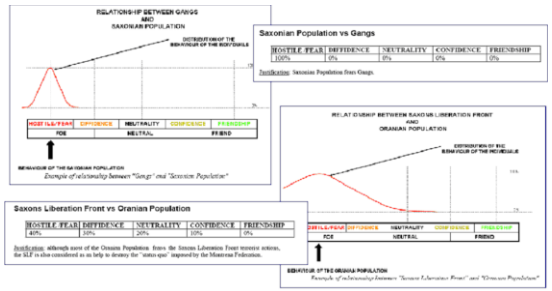
PIOVRA

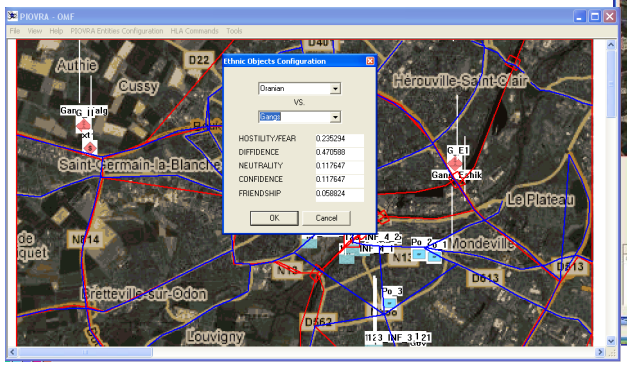
Polyfunctional Intelligent Operational Virtual Reality Agents

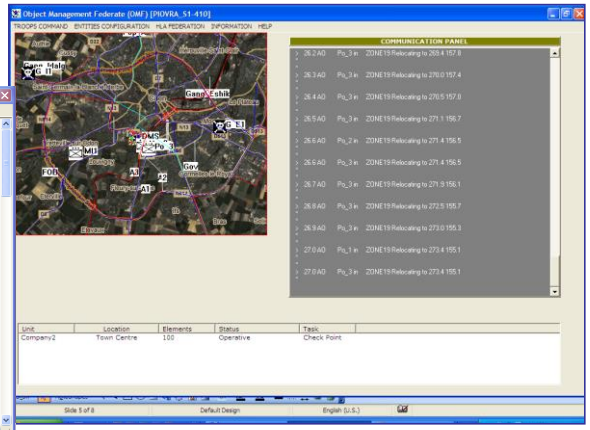
PIOVRA was an EDA Project developed in cooperation with Italian and French MoDs in partnership between MISS DIPTEM & LSIS.

PIOVRA allowed to develop a new Generation of CGF able to simulate "Intelligent" behaviors, filling up the gap between user requirements and current available CGF performances

PIOVRA demonstrated the new intelligent agents directing the CGF as effective models integrated in HLA Simulation reproducing Urban Disorders integrated in a Theater Simulation







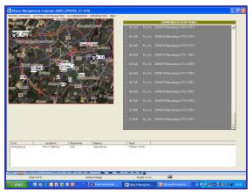
Simulation Objects

PIOVRA (Polyfunctional Intelligent Operational Virtual Reality Agents**) Project involved the following Object :**

Comportment Objects are dedicated to the simulation of actors that represents behaviors of populations, movements or analog entities to where units on the field belongs.

Action Objects **units with the task of simulating elements acting the scenario (i.e.military unit, terrorist, leader) or events (i.e.riots, demonstrations) Action Objects are referencing corresponding Comportment Object with mutual and are characterized by mutual influence**

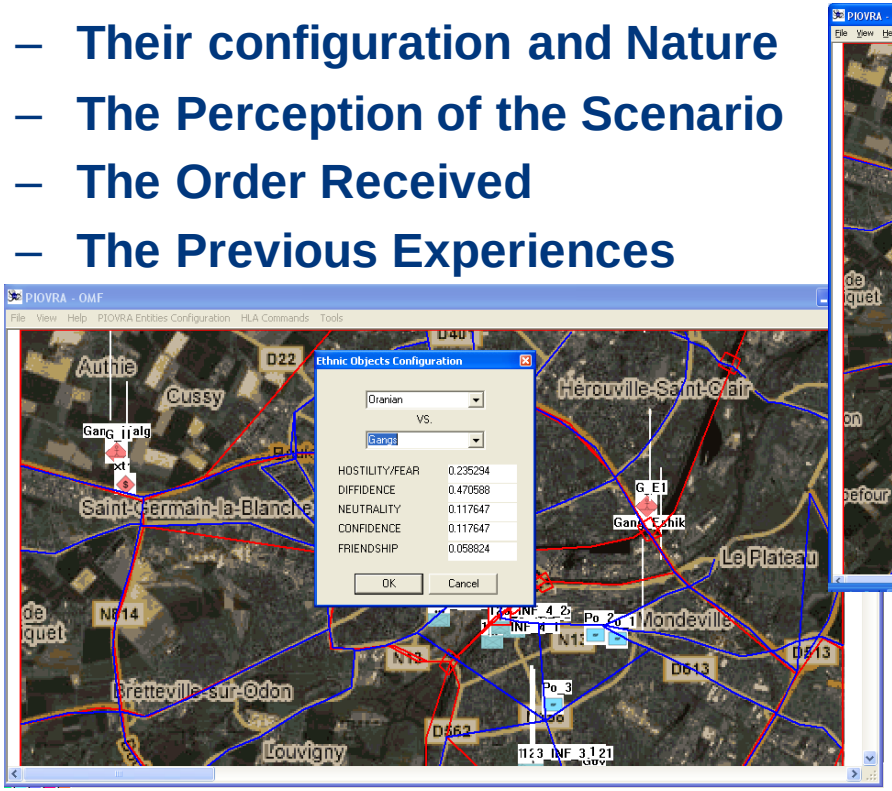
Support Objects include objects representing influent phenomena corresponding to boundary conditions such as Environment Data Representation including Zone, Layer and Weather Objects.

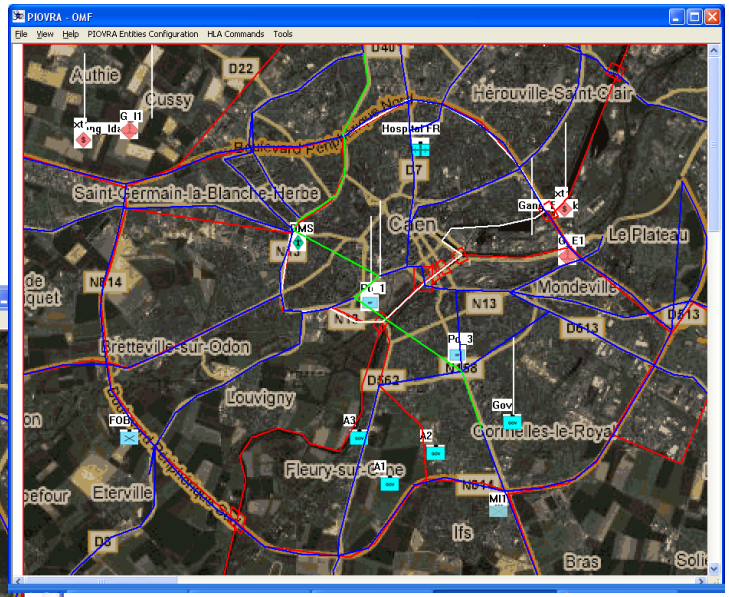


Action & Compartment Objects

The different Units are driven by the Agents and apply different procedures and ROE based on:

- **Their configuration and Nature**
- **The Perception of the Scenario**
- **The Order Received**
- **The Previous Experiences**

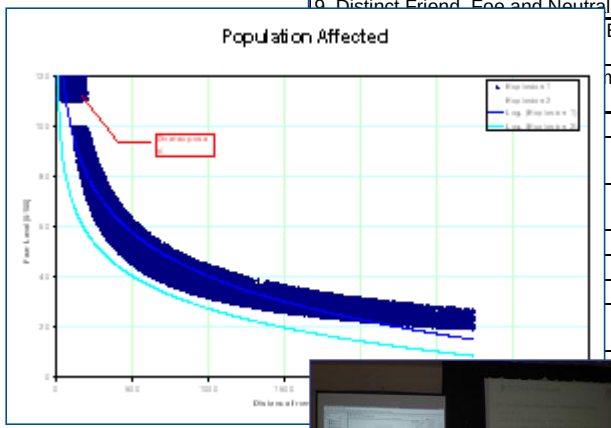




Simulation Team

VV&A Features

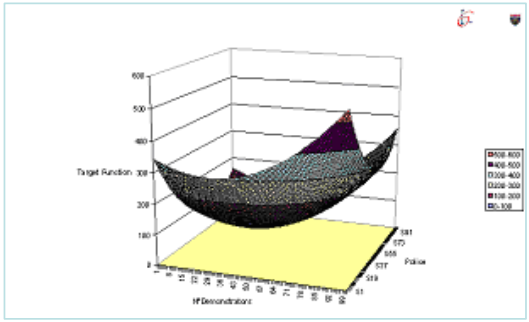
Feature/Objective	*Present*	*Example and Note*
1. User-Defined Initializing Parameters	YES	The user defined the profile of the Gang as well as the ROE to be used by Blue Units
2. Analyze Surrounding Envinroment and React Respectively Capability	YES	The Blue Units encountering the Riot and the Gang takes actions to stop the looting
3. Cooperation Capacity	YES	Some Blue unit are providing support on others reaching the demonstration/riot
4. Force Aggregating/Disaggregating Capability and relevant military hierarchy	YES	Disaggregation of Blue unit in two Squads after dissolution of the Riot
5. Resultant Aggregation Levels different from aggregating/disaggregating elements sum/subtraction	YES	The combination of Demonstration and Gang looting create impact on the area different from the sum of the single entities and introduces the generation of a riot
6. Limit Proper Autonomy to Achieve Common Objective Capability	YES	It is possible to enable/disable the possibility for the Blue Unit to request direct support to the other ones and to let the scenario evolve with this other condition
7. Stress Level Indicator applicable for the entities behavior definition	YES	These aspects affect both Population and Military Units all along the simulation
8. Implementation of Typical Human Behavior (survival instinct and moral/ethical motivations)	YES	It is possible to enable/disable the feature and check, versus critical riots, the different respect of ROE by Military Units
9. Distinct Friend, Foe and Neutral Units	YES	Distinction betweeen Gang and Militia
Behavior	YES	Each entity provides a Log including the conditions under what each different ROE applied
mmanders Capability	YES	Reporting that includes encounters with other units, Riots and situation evolution
	YES	Each entity provides a Log related to the factors affecting their actions
	YES	Blue Unit moving among cells of an ethnic group affects the population evolution and the eventual creation of a Riot
	YES	A single entity is representing the agitators that change the attitude of the demontration/riot
	YES	The militia unit is corresponding to a team
	YES	The Blue Unit in patrol corresponds to a Squad
	YES	The Blue Unit providing support corresponds to a Platoon
	YES	Reports about actions and events are distributed as interaction in the HLA Federation during Simulation Runs

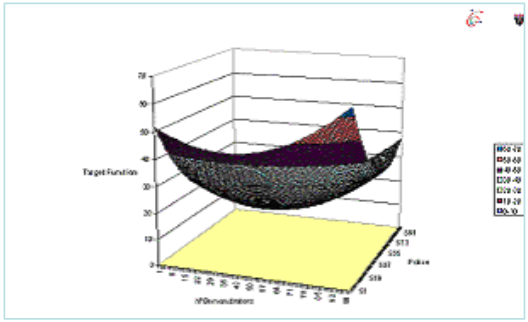


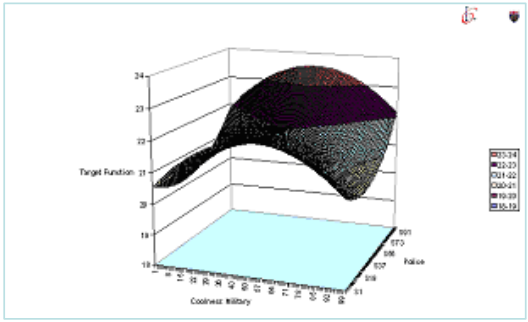
Example of Testing the Features of IA

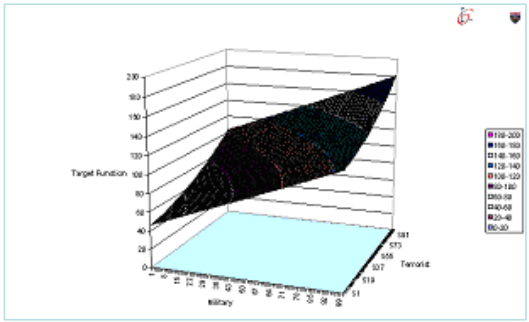
It is critical to guarantee proper VV&A for models especially due to HBM and Interoperability Issues

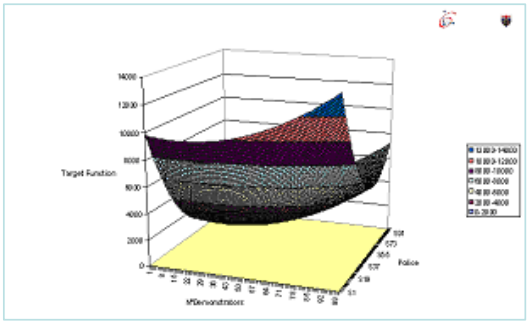
Example of Scenario Experimental Analysis

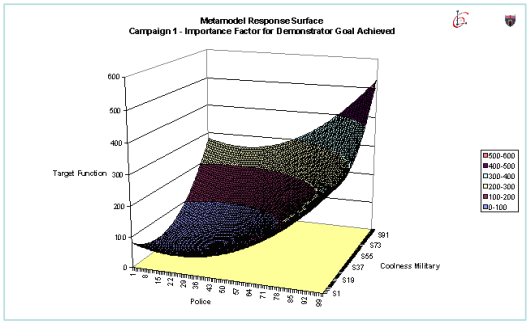




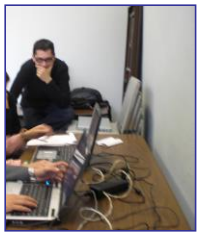




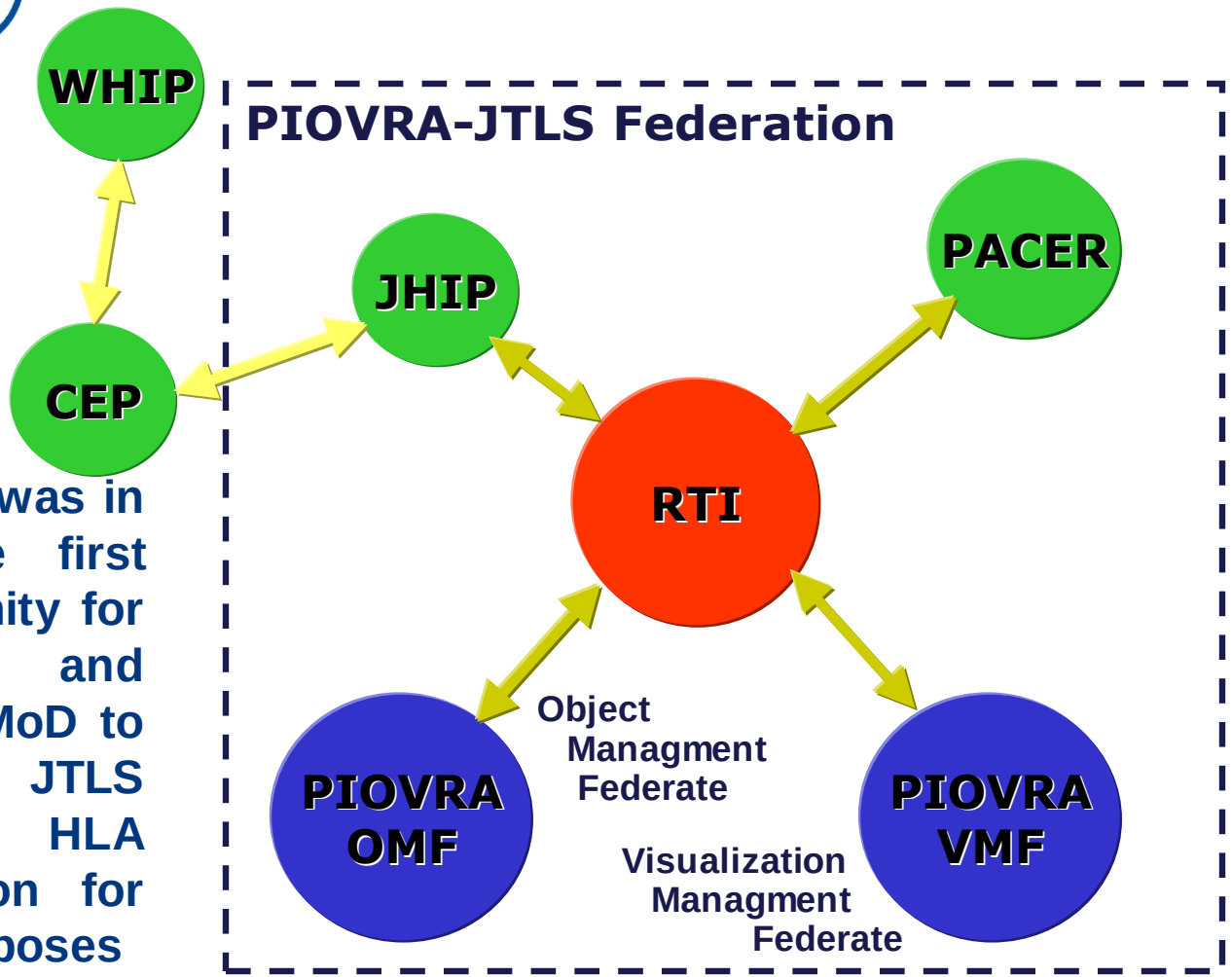




Example of Response Surface Methodology and Design of Experiments obtained by running Urban Disorder scenarios with IA-CGF Agents and correlating urban stabilization metrics with operational planner actions



PIOVRA JTLS Federation



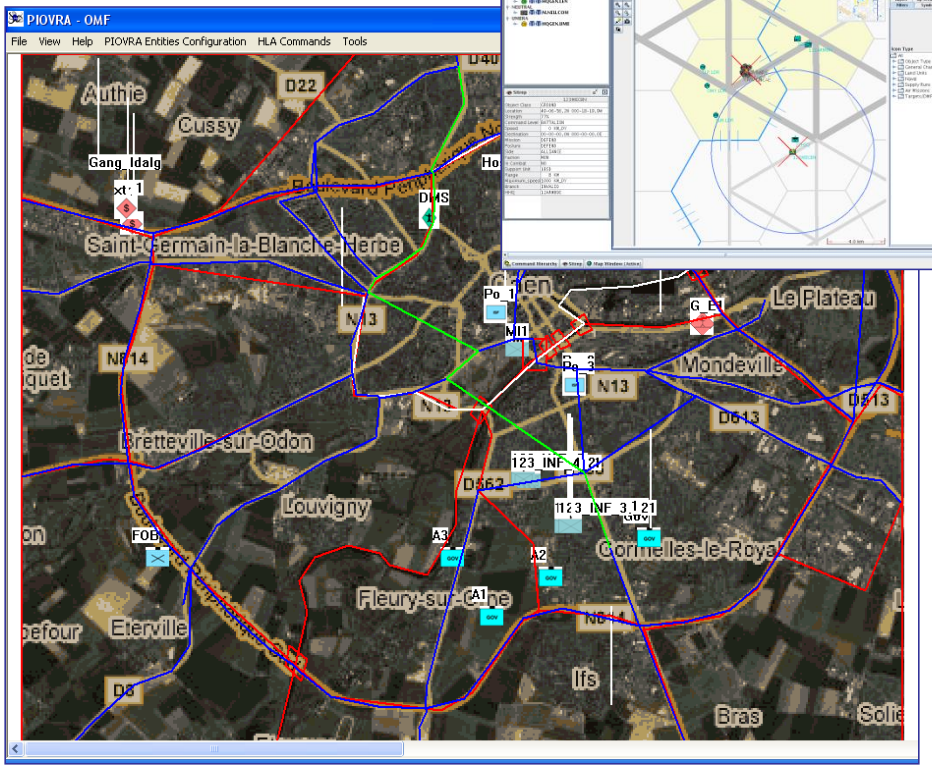
PIOVRA was in fact the first opportunity for Italian and France MoD to integrate JTLS in an HLA Federation for CAX purposes

JTLS Units Entering in the PIOVRA Zone

When a PIOVRA Unit from JTLS is entering in the Piovra Zone it is exploded in its components defined in PIOVRA Structure with attributes based on current situation in JTLS, and controlled by PIOVRA Agents.

When the Unit exit from PIOVRA Zone its components are reassembled and the JTLS unit is reconstructed and updated (i.e. casualties)

PIOVRA and JTLS exchange position, strength, unit type and reports



PIOVRA / JTLS Federation

RUN TIME Infrastructure Substitution

The introduction of the JTLS Federate took to the substitution of the RTI from the RTI 1.3 v7 to the RTI NG Pro v4.0.

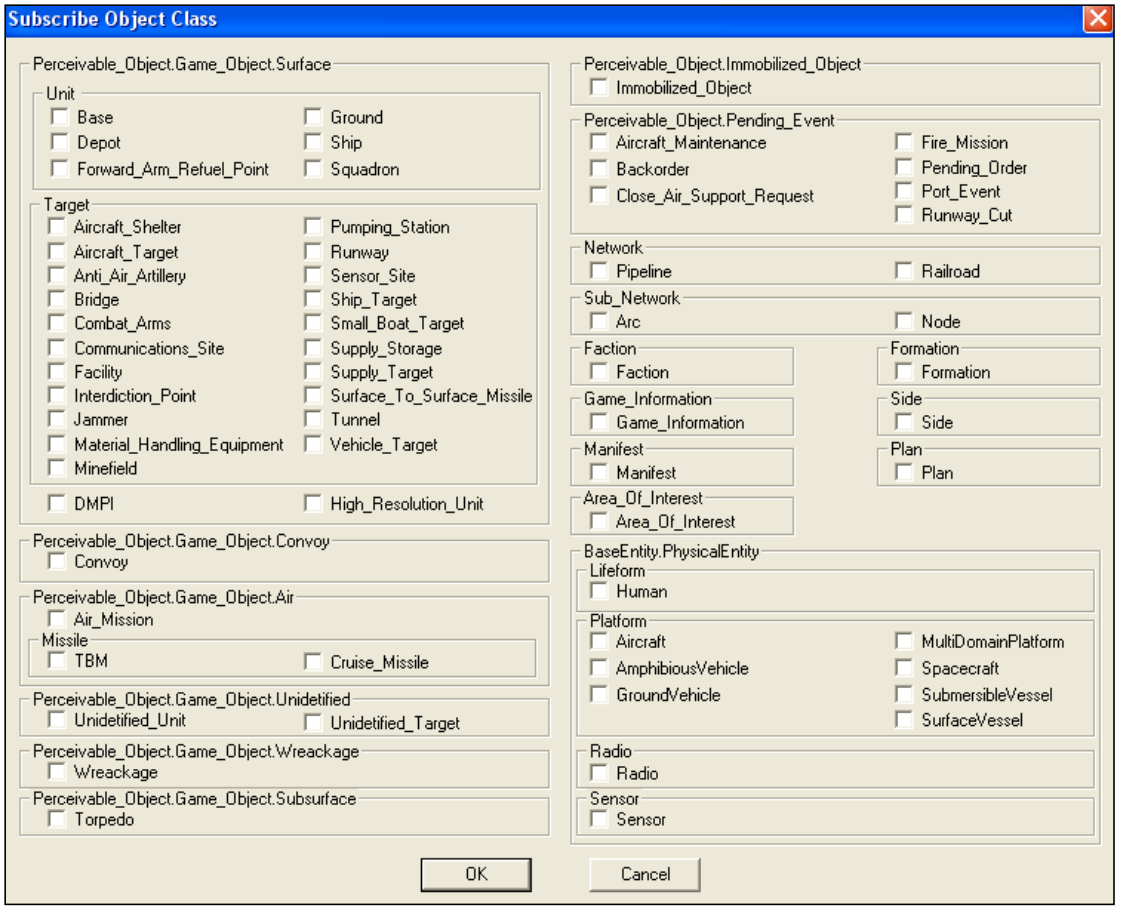
The RTI NG Pro v4.0 is an implementation corresponding to the High Level Architecture (HLA) Interface Specification v1.3.

Initial support is also provided for IEEE 1516.1-2000.

The introduction of the new RTI caused a change in most RTI callbacks implementation, expecially in the part relevant to Time Management.

JTLS SOM Object Integration

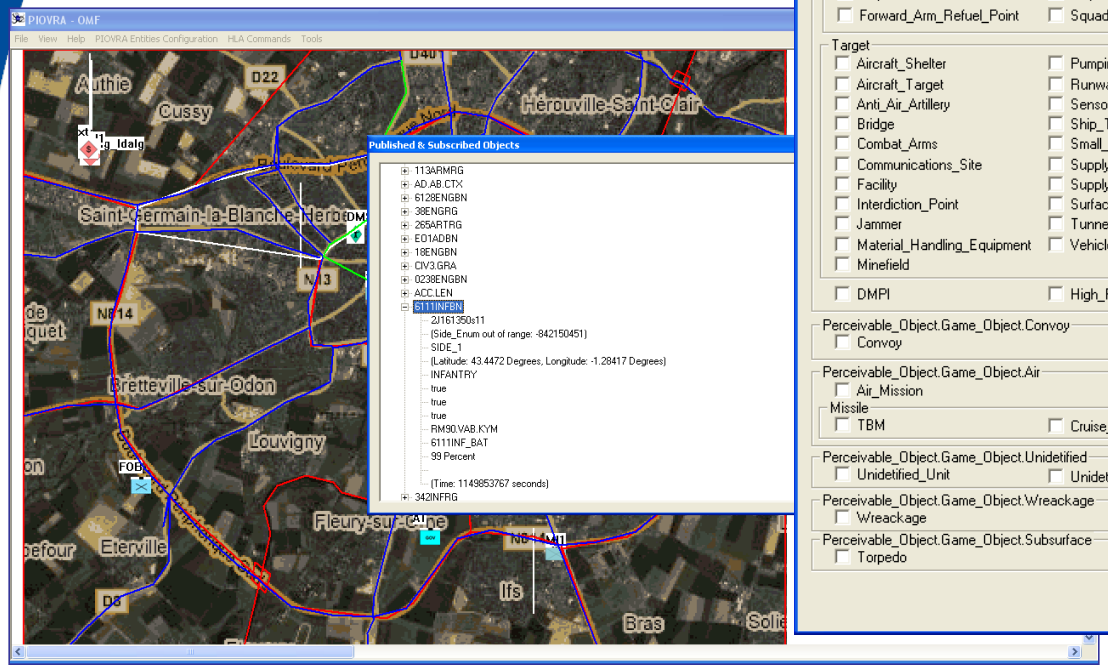
In order to have a complete integration in the JTLS scenario, it was decided to implement the subscription of all the JTLS Objects

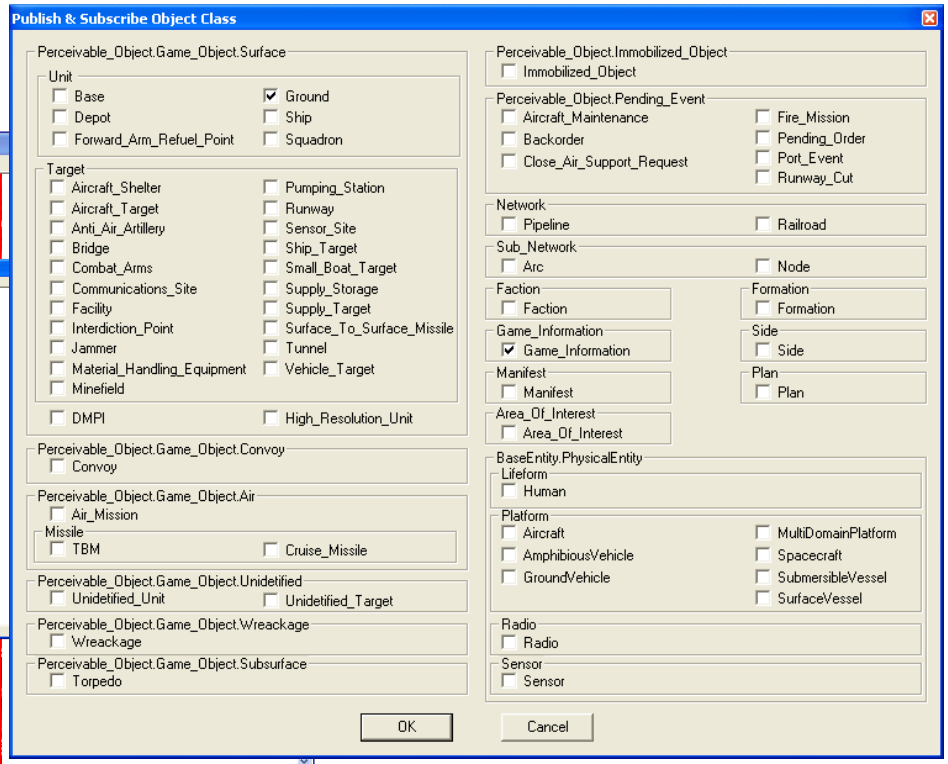


Simulation Team

Joining PIOVRA OMF/VMF to PIOVRA FEDERATION

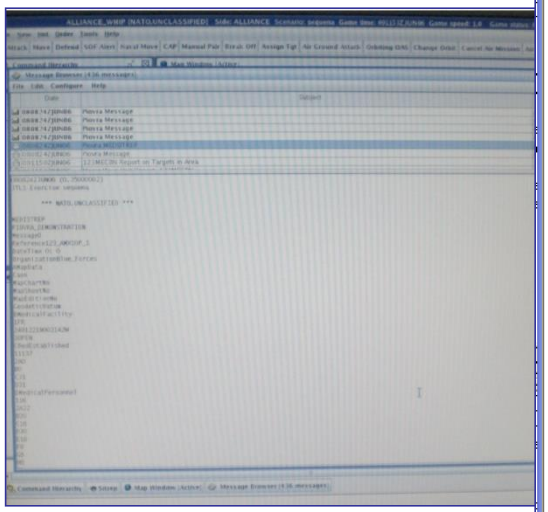
PIOVRA OMF/VMF is able to Create/Destroy the Federation, to Join/Resign and to Publish/Subscribe both Objects and Interactions.

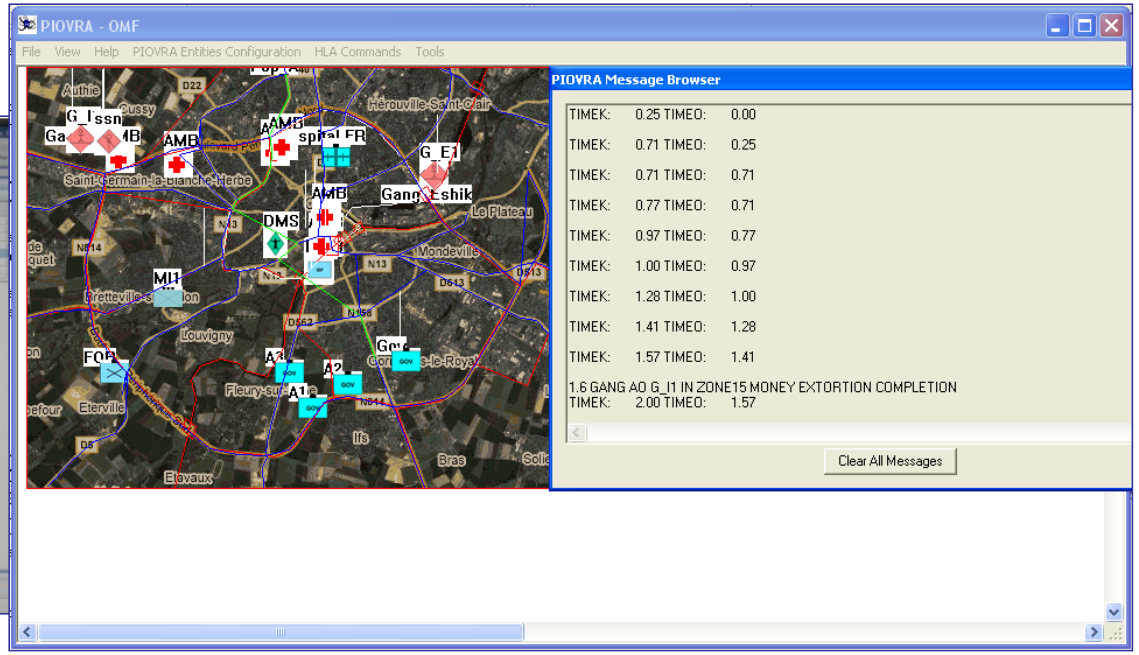




PIOVRA Generation of Standard NATO Message

PIOVRA reports the activities and distributes the message to the JTLS Message Browser. For instance in case of bomb attacks or gang attacks Medical Support is sent by the Hospital to the Zone for bringing back wounded people; when the procedure is completed a MEDSITREP is generated with details on the event.

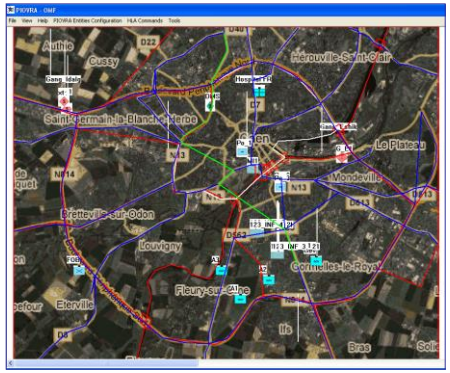




Psychological Modifiers

Human Factors in the model are represented by the Following Psychological Modifiers :

- **Stress Algorithms & Levels**
- **Fatigue Algorithms & Levels**
- **Fear Algorithms & Levels**
- **Aggressiveness Algorithms & Levels**

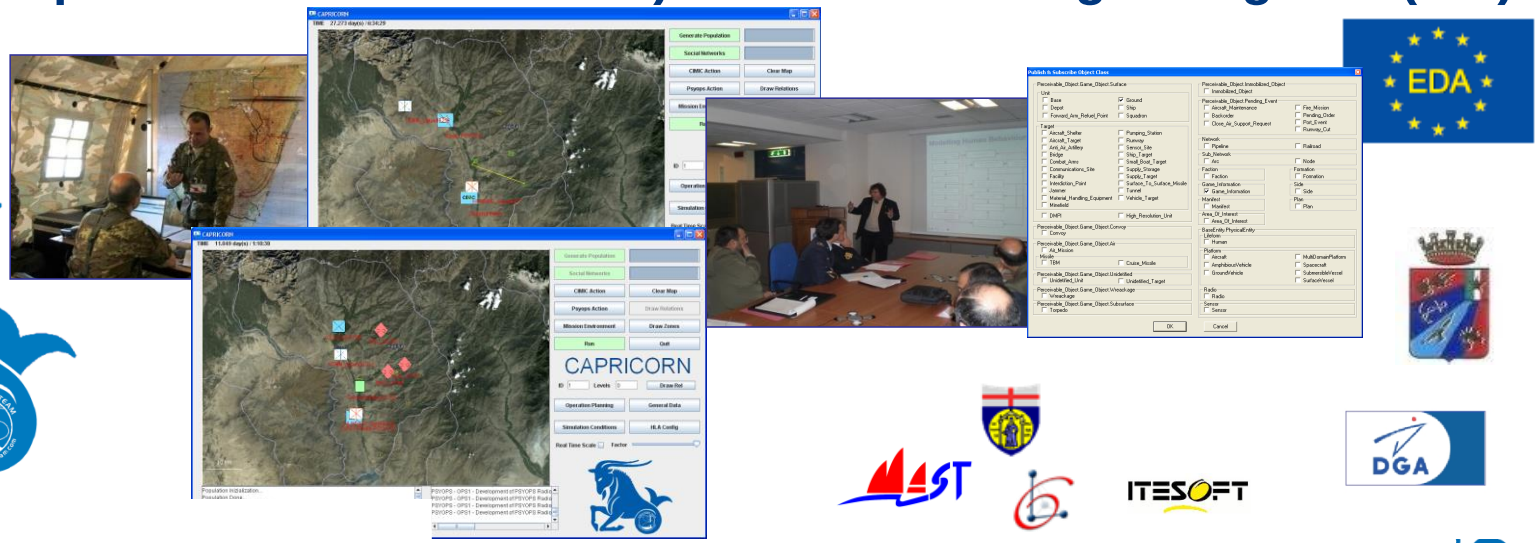


Simulation Team

CAPRICORN

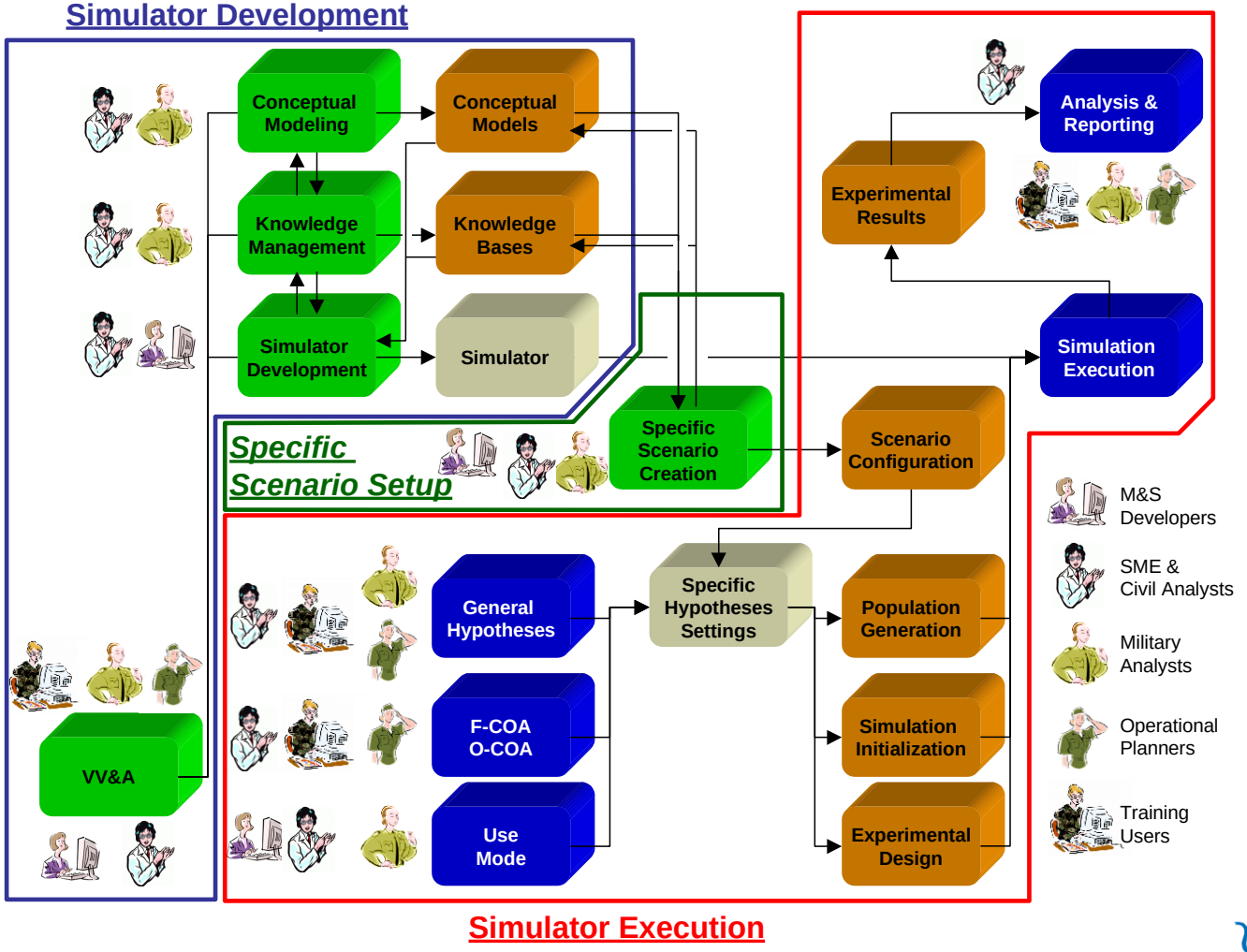
Civil Military Co-operation And Planning Research in Complex Operational Realistic Network

CAPRICORN is an EDA R&D Project devoted to develop capabilities in the complex and critical sector of Military Operation Planning, specifically for asymmetric warfare scenarios involving CIMIC and PSYOPS, by using CGF (Computer Generated Forces) based on Intelligent Agents (IAs)

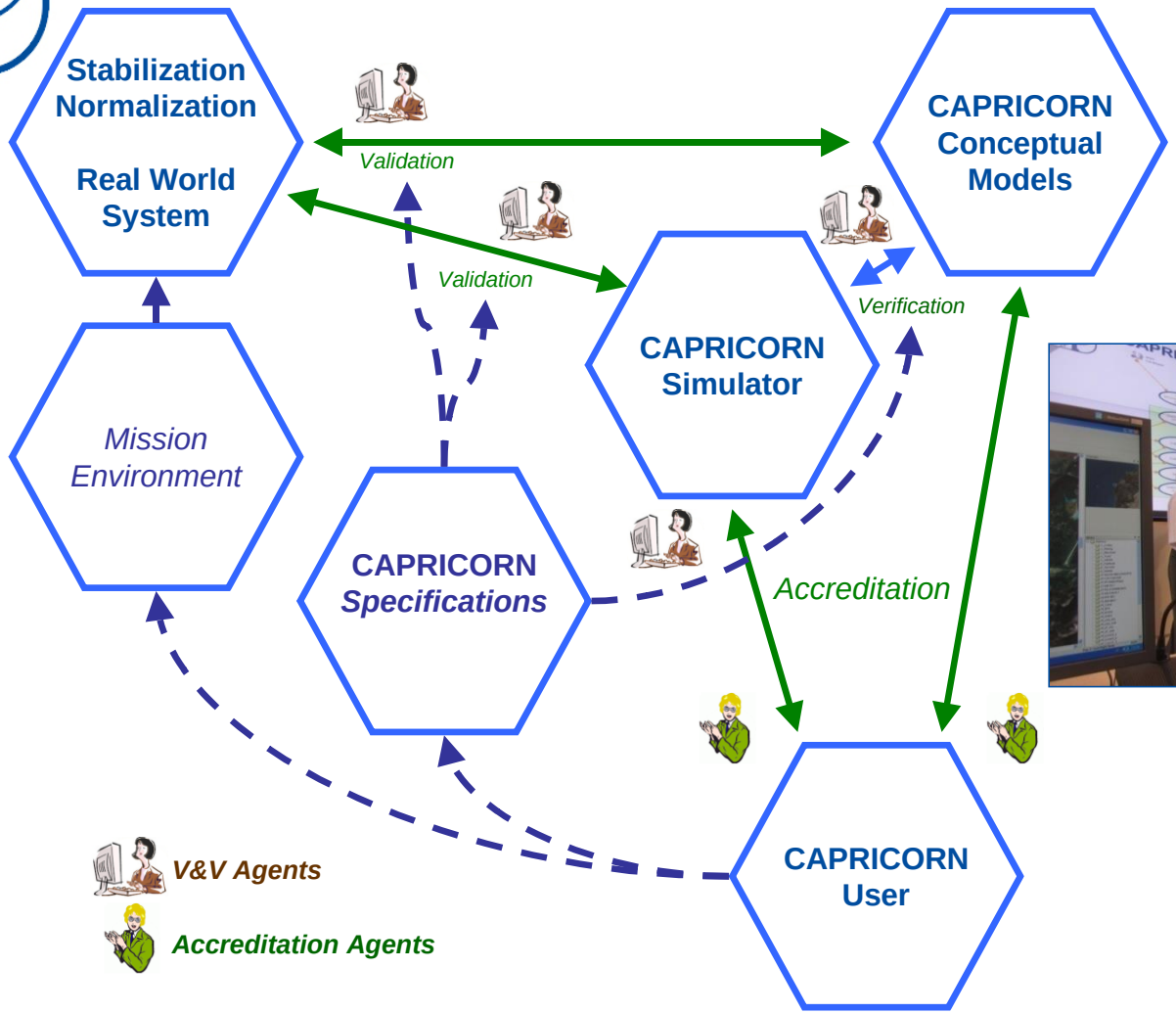


Simulation Team

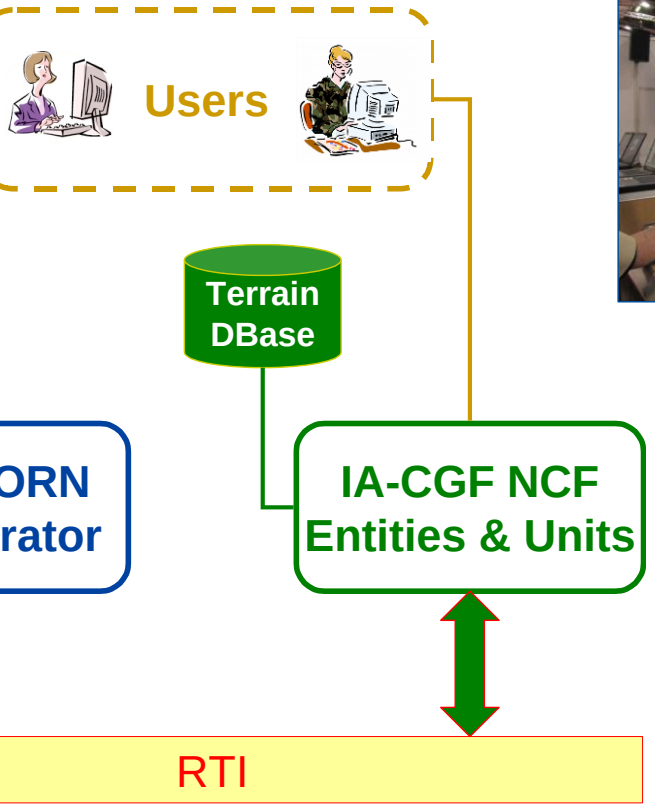
CAPRICORN Processes & Key Elements



VV&A in CAPRICORN

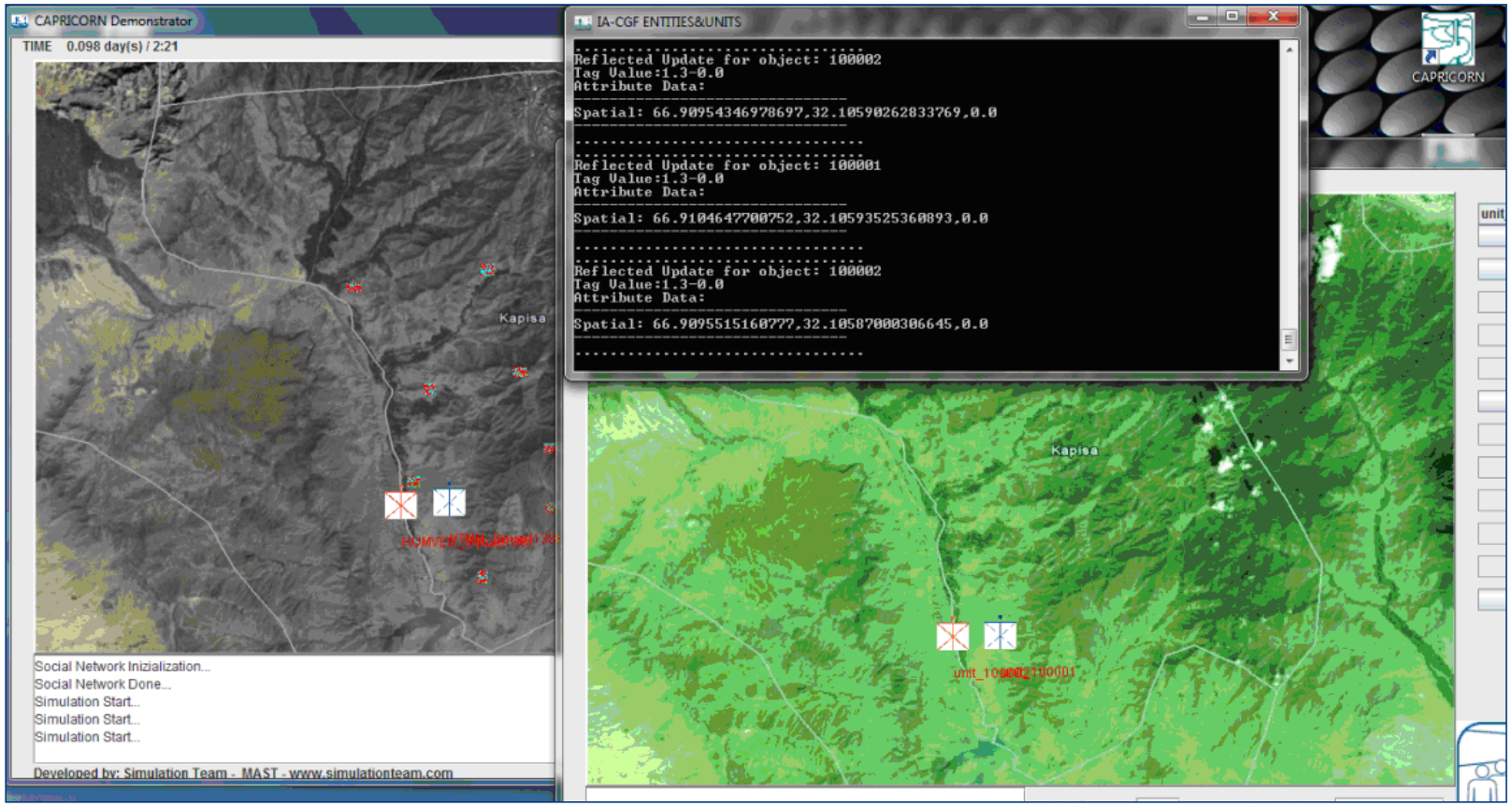


CAPRICORN in HLA: IA-CGF Federation



Simulation Team

CAPRICORN Integration Test



M&S Conferences and Initiatives

Simulation Team

www.liophant.org/i3m

I3M

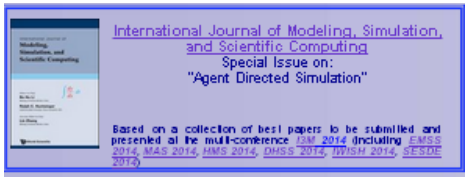
International Multidisciplinary Modelling & Simulation Multiconference

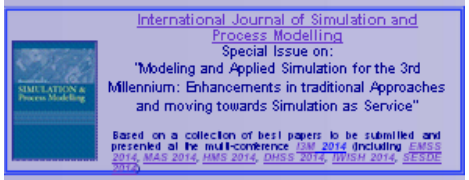
The M&S Multiconference moving around the World and along the Years attendeed by Top Experts from Mediterranean, Latin & North Americas, Europe, Asia, Africa and Australia

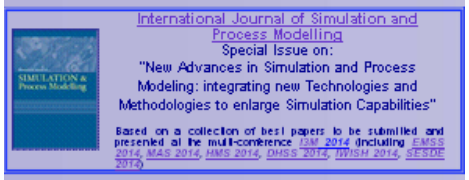
www.liophant.org/i3m/emss2017

EMSS 2017

30th European Modeling & Simulation Symposium





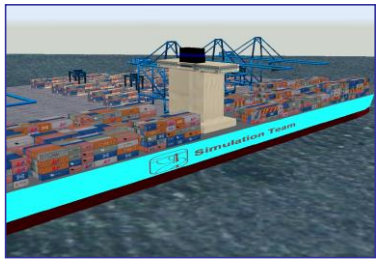


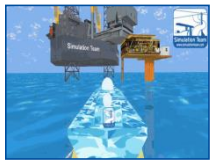
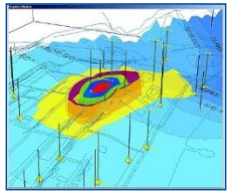
DIPTEM
Università di Genova

www.liophant.org/hms

The 20th International Conference on Harbour, Maritime & Multimodal Logistics Modelling and Simulation

HMS 2017




The 15th International Conference on Modelling & Applied Simulation.

MAS 2017

Workshop on Virtual and Augmented Reality

- **Workshop on M&S of Food Processing and Operations**
- ***Workshop on SG in Security, Crisis Management and Safety, GALA***

www.liophant.org/mas

DIPTEM
Università di Genova

www.liophant.org/conferences/dhss

The 8th International Defense and Homeland Security Simulation Workshop

DHSS 2017

DIPTEM
Università di Genova

The 6th International Workshop on Innovative Simulation for Health Care

2017 IWISH
The International Workshop on Innovative Simulation for Health Care

IMAACA

The 10th International Workshop on Innovative Simulation for Health Care

DIPTEM
Università di Genova

The 5th International Workshop on Simulation for Energy, Sustainable Development & Environment

SESAME

FoodOPS

The 3nd The international Food Operations & Processing Simulation Workshop focuses on M&S applied to Food Industry

DIPTEM
Università di Genova

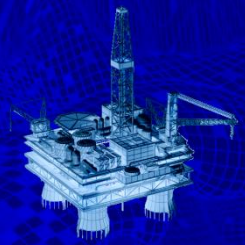
M&SNet
WORKSHOP

NSP

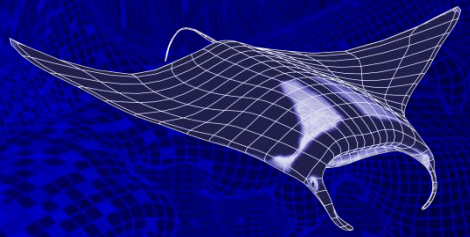
McLeod
WORKSHOP

Last Year I3M 2016 was in Larnaca, Cyprus

This Year I3M MMXVII moved to Barcelona. Next Year *BUDAPEST*



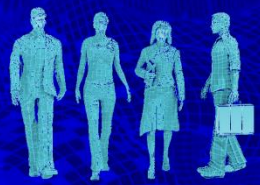
AMS
RIO.2004



AMS BRAZIL.2006

WAMS
BUZIOS.2010

WAMS
ST.PETERSBURG.2011

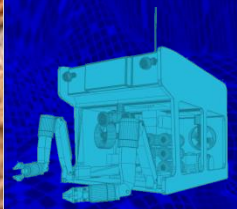


WAMS
ROME.2012

WAMS
BUENOS AIRES.2013

Florenze, Italy October

WAMS
ISTANBUL.2014



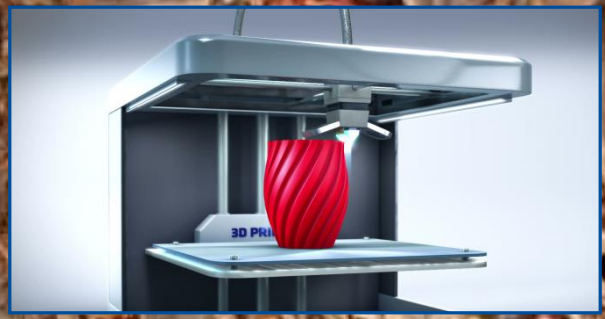
WAMS
2015

WAMS
FLORENCE2017

Florenze, Italy October

WAMS

FLORENCE2017



Florenze, Italy October

WAMS

FLORENCE2017

Simulation Team

The International Multidisciplinary Council of Simulation

active in Mediterranean, Europe, Latin & North America, Asia, Africa & Australia

I M CS

DIPTEM
Università di Genova

Gianni Cantice Award for Gifted Simulation Students

www.liophant.org/i3m/cantice







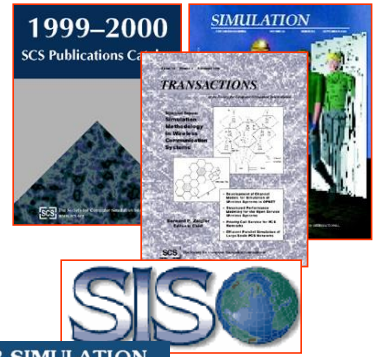
The day that grief visits our hearts is not a time for short summaries and quick snapshots of our loved one's life.
It is a time to remember deeply a man how's ready to sacrifice for Noble Goals, me and all his friend here in Iraq, we will never forget one of Italian heroes and how he helped our People against the Terrorism at the time where the real friend were very few. We will never forget a man with big heart and a sweetest smile such as Gianni.

Gen.Ali Mekki, Iraq Army Forces

Networking fo M&S in the World

World Players in M&S

M&S Net	McLeod Network for M&S
SCS	The Society for Computer Simulation International
Eurosim	(i.e. Italian Society for Computer Simulation, ASIM, UKSIM, etc.)
SISO	Simulation Interoperability Standards Organization
NTSA	National Training & Simulation Association
Liophant	Simulation
IMCS	International Mediterranean & Latin American Council of Simulation



Governmental Agencies

M&SCO	M&S Coordination Office
NCS	National Center for Simulation
IST	Institute for Simulation & Training University of Central Florida
NATO	Modeling and Simulation Group
NAVMSMO	Naval Modeling & Simulation Management Office
AMSO	Army Model and Simulation Office
AFAMS	Air Force Agency for Modeling and Simulation
PEO-STRI	Program Executive Office for Simulation Training and Instrumentation

Other Association for M&S

- *American Statistical Association (ASA)*
- *Association for Computing Machinery: Special Interest Group on Simulation (ACM/SIGSIM)*
- *Institute of Electrical and Electronics Engineers: Computer Society (IEEE/CS)*
- *Institute of Electrical and Electronics Engineers: Systems, Man, and Cybernetics Society (IEEE/SMCS)*
- *Institute for Operations Research and the Management Sciences: College on Simulation (INFORMS-CS)*
- *Institute of Industrial Engineers (IIE)*
- *National Institute of Standards and Technology (NIST)*

Simulation Team

Education & Training in Simulation

There are different channels for supporting training and education in M&S Sector:

- Academia
  - Master Programs
  - PhD Programs
- Professional Courses
  - Professional Certification
    - NTSA
    - M&S Net

www.itim.unige.it **www.liophant.org/siren**

Simulation Team

Simulation Conferences Next Year

www.liophant.org/conferences

International Multidisciplinary Modelling & Simulation Multiconference

I WISH

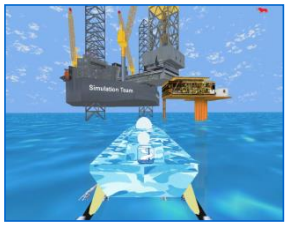
MAS Modeling & Applied Simulation EMSS 2017 Barcelona

IMAACA

HMS

I3M

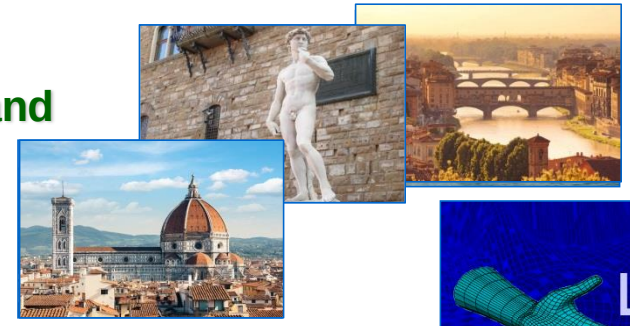
www.liophant.org/i3m

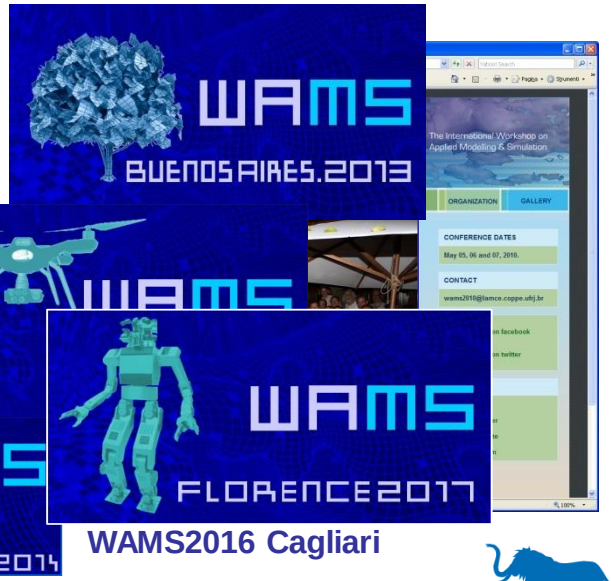


- INVITED GUESTS from Industry, Academia and Military
- Large Attendance
- Wonderful Organization
- Potential New Project Arising

DHSS

Defense and Homeland Security Simulation Workshop





WAMS was in Florence

WAMS2016 Cagliari

Summary & Questions

M&S Technical and Scientific References

Scientific References

1/6

- Amico Vince, Guha R., Bruzzone A.G. (2000) "Critical Issues in Simulation", Proceedings of Summer Computer Simulation Conference, Vancouver, July
- Banks J. (1996) " Selecting Simulation Software", Proceedings of WinterSim, San Diego, California
- Banks J. (1998) “Handbook of Simulation - Principles, Methodology, Advances, Applications and Practice” Danvers, MA01923
- Barros F., Bruzzone A.G., Frydman C., Giambiasi N. (2005) "International Mediterranean Modelling Multiconfernece - Conceptual Modelling & Simulation Conference", LSIS Press, ISBN 2-9520712-2-5 (pp 232)
- Bossomaier T., Green G.D. (2000) “Complex Systems”, Cambridge University Press, Cambridge
- Bruzzone A.G., Gambardella L.M., Giribone P., Merkuryev Y.A. (2000) "Harbour Maritime & Multmodal Logistics Modelling & Simulation 2000", SCS Europe, Genoa, ISBN 1-56555-207-5
- Bruzzone A.G., Orsoni A. (2000) "Advanced Modelling for Multilevel Analysis in Complex Processes Involving Ship Construction"JORBEL (Journal of the Belgian Operations Research Society), Vol. 40, no. 3-4, pp. 219-234 ISSN:0770-0512
- Bruzzone A.G., Kerckhoffs (1996) "Simulation in Industry: 8th European Simulation Simposium", Genoa, Italy, October, Vol. I &II, ISBN 1-56555-099-4
- Bruzzone A.G., Giribone P. (1998) "Decision-Support Systems and Simulation for Logistics: Moving Forward for a Distributed, Real-Time, Interactive Simulation Environment", Proceedings of the Annual Simulation Symposium IEEE, Boston, 4-9 April
- Bruzzone A.G., E.Page, A.Uhrmacher (1999) "Web-based Modelling & Simulation", SCS International, San Francisco, ISBN 1-56555-156-7
- Bruzzone A.G., Giribone P., Vio F. (1999) "Genetic Algorithms and Simulation for Supporting Layout Re-Engineering of Automotive Component Production Facilities", International Journal of Flexibile Automation and Intelligent Manufacturing, Vol 7, Issue 3-4, 379-391 ISSN 1064-3645
- Bruzzone A.G., Merkuryev Y.A., Mosca R. (1999) "Harbour Maritime & Industrial Logistics Modelling & Simulation", SCS Europe, Genoa, ISBN 1-56555-175-3
- Bruzzone A., Signorile R. (2001) "Container Terminal Planning by Using Simulation and Genetic Algorithms", Singapore Maritime & Port Journal, pp. 104-115 ISSN 0219-1555.
- Bruzzone A. et al. (2001) "Forecasts Modelling in Industrial Applications Based on AI Techniques", International Journal of Computing Anticipatory Systems (extended from Proeedings of CASYS2001, Liege Belgium August 13-18), Vol 11, pp. 245-258, ISSN1373-5411
- Bruzzone A.G., Giambiasi N., Gambardella L.M., Merkuryev Y.A. (2001) "Harbour, Maritime & Multmodal Logistics Modelling & Simulation 2001", SCS Europe, Genoa, ISBN 90-77039-03-1
- Bruzzone A.G. et al. (2001) "FLODAF: Fuzzy Logic Applied to a Multi-Sensor Data Fusion Model", Proceedings of FLODAF, Montreal, August
- Bruzzone A.G. (2002) "Supply Chain Management", Simulation, Volume 78, No.5, May, 2002 pp 283-337 ISSN 0037-5497

Scientific References

2/6

- Bruzzone A.G., Merkuryev Y., Mosca R. (2002) "Harbour, Maritime & Multmodal Logistics Modelling & Simulation - Modelling & Applied Simulation 2002", DIPTEM University of Genoa, Genoa, October, ISBN 88-900732-9-2
- Bruzzone A.G., Itmi M. (2003) "Summer Computer Simulation Conference 2003", SCS International, San Diego, ISBN 1-56555-268-7
- Bruzzone A.G., Mosca R. (2003) "Modelling & Applied Simulation", DIPTEM Press, Genoa, ISBN 88-900732-3-3 (197pp)
- Bruzzone A.G. et al. (2003) "Logistic Cooperative Functional Training System based on HLA Distributed Simulation" SIMULATION SERIES 2003 VOL 35; PART 3, page(s) 776-781 Society for Computer Simulation, ISSN-0735-9276
- Bruzzone A.G. et al. (2003) "Simulation for the Reverse Management of Business Processes" SIMULATION SERIES 2003 VOL 35; PART 3, page(s) 61-65 Society for Computer Simulation, ISSN-0735-9276
- Bruzzone A.G.et al. (2003) "Advances in Supply Chain Management: An Agent Based Approach for Supporting Distributed Optimization", SIMULATION SERIES 2003 VOL 35; PART 3, page(s) 497-502 Society for Computer Simulation, ISSN-0735-9276
- Bruzzone A.G. et al.(2003) "VV&A for Innovative Concept Design in New Vessels Simulation and Virtual Prototypes" SIMULATION SERIES 2003 VOL 35; PART 3, page(s) 748-754 Society for Computer Simulation, ISSN-0735-9276
- Bruzzone A.G., Cunha G.G., Landau L., Merkuryev Y. (2004) "Harbour and Maritime Simulation", LAMCE Press, Rio de Janeriro, ISBN 85-89459-04-7 (230 pp)
- Bruzzone A.G., Frydman C., Giambiasi N., Mosca R. (2004) "International Mediterranean Modelling Multiconfernece", DIPTEM Press, ISBN 88-900732-4-1 Vol I e II (884 pp)
- Bruzzone A.G., Massei M., Simeoni S., Carini D.B.M. (2004) "Parameter Tuning in Modelling Human Behaviours by Using Optimization Techniques", Proceedings of ESM2004, Magdeburg, Germany, June
- Bruzzone A.G., Wiliams E. (2004) "Summer Computer Simulation Conference", SCS International, ISBN 1-56555-283-0 (597 pp)
- Bruzzone A.G., Williams E.,(2004) "Modeling and Simulation Methodologies for Logistics and Manufacturing Optimization", Vol 80, No.3 pg 119-174 ISSN 0037-5497
- Bruzzone A.G., Frydman C., Junco S., Dauphin-Panguy G. (2005) "International Mediterranean Modelling Multiconfernece - International Conference on Integrated Modelling and Analysis in Applied Control and Automation", LSIS Press, ISBN 2-9520712-5-X (pp 194)
- Bruzzone A.G., Frydman C., Merkuriev Y., B.M. (2005) "International Mediterranean Modelling Multiconfernece - International Workshop on Harbour, Maritime and Multimodal Logistics Modelling and Simulation", LSIS Press, ISBN 2-9520712-4-1 (pp 94)
- Bruzzone A.G. et al. (2005) "Agent Directed HLA Simulation for Complex Supply Chain Modeling", Simulation, Vol.81,Issue 9, September 647-655, ISSN 0037-5497
- Bruzzone A.G., Mosca R., Williams E., B.C. (2005) "Modelling & Applied Simulation 2005", DIPTEM Press, Genoa, ISBN 88-900732-8-4 (pp 97)

Scientific References

3/6

- Bruzzone A.G., Williams E. (2005) "Summer Computer Simulation Conference", SCS, San Diego, ISBN 1-56555-299-7 (pp 470)
- Bruzzone A.G., Cunha G.G., Landau L., Saetta S. (2006) "Applied Modelling & Simulation", LAMCE Press Rio de Janerio, ISBN 85-285-0089-6 (240 pp)
- Bruzzone A.G., Guasch A., Piera M.A., Rozenblit J. (2006) "International Mediterranean Modelling Multiconference", Logsim, ISBN 84-690-0726-2 (768 pp)
- Bruzzone A.G., Williams E. (2006) "Summer Computer Simulation Conference", SCS International, ISBN 1-56555-307-1 (504 pp)
- Bruzzone A.G., (2007) "Challenges and Opportunities for Human Behaviour Modelling in Applied Simulation", Keynote Speech at Applied Simulation and Modelling 2007, Palma de Mallorca
- Bruzzone A.G., Longo F., Merkuryev Y., Piera M.A. (2007). International Mediterranean And Latin America Modelling Multiconference. ISBN: 88-900732-6-8. GENOVA: DIPTEM Press (ITALY)
- Bruzzone A.G., Elfrey P., Papoff E., Massei M., Molnvar I. (2008). 7th International Workshop on Modeling & Applied Simulation. ISBN: 978-88-903724-1-4. GENOVA: DIPTEM Press (ITALY)
- Bruzzone A.G., Longo F., Merkuryev Y., Mirabelli G., Piera M.A. (2008). 11th International Workshop on Harbor, Maritime & Multimodal Logistics Modelling and Simulation. ISBN: 978-88-903724-1-4. GENOVA: DIPTEM Press (ITALY)
- Bruzzone A.G., Longo F., Piera M.A, Aguilar R. M, Frydman C. (2008). European Modelling Simulation Symposium. ISBN: 978-88-903724-0-7. GENOVA: DIPTEM Press (ITALY)
- Bruzzone A.G., Cantice G., Morabito G., Mursia A., Sebastiani M., Tremori A. (2009) "CGF for NATO NEC C2 Maturity Model (N2C2M2) Evaluation", Proceedings of I/ITSEC2009, Orlando, November 30-December 4
- Bruzzone A.G., Frydman C., Cantice G., Massei M., Poggi S., Turi M. (2009) "Development of Advanced Models for CIMIC for Supporting Operational Planners", Proceedings of I/ITSEC2009, Orlando, November 30-December 4
- Bruzzone A.G., Reverberi A., Cianci R., Bocca E., Fumagalli M.S, Ambra R. (2009) "Modeling Human Modifier Diffusion in Social Networks", Proceedings of I/ITSEC2009, Orlando, November 30-December 4
- Bruzzone, A. G., Fancello, G., Fadda, P., Bocca, E., D'Errico, G., & Massei, M. (2010). Virtual world and biometrics as strongholds for the development of innovative port interoperable simulators for supporting both training and R&D. International Journal of Simulation and Process Modelling, 6(1), 89-102.
- Bruzzone A.G. Tremori A., Massei M. (2011) "Adding Smart to the Mix", Modeling Simulation & Training: The International Defense Training Journal, 3, 25-27, 2011
- Bruzzone A,G. (2013) “Intelligent agent-based simulation for supporting operational planning in country reconstruction”, Int.Journal of Simulation and Process Modelling, Volume 8, Issue 2-3, pp.145-151

Scientific References

4/6

- Bruzzone A.G., Merani D., Massei M., Tremori A., Bartolucci C., Ferrando A. (2013) "Modeling Cyber Warfare in Heterogeneous Networks for Protection of Infrastructures and Operations", Proc.of I3M2013, Athens, Greece, September
- Bruzzone, A.G., Berni, A., Fontaine, J.G., Cignoni, A., Massei, M., Tremori, A., Dallorto, M., Ferrando, A. (2013) "Virtual Framework for Testing/Experiencing Potential of Collaborative Autonomous Systems", Proc. of I/ITSEC, Orlando. FL USA
- Bruzzone A.G., Massei M., Poggi S., Bartolucci C., Ferrando A. (2014) "IA for HBM as Support to Operations", Simulation and Modeling Methodologies, Technologies and Applications, Advances in Intelligent Systems and Computing, Springer, London, Vol. 319, pp 119-132
- Bruzzone A.G., Massei M., Tremori A., Longo F., Nicoletti L., Poggi S., Bartolucci C., Picco E., Poggio G. (2014) "MS2G: simulation as a service for data mining and crowd sourcing in vulnerability reduction", Proc. of WAMS, Istanbul, September
- Bruzzone A.G., Massei M., Poggi S., Bartolucci C., Ferrando A. (2014) "Intelligent Agents for Human Behavior Modeling as Support to Operations", Simulation & Modeling Methodologies, Technologies and Applications, Advances in Intelligent Systems and Computing, Springer,London, Vol. 319, pp 119-132
- Bruzzone A.G., Massei M., Longo F., Nicoletti L., Di Matteo R., Maglione G., Agresta M. (2015) "Intelligent Agents & Interoperable Simulation for Strategic Decision Making on Multicoalition Joint Operations", Proc.of DHSS2015, Bergeggi, Italy, September
- Bruzzone A.G., Massei M., Longo F., Cayirci E., di Bella P., Maglione G.L., Di Matteo R. (2016) "Simulation Models for HybridWarfare and Population Simulation", Proc. of NATO Symposium on Ready for the Predictable, Prepared for the Unexpected, M&S for Collective Defence in Hybrid Environments and Hybrid Conflicts, Bucharest, Romania, October 17-21
- Bruzzone A.G., Massei M., Maglione G.L., Di Matteo R., Franzinetti G. (2016) "Simulation of Manned & Autonomous Systems for Critical Infrastructure Protection", Proc. of I3M, Larnaca, Cyprus, September
- Bruzzone, A. G., Longo, F., Agresta, M., Di Matteo, R., & Maglione, G. L. (2016) "Autonomous systems for operations in critical environments", Proc. of the Modeling and Simulation of Complexity in Intelligent, Adaptive and Autonomous Systems, (MSCIAAS) and Space Simulation for Planetary Space Exploration (SPACE), Pasadena, CA, April
- Bruzzone A.G., Massei M., Di Matteo R., Agresta M., Franzinetti G., Porro P. (2016) "Modeling, Interoperable Simulation & Serious Games as an Innovative Approach for Disaster Relief", Proc.of I3M, Larnaca, Sept. 26-28
- Bruzzone A.G., Massei M., Longo F., Cayirci E., di Bella P., Maglione G.L., Di Matteo R. (2016) "Simulation Models for HybridWarfare and Population Simulation", Proc. of NATO Symposium on Ready for the Predictable, Prepared for the Unexpected, M&S for Collective Defence in Hybrid Environments and Conflicts, Bucharest, Romania, Oct.17-21
- Bruzzone, A. G., & Massei, M. (2017). Simulation-Based Military Training. In Guide to Simulation-Based Disciplines (pp. 315-361). Springer, Cham.
- Bruzzone A.G., Massei M., Longo F., Sinelshchikov L., Di Matteo R., Cardelli M., Kandunuri P.K. (2017) "Immersive, Interoperable and Intuitive Mixed Reality for Service in Industrial Plants", Proc. of I3M, Barcelona, September 18-20

Scientific References

5/6

- Cayirci, E., & Marincic, D. (2009) “Computer Assisted Exercises and Training: A Reference Guide”, John Wiley & Sons, NYC
- Chung S., Loper M. (1994) "Synchronizing simulations in distributed interactive simulation", Proc.of Wintersim, Lake Buena Vista, FL
- Frydman C., Guasch A., Piera M.A.B.C. (2005) "International Mediterranean Modelling Multiconfernece - European Modelling & Simulation Symposium", LSIS Press, ISBN 2-9520712-3-3 (pp 260)
- Fu, M.C. (1994) ""A tutorial review of techniques for Simulation Optimization", Wintersim 1994, La Jolla, CA
- Giribone P., A.G. Bruzzone (1999) "Artificial Neural Networks as Adaptive Support for the Thermal Control of Industrial Buildngs", International Journal of Power and Energy Systems, Vol.19, No.1, 75-78 (Proceedings of MIC'97, Innsbruck, Austria, February 17-19, 1997) ISSN
- Gogg J. T., Mott J.R.A. (1992) “Improve Quality & Productivity with Simulation” Palos Verdes (California)
- Hamilton Jr. J.A., Nash D.A., Pooch U.W. (1997) “Distributed Simulation” Boca Raton, Florida
- Harrel C.R., Bateman R.E., T.J. Gogg, J.R.A. Mott (1996) “System Improvement Using Simulation” Orem,Utah
- Kelton W., Sadowski R., and Swets N. (1997) "Simulation with Arena", McGraw Hills, New York
- Khoshnevis, B. (1994) "Discrete System Simulation", Mc- Graw Hill, NYC
- Law, A.M. andW.D. Kelton (1991)"Simulation modeling and analysis", 2nd ed. New York: McGraw- Hill, NYC
- Law A.M. (2007) ”Simulation Modeling & Analysis” Arizona
- Massei, M. Simeoni, S. (2003) “Application of Simulation to Small Enterprise Management & Logistics” SIMULATION SERIES 2003 VOL 35; PART 3, page(s) 829-834 Society for Computer Simulation, ISSN-0735-9276
- Massei, M., Poggi, S., Agresta, M., & Ferrando, A. (2014) "Development Planning Based on Interoperable Agent Driven Simulation", Journal of Computational Science, 5(3), 395-407
- Massei M., & Tremori A. (2014) “Simulation of an Urban Environment by Using Intelligent Agents within Asymmetric Scenarios for Assessing Alternative Command and Control Network-Centric Maturity Models”, the Journal of Defense Modeling and Simulation, 11(2), 137-153
- McLeod J. (1982) "Computer Modeling and Simulation: Principle of Good Practices", SCS Int., San Diego, CA
- McLeod, J., & McLeod, S. (1984) “Simulation of the Society”, Simulation, 43(6), 320-323
- Merkuriev Y., Bruzzone A.G., Novitsky L (1998) "Modelling and Simulation within a Maritime Environment", SCS Europe, Ghent, Belgium, ISBN 1-56555-132-X
- Merkuryev Y., Bruzzone A.G., Merkuryeva G., Novitsky L., Williams E. (2003) "Harbour Maritime and Multimodal Logistics Modelling & Simulation 2003", DIPTEM Press, Riga, ISBN 9984-32-547-4 (400pp)
- Merkuryev Y., Merkuryeva G., Piera M.A.,Guasch A. (2009) “Simulation- Based Case Studies in Logistic” Girona, Spain
- Montgomery D.C. (2000) "Design and Analysis of Experiments", John Wiley & Sons, New York

Scientific References

6/6

- Ostle B. (1963) " Statistics in Research: Basic Concepts and Techniques for Research Workers", Iowa State University Press, Iowa City
- Ören, T.I. (1977). Software for Simulation of Combined Continuous & Discrete Systems: A State-of-the-Art Review. Simulation, 28:2
- Ören, T.I., Zeigler, B.P. (1979). Concepts for Advanced Simulation Methodologies. Simulation, 32:3, 69-82. SAGE Journals Online
- Ören, T.I. (1995). Enhancing Innovation and Competitiveness Through Simulation. Preface of the Proceedings of 1995 Summer Computer Simulation Conf., Ottawa, Ont., July 24-26, SCS, San Diego, CA., pp. vi-vii.
- Ören, T.I., S.K. Numrich, A.M. Uhrmacher, L.F. Wilson, and E. Gelenbe (2000 - Invited Paper). Agent-directed Simulation: Challenges to Meet Defense and Civilian Requirements. Proc. of the 2000 WinterSimulation Conference, J.A Joines et al., eds., Dec. 10-13, 2000, Orlando, Florida,
- Ören, T.I. and F. Longo (2008). Emergence, Anticipation and Multisimulation: Bases for Conflict Simulation. Proceedings of the EMSS 2008-20th European Modeling and Simulation Symposium. (Part of the IMMM-5 - The 5th International Mediterranean and Latin American Modeling Multiconference), September 14-17, 2008, Campora San Giovanni, Italy, pp. 546-555.
- Ören, T.I. and F. Longo (2008). Emergence, Anticipation and Multisimulation: Bases for Conflict Simulation. Proceedings of the EMSS 2008- 20th European Modeling and Simulation Symposium. (September 14-17, 2008, Campora San Giovanni, Italy, pp. 546-555
- Pegden, C.D., Shannon, R.E. and Sadowski, R.P. (1990),. "Introduction to Simulation Using SIMAN", McGraw-Hill,. New York
- Prisker A.A.B. (1986) "IIntroduction to Simulation and SLAM" 3rd Edn, J.Wiley & Sons, New York (1986).
- Reverberi A.P., Bruzzone A.G.,Maga L., Barbucci (2005) "Montecarlo Simulation of a Ballistic Selective Etching Process in 2+1 Dimensions", Physica A 354, 323-332 - ISSN: 0378-4371
- Shannon, R.E., Long, S.S. and Buckles, B.P. Operating research methodologies in industrial engineering. AIIE Trans. 17, 4 (Dec. 1980). 364-367
- Signorile R., Bruzzone A.G. (2003) "Harbour Management using Simulation and Genetic Algorithms", Porth Technology International, Vol.19, Summer2003, pp163-164, ISSN 1358 1759
- Sokolowski J.A., Banks C.M. (2009) “Modeling and Simulation for Analyzing Global Events” Old Dominion University,Suffolk
- Sokolowski J.A., Banks C.M.(2009) “Principles of Modeling and Simulation” Old Dominion University,Suffolk Virginia
- Sokolowski J.A., Banks C.M. (2010) “Modeling and Simulation Fundamentals Theoretical Underpinnings and Practical Domains” Old Dominion University,Suffolk
- Swain J.J. (1995) "Simulation Survey: Tools for Process Understanding and Improvement", OR/MS Today, August: 64-67
- Thesen, A., Thravis, L. (1992), Simulation for Decision Making, West, St Paul, MN.,
- Williams E., Mosca R., B.C. (2004) "Design of Experiments for Simulation Projects", SCSC2004 Tutorial , San Jose'
- Yilmaz, L., T.I. Ören, and N. Ghasem-Aghaee (2006). Simulation-Based Problem Solving Environments for Conflict Studies. Simulation, and Gaming Journal. vol. 37, issue 4, pp. 534-556
- Zeigler, B.P. and T.I. Ören, (1979). Theory of Modelling and Simulation. IEEE Trans.on Systems, Man, and Cybernetics. Vol. 9, Issue 1, p. 69.
- Zeigler B.P., Hammonds P.E. (2007) “Modeling and Simulation-Based Data Engineering” San Diego, California

Interoperability References

- 1278.1a-1998 (R2002) IEEE Standard for Distributed Interactive Simulation--Application Protocols
- 1278.1-1995 (R2002) IEEE Standard for Distributed Interactive Simulation--Application Protocols (Revision and redesignation of IEEE Std 1278-1993)
- 1278.2-1995 (R2002) IEEE Standard for Distributed Interactive Simulation--Communication Services and Profiles
- 1278.3-1996 (R2002) IEEE Recommended Practice for Distributed Interactive Simulation--Exercise Management and Feedback
- 1278.4-1997 (R2002) IEEE Trial-Use Recommended Practice for Distributed Interactive Simulation--Verification, Validation, and Accreditation
- 1516-2010 IEEE Standard for Modeling and Simulation (M&S) High Level Architecture (HLA)---Framework and Rules
- 1516.1-2010 IEEE Standard for Modeling and Simulation (M&S) High Level Architecture (HLA)---Federate Interface Specification
- 1516.2-2010 IEEE Standard for Modeling and Simulation (M&S) High Level Architecture (HLA)---Object Model Template (OMT) Specification
- 1516.3-2003 IEEE Recommended Practice for High Level Architecture (HLA) Federation Development and Execution Process (FEDEP)
- 1516.4-2007 IEEE Recommended Practice for VV&A
- 1516-2010 - IEEE Standard for Modeling and Simulation (M&S) High Level Architecture (HLA)-- Framework and Rules
- 1730-2010 IEEE Recommended Practice for Distributed Simulation Engineering and Execution Process (DSEEP)

- Bruzzone A.G., E.Page, A.Uhrmacher (1999) "Web-based Modeling & Simulation", SCS International, San Francisco, ISBN 1-56555-156-7
- Bruzzone A.G., Kerckhoff E. (1996) “Simulation in Industry”, SCS Press
- R. Fujimoto, “Parallel and Distributed Simulation Systems”, Wiley Interscience, 2000.
- F. Kuhl, R. Weatherly, J. Dahmann, “Creating Computer Simulation Systems: An Introduction to the High Level Architecture for Simulation”, Prentice Hall, 1999.
- Loftin B. A “Comparison of Military Synthetic Environments and Virtual Battlespaces”, I/ITSEC2003, VMASC
- Miller, Thorpe (1995), “SIMNET: The Advent of Simulator Networking,” Proceedings of the IEEE, 83(8): 1114-1123.

Simulation Team

References

Agostino G. BRUZZONE
Director of M&S Net (34 Centers WorldWide)
Director of the McLeod Institute Genoa Center
President Simulation Team (26 Partners)

Full Professor in
DIME University of Genoa

via Opera Pia 15
16145 Genova, Italy

Email agostino@itim.unige.it
URL www.itim.unige.it

MITIM
Simulation Team
Genoa Center

M&SNet