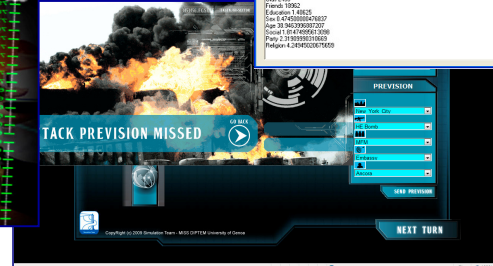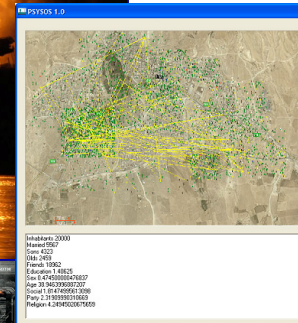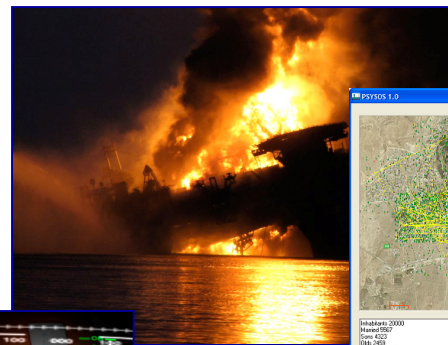**Simulation Team**

Critical Issues in Advancing Modeling & Simulation

Agostino G. Bruzzone
Simulation Team MISS DIPTEM
University of Genoa, Italy
Email agostino@itim.unige.it
URL www.itim.unige.it

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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 (i.e. IBM, LMC, Boeing, Fiat Group, COOP, Ansaldo, Selex, Solvay) and Agencies (i.e. Italian Navy, NASA, DGA, DoD, etc.).
- Full Professor in DIPTEM, University of Genoa
- Visiting Professor in Several Universities in North & Latin America, Europe, Australia, Africa and Asia
- 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 within last 10 years
- Director of the Master Program in Industrial Plants ("Impiantistica Industriale") for Genoa University.
- Founder and President of Liophant

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Who We Are?

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

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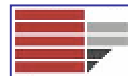
M&SNet Genoa

CentraLabs Cagliari

CRiCS Centre for Research In Complex Systems **CSU Australia**

CIREM Università di Cagliari

MSC-LES

Antoptima we speed up your business

DLM Solutions Simulating Real Processes for Better Decisions

Blizzard Srl

VIRTUALY

Mik Riga TU

DIPMEC Università Calabria

MISS Universitat Autonoma de Barcelona

MISS Università di Perugia

LSIS Marseille

GRVa LAMCE COPPE.UFRJ.BR **Rio de Janeiro Brazil**
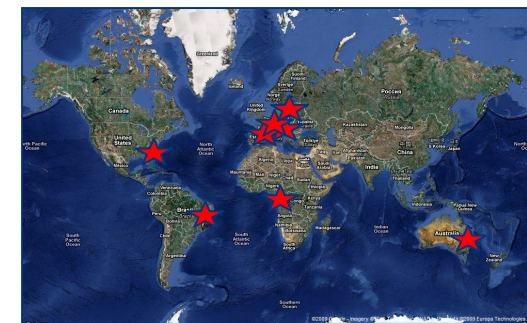
McLeod Institute of Simulation Science Genoa

IMS-LAPS Univ.Bordeaux

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# Some Background:
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

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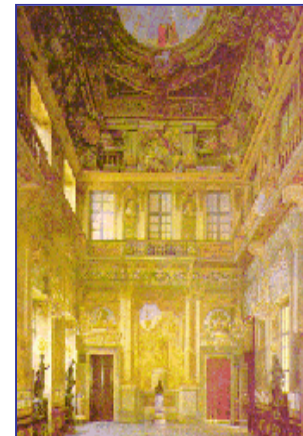
What Department?
DIPTEM - University of Genoa

DIPTEM was founded in 1997 as evolution of the Institute of Technology and Industrial Management (ITIM) that was operative from '60. DIPTEM is composed by about 65 faculty members, 15 technicians and administrative, plus several PhD Students, external Researchers and Consultants. DIPTEM teachers are involved in Undergraduate, Postgraduate and Professional activities in Engineering, Management.

DIPTEM active in R&D Projects for major Institutions, Companies and Governmental Organisations. DIPTEM co-operates actively with major Excellence Centers World-Wide.

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Savona Campus & Facilities

The University of Genoa includes a new campus in Savona about 2 km outside Downtown; bus services and large parking areas guarantee easy access.

That structure has been obtained transforming Army barracks; today the campus includes a big park with facilities such as tennis courts and sport grounds.

The campus holds Depts on Engineering, Economy and Education; new laboratories have been realised by Simulation Team (Cybersar Mobile Lab, HLA Lab).

Facilities for Professional Congress Centres are available in the surroundings

Savona Campus

Simulation Team Labs

Congress Centre

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Simulation Team MISS DIPTEM

The Simulation Team - DIPTEM of *Genoa University* carries out many industrial simulation projects in cooperation with the large corporations and small and medium sized Enterprises; some example of recent industrial simulation project are following:

Polimeri
Europa ENI   Fleet Management Planning & Scheduling
                        Chemical Plant Logistics Optimization

Ansaldo   Service and Optimization
                        for Power Plant Design

Cetena   Simulation & Virtual Project Management
Fincantieri   of Car Deck Construction for Fast Ferry

COOP   Simulation for Re-Engineering Supply Chain
                        in a Large Chain of Grocery Stores

Members of MISS are appointed in several positions in simulation community such as:
- General Director M&S Net (34 M&S Centers worldwide)
- Associate Vice President of SCS and Chairman of Technical Chapter
- Member of NATO SAS and NIAG
- Italian Point of Contact of ISAG (International Simulation Advisory Group)

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Simulation Team

Partners & Spin-Off

Former Students and Researchers from MISS DIPTEM Simulation Team created over the years spin off and companies that currently cooperate in M&S. MAST srl (**M**anagement of **A**dvanced **S**olutions and **T**echnologies) is devoted to drive Innovation to Success in a wide spectrum of Application for different Business Sectors, Companies, Corporations, Agencies, Societies and Governmental Services.

MAST puts *Modeling and Simulation* to work by creating Outstanding Solutions Essential to a Better, Safer, Healthier and Wealthier Life operating worldwide.

MAST offers a wide range of innovative products and services for markets including:

- Aerospace
- Defense
- Electronics
- Engineering
- Safety and Security
- Retail

- Environment
- Logistics
- Service to the Society (nutrition, health care)
- Petrochemical
- Energy and Power
- Shipping & Transportation

OverWindows

Blizzard Srl

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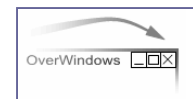
Simulation Team

McLeod Institute Simulation Science
M&S Net Genoa Center

Email: agostino@itim.unige.it   **URL: www.itim.unige.it/mcleod**
                                              www.simulationscience.org

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M&S Net

The research group of DIPTEM of *Genoa University* is active from '60 in Simulation applied to Industrial Engineering and is part of MISS 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:	Chemical Facilities	Power Plants	PM
	Harbor Terminals	Public Services	Environment
	Manufacturing	Assembling	Logistics
	Public Transportation		

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.
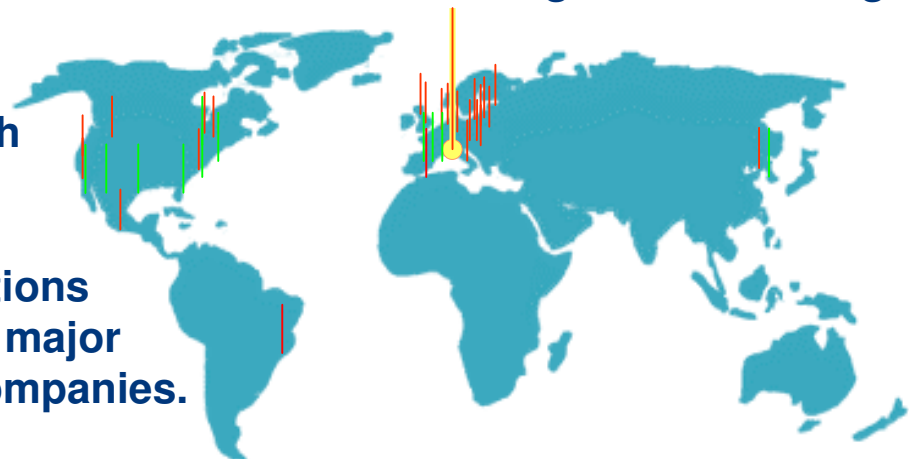
28 MISS Centers, 34 M&S Net Centers World-Wide

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Simulation Team

Simulation Team MISS DIPTEM

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- Associate Vice President of SCS and Chairman of Technical Chapter
- Member of NATO SAS and NIAG
- Italian Point of Contact of ISAG (International Simulation Advisory Group)

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Liophant Simulation

Email   info@liophant.org

The *Liophant Simulation* involves World-Wide over 120 Scientists and Technicians working in Companies and Academia. The *Liophant* develops Advanced R&D Projects for Real Applications:

The *Liophant Simulation* promotes international Cooperations and exchanges with Excellence Centers World-Wide (i.e. NCS, KSC, VMASC, KPI

Liophant ● Members   &   ■ Links
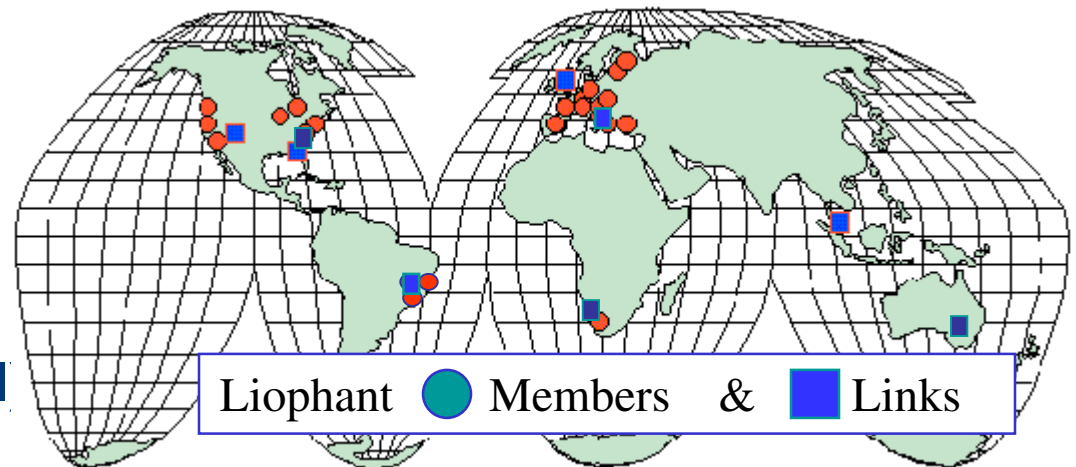
www.liophant.org

Simulation Team

The International Activity of Liophant Simulation 2010

CAX Forun
Munich, *September*

ESISA
Fes, *June*
M.Hamri
F.Madeo,
F.Tarone

ITEC
London, *May*

Capricorn
Paris, *August*

Clermont-Ferrant
August, A.Claudel

PKI, Lincoln NE,
March, A.Pessina
EBR, Vienna VA
Dec, D.Maino

Marseille, *May*
M.Hamri, F.Madeo, F.Tarone

Michigan Univ.
Detroit, *October*
G.Gazzale

BOEING
Seattle, *Feb*
A.Pessina

NASA
Orlando, *May*
A.Cimino
CSC, Orlando
March, A.Pessina

I/ITSEC Orlando,
November

PMC
Detroit, *October*
G.Gazzale

Harvard Med.School
Oct-Nov
C.Cereda

VMASC
Norfolk, *April*
F.Madeo, F.Tarone

SpringSim
Orlando, *April*
F.Madeo
F.Tarone

Exchange Activity
PhD, Master, BS
Simulation Team
Genoa
A.Ceylan, A. Claudel

EDA, Capricorn
Rome, *July*
F.Madeo
MIMOS Virtual Testing
Napoli

LAMCE_COPPE
Rio, *Nov-Dec*
G.Gazzale

UFRJ PETROBRAS BR

VMASC, DLL, Norfolk State Univ
Nov-Dec D.Maino

ICAMES2010, Istanbul, *May*
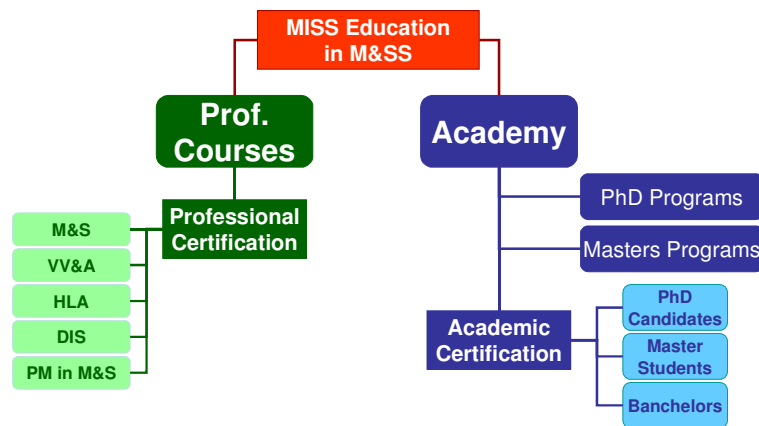F.Madeo, L.Nicoletti, S.Mannis,
T.Pizzuti

MISS M&SNet

Simulation Team

Simulation Technology Transfer

Since 2000 Simulation Team - DIPTEM support Professional and Academic MISS International M&S Certification Program:

```
                    ┌─────────────────┐
                    │ MISS Education  │
                    │   in M&SS       │
                    └─────────────────┘
              ┌───────────┴────────────┐
        ┌──────────┐              ┌──────────┐
        │  Prof.   │              │ Academy  │
        │ Courses  │              └──────────┘
        └──────────┘                   │
              │                    ┌──────────────────┐
        ┌──────────────┐           │  PhD Programs    │
        │ Professional │           └──────────────────┘
        │ Certification│           ┌──────────────────┐
        └──────────────┘           │ Masters Programs │
   ┌──────┐                        └──────────────────┘
   │ M&S  │
   ├──────┤           ┌──────────────┐    ┌─────────────┐
   │ VV&A │           │  Academic    │    │    PhD      │
   ├──────┤           │ Certification│    │ Candidates  │
   │ HLA  │           └──────────────┘    ├─────────────┤
   ├──────┤                               │   Master    │
   │ DIS  │                               │  Students   │
   ├──────┤                               ├─────────────┤
   │PM in │                               │ Banchelors  │
   │ M&S  │                               └─────────────┘
   └──────┘
```

- The Lecturers included experts from major excellence centres (i.e. Boston College, Genoa University, NASA, DMSO, National Center for Simulation, SAIC, Aegis, CSY., Riga TU, UCF , McLeod Institute of Simulation Science).
- The Professional course attendance (PM >100, M&S 60, HLA 40, VV&A 20) included Companies (i.e. Piaggio Aero Industries, Alenia Aeronautica, Alenia Marconi, SIA, Fincantieri, COOP), Academia (Pol.Torino, TU Delft, Univ.Marseille, Pol.Milano, Univ.Firenze, Univ.Bari, Univ.L'Aquila, etc.) and National and International Services (i.e. Army, Navy, Air Force, Joint Forces)

Course Location

Lecturing

Team Working & Exercises

Unclassified

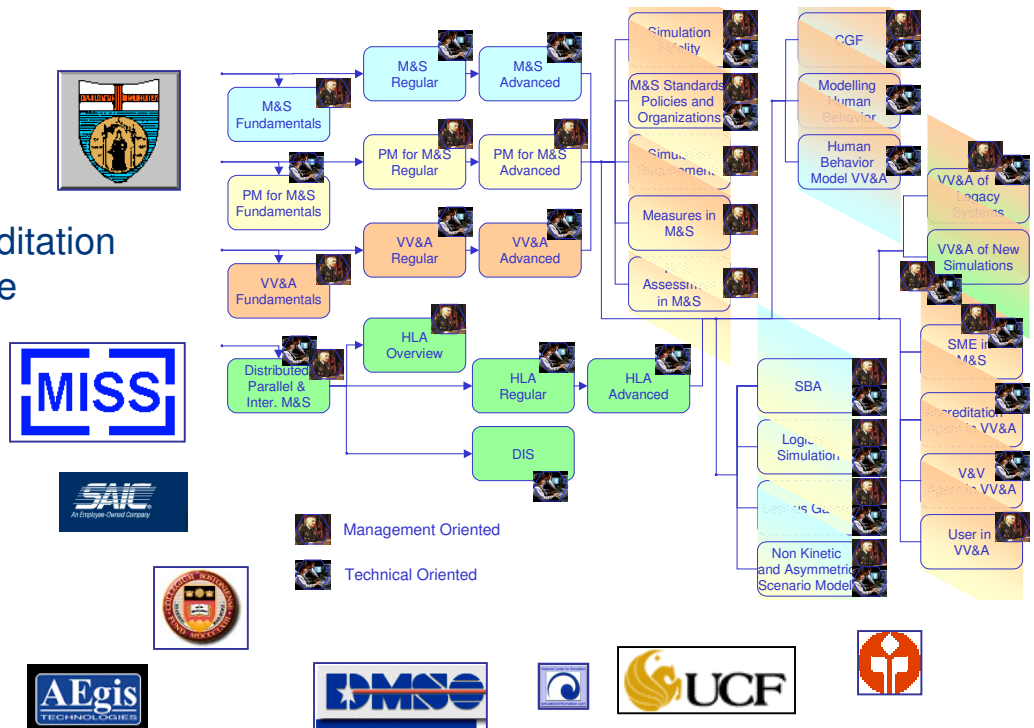**DIPTEM**
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Project: SIREN Professional Courses

- The professional courses have been organized since 2000
- for World-Wide professional experts and technicians, in English, Italian and French, including:
  – PM: Project Management for M&S
  – M&S: Modeling & Simulation
  – Interoperability M&|S
  – HLA: High Level Architecture
  – VV&A: Verification, Validation & Accreditation
  – RCM: Reliability Centered Maintenance

The courses include lecturing and exercises; teachers are usually world wide experts from major excellence centers (i.e. Boston College, MISS, Genoa University, NASA, DMSO, National Center for Simulation, SAIC, Aegis Technologies, CSU, Riga TU, UCF, McLeod Institute of Simulation Science, etc.).

M&S Fundamentals → M&S Regular → M&S Advanced

PM for M&S Fundamentals → PM for M&S Regular → PM for M&S Advanced

VV&A Fundamentals → VV&A Regular → VV&A Advanced

Distributed Parallel & Inter. M&S → HLA Overview → HLA Regular → HLA Advanced

DIS

Simulation ... ity

M&S Standards Policies and Organizations

Simu... ...ment

Measures in M&S

... Assessm... in M&S

SBA

Logic... Simulation

...s ...

Non Kinetic and Asymmetric Scenario Model

CGF

Modelling ...uman Behavior

Human Behavior Model VV&A

VV&A of ...egacy ...tems

VV&A of New Simulations

SME i... M&S

...creditation ... ... VV&A

V&V ... VV&A

User in VV&A

Management Oriented

Technical Oriented

MISS

SAIC — An Employee-Owned Company

AEgis TECHNOLOGIES

DMSO

UCF

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Why Modeling & Simulation?

Internal Complexity   →   Complex Behaviors

↓

Simulation:
More Efforts
More Capabilities   ←   Not Linear Systems
Reusable Model   Not valid Simplification Hypotheses
Boundary Conditions are Critical
No Generalization

↑

External Complexity   →   Many Interaction
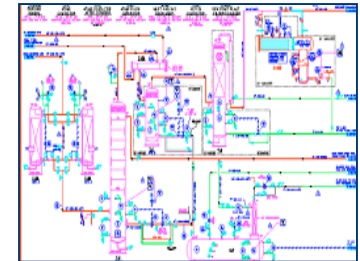
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Simulation Origin?

Simulator

Simulator Figurae

Ovid's Metamorphoses, 11, 634, 8 AD

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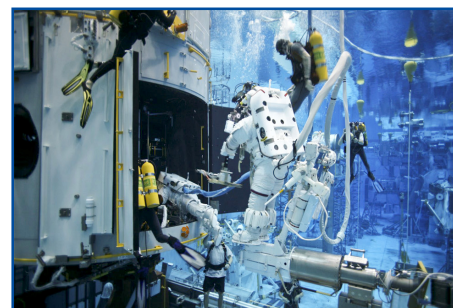
Simulation Origin?

Simulator

Simulator Figurae

Ovid's Metamorphoses, 11, 634, 8 AD

Computer Simulation

The Use of a Computer Model instead of an actual opr hypothesized   system -- the simuland -- to run experiments designed to determine   the characteristics of the model and, by implication, of the system

Simulator

The equipment used by Simulation

Simuland

The real or hypothezised system which is, ot is to be, simulated

John McLeod, Computer M&S, 1982 AD

Simulation Team

Simulation Origins

'50   now

Defense

Engineering

Training

Decision Support

Interoperability

Simulation based Acquisition

Microsoft Flight Simulator ™

Static M 346 CAE

5DoF F18 Aegis

6DoF Jaguar CAE

Bleriot
Recruiter

Industry
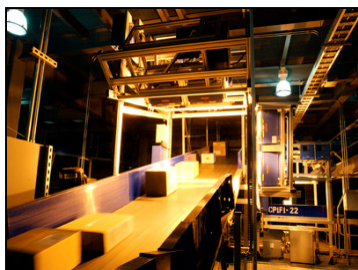
Manufacturing

Process Optimization

Operations Management
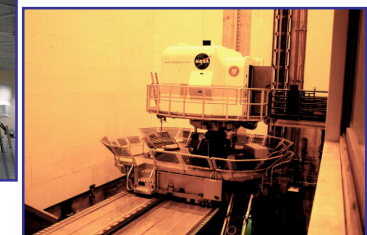
Decision Support

V22 Vertical Flight Simulator
NASA Ames

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Simulation Origins

'50   now

Defense

Engineering

Training

Decision Support

Interoperability

Simulation based Acquisition

Industry

Manufacturing

Process Optimization

Operations Management

Decision Support

ST_VP 6DoF Mobile Virtual Live Constructive HLA Simulator

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What is a Simulation?

Simulation is the reproduction of the reality by using computer models.

The simulation allows to build up a *Virtual Environment* and to run dynamic scenarios in order to analyze or optimize the real system.

A simulation project is devoted to develop and

use Simulation to solve problems

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Simulation Team

What is a Simulation?

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Simulation Types

Stand-Alone		Deterministic
Distributed		Stochastic
Parallel		Man-in-the-Loop
Web-Based		Object-Oriented

SIMULATION

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

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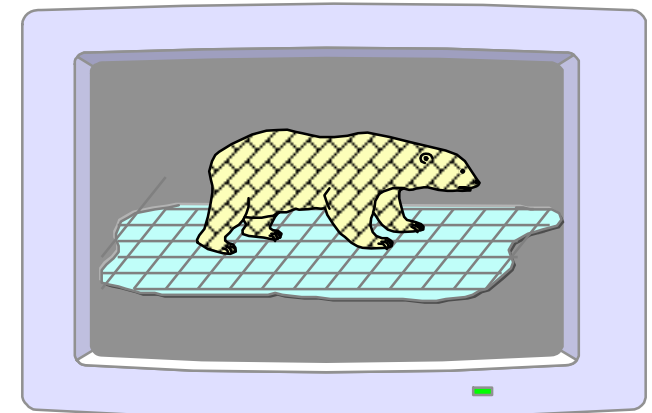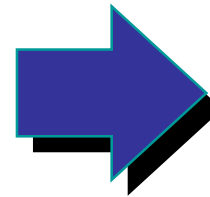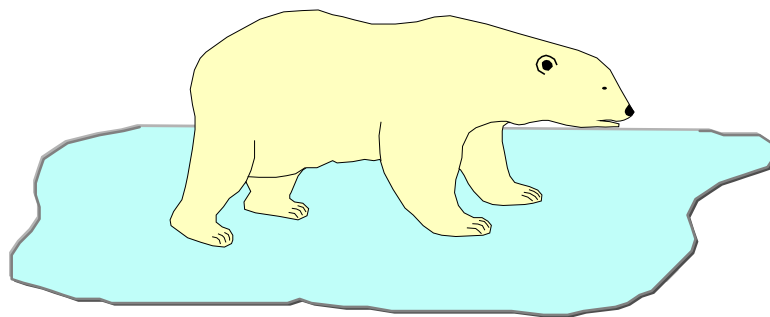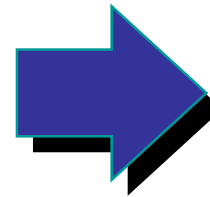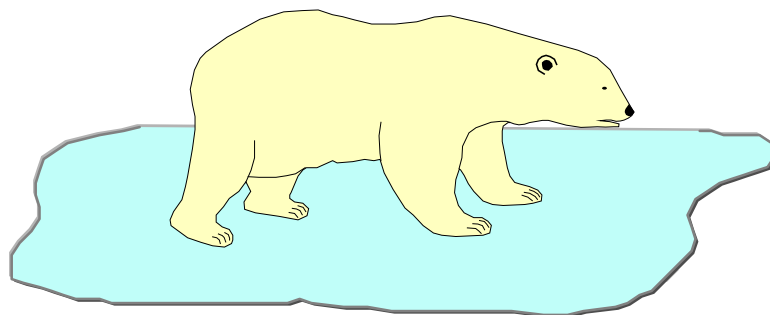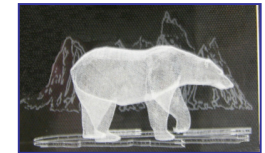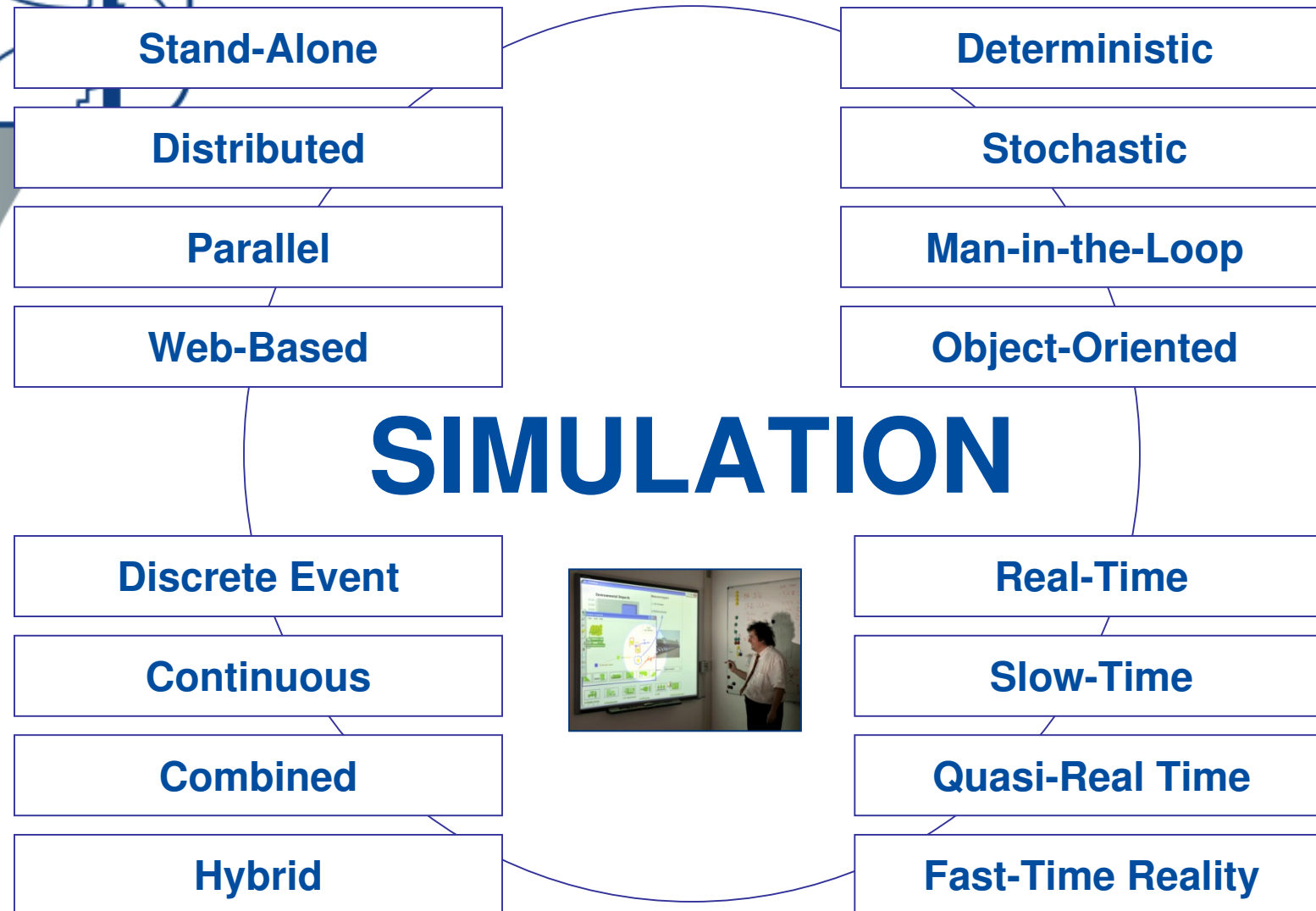
Simulation Team

Software Development vs. M&S

Simulation Projects are different from SW Projects because needs to face strong VV&A versus real Systems

- Simulation Projects deadlines and requirements are often related to other on-going Projects
- Simulation Knowledge needs to be used for Model Development as strong background for Implementation phase

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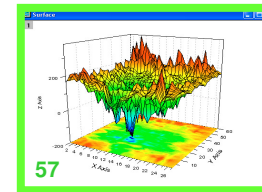
Model Nature

Classification on the base of the Model Nature:

• **Deterministic Simulation**
   A Simulation based on models where statistical distribution are not in use, including just deterministic behaviors

•**Stochastic Simulation**
   A Simulation reproducing a system with variables regulated by not known statistical phenomena by implementing pseudorandom variables

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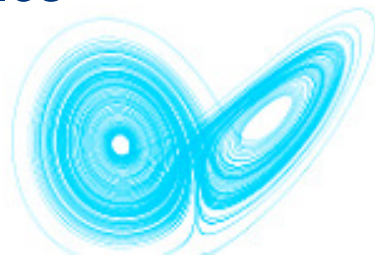
Purposes of Simulation Modeling

- Simulations allow inferences to be drawn about systems without building them or disturbing them.

- Simulation can be used for
  - ⇨ design
  - ⇨ operational analysis
  - ⇨ performance assessment
  - ⇨ education & training

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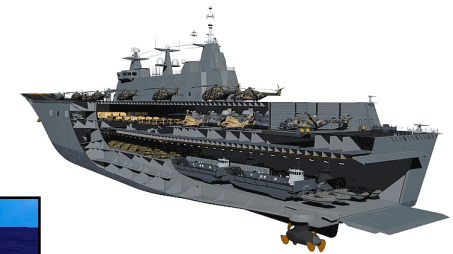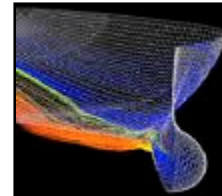
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Major Questions

Simulation is able to answer to the following questions:

- **What if ?** *(directly)*
- **How To ?** *(indirectly)*
- **Why ?** *(indirectly)*

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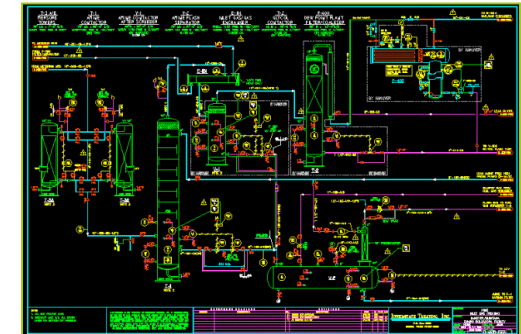
Simulation Team

A Quick Overview on
Hot Spots

Simulation is becoming quite popular
- **New Application areas require innovation to face new Challenges**
- **Interoperability Challenges are still open issues**
- **Interdisciplinary Modeling is an emerging need**
- **Needs for Advances Simulation Technologies while Enabling Technologies are available**
- **Growth in Size & Complexity of M&S**
- **Need to motivate Effectiveness of M&S**

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Open Issues in M&S

Multidisciplinary Teams → ● ← **Large Projects**

Distributed Teams → ● ← **Ambitious Goals**

Scenario Definition → ● ← **Complex RAM**

Skills & Experiences → ● ← **Development Bottlenecks**

Legacy Dreaming → ● ← **Discovering the Real Models**

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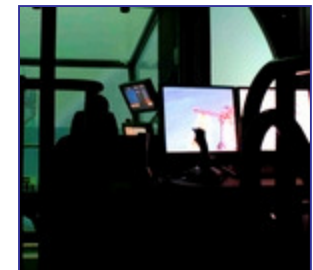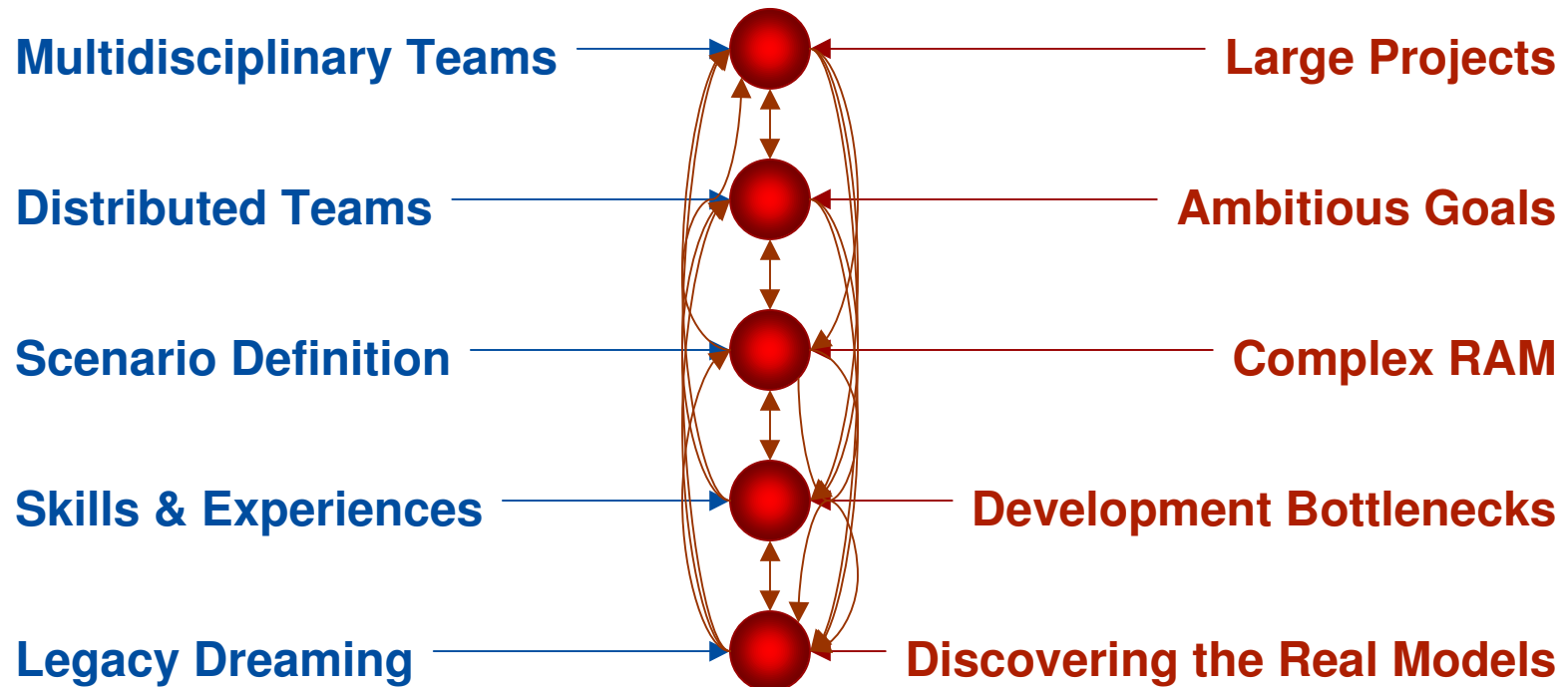
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M&S Exogenous Critical Issues

The Simulation Development Processes and Project Management represent another source of critical issues related to aspect such as:

- **Establish Requirements**
- **Budget Planning Limitations**
- **The Length of the Development Cycle**
- **Communications during the Development Cycle**

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Current Situation in Project Management for M&S

Proiect Management Issues in M&S are related to:

- Proper Identification of the Critical Issues in PM applied to development of new Simulators
- Propose Solutions for Distributed Teams operating over Interoperable Simulation Project Management
- Construct the Bridge to Overpass PM Problems

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Current Situation in Project Management for M&S

Proiect Management Issues in M&S are related to:

- *Proper Identification of the Critical Issues in PM applied to development of new Simulators*
- *Propose Solutions for Distributed Teams operating over Interoperable Simulation Project Management*
- *Construct the Bridge to Overpass PM Problems*

Using PM Methodologies could strongly benefit the Projects:

- ***Project Time Control***
- ***Project Cost Control***
- ***Project Team Management***

In New Large Projects involving geographically distributed teams these aspects are stressed

Simulation Team

M&S Standards & Tool Dreaming

Project Teams are often expecting to find M&S Project Solution in new tools acquisitions while this needs to face with:

- **Proper Tool Acquisition based on Alternative Overview**
- **Training and Knowledge Acquisition Issues**
- **Conceptual Model Proper Fundamentals**

Simulation Team

Time as Critical Issue in M&S

Old Situation

Simulation Project Kick Off

- Target Definition
- System Analysis
- Data Collection
- Conceptual Model Design
- Model Implementation
- Testing

Simulator Ready for Use

Time

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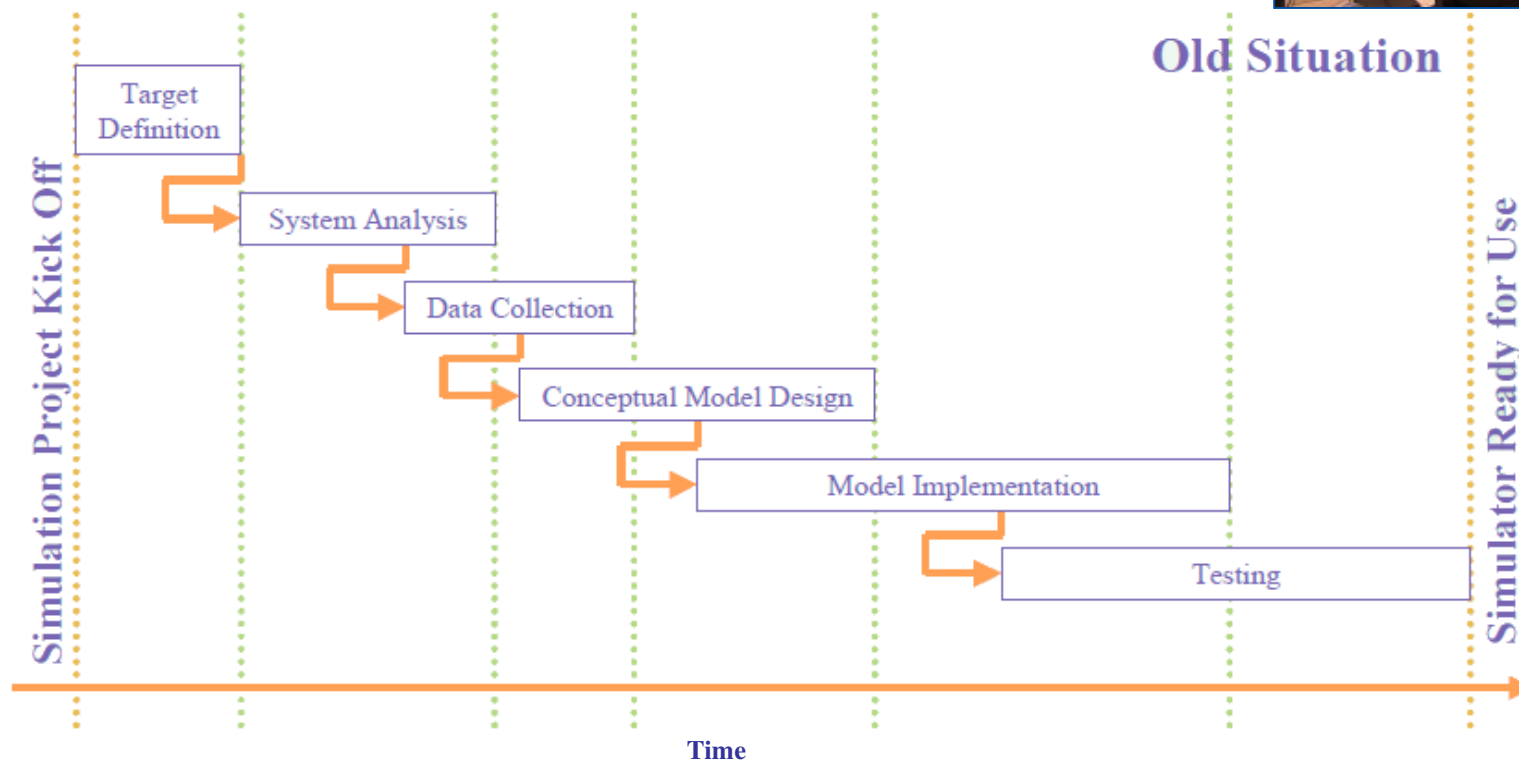
Time as Critical Issue in M&S

Development Time: Now

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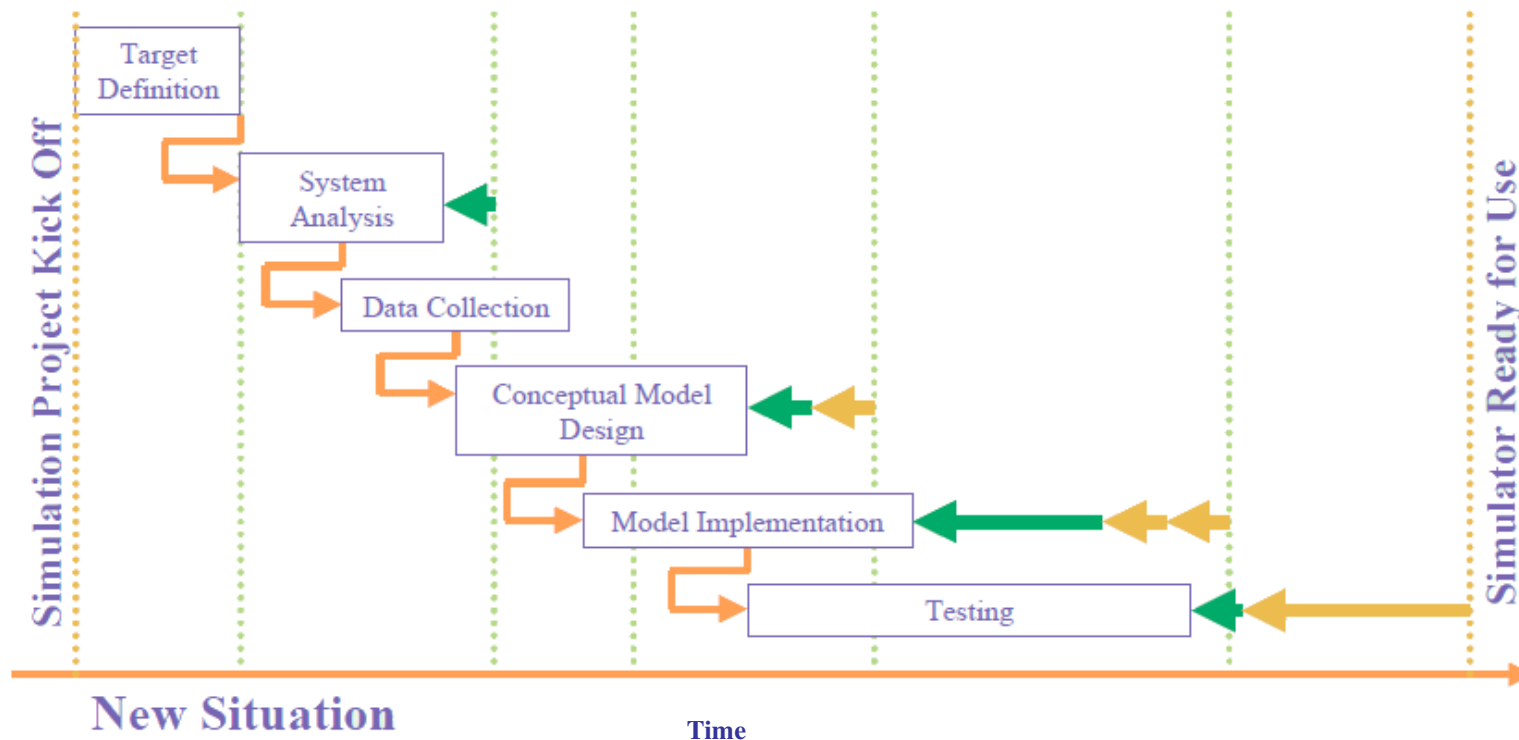
Residual Inertia in COTS

The COTS in M&S evolved along last years, therefore there are some residual aspects to be arranged in order to face new challenges such as :

- **Existence of old Protected Markets &** *Afficionados*
- **Development of** *Compliant* **instead of** *Compatible* **Solutions**
- **New Releases versus New Features**
- **Reinventing the wheel respect Available Low Costs Technologies**

Simulation Team

Legacy Systems & Simulation Projects

Unfortunately Legacy Systems are generating Dreams in Final Users in term of expectation about:

- Reusability
- Fidelity
- VV&A Saving

Reusability of the Model is important until the Model is Consistent considering new requirements

Fidelity of a Model used for a Different Purpose could change Drastically

VV&A of new Developments is strongly based on the new configuration

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M&S Endogenous Critical Issues

The four basic phases of a simulation project include:
• **Modeling**
• **Data and Knowledge**
• **Implementation**
• **Validation**

The critical issues associated with those phases determine the effectiveness of the simulation.

This presentation addresses the factors that contribute to those issues that may result in decreased effectiveness or invalidate the simulation. Suggestions are offered to assist in the early identification of potential for difficulties, thus leading to simulation that can achieve the objectives successfully

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Simulator Development Needs

Value

Simulation Result Value

100.0%
90.0%
80.0%
70.0%
60.0%

Simulation Result
Deadline for Perfect
Timing

Latest Time
for Use the
Simulation
Results

10.0%

60   80   100

Modelling

Data

Implementation

Validation

Real System
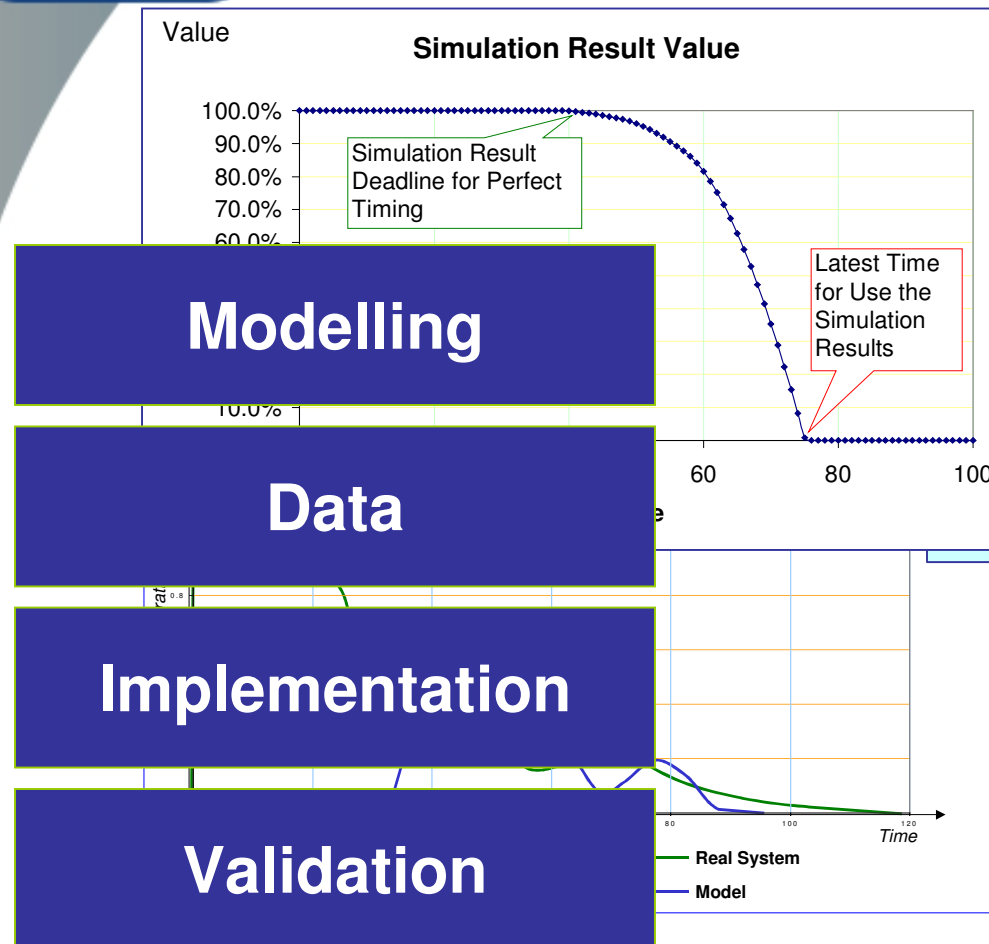
Model

Time

Budget Planning Limitation

Length of Development Cycle

Communication during Development Cycle

Development Process

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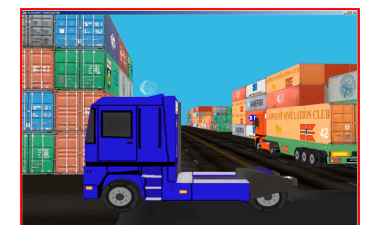
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Just in Time on Simulator Deliverables

Simulation Result Value

Simulation Result Deadline for Perfect Timing

Latest Time for Use the Simulation Results

Value

Time

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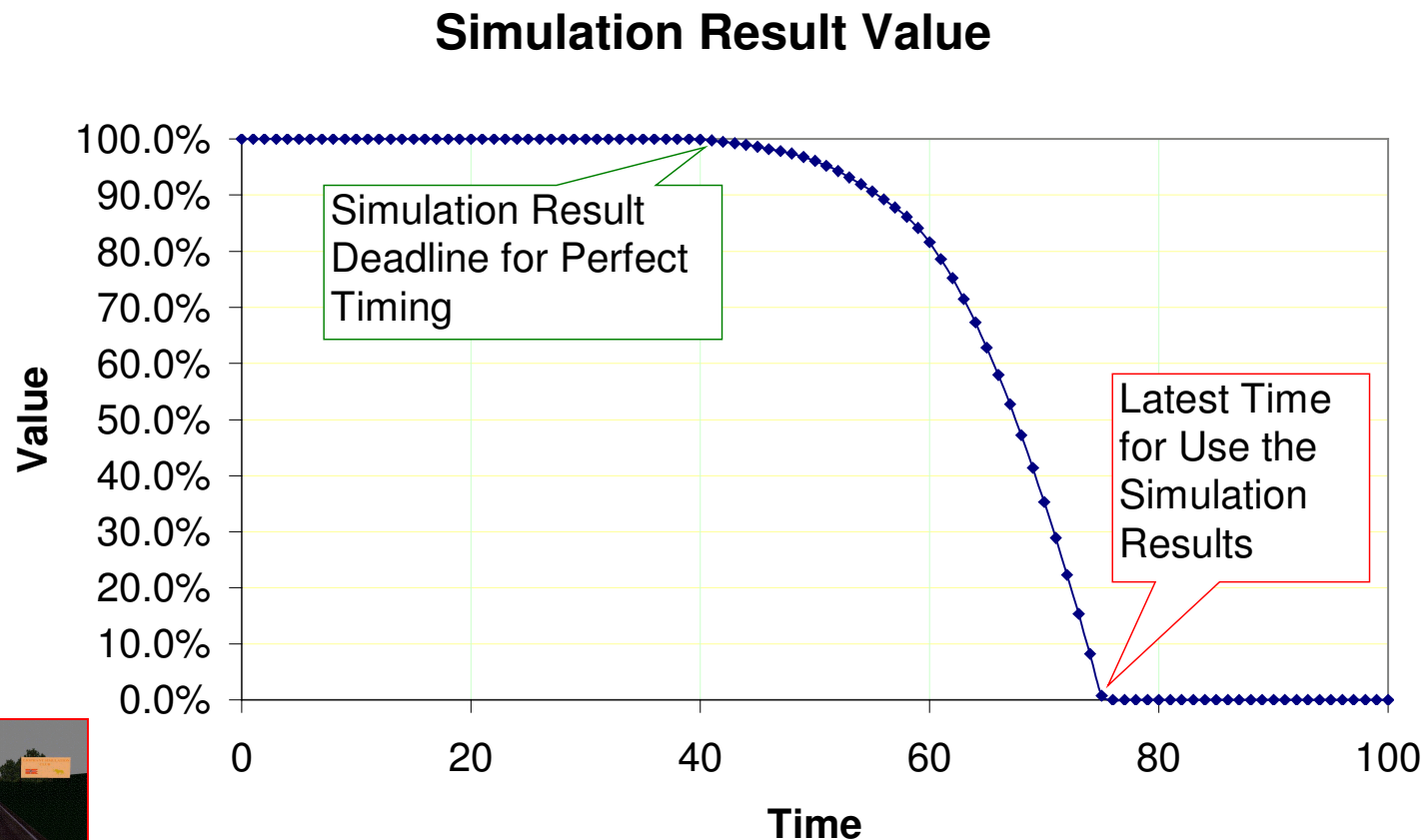
System Configuration Dynamics

System & Simulation Project Evolution

Risk to Work on a Model
Different from the New
Configuration/Scenario
of the Real System

Configuration Changes

Time

i.e. Human Behavior Analysis introduces Drastic Changes in the Model Infrastructure

—— **Real System**

—— **Model**

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Usability vs. Fidelity in M&S

- **A model Output could be considered in relation to a credibility level. If correctness grows, development cost of the model grows; meanwhile usability of the model increases, but with a non-linear, and usually at decreasing, rate.**

Controlled Fidelity

Lean Simulation

Cost

Usability

Model Usability

Model Development Cost

Fidelity of the Model

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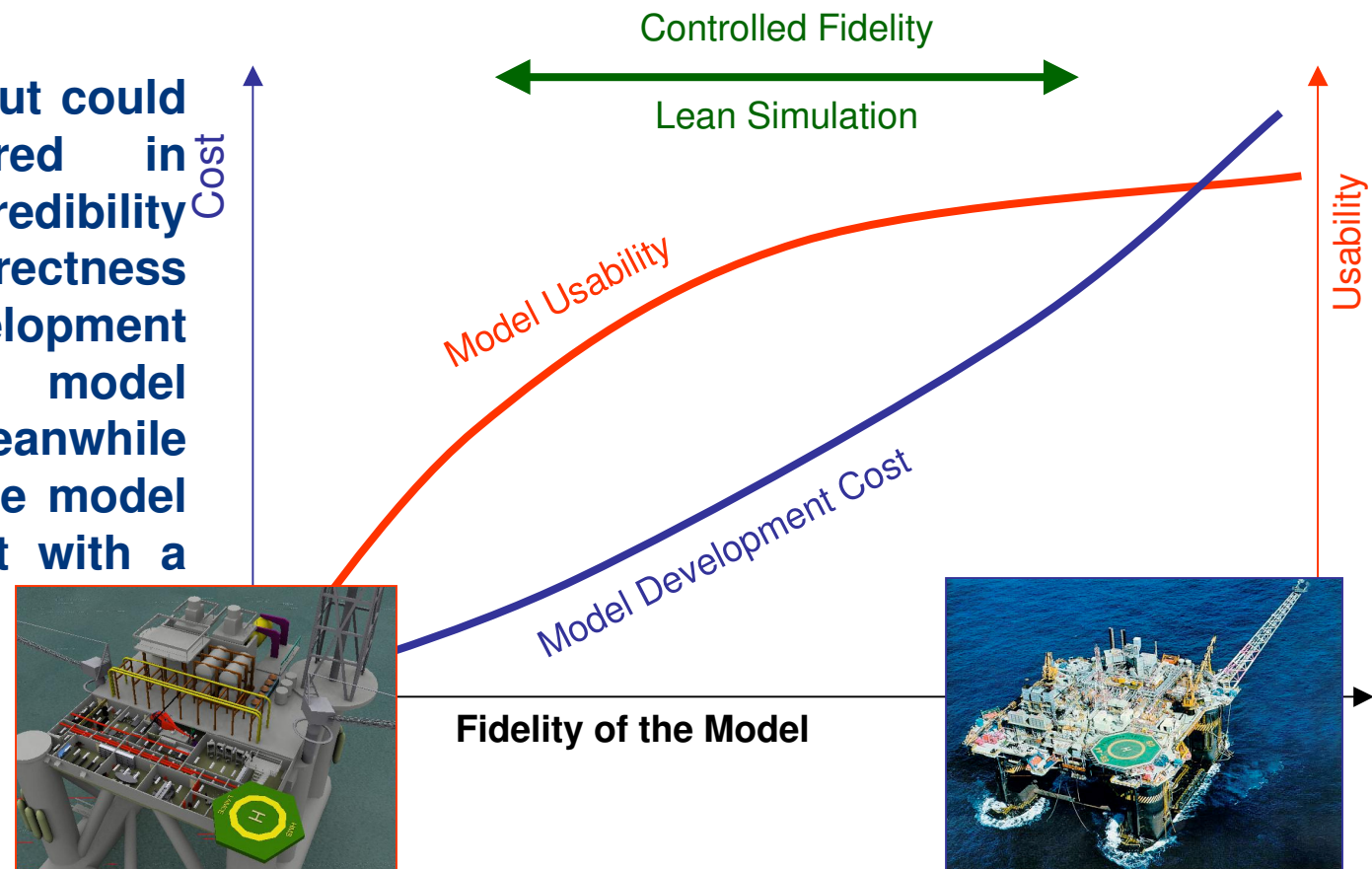
Validation and Verification as Critical Issues

- 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.

Real -World System — Validation — Conceptual Model

Real -World System — Validation — Simulation Program

Simulation Program — Verification — Conceptual Model

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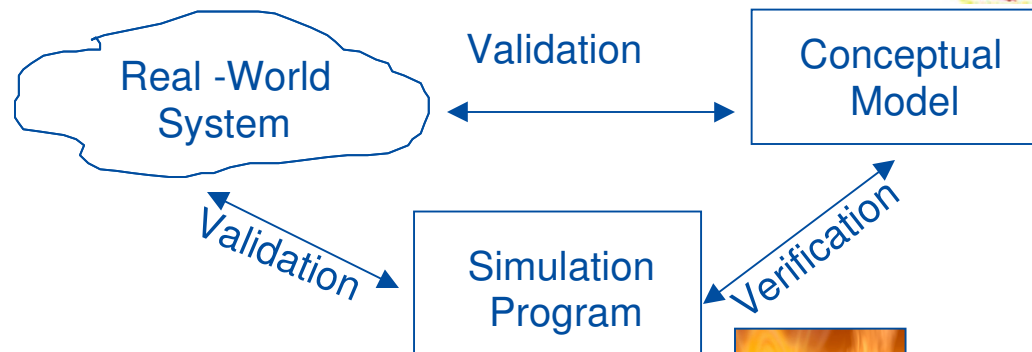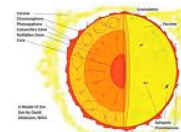
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V&V for Complex Systems

131
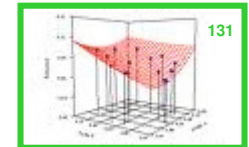
- **It is critical to understand, that due to the high not linear nature of most of simulation models it is not possible to apply superposition principle.**

- **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**

Subsystem Federates

Component Federates

Management System Federate

Ship Federates

Vehicle Federates

Environment Federates

MIL Federates

HIL Interface Federates

Run Time Infrastructure

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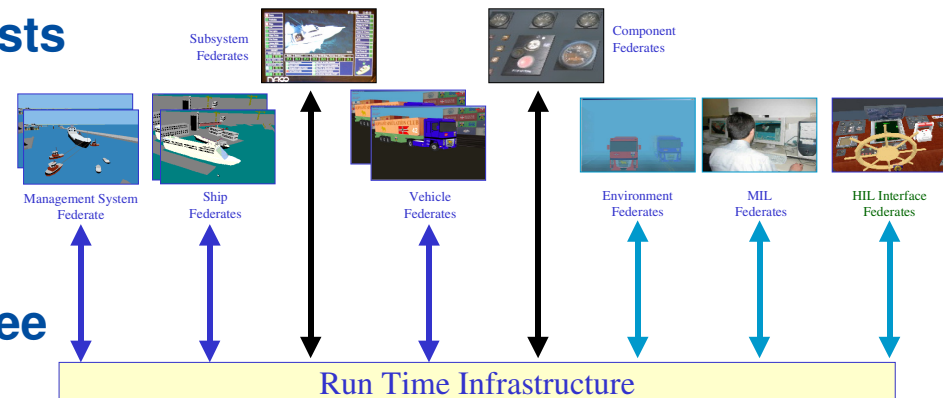
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Critical Issues in Simulation Costs

Resource Cost — *Issues*

- Situation of Available Resources
- Specific Training & Expertise
- Proprietary Issues !?
- Life Cycle Issues !?
- Maintainability
- Portability
- Value of Deliverables versus Planning
- VV&A Responsibility Assignments !?
- ......
- Miscellaneous

Development & Integration Costs

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Estimating VV&A Costs

The estimation of total costs can't be generalized.
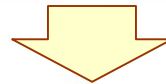
It is possible to outline a set of examples reporting about the resources, scheduling and costs related to the VV&A.

Example Elements:
- *Outline Boundaries*
- *Describe Expert Selection and Use*
- *Describe responsibility*
- *Report on time and costs*

VV&A 16.2%
Model Definition
User Interface
Operative Procedures
Object Behaviour
Shapes & Static Environemnt
Data Collection

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General Cost Drivers

VV&A Models	Model Size	New Development
Certified Database	Model Complexity	Interoperability
VV&A Documentation	Federation Complexity	Information Availability
Existing & Reusable	Model Dimension	Risk & Uncertainty

(-)   (+)   (+)

M&S VV&A
Costs

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Cost Driver Overview

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Simulation and Integration with Other Advanced Techniques

Artificial Intelligence (AI) & Intelligent Agents (IA)	Advanced Techniques
Knowledge Based Systems	Simulation
Artificial Neural Networks	Chaos Theory
Fuzzy Logic	Metamodels & DOE
Genetic Algorithms	Optimization Techniques
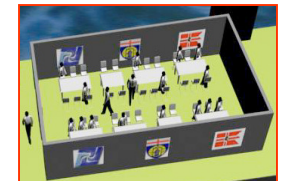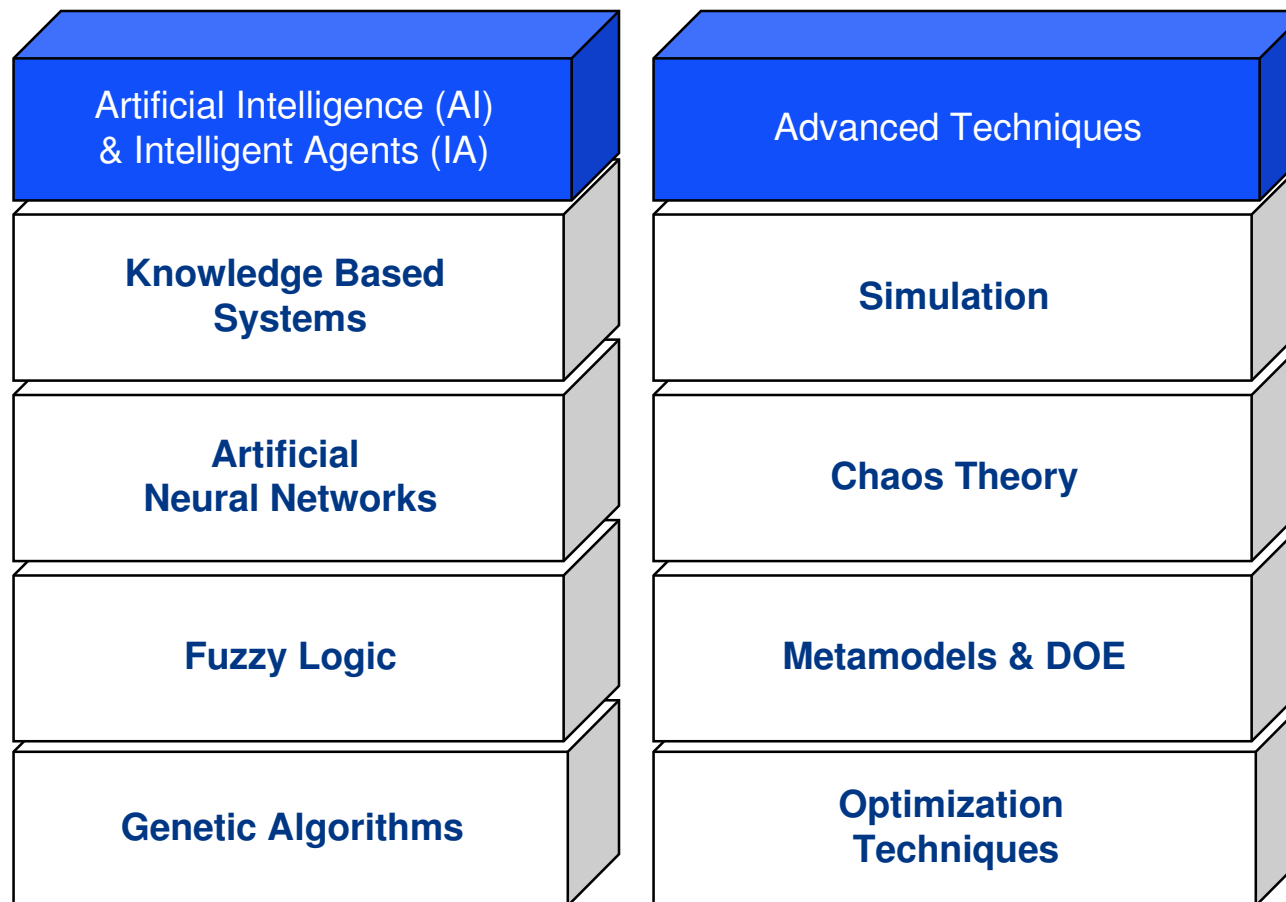
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Integration as Additional Challenge

The square stone to success in the application of new methodologies is the integration of different techniques and on interoperability among multidisciplinary models

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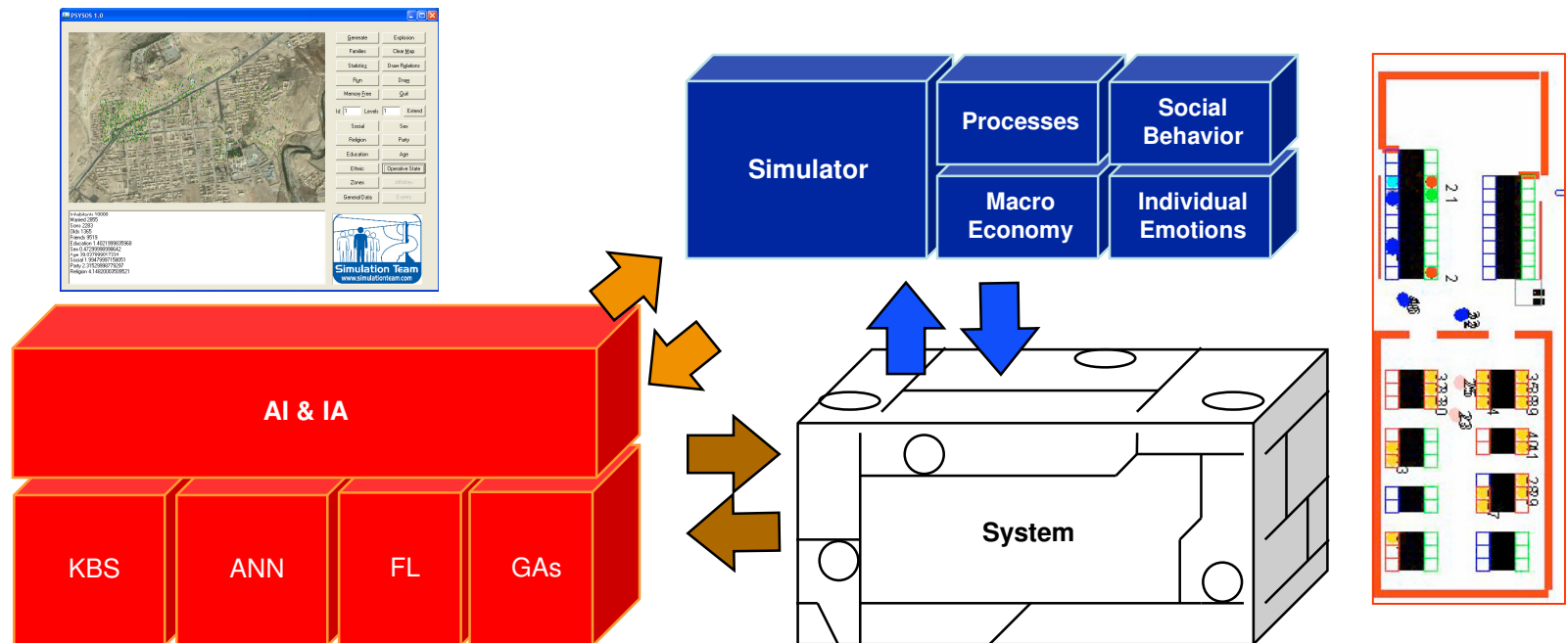
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Simulation & Human Time Horizon
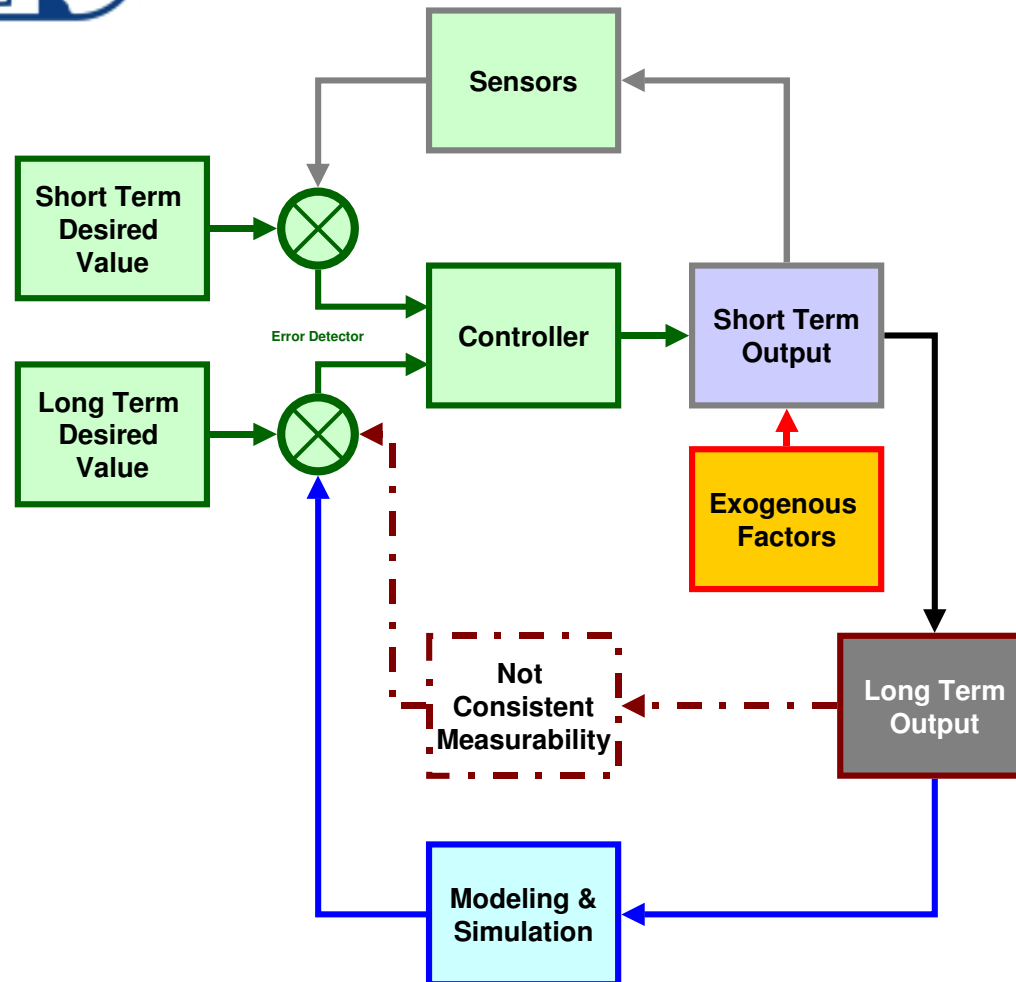
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Specific Nature of Simulation Projects

- Simulation Projects are usually a support for Larger Initiatives
- Simulation Projects deadlines and requirements are often related to other on-going Projects
- Simulation Projects are different from SW Projects because needs to face strong VV&A versus real Systems
- Simulation Knowledge needs to be used for Model Development as strong background for Implementation phase

Most Problems strongly involves Humans Behavior (HB)

HB M&S introduces new challenges in Simulation projects

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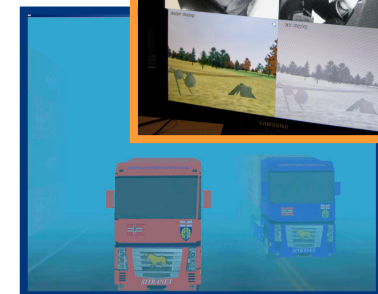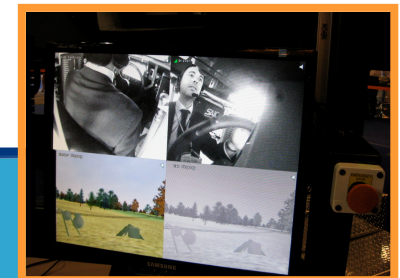
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Life Cycle: How many Models?

The Virtual Product Life Cycle
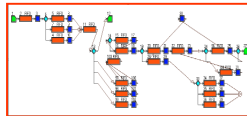
•Simulation is able to support different phases in Complex System Life Cycle eventually with different models to be reused in different projects

OPERATION

LESSONS LEARNED

OPERATIONAL & LOGISTICAL SIMULATIONS

DEPLOYABLE SYSTEM

COST AND OPERATIONAL EFFECTIVENESS ANALYSIS

TRAINING SIMULATIONS

REQUIREMENTS

OPERATIONAL SYSTEM

DEVELOPMENT

SIM-BASED DESIGN CAR ENGINEERING

THE PRODUCT-MODEL BASED VIRTUAL PROTOTYPE

VIRTUAL TESTING

PRODUCT DEFINITION

VIRTUAL MANUFACTURING

PRODUCT

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

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Quick and Dirty Context: Need for a New Paradigm

Simulation Challenges in Quick and Dirt Problems such as **_Small & Medium Size Enterprises_** (SME) & **_Early Stage Evaluations (ESE)_** are growing problems requiring new Paradigms

A potential solution is **Lean Simulation:** an innovative approach devoted to guarantee development of M&S (Modeling and Simulation) projects with reduced resources and in quick time by fast track procedures. The key point of this approach is to be able to relax fidelity requirements and ancillary activities keeping under control the model confidence respect to the application requirements.

What is Lean Simulation?
Lean Simulation key points could be summarized as follows:
– **Essential Statement of Work for Simulation Success**
– **Minimal Fidelity for Satisfy Project Requirements**
– **Quantitative Control on Model Confidence**
– **Tailored Protocols and Procedures per Application Categories**
– **Compact Simulation Unit**

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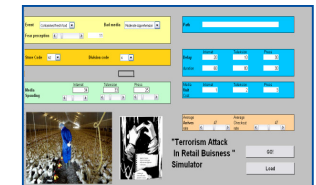
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Complex Problems & Multi Layer Modeling

Activities related to the Large Complex Systems can't be analyzed stand alone they are strongly related with many factors; so new Simulation models need to take care of all these aspects and their interactions

CONTAINMENT AGENTS

IA

Industry

Media & Information

Finance

...

...

...

Power

Transportation

Communications

CRISIS

IA
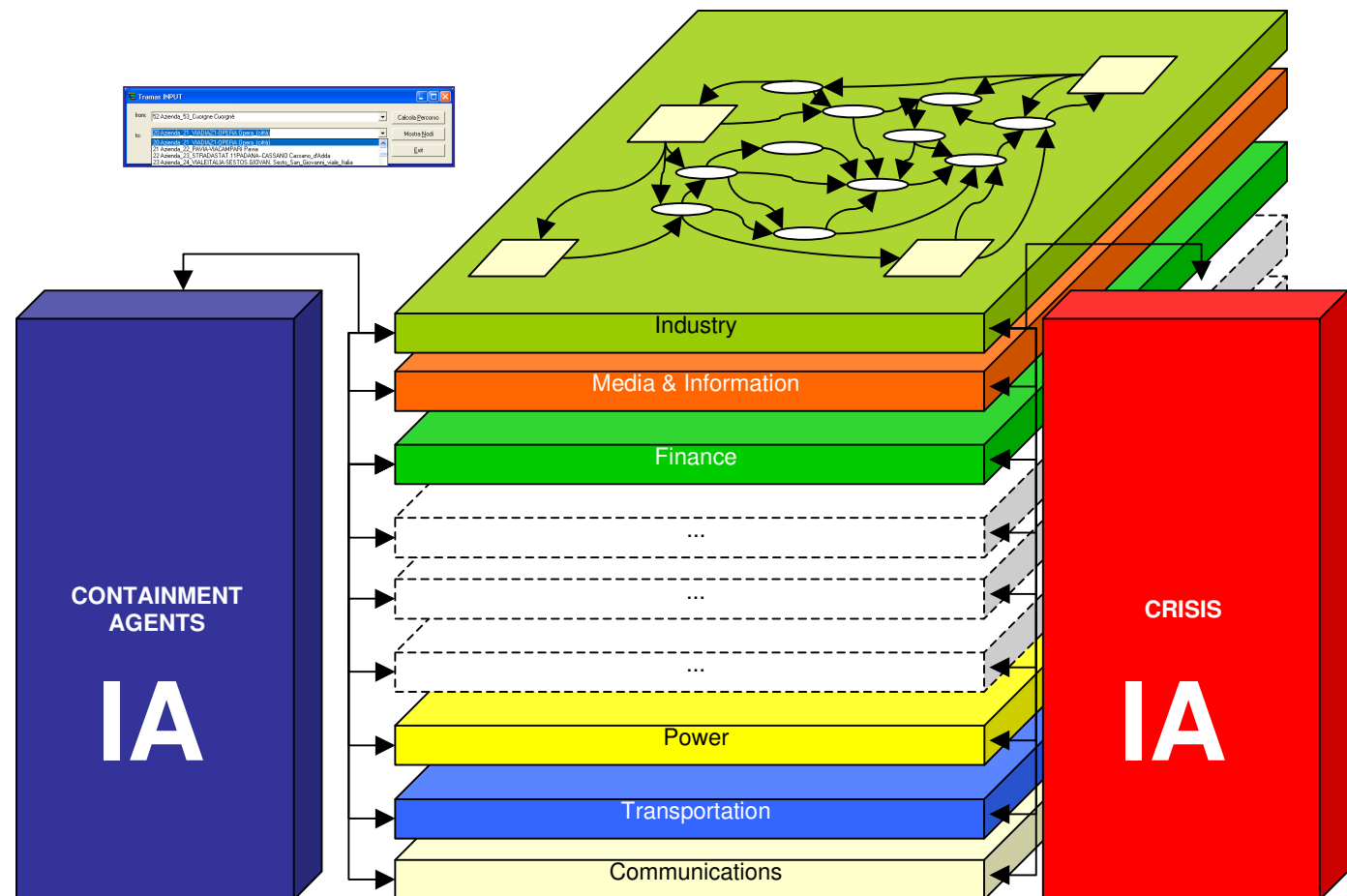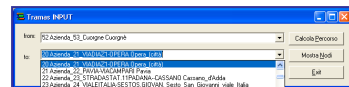
EXPONENTIAL COMPLEXITY FOR MODELING AND SIMULATION

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Boundaries and Constraints

This new Generation Simulations have to face big challenges
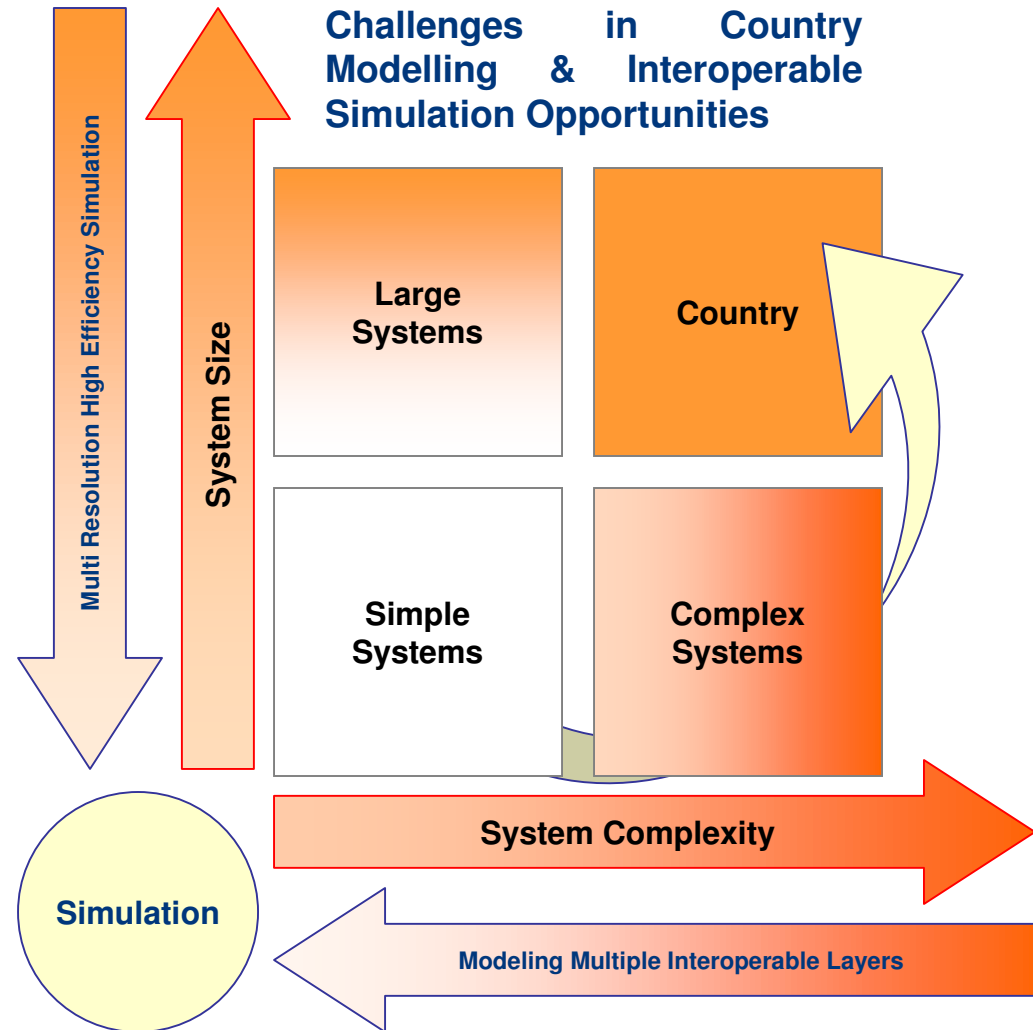
Challenges in Country Modelling & Interoperable Simulation Opportunities

Multi Resolution High Efficiency Simulation

System Size

| Large Systems | Country |
| Simple Systems | Complex Systems |

Simulation

System Complexity

Modeling Multiple Interoperable Layers

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Human Modeling Challenges

- **RATIONAL DECISION MAKING**
  - **Intelligent Individual Behavior**
  - **Organization & Hierarchies**

- **EMOTIONS & ATTRIBUTES**
  - **Psychology, Culture, Social**
  - **Crowd Behavior**
  - **Social Networks**

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Project for M&S HBE
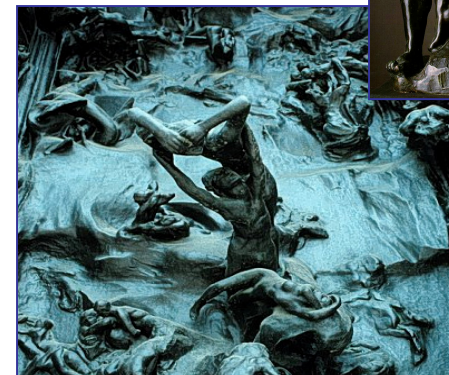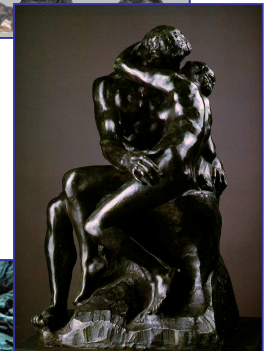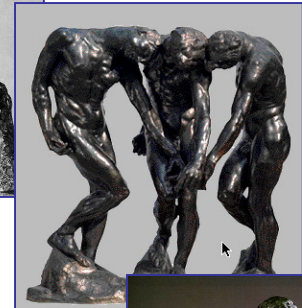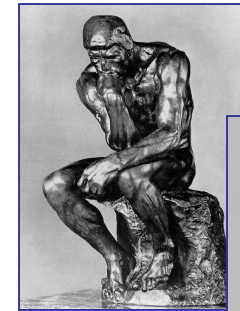
Modelling Human Behaviour

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Avoid HBE issue

Decision about Most Effective HBE Modeling Approach

There are Human Behavior Elements (HBE) in our System?

Identify Target Functions Affected by HBE

Identify Different Possible HBE Models

HBE Affects the System in relation to our Goals?

The HBE have an high degree of variability?

Estimate the Impact on the Simulation Project Goals

Estimate Model Fidelity/Usability

The HBE input are significant on their outputs?

Estimate Costs for Conceptual Model Development

HBE knowledge is available or could be acquired

Estimate Development Efforts

Estimate Model Return of Investment (ROI)

HBE Data are available or could be acquired?

Estimate Costs for Data Acquisition and Maintenance

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Advances and Enablers vs. Requirement Evolution

Operational World is evolving so new Requirements are emerging for Training

New Technologies are appearing becoming enablers for new Training approaches

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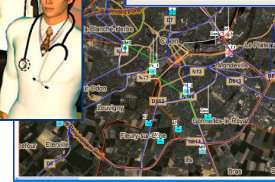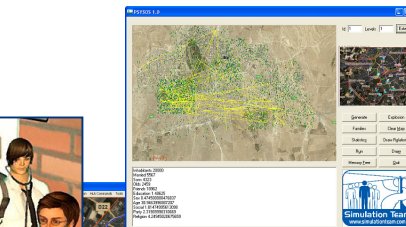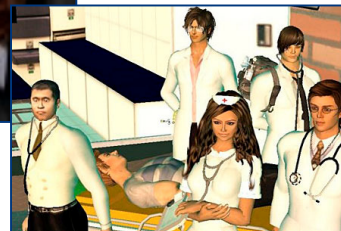
Operational Drivers....

From Modeling Oil Platforms for Helicopter Landing, Operator Training, Crew Coordination
forward to Eco-Mega-Crisis Management

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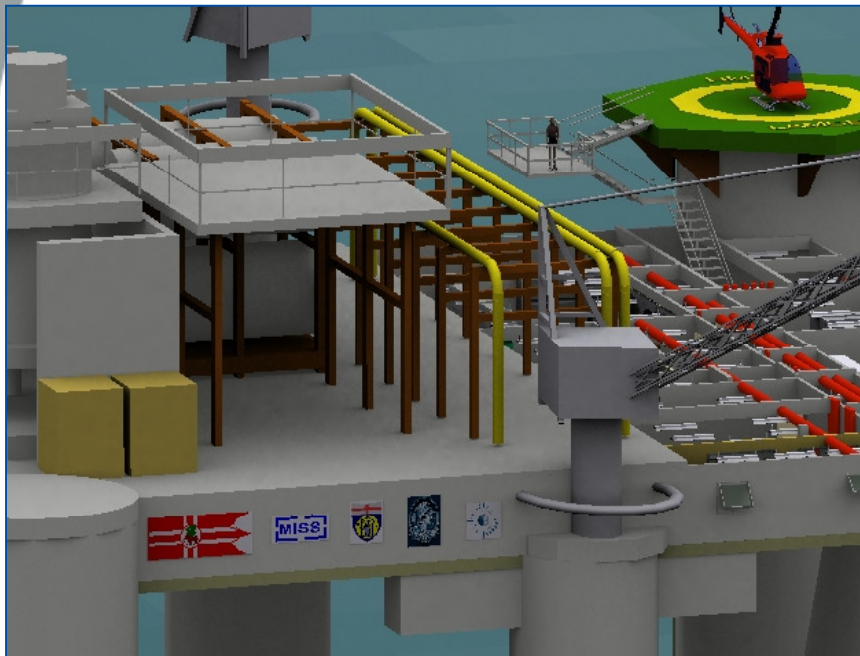
... Technology Enablers

Traditional progressive improvements on systems is sometime going into cul-de-sac

but new approaches arise from new technologies

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Looking Forward for new decade Training Solutions

Some of major issues arising on simulation for training will be focused on following issues:

– Serious Games
– Human Behavior Modeling
– Mobile Training
– Virtual Worlds & Augmented Reality

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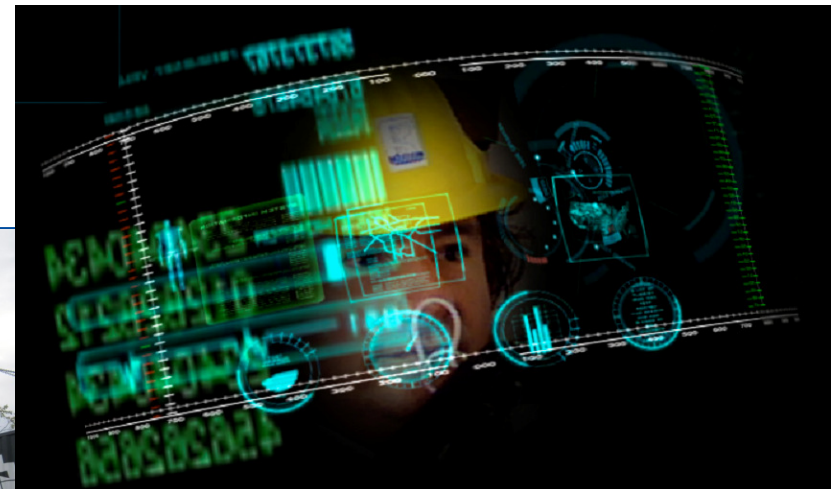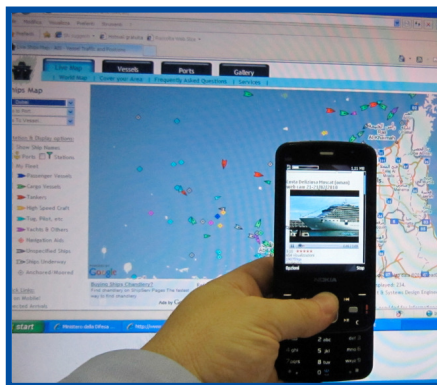
An Explanatory Example from the Past looking to the Future

Modeling is critical to train people to evaluate Strategies in Threat Identification, Decision Making & Evolution Prediction:

- **Once upon Time we was used to identify threats based on Platform Detection, Identification and Classification**

- **In Some case the same Platform is in use on multiple sides**

- **In some case the Platform is becoming a Menace just based on own it is operating**

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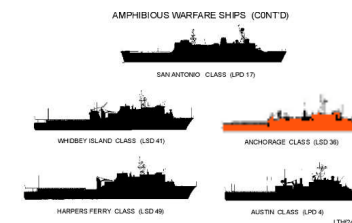
The Real World: Multi Dimension and Multi Layer Resolution

An Example on a Sea Scenario

- A Real World on **_Multi Dimensions_**:
  - Surface
  - Underwater
  - Air
  - Space
  - Cyber
  - Ground
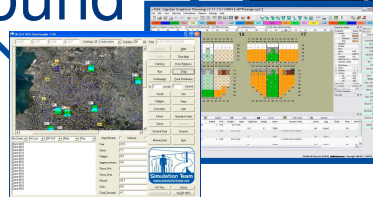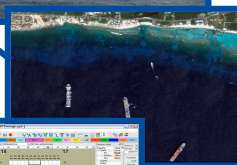
- A **_Multi Layers & Resolutions_** Frame
  - Fleets and Parties
  - Ships and Commercial Traffic
  - Crew & People Acceding Ports/Vessels
  - Services & Infrastructures

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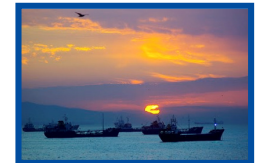
M&S for New Scenarios and Asymmetric Warfare: i.e. at Sea

- It is necessary to Create Models and Modules able to Interoperate within a Federation for including the critical Components of such Scenarios:
  - Non Conventional Operations
  - Human Behaviors on (i.e.Crew, Stakeholders, Domestic Opinion)
  - Services & Infrastructures
  - Commercial Traffic & Yachting
  - Port Infrastructures and Resources
  - Joint Operations (i.e.Ship Inspections, Litoral Control, C5I2   )
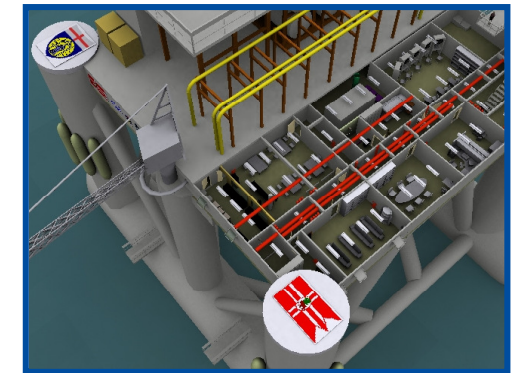
*Community, Consensus, Cooperation, Communication, Cybernetics, Intelligence and Intuition,
Command & Control, Computers, Communication, Co-ordination, Intelligence & Information
Command, Control, Communications, Computers, Counter-Measures, Intelligence and Inter-Operability*

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Vessel Traffic and Naval Asymmetric Warfare

- The IA-CGFs need :

  – To be able to adopt "Intelligent Behaviors"
    - conservative and smart use of sensors
    - adopting behavior of general traffic
    - compromising info source
    - grouping and desegregating on the coast

  – To have Capabilities in Scenario Awareness and

  – To have Capabilities in term of Autonomy

  – To have capabilities in Coordinating different Agents

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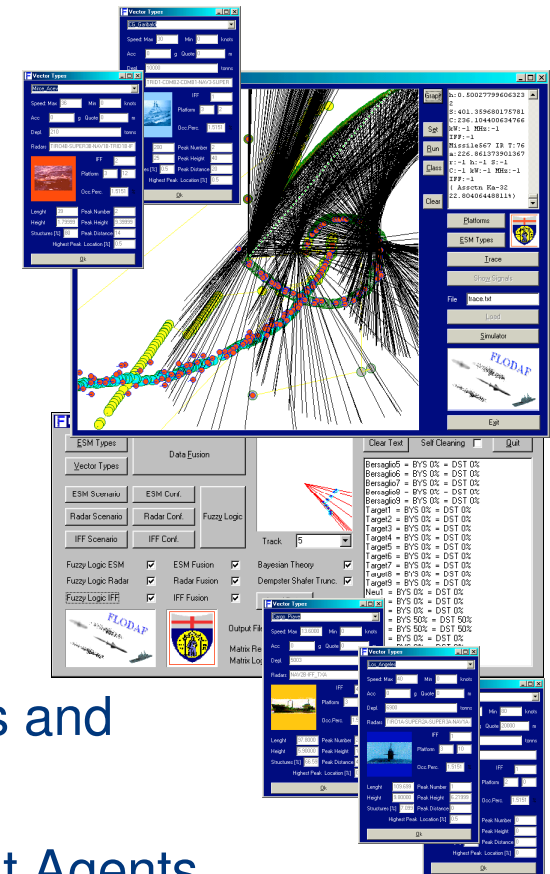
PANOPEA

*Piracy Asymmetric Naval Operation
Patterns modeling for Education & Analysis*

- PANOPEA is a IA-CGF Framework for reproduction of **Piracy activities** and for evaluating different strategies in NEC C2 M2 (Netcentric Command and Control Maturity Models).
- PANOPEA reproduces military vessels and helicopters, ground base, cargos as well as fisherman and yachts traffic as well as Pirates
- **Pirates are directed by Intelligent Agents** and apply strategies for succeeding

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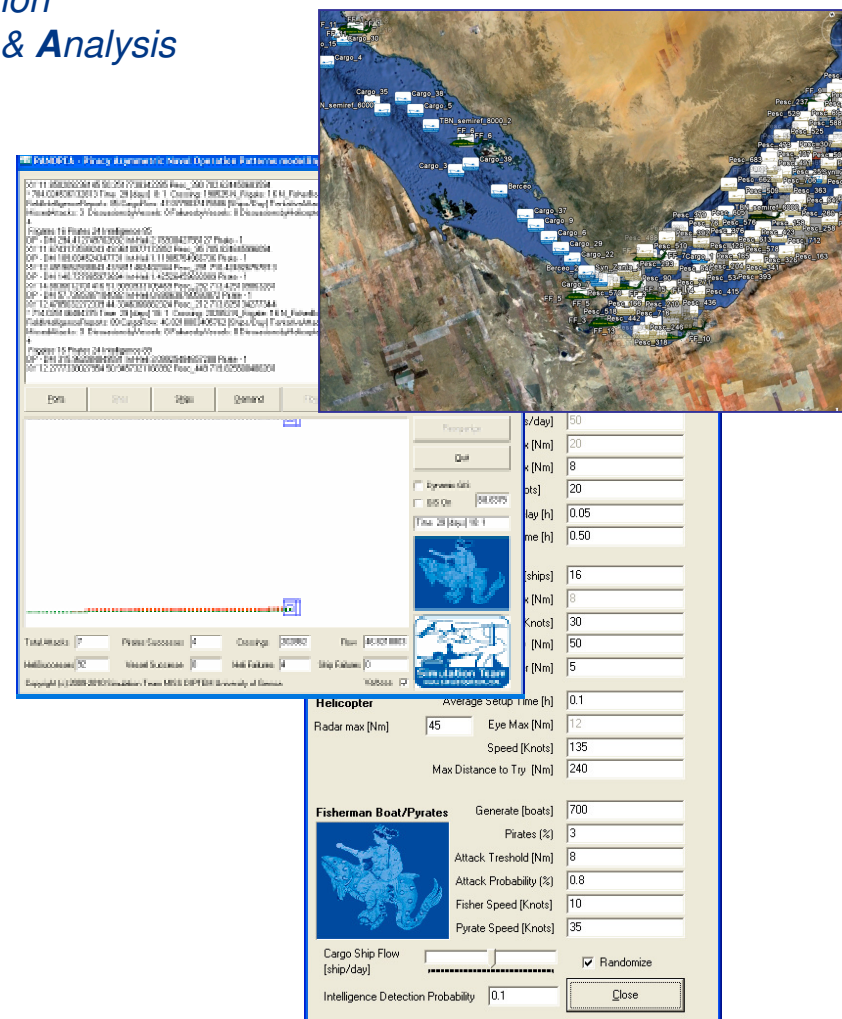
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Simulation Opportunities from Serious Games...

There are different incoming ideas from Serious Games:

– **New Virtual Environments**

– **Substitution of Interfaces with Game Devices**

– **New Opportunities by New Games Device**

– **Introduction of Massive Multiplayer On-Line Games**

– **New Web Games**

– **Physical Devices integrated by Games in Training**

– **Games as New Learning Approach**

– **Mobile Platforms**
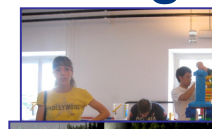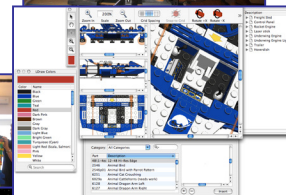
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...a Serious Games Evolution Roadmap by Simulation Team

Training on the Job

Simulation for Training

Experimenting on the Simulator

Serious Games for Training

Playing while Learning

Experimenting on Games

Many More Installations
Many More Users

New Utilization Modes

[Nuclear War]
..a strange game the only winning move is not to play

Joshua in War Games Movie
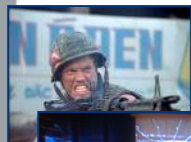
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SIBILLA Game
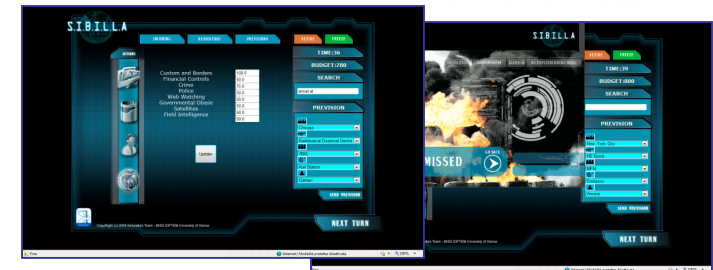
- **Terrorist Actions organized by different Terrorist Organizations are set up in term of:**
  - **Terrorist Group**
  - **Threat Type**
  - **Target**
  - **Site**

Terrorist Action Concept	Terrorist Action Planning	Terrorist Action Preparation	Terrorist Action Execution	Dummies
				Mis-Communication
				Comprimezed Sources

| Intelligence Reports | Intelligence Reports | Intelligence Reports | Prevention |
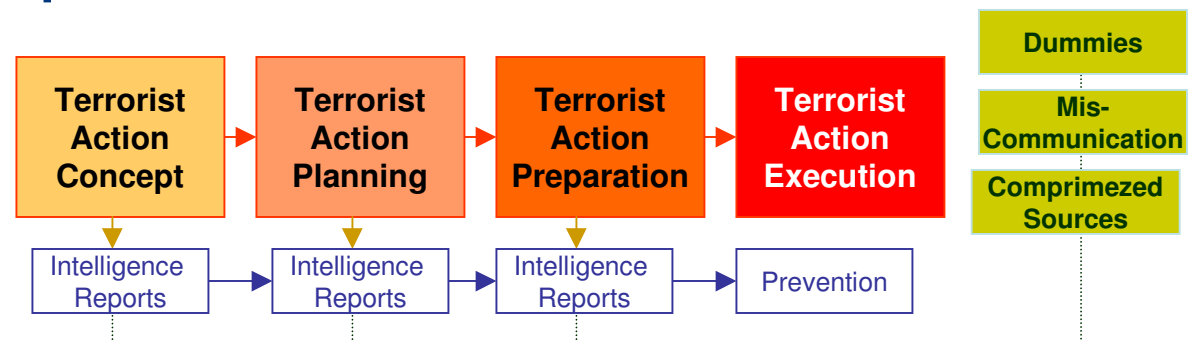
- **The intelligence reports are distributed among the players based on their capabilities and shared by a stochastic engine**
- **The Identification of the attacks in time is the key for individual success**
- **Threat missed to be identified generate terrorist attacks that reduce global trust and support to intelligence agencies**

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Coupling Human Behavior in Simulation

- Serious Games usually have a Stronghold in Graphics, Usability, Interfaces and Multiplayer capabilities.

- Games Frameworks needs to guarantee proper Fidelity and correct Models for their specific Purpose

- The potential application areas usually introduce the necessity to add Artificial Intelligence (AI) able to add realism by introducing Human Behaviors and Intelligent Agents (IA)
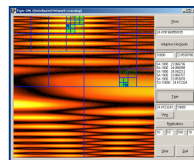
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Human Modeling Challenges

- •RATIONAL DECISION MAKING
  - •Intelligent Individual Behavior
  - •Organization & Hierarchies
- •INSTINCTIVE & EMOTIONAL
  - •Emotions & Psychology
  - •Socio-Cultural
  - •Crowd Behavior

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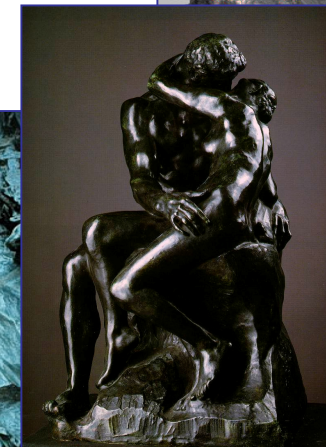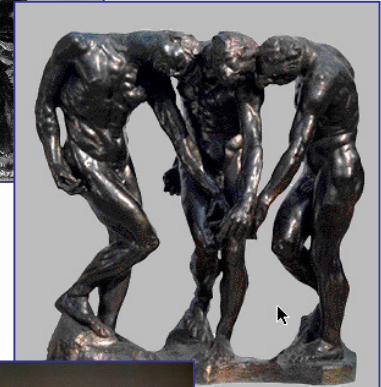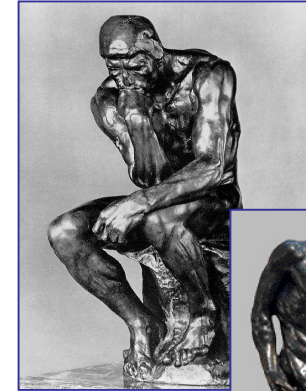
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What is Human Behavior Simulation?

Human Behavior Modelling & Simulation (HBM&S) is the reproduction of the Humans by using computer models.

Usually this requires to simulate aspects related to **Emotions, Rational Thinking, Psychology, Ethology and Sociology** with the detail required by the specific Modeling & Simulation Project

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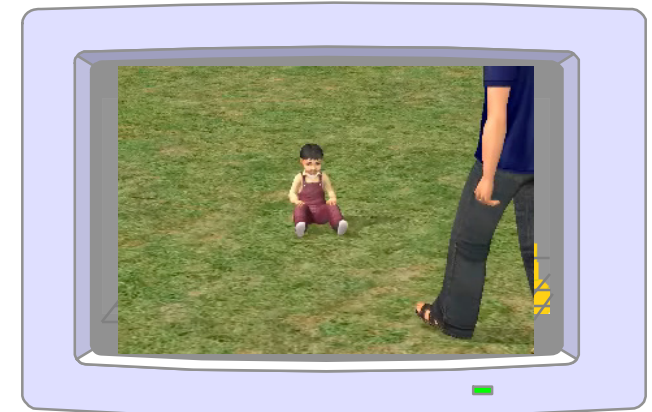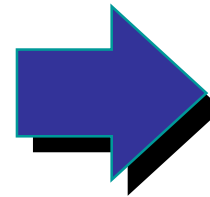
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Human Behavior & Simulation

The human behaviour involving have a strong impact and due to the new advances also due to Games it becomes possible to face this problem: i.e. Behaviour Collection in Massively Multiplayer On-Line Games.

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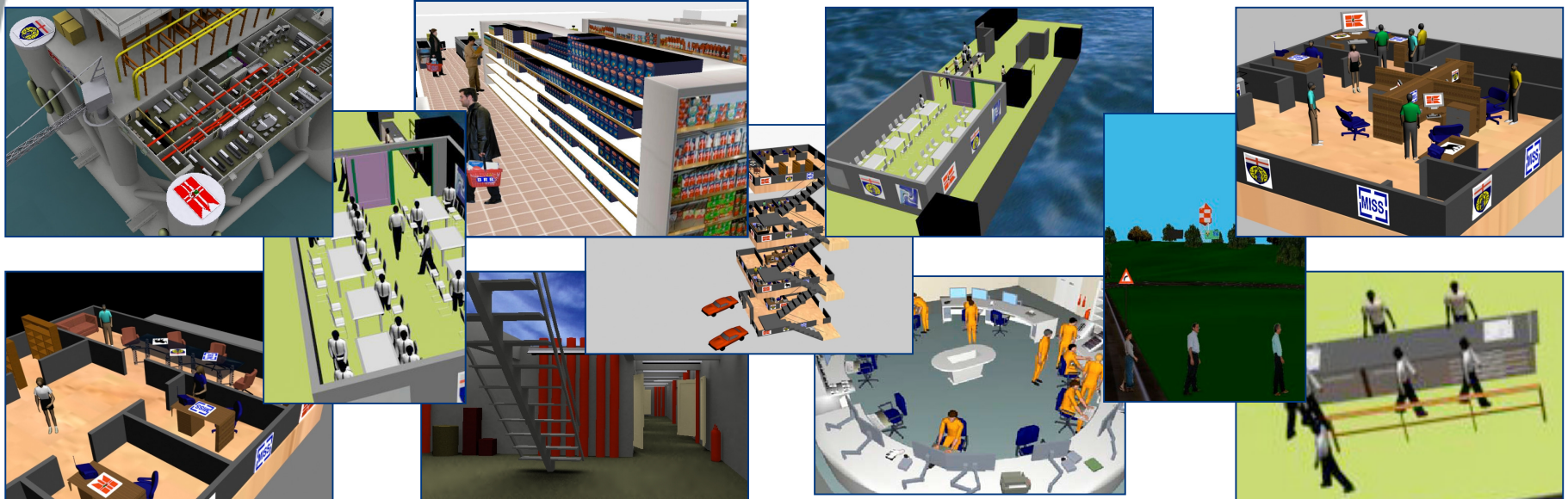
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What kind of Human Model?

- Medal of Honor (Shoot Game)
- Americas Army (Game/Training)
- 2nd Life (Massively Multiplayer)
- Sims (Strategy Game)
- Comadreja (Business Simulation)
- Brainsim (Sensorial Model)
- IA-CGF (CGF)
- Piovra (CGF)
- Modsaf (CGF)
- MAAD (CGF)

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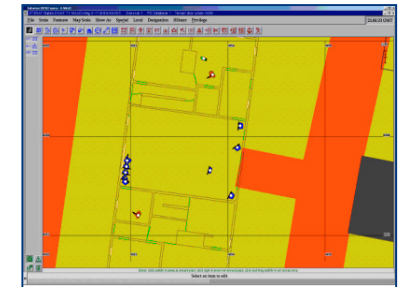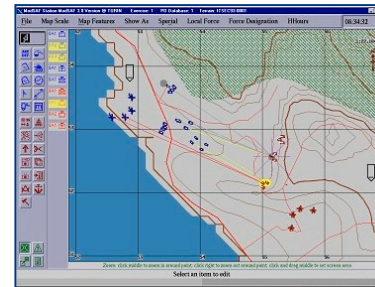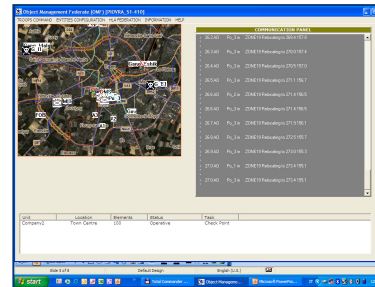
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Detailed Humans don't Means Better Simulation

What Kind of Details are Significant for our Problem

- *Intelligent Capabilities*
- *Real Time Capabilities*
- *Graphic Details*
- *Rendering Quality*
- *Emotional Details*
- *Interaction Details*

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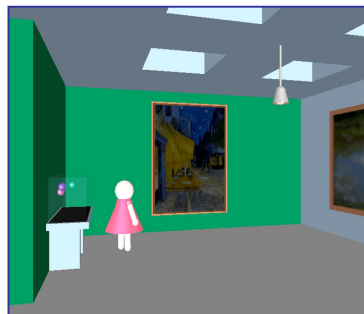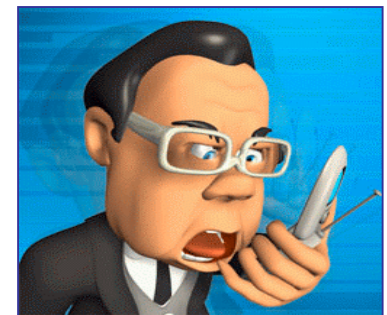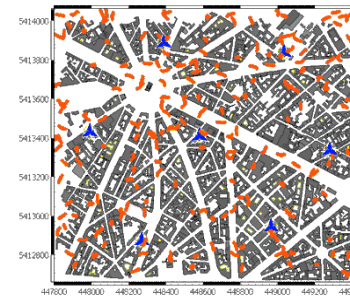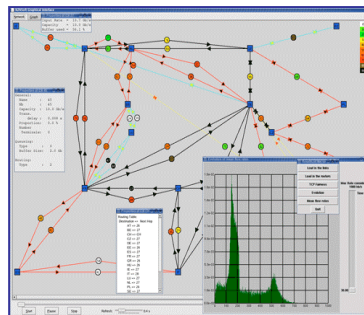
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IA-CGF MODULES

The *IA-CGF* Modules, developed by Simulation Team, are focusing on reproducing complex scenarios and include:

- *IA-CGF Units*
- *IA-CGF Human Behaviors*
- *IA-CGF Non-Conventional Frameworks*

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www.simulationteam.com

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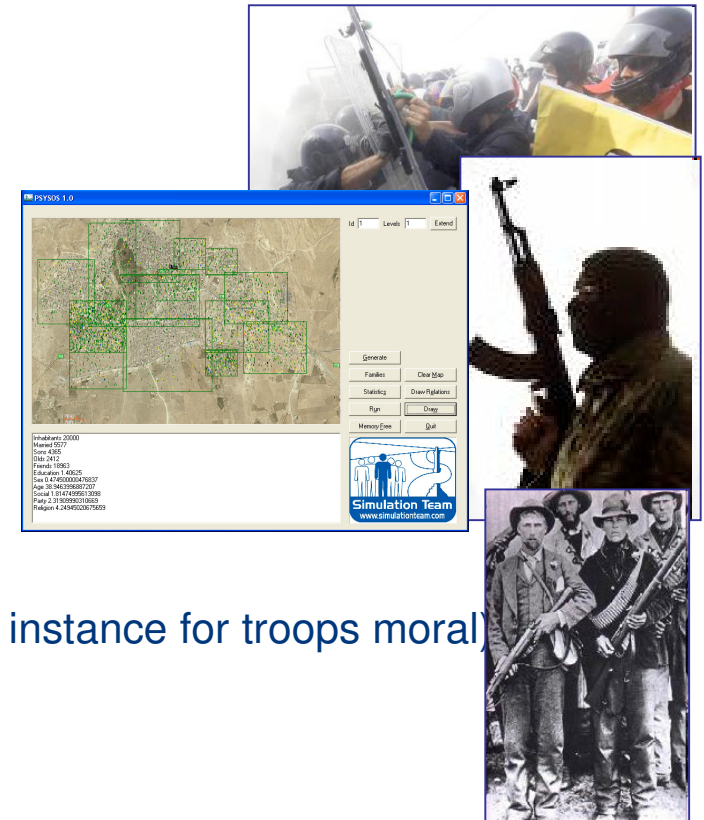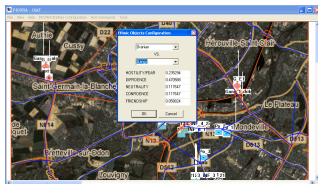
These are examples of non-conventional units controlled by IA-CGF

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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. while in constructive simulation every unit in the scenario have on weapons (i.e. type of ammo), by IA-CGF it is introduced the dynamic information about level of fear and stress and these Units will perform according to their human behavior modifiers

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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 and/or contexts:

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

In non conventional scenarios for particular training purposes,
there are different active non conventional Frameworks, in different locations, with different level of detail inside
the simulated theater.

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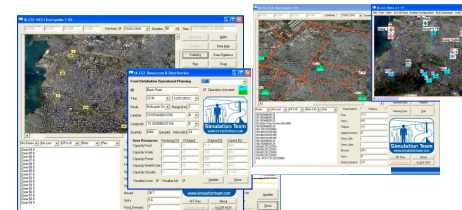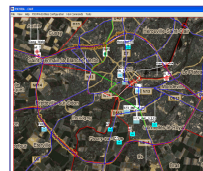
Haiti Humanitarian Support Demonstration

- JTLS
- JCATS
- **IA-CGF Riots**
- **IA-CGF EQ**
- VBS2
- DI-GUI
- PLEXSIS

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CAPRICORN Project

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

- **CAPRICORN is an active 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)**

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CAPRICORN:
User in the Loop

Specific Scenario Definition

- Simulator
- Conceptual Models
- Knowledge Bases
- Data from Field

Simulation Fine Settings

User Experimental Input

Simulation Execution

Simulation Results

What if Analysis

Simulated COA vs. DFE

Comparison of Different Plans

Ranking Different Alternatives

Costs/Benefits Evaluation

Risks related to each Planning

Decision on Operational Planning

CAX Preparation

Quick Hypotheses on Scenario

Population & Humans Data

Social Networks Parameters

Terrain
- Mapping
- Layers
- Zones & Humans Factors
- Roads Networks
- Power Grid
- Resources networks
- Food & Water Grid
- Communication Network
- Media Networks

Behavioral Models

Metamodels
- Logistics
- Weather
- Economics
- Development
- Network Dynamics
  - Power
  - Water
  - Food
  - Petrol
  - Individual Communications
  - Radio
  - TV

Actors
- Local Population
- Interest Groups, Parties
- Actors of Threats
- Coalition Forces
- Local Forces
- Domestic Opinion
- NGOs

Operational PlanningF- COA/O-COA

Operations
- Where
- What
- Who
- When
- How

Simulation Parameters
- Duration
- Replications
- Mode

CIMIC Actions
- Security Actions
- Education
- RRD & Agriculture
- Social
- Health

PSYOPS Actions
- SPA
- PCA
- BPA
- PSPA

Measuring Territory Control
- Coalition Forces
- Local Forces
- Insurgents

Human Factors for All Scenario Actors
- Trustiness
- Satisfaction
- Aggressiveness
- Fear
- Stress
- Fatigue

Achieving DFE
- Time Requested
- Risk
- Costs
- Situation Improvement

General Issues
- Costs related to operations
- Scenario Stability
- Economy & Wellness
- Food, Water, Power & Security Demands
- Safety & Health Care Issues
- Security Issues
- Population Mobility
- Environmental Issues
- Human Rights Issues
- Democracy Diffusion

High Level KPIs
- Effectiveness Local Leaderships
- Effectiveness Domestic Leaderships
- Effectiveness Coalition Leaderships
- Insurgent Political Influence
- Insurgent Capabilities
- Domestic Opinion Orientation

Result Tolerances & Confidence

- M&S Developers
- SME & Civil Analysts
- Military Analysts
- Operational Planners
- Training Users

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CGF C4 IT

Computer Generated Forces Command, Control, Communication & Computers in Italy

- **CGF C4 IT is a project federating several simulators in HLA able to reproduce the a complex asymmetric warfare within a Urban Environment. Different forces (Coalition, Local Army, Local Police) are simulated and the related C4 could be investigated along different maturity models (i.e. conflicted, deconflicted, cooperative, collaborative and edge) for identify critical issues and benefits**

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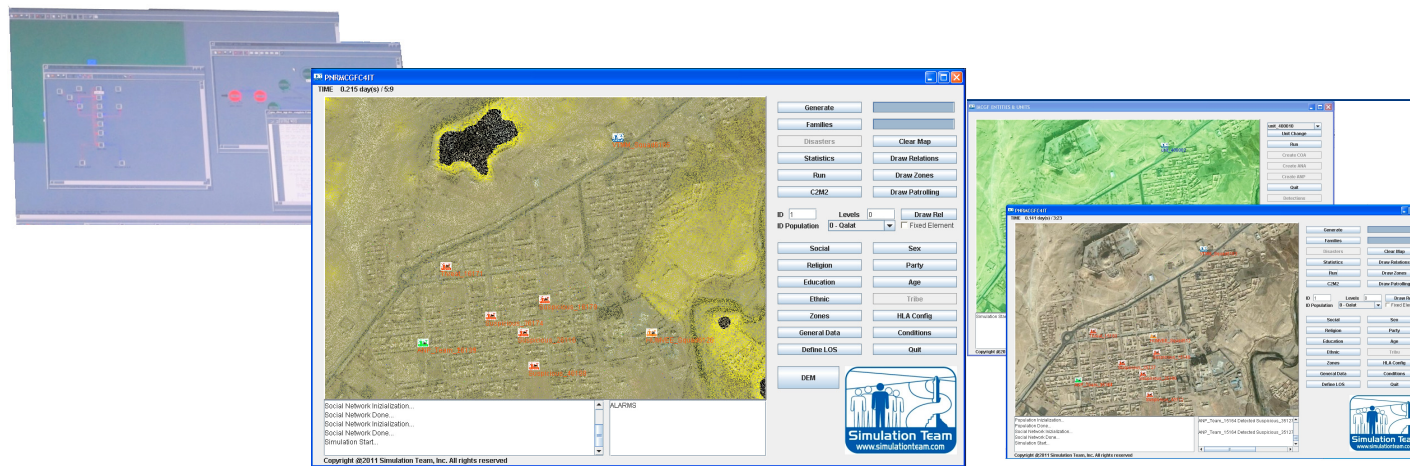
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Mobile Training

Simulation have great potential in many applicative areas therefore currently there is a growing need for developing Mobile Training Simulation Solutions

"there are three ways that learning can be considered mobile: in term of **space**, in different **areas of life** and with respect of **time**"

Vavoula and Sharples

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Potential of Simulation for Mobile Training

Simulation represent a very powerful Technology Enabler for Mobile Training considering:

- **Simulation create Virtual Worlds where it is possible to interact**
- **Simulation is able to be distributed and/or moved**
- **Model can be reused and adapted to different scenarios**
- **Simulation is maintainable along time**

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Mobile Synthetic Environment Solutions

Aspects on Devices

Effective Design of mobile SE requires attention on:
- Device: is important to assess usability, mobility and reusability
- User: user abilities, knowledge, motivations are critical
- Social aspect: social interaction and cooperation have to be considered in reference to exchanges, learning process and knowledge management

Social Aspects

User Profile

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Mobile Training Use

The use of mobile training requires to define properly procedures for using them effectively in order to obtain benefits in different contexts.

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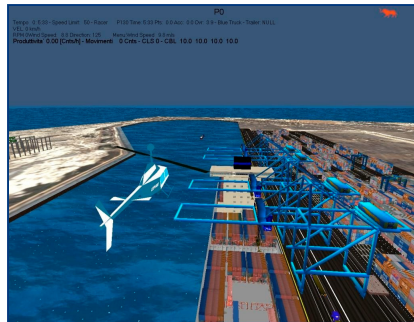
Quick Re Deployable Simulators

In order to be effective mobile solution requires to be quickly deployable. It is fundamental to approach the following issues:
- Easy Packaging
- Modular Configuration
- Compact Solutions
- Maintainable Components
- Support for World-Wide Operations

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ST_PT & ST_RS Simulators

A Solution by Simulation Team MISS DIPTEM Genoa
http://st.itim.unige.it

A Solution by Simulation Team MISS DIPTEM Genoa
www.simulationteam.com
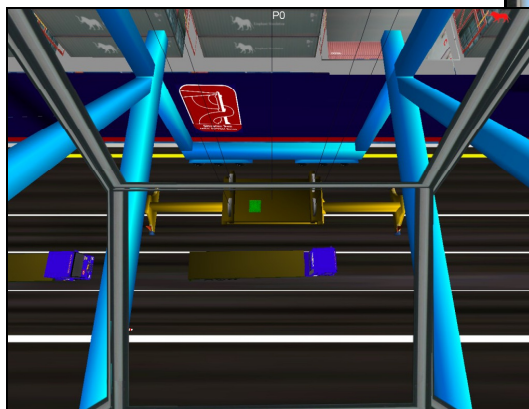
This new generation of simulator is mobile, real-time, scalable and interoperable and compliant with state of art technology and standards
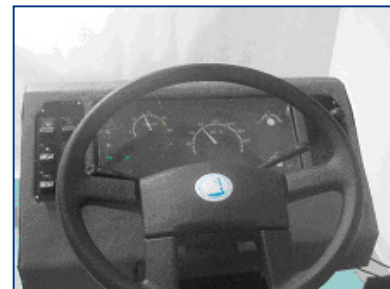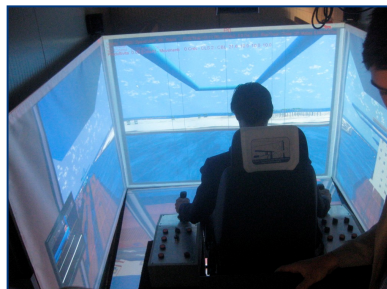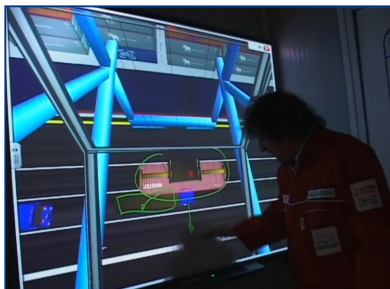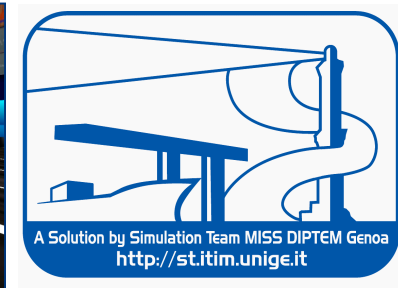
Shelter & Facilities   **ST_PT Crane Sim**   **ST_PT Truck Sim**

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Atout in Virtual Port Simulation

Training & R&D

Cave H270° V130° within a Shelter

Containerized

Fully Integrated

Interactive Aula

On-Line Action Review

HLA Federation

Full Motion, Sound & Vibrations

Real-Time Distributed Simulation

Bio-measures Integrated in Simulation

Strong VV&A

Scalable Solutions

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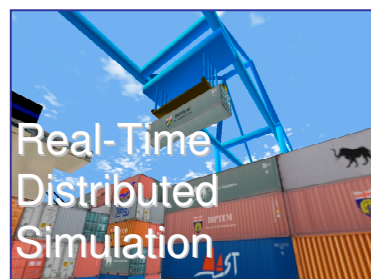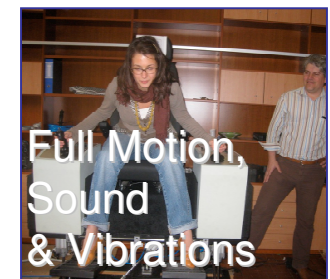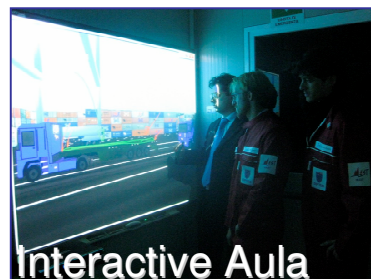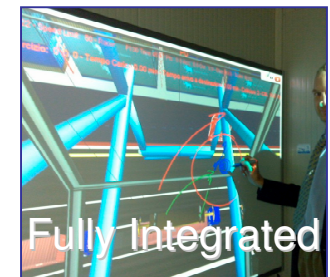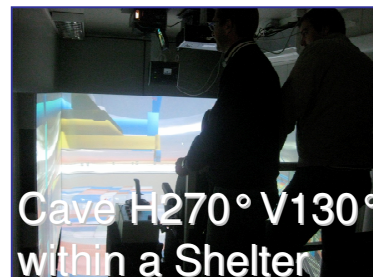
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An Example Comparing Alternative Solution

As example is proposed a comparison among different solutions for Port Training:

➢ Mobile Training based on Interoperable Simulation

➢ Traditional Mobile Pack with Crane Simulator

➢ Traditional Containerized Crane Simulator

➢ Fixed Solution for Crane Simulator

➢ Traditional Training on a Real Crane

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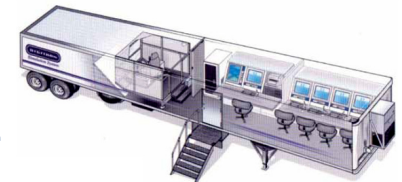
Some Example on Costs/Benefits

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Comparison on Scenario with Tailoring

Direct Training Experience [hours] — *Costs [Euro/Site]*

Chart categories: Mobile Training, Containerized Simulator, Pack Simulator, Fixed Simulation, Real Crane

Including Tailoring		Mobile Training	Containerized Simulator	Pack Simulator	Fixed Simulation	Real Crane	
Ttot	Total Training Time for a Site	228.8	696.8	677.6	672.8	120.4	[hours]
Nports	Number of serviced Ports over P timeframe	4.62	1.52	1.56	1.57	8.77	[ports]
Ex	Trainee time operating directly	25	10	10	10	10	[hours]
Ctot	Total Costs on a Site including all sessions	54,099	209,682	128,753	250,015	306,566	[euro/site]

Excluding Tailoring		Mobile Training	Containerized Simulator	Pack Simulator	Fixed Simulation	Real Crane	
Ttot	Total Training Time for a Site	204.8	216.8	197.6	192.8	120.4	[hours]
Nports	Number of serviced Ports over P timeframe	5.16	4.87	5.34	5.48	8.77	[ports]
Ex	Trainee time operating directly	25	10	10	10	10	[hours]
Ctot	Total Costs on a Site including all sessions	47,739	61,428	33,131	112,287	306,566	[euro/site]

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Sample of Federated Objects: Marine Environment

SHIPS (CGF)
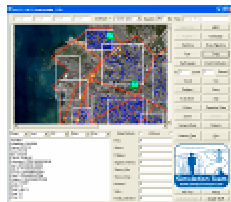
THREATS (CGF)
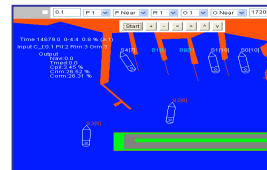
PILOTS, TAG MOORING

VIRTUAL YARD CONTROL

AUV/UAV

RTI
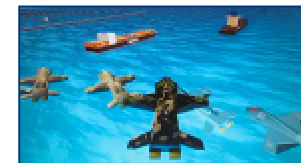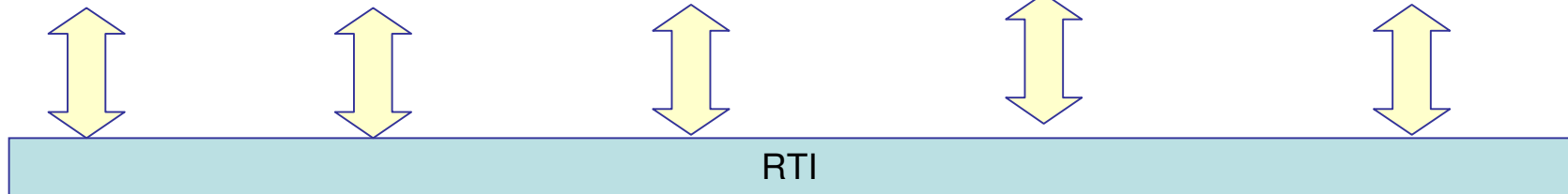
LOGISTIC NETWORK

CUSTOM OPERATIONS
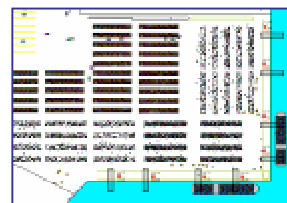
POLICE and SECURITY

ENVIRONMENT IMPACT

INTELLIGENCE

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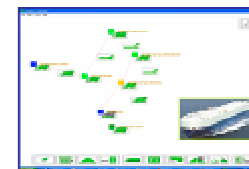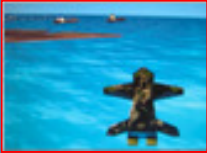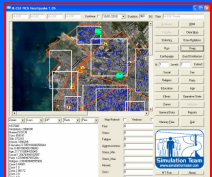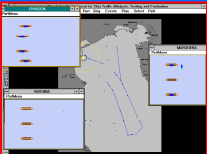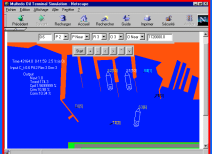
Live Virtual & Constructive Interoperable Solutions *(1/2)*

Simulation Team	AUV/UAV (CGF)	Vessels (CGF)	Terminal	Nautical Services	Intelligence	Environment
Live						
Virtual						
Constructive						

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Live Virtual & Constructive Interoperable Solutions *(2/2)*

	Custom	Town	Region	Coast Guard	Firefighting	Threats (CGF)
Live						
Virtual						
Constructive						

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Human Performances... a Step Forward during Training

Virtual Solution integrated with Biomedical Devices to measure the Human Performances within HLA federation allows to Measure Fatigue, Stress for correlating Human Factors during Operations & Training in order to improve Efficiency and Safety
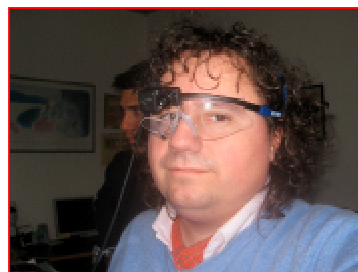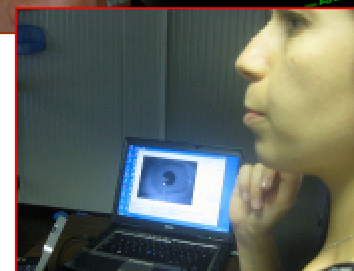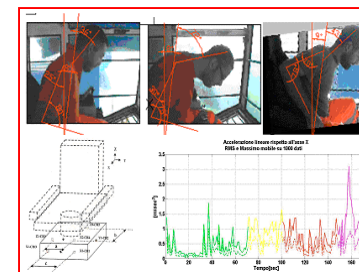
VELA

Interoperable Biometrics

ST_VP Solution

Cybersar^{TM}

ST_PT

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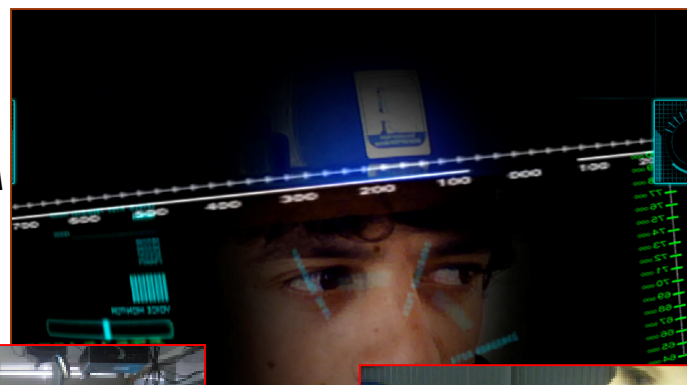
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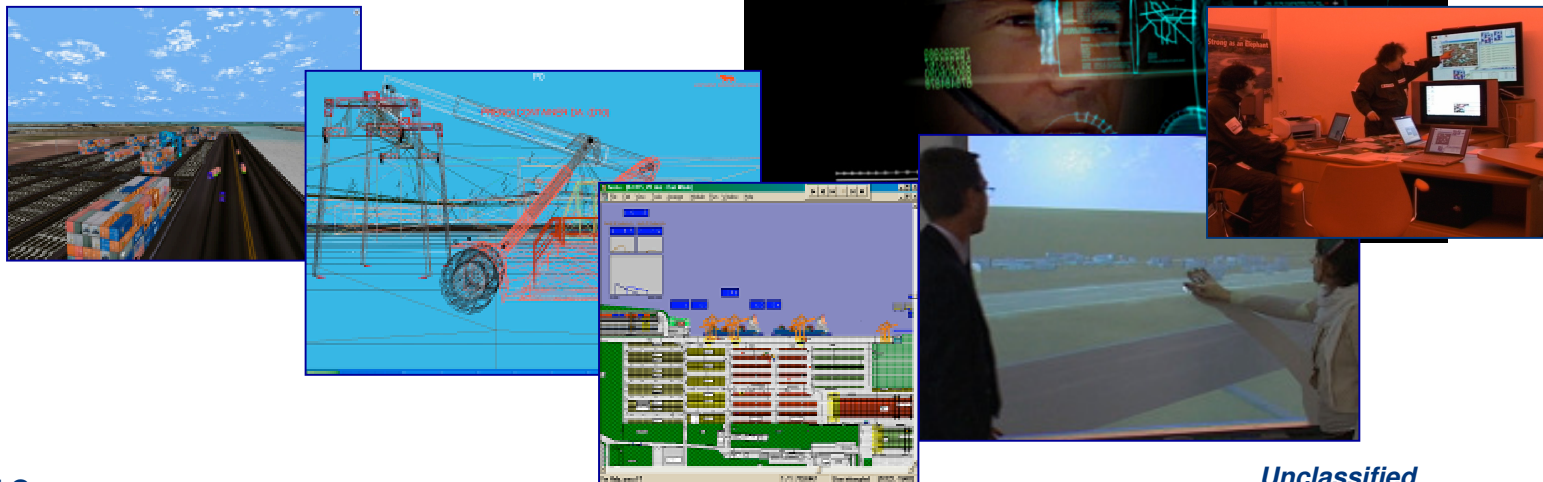# Modularity & Flexibility

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Why putting Virtual & Augmented Reality Everywhere?

Today technology is available for improving Efficiency through Virtual Environments, Augmented Reality & Phenomena Simulation the decision process so we need to use it for developing :

• **New Operational Supports**
• **New Training Solutions**

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Training on Virtual Simulation

The Simulators are an important support in Training both for Operative Resources and Decision Makers.

The Interoperability of our simulators emphasize in addition to traditional stand-alone training in Operating, even Concurrent Cooperative Training in Operations and Policies; it is critical to have long experience in Professional and Executive Training.

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Virtual Environment, Live systems and Augmented reality

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Summarizing

- **Critical Issues are related to classic issues therefore in this moment the shortage of Money, Time are becoming very significant in new M&S initiative**

- **Quick and Dirty Projects requires to speed up and downsize simulation**

- **Complex Systems require to introduce new intelligent elements (i.e. Intelligent Agents) and multidisciplinary approach for succeeding**

- **New Technologies are enabling new solutions such as AR, VR, Wireless and Web 3.0**

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Conclusions

The final goal is to develop applications that can easily be managed and diffused
Simulation based on modern technologies and up-to-date methodologies need to be capable of much more effective exploitation: simulation need to address the needs and expectations of a very large number of new users
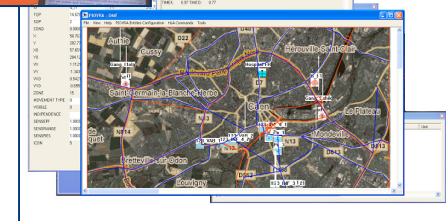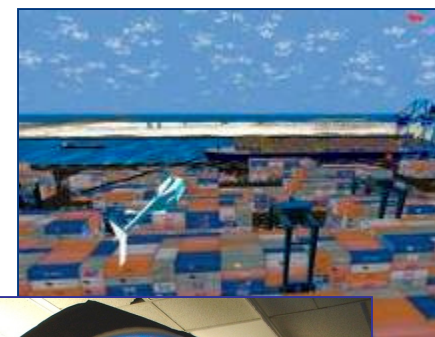
Simulation Team

Thank You …

….Time for Questions

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Simulation Team
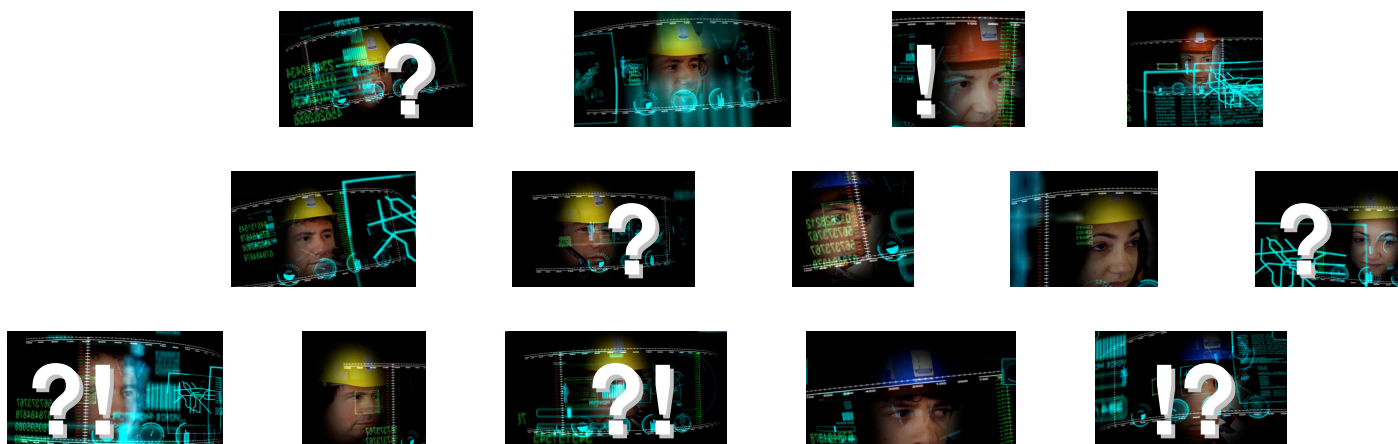
References

DIPTEM University of Genoa
via Opera Pia 15
16145 Genova, Italy
www.itim.unige.it
Agostino G. Bruzzone
agostino@itim.unige.it

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