Simulation Team

Strategic Engineering

Models devoted to couple Simulation, Data Analytics & Artificial Intelligence in Liquid Bulk Logistics

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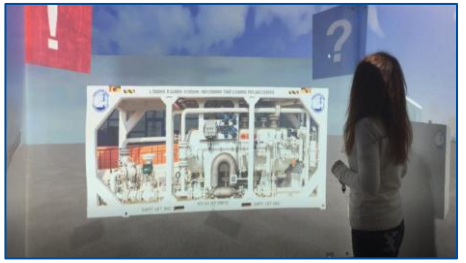
www.liophant.org

Simulation Team

Simulation Team.. Who We Are?



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

DIME Università di Genova

Liophant Simulation

CentraLabs Cagliari

CSU Australia

CIREM Università di Cagliari

Genoa

Mik Riga TU

Universidad de la Rioja

SimCenter Universitat Autonoma de Barcelona

DIPMEC

labria

Università di Perugia

LSIS Marseille

SPIIRAS Russian Academy of Science

McLeod Institute of Technolc
Interoperable Modeling Simu
Genoa

IMS-LAPS Univ.Bordeaux

Rio de Janeiro Brazil

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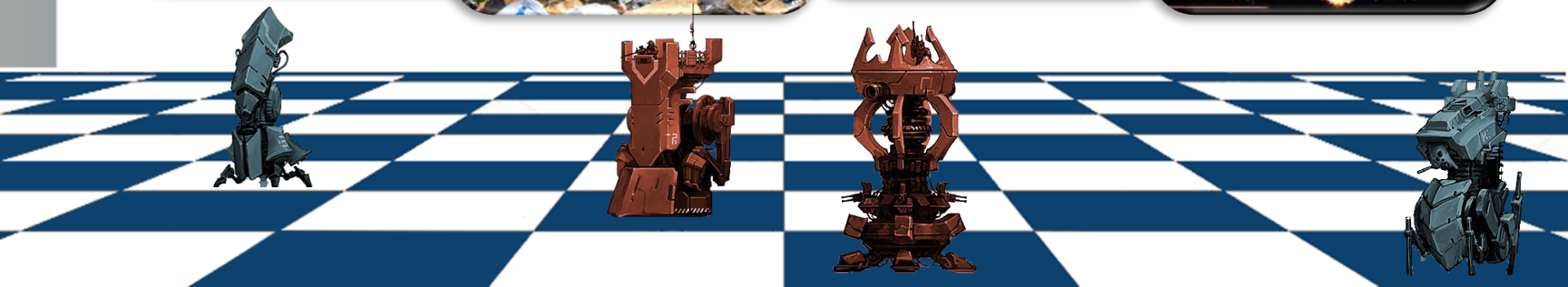
Strategic Engineering & dealing with Future… and Present



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Example of Overall Architecture

Smart Planner

Man on the Loop

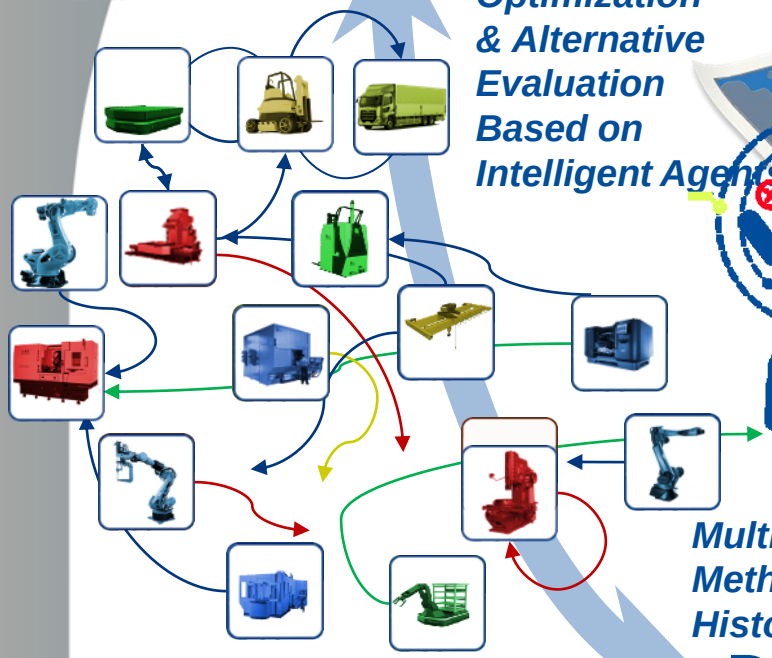
VR & AR

Real Situation

Manual & Automated Planning

Simulation

Simulation for Optimization & Alternative Evaluation Based on Intelligent Agent



MR

Multiple Methods for Analyzing Historical & Current Data

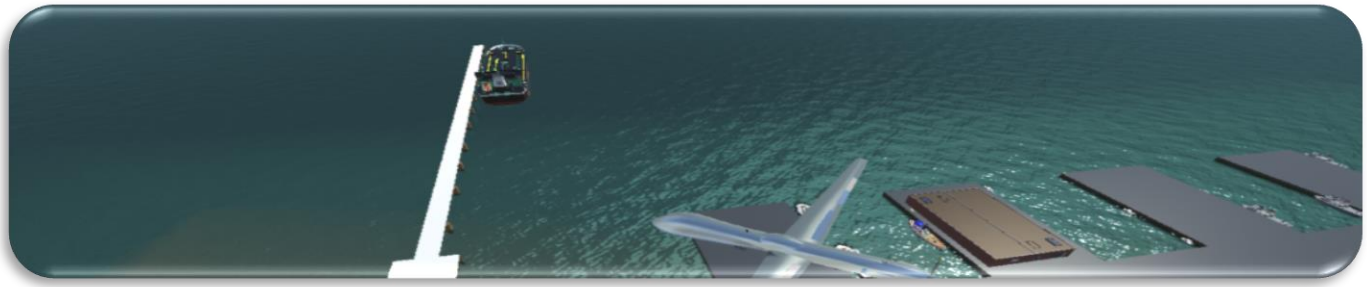
Data Analytics

Innovative solutions integrating Artificial Intelligence, Simulation, VR & AR, Data Analytics for improving the whole process

Port Traffic…

Top 10 ports of the World, 2018 - 2015

			2018	2017	2016	2015
1	Ningbo & Zhoushan	China	1080.0	1010.0	920	889.0
2	Shanghai	China	730.5	750.5	701.8	717.4
3	Tangshan	China	637.0	570.0	520.0	490.0
4	Singapore	Singapore	630.1	627.7	593.3	575.8
5	Guangzhou	China	613.0	590.0	543.6	519.9
6	Qingdao	China	540.0	510.0	510.0	500.0
7	Suzhou 1 (river port)	China	532.4	605.0	579.0	540.0
8	Port Hedland	Australia	519.4	500.9	460.4	452.9
9	Tianjin	China	508.0	501.0	551.0	541.0
10	Rotterdam	The Netherlands	469.0	467.4	461.2	466.4



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Port Traffic… new Issues…

					593.3	575.8	
5					543.6	519.9	
6					510.0	500.0	
7					579.0	540.0	
8					460.4	452.9	
9	Tianjin	China	508.0	501.0	551.0	541.0	
10	Rotterdam	The Netherlands	469.0	467.4	461.2	466.4	

10% more than first European Port

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… and Safety and Security

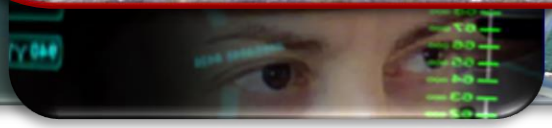
Top 1

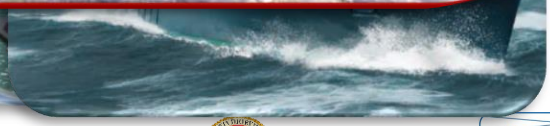
Town, Port and **Industry growth** created a intensive **dangerous Area**

Tianjin Explosion
August 12th, 2015
800 tons Ammonium Nitrate, 336 tons of TNT explosion equivalent
173 casualties, 2km range, 9bUSD Insurance Damages

6
7
8
9 Tianjin

Just a Huge Accident caused by the Dangerous Materials present in the Port & Errors





Lets look at some Examples…

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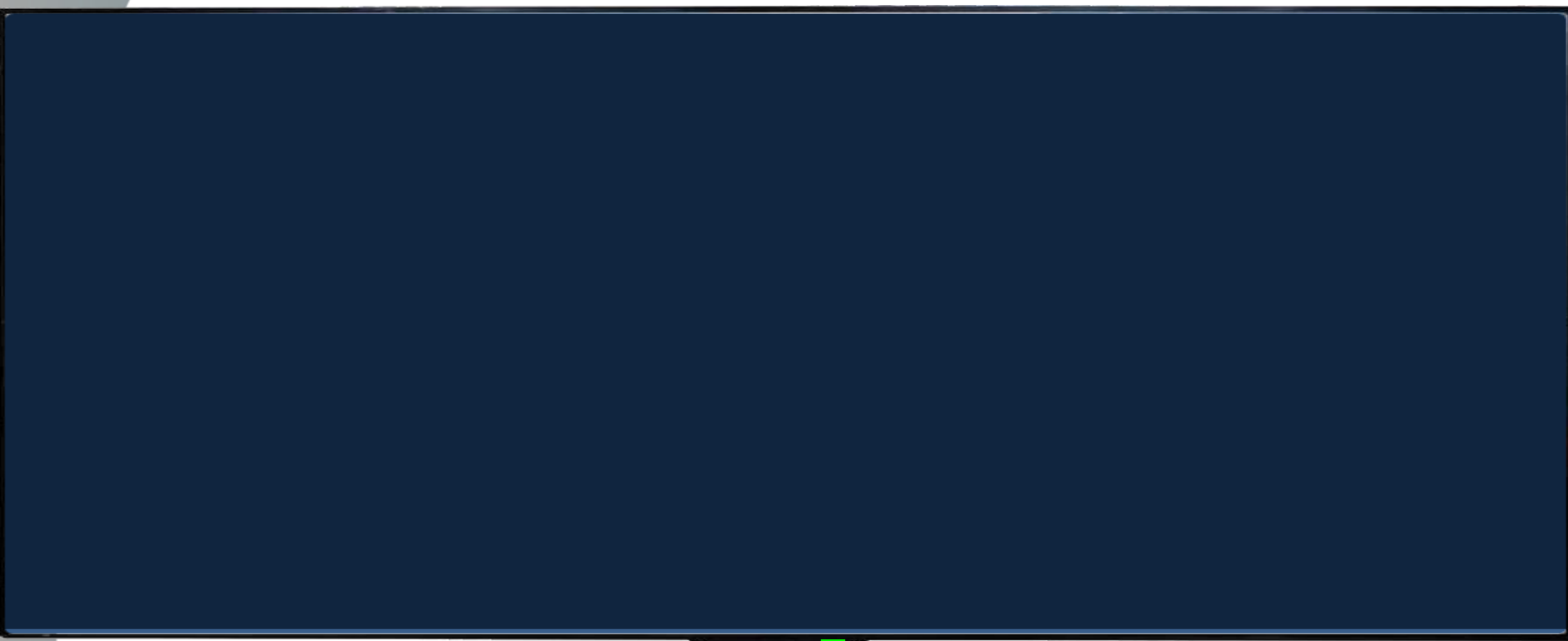

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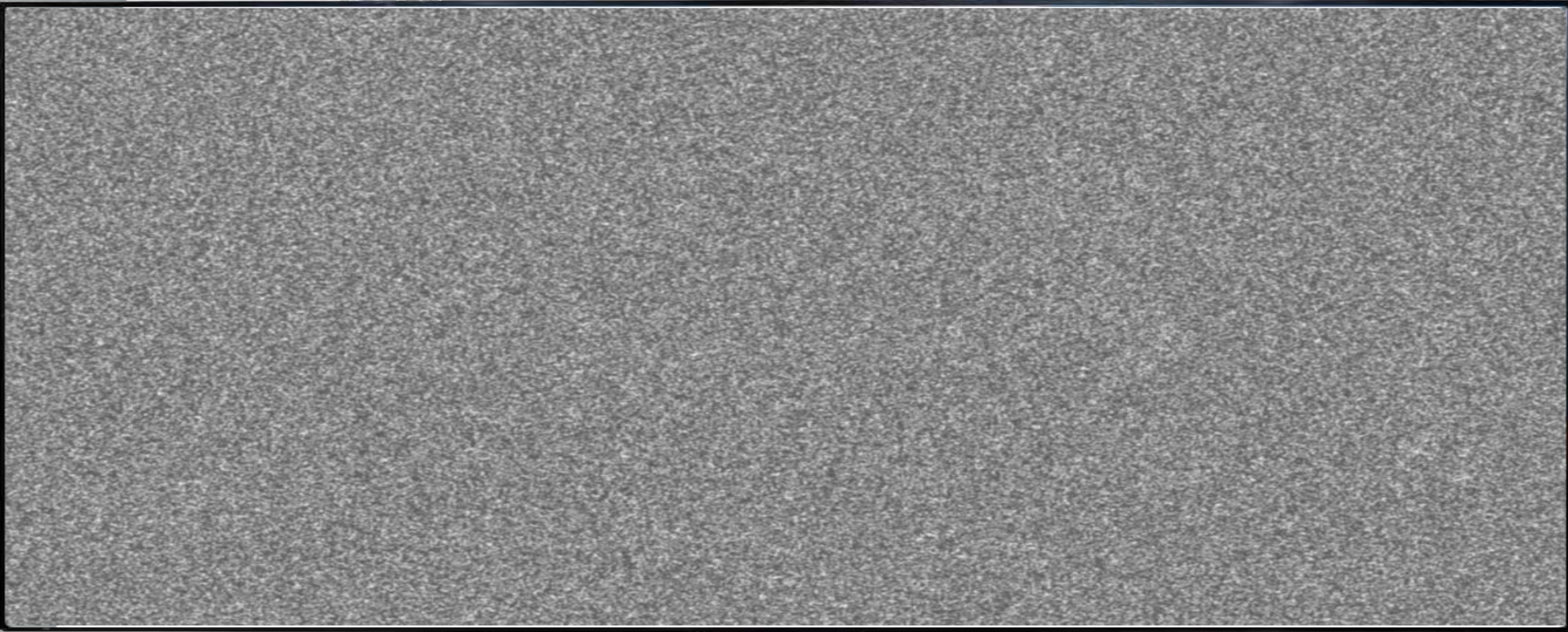
Lets look at some Examples…



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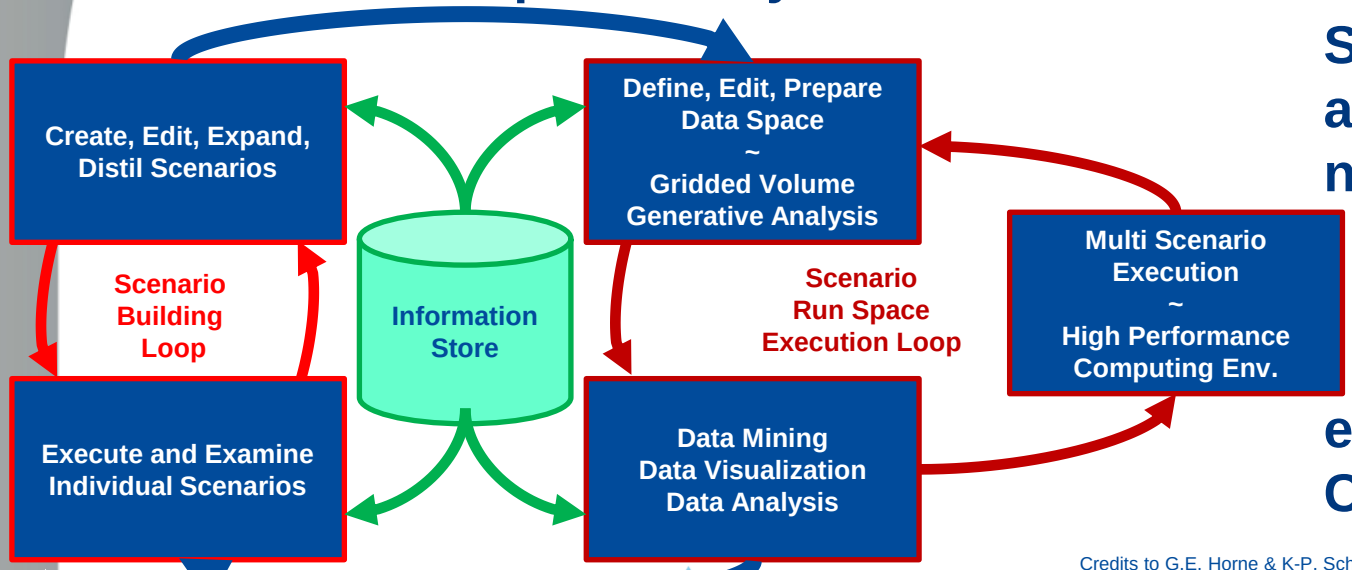
Data Opportunities: Big Data & Data Farming

We have to guarantee **Data Dominance** **being able to:**

- **Mine Data received by IoE and IoT**
- Data Farming about Future by M&S
- **Extract & Process Information**
- **Complete Analysis & Draw Conclusions**

IoT Internet of Things
IoE Internet of Everything



Smart Simulation is allowing to develop new Models based on Big Data and to feed Investigators by Data Farming & enabling the use of Crowdsourcing

Credits to G.E. Horne & K-P. Schwierz for Data Farming Iterative Process Scheme
Credits to M.Massei & G.L.Maglione for ST_VM as Example of Lean Simulation based on DOE & Data Farming

Simulation Team

A new Approach to Enhance Education and Training

Integrated Solutions for E&T that combines Simulation, AR & VR are able today, especially for new Young Generation, to enhance Efficiency and Effectiveness of Education Programs.

In particular it becomes possible to *Engage* and *Motivate* in new ways the Trainees as well as to provide them a *Realistic Virtual Labs* where to *Test* and *Experience* the studied theories and procedures, as well as to *Exercise* on *Complex Simulated Scenarios*. MR is further reinforcing these concepts. It is evident the necessity to tailor and integrate these technologies in the whole E&T process.

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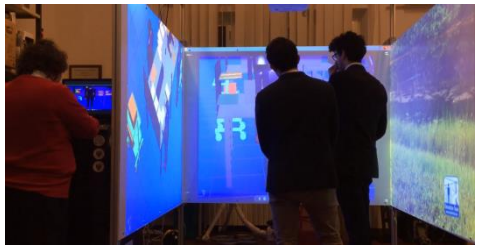
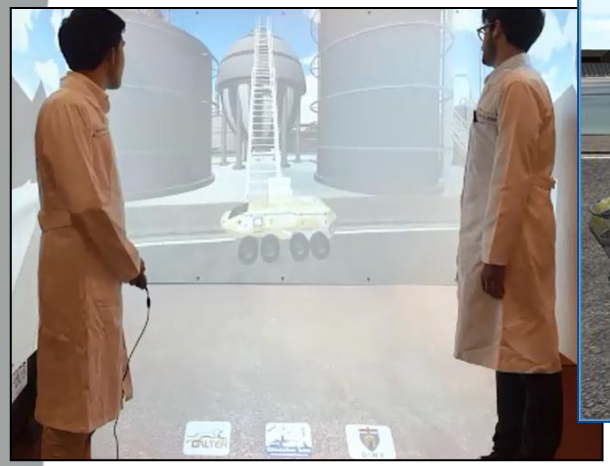
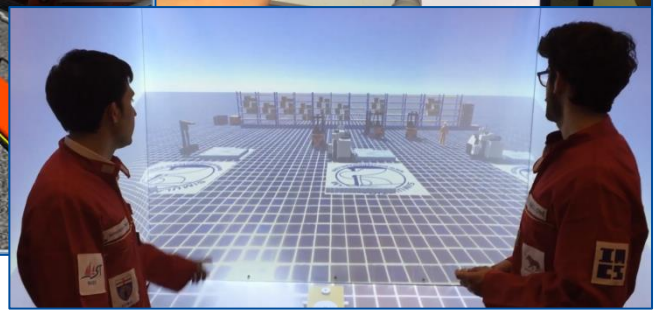
MS2G Paradigm as new Enabler



The innovative concept of *MS2G* (*Modeling, interoperable Simulation and Serious Games*) allows to develop interoperable scalable and reusable simulators with benefits of new Immersive Solutions. MS2G is very flexible and enable use from different platforms: regular laptops, computers, CAVE (Computer Automatic Virtual Environment) large enough to immerse 4-5 people in the Virtual World, HDM, HoloLens as well as Smartphones and Tablets





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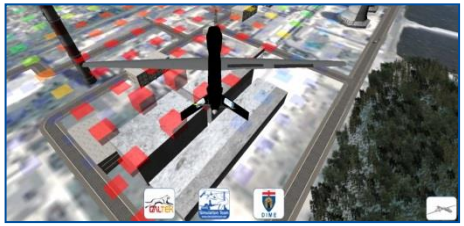
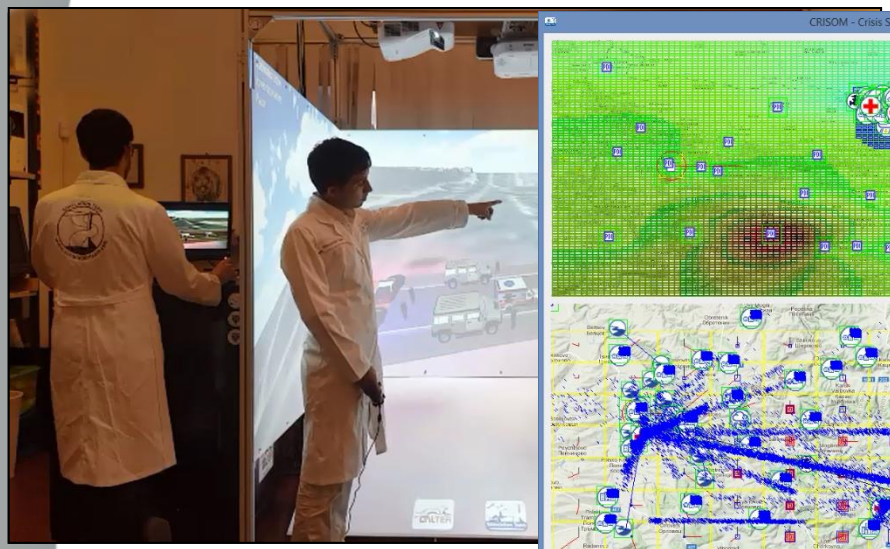
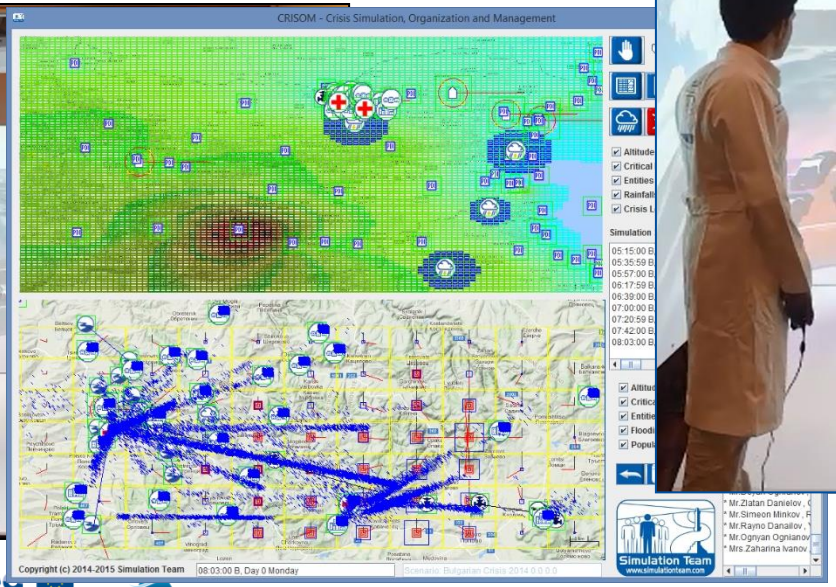


MS2G and IA-CGF

The MS2G (Modeling, interoperable Simulation and Serious Games) could be combined with use of IA (Intelligent Agent such as IA-CGF by Simulation Team). The AIs (Artificial Intelligences) drive concurrently many actors, people and related actions enabling to recreate and study very complex scenarios to improve simulation capabilities & Training Efficiency





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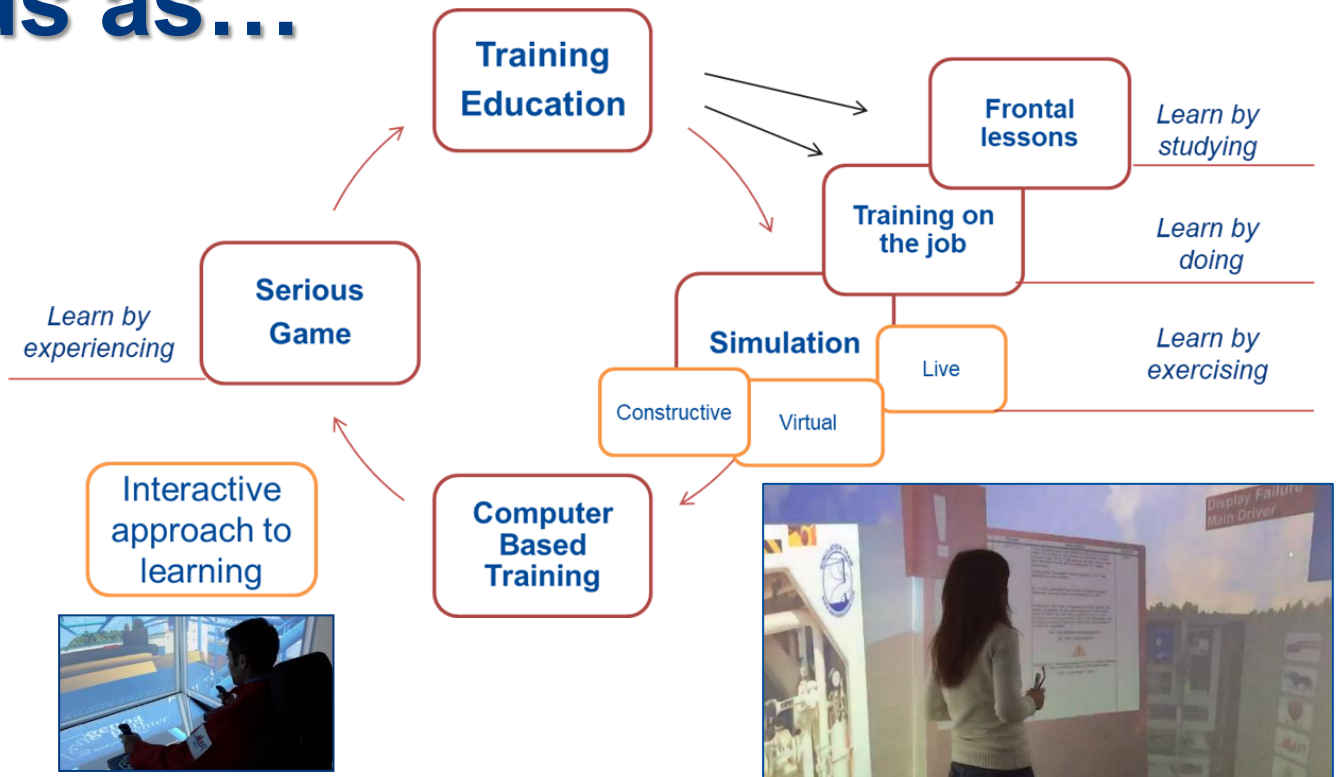
Education & Training Aids as…



"Tell me and I will forget. Teach me and I will remember. Involve me and I will learn",
Confucius

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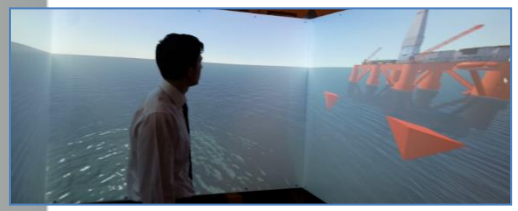
… Serious Games Evolve into Simulation Team Roadmap



Training on the Job

Simulation for Training

Experimenting on the Simulator

Serious Games for Training

Playing while Learning

Experimenting on Games

Many Installations
Many More Users

New Education Modes
New Utilization Modes

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

MMO *Massively Multiplayer Online Game*
MMORPG *massively Multiplayer Online Role-play Game*

Multiple Issues addressed

SPIDER is a Virtual Immersive, Interactive, Interoperable cube 2x2x2.6m recreating and simulating Plants, Skids and Machineries

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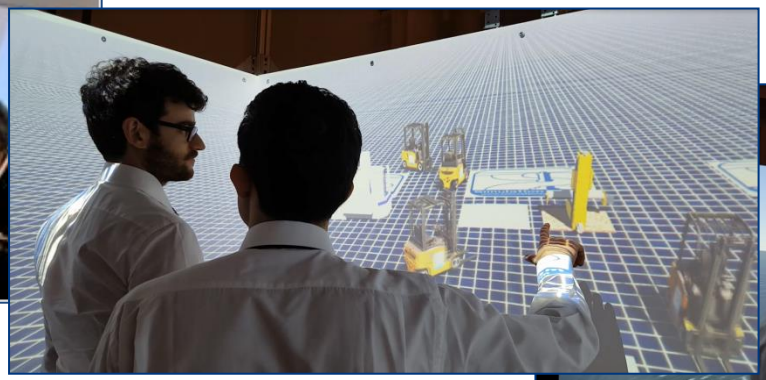
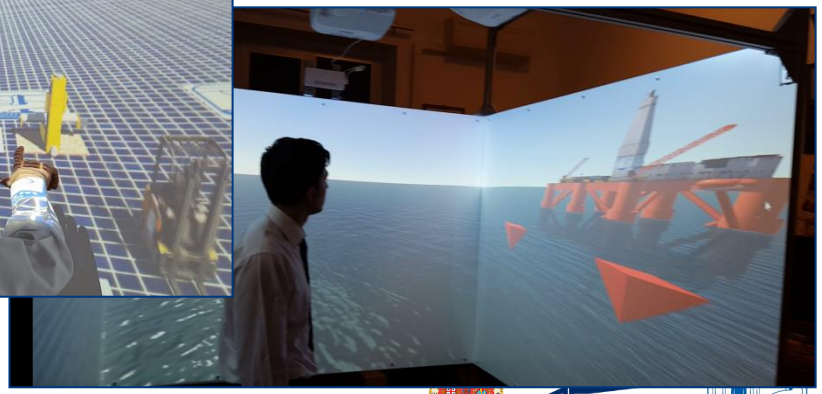
SPIDER

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.

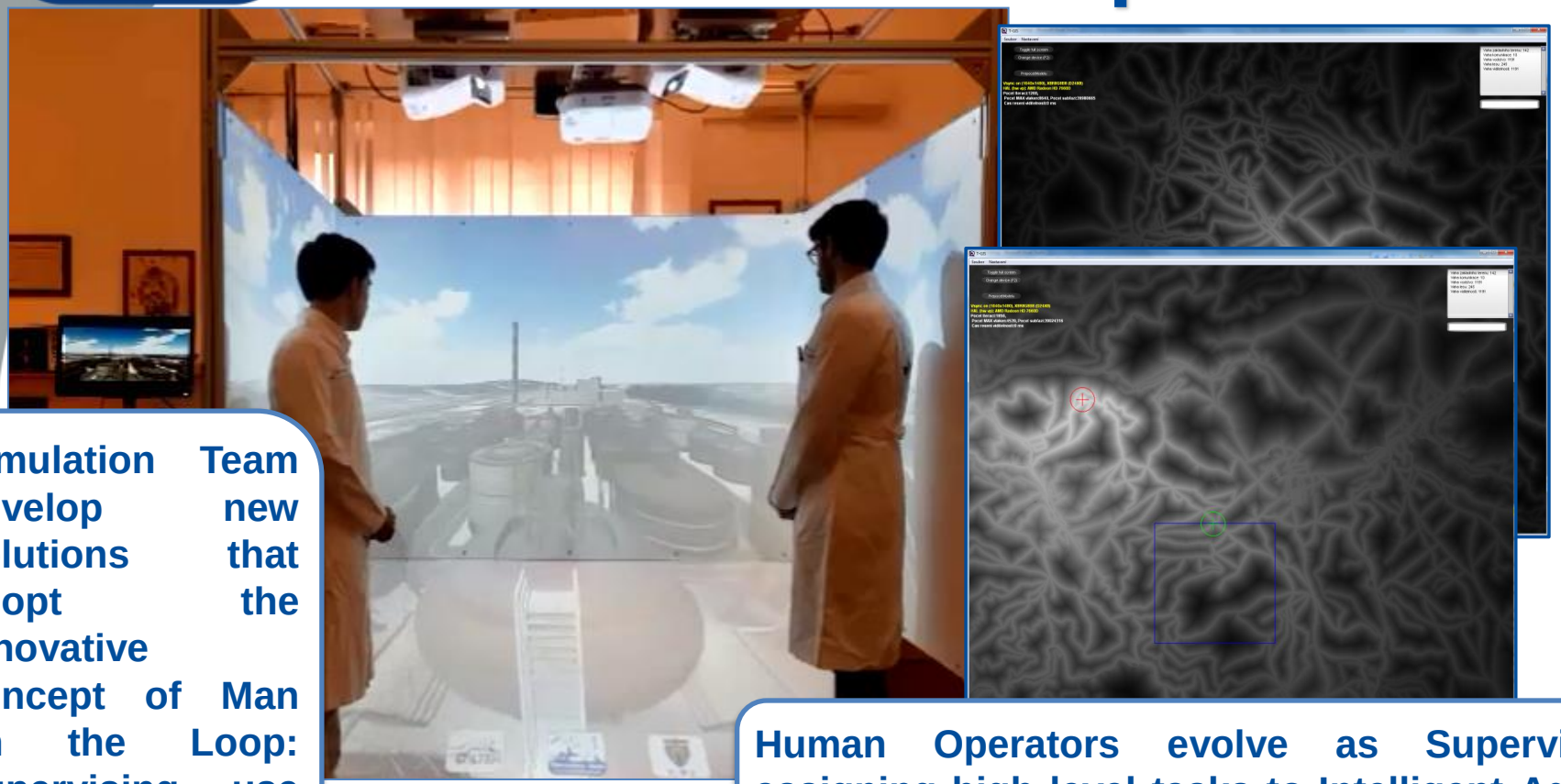
The SPIDER is interactive through touch screen technologies.





The SPIDER is fully Immersive including sound and motion.

AI & Man on the Loop vs. Man in the Loop



Simulation Team develop new solutions that adopt the innovative concept of Man on the Loop: Supervising use of UxV and RAP

UxV Unmanned multiple domain Vehicle
RAP Robotic Process Automation

Human Operators evolve as Supervisors assigning high level tasks to Intelligent Agents driven by Artificial Intelligence Solutions

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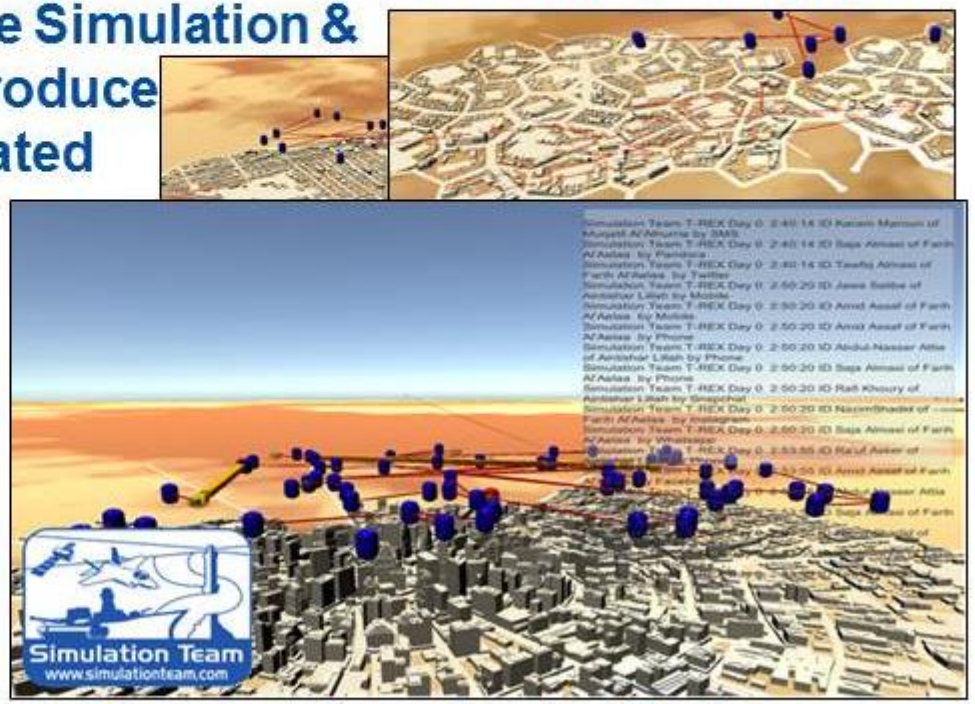
T-REX

Threat network simulation for REactive eXperience

T-Rex (*Threat network simulation for REactive eXperience*) is a MS2G (Modeling, interoperable Simulation & Serious Game) devoted to reproduce Hybrid Warfare and to be federated with other elements to evaluate the impact of these actions.



T-REX reproduces urban, as well as extra urban contexts over multiple domains including land, air, sea, space and cyberspace. The models allows to consider media communications and possibility to use different assets and to experiment virtually the different decisions in terms of COAs (Courses of Actions)

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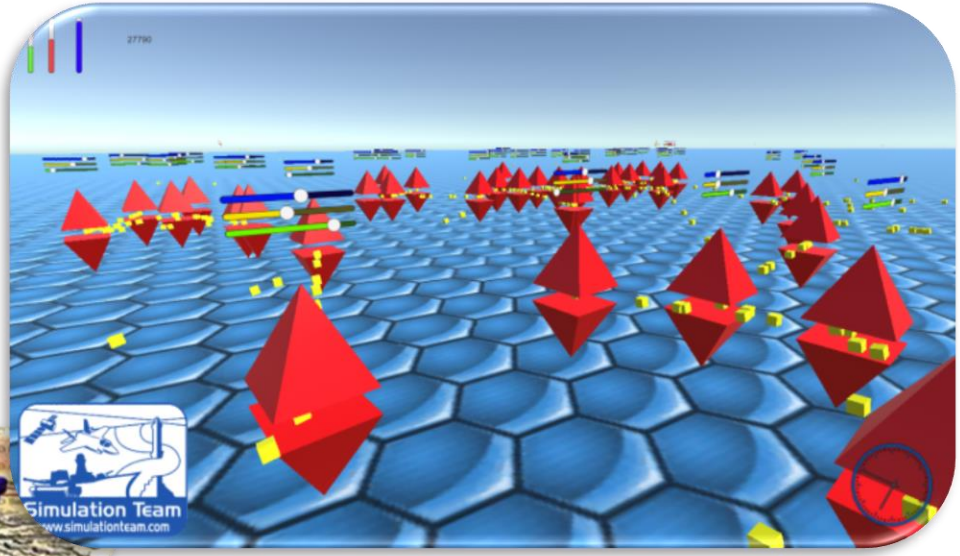
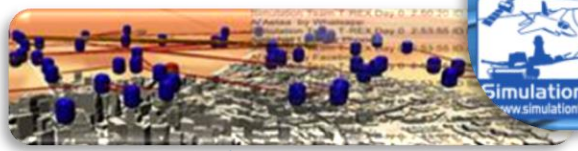
T-REX Cyber Layer

T-REX and IA-CGF (Intelligent Agents Computer Generated Forces) drive actions on the Cyber Layer where it is mapped the ICT domain and related levels of Confidentiality, Accessibility and Integrity for *each node and link*

Cyber Attack:
- Resources
- Responsiveness
- Efficiency
- Effectiveness
- Virus Dynamism
- Virus Initial Injection
- Virus Infectivity
- Virus Resilience
- Virus Level

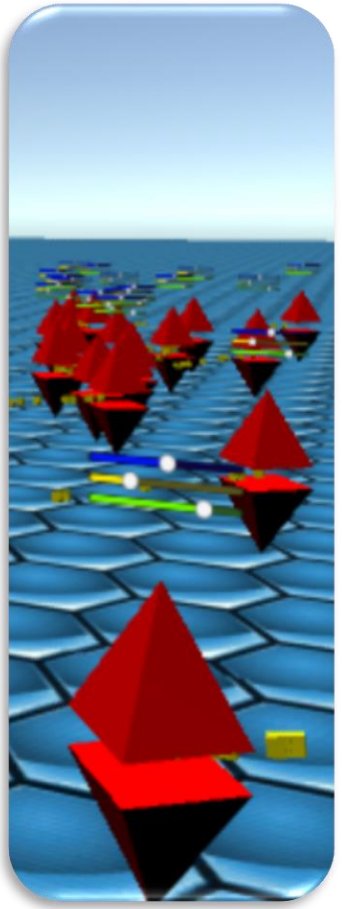
Cyber Defense:
- Resources
- Responsiveness
- Efficiency
- Effectiveness
- Anti Virus Diffusion
- Anti Virus Resilience
- Anti Virus Level





CIAP: Confidentiality, Integrity, Availability, Privacy

CIAP are concepts which have vast goals in Information Security:



- **Confidentiality:** Ensures that data or an information system is accessed by only an authorized person. User Id's and passwords, access control lists (ACL) and policy based security are some of the methods through which confidentiality is achieved
- **Integrity:** Assures that the data or information system can be trusted. Ensures that it is edited by only authorized persons and remains in its original state when at rest. Data encryption and hashing algorithms are key processes in providing integrity
- **Availability:** Data and information systems are available when required. Hardware maintenance, software patching/upgrading and network optimization ensures availability
- **Privacy:** Capability to capture private information to create new profiles and promote Identity Theft

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T-REX: Socials & Population

The Simulator reproduces the Social Network, Cyber Space and Population and how they react to their perception of the Scenario Evolution.

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T-REX: Autonomous Systems

Autonomous Systems, on both sides, **are driven by Intelligent Agents and interact with traditional Assets. Coalition UxV (Umanned multidomain Vehicles) support JISR (**Joint Intelligence, Surveillance and Reconnaissance)**, while hostile UAV (Unmanned Aerial Vehicles) are conducting coordinated attacks**

Simulation Team demonstrated this attack in 2015… on September 14, 2019 an equivalent attack was successfully carried out by drones on Saudi Aramco's Abqaiq, the World Largest Oil Refinery

ALACRES2 Project

La coopération au cœur de la Méditerranée
La cooperazione nel cuore del Mediterraneo

To address port safety, the authors propose utilization of innovative modeling & simulation solutions, capable of predicting outcome of different scenarios in various initial conditions. The idea is framed within an international project named ALACRES2 (*Servizio Avanzato di Laboratorio per Crisi ed Emergenze, in porto nello Spazio di cooperazione dell'alto tirreno, basato su Simulazione*) carried out among different Universities and Institutions that foresees identification of scenarios of interest for port safety and their application to several ports of interest in order to create a virtual lab able to support definition of policies and guidelines as well as to turn into an efficient modern training equipment for managers, decision makers and operators Ṭhe presented research is carried out under the EU research funding program Italy – France INTERREG Maritime14-20 which supports the development of the project named ALACRES2 and lead by Genoa University.
http://interreg-maritime.eu/

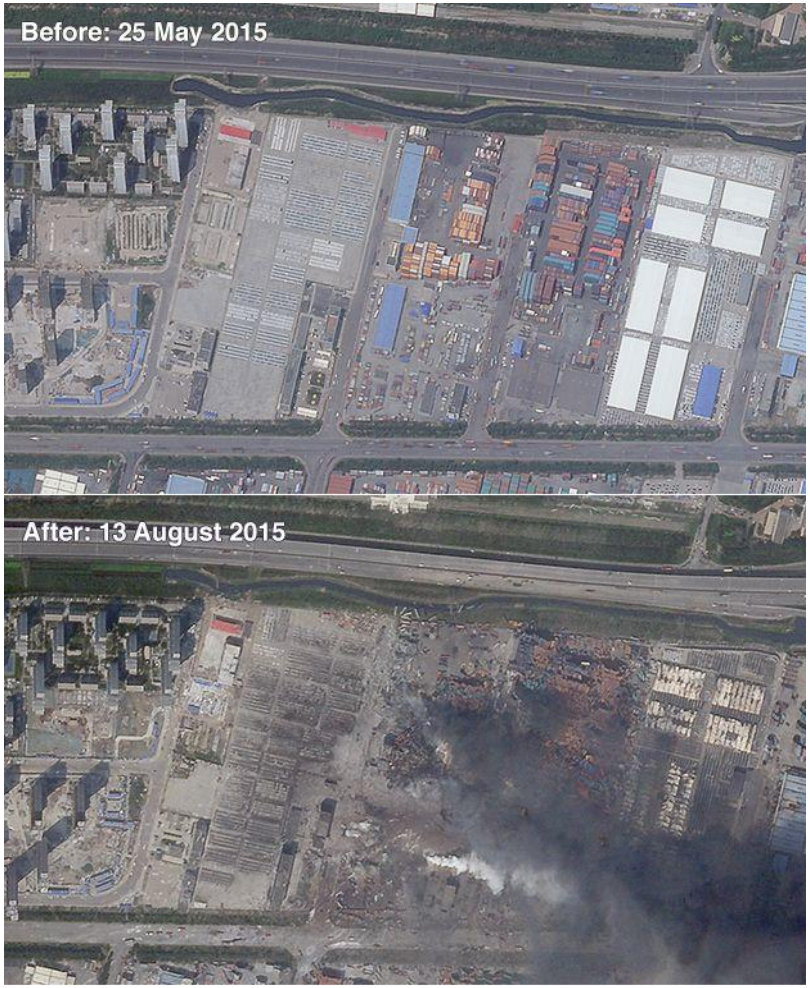
Interreg
MARITTIMO–IT FR–MARITIME
UNION EUROPÉENNE
UNIONE EUROPEA
Fonds européen de développement régional
Fondo Europeo di Sviluppo Regionale

ALACRES·2

Recent Cases: Explosions

Even modern big ports face sometime issues with planning and communication, which impact safety of persons.

For instance, in case of Tianjin port explosion (China), firefighters were not informed about presence of calcium carbide and tried to extinguish fire by water, which is considered as one of main cause of the explosion. Furthermore, distance between the storage of hazardous materials and nearby houses was less than one km, which caused additional casualties



Tianjin port explosion (China)
Source: bbc.com

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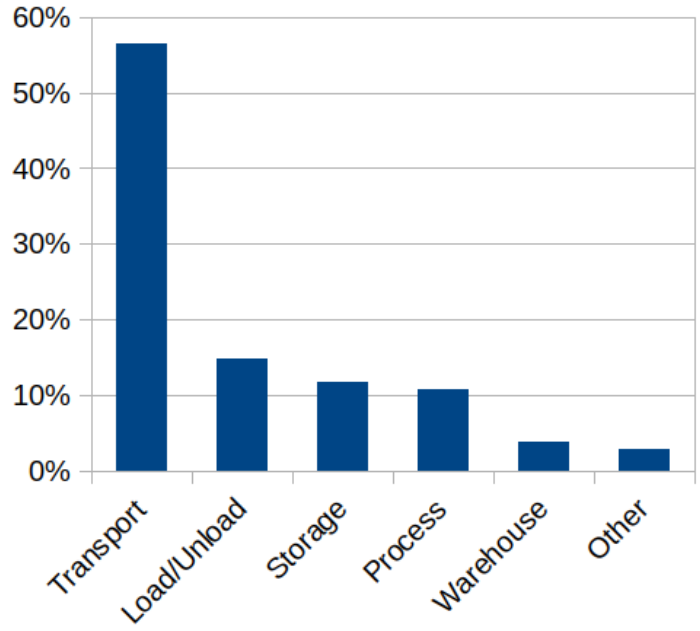
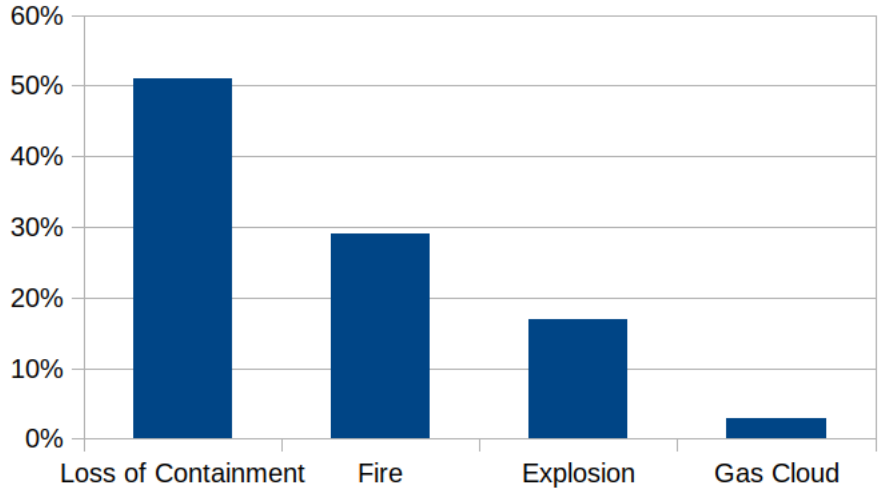
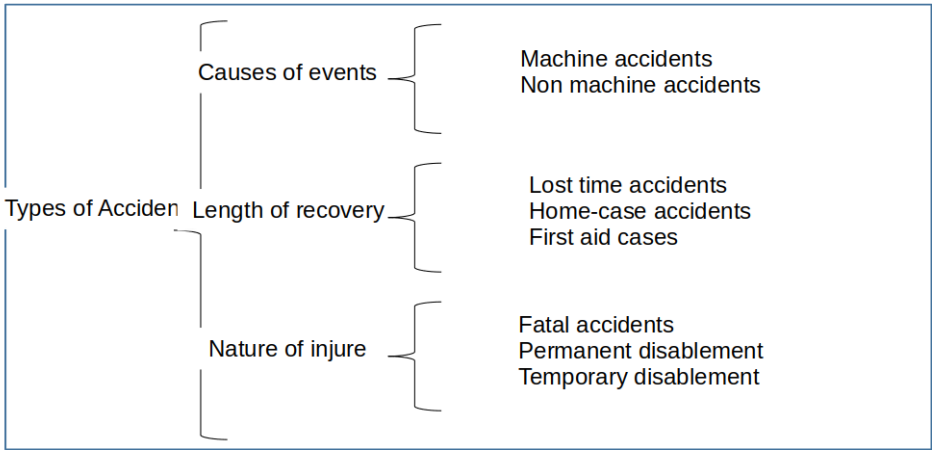
Analysis of Typical Problems



Place or activity in which the accident occurred: process plant, storage, transport, load/unload, waste, other



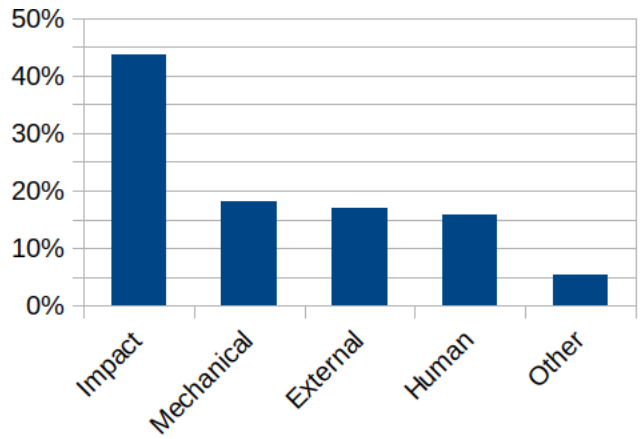
Occurrence rate of accidents by type



Classification of accidents

Causes and Effects

In general, analyzing the statistical data, it is possible to conclude that number of accidents in seaports is constantly growing despite continuous improvements in safety procedures, even due to a constant increase in flows and operations. This could be explained by continuously increasing sea traffic. In the same time, frequency of domino effect accidents is decreasing, even if their occurrence is still quite high.



Causes of accidents

Fire and chemicals leak in Laem Chabang

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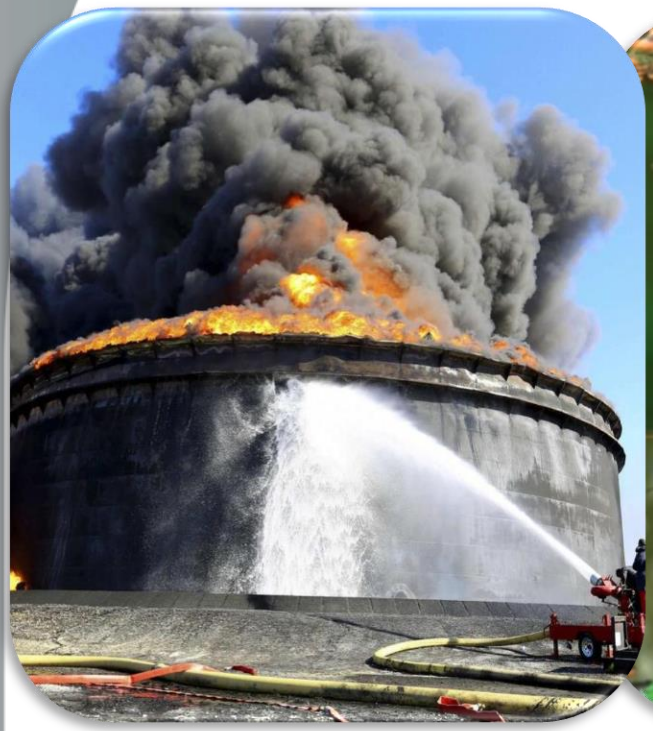
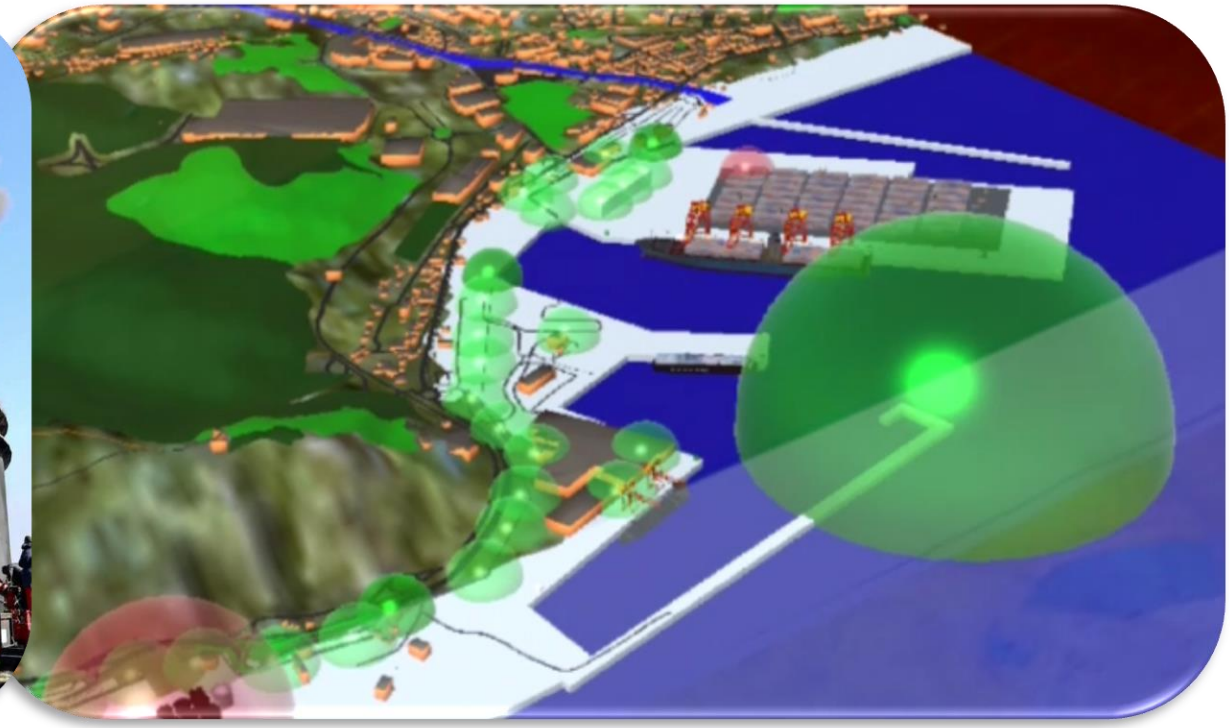
Virtual Lab for Ports

In virtual laboratory it is possible to test the effectiveness of new technological and infrastructural solutions to reduce vulnerability, mitigate damage and prevent emergencies. The simulation techniques adopt the new MS2G paradigm (Modeling, interoperable Simulation and Serious Games) to combine different models.





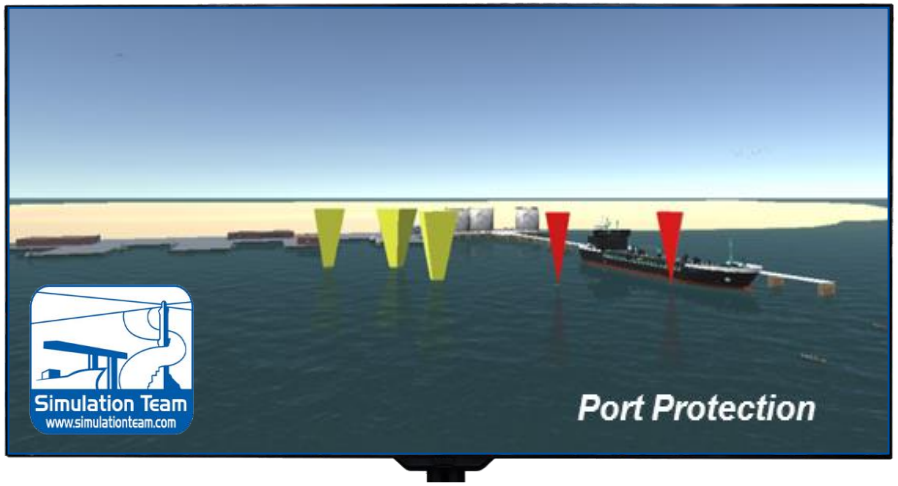
Libya Es Sider port oil tank fire (2014)

AI & IA

Artificial Intelligence (AI) is based on techniques designed to reproduce intelligent processes. The M&S and AI are strongly connected because simulation often has to incorporate intelligence to control assets, virtual human beings, virtual organizations, planning activities.

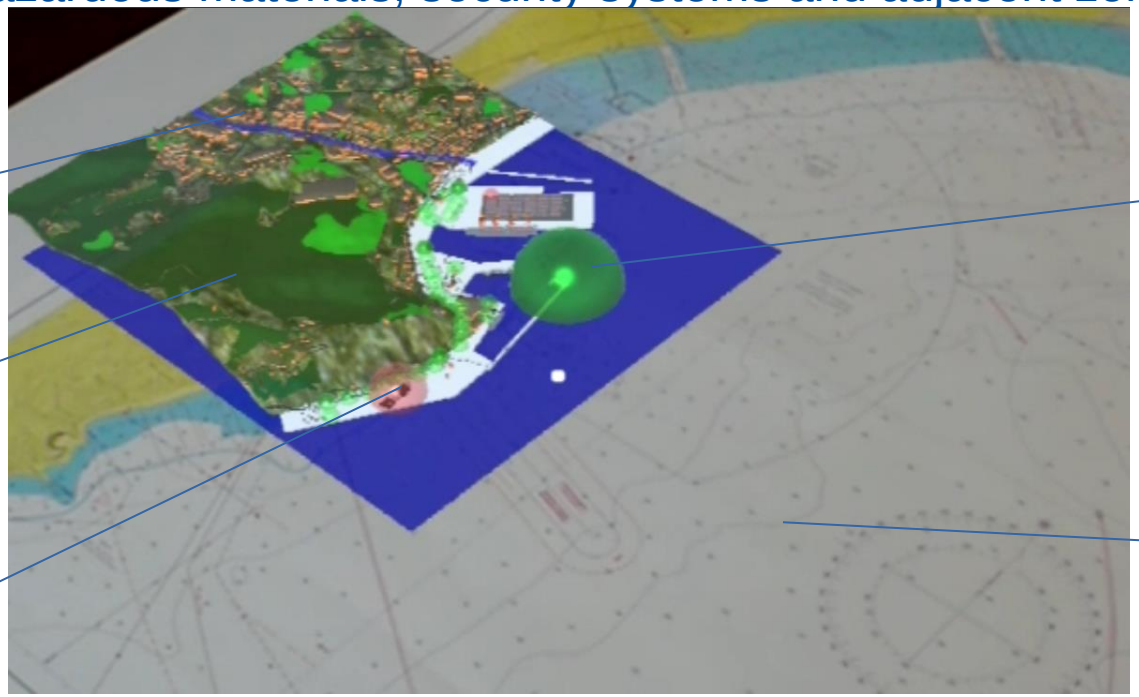
Intelligent Agents (IA) represent a crucial element for coupling complex scenarios with many entities that interact in a complex way. AI generally represent people, groups or units and reproduce the corresponding desired behaviors.

IAs allow an object to react to situation changes based on his perception. The use of AI-driven simulations reproducing the behavior human (HBM) is fundamental to recreate complex and extended scenarios which include the reactions of people and the population.



Devices and Equipment - AR

Augmented Reality allows the 3D terrain and port infrastructure to be overlapped with the real nautical map of the zone of interest; such technology allows to extend information provided by "hardcopy" map. In this example, it adds information regarding hazardous materials, security systems and adjacent zones



Interactive 3D model of port overlapped with nautical map, view from Hololens

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Recent Cases: Fire & Leakages

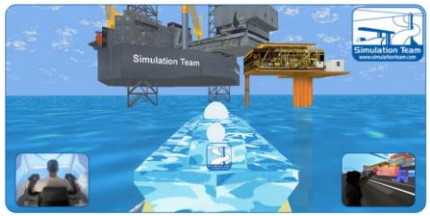
Ferry collided with port crane causing fire, Barcelona (October 2018)

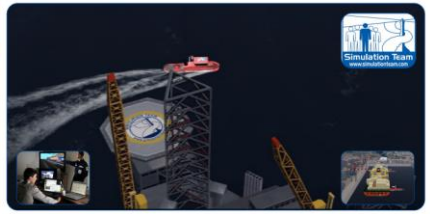
Fire in containers with trichloroisocyanuric acid at Port Metro Vancouver (March 2019)

More than 120 persons hospitalized after chlorine leakage in Mumbai Port (July 2010)

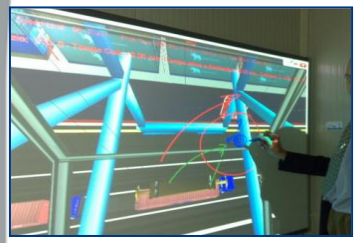
Hundreds of cars burned in Savona port during storm (October 2018)

ST_VM: Virtual Marine





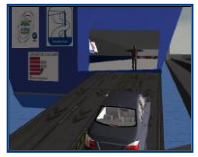
The ST-VM is the ultimate Marine Simulator developed by Simulation Team and includes many different Marine components, equipment and platforms as well as New Solutions for Terminal Design, Operator Training, Safety and Security, Procedure Definition, Equipment Design and Virtual Prototyping



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

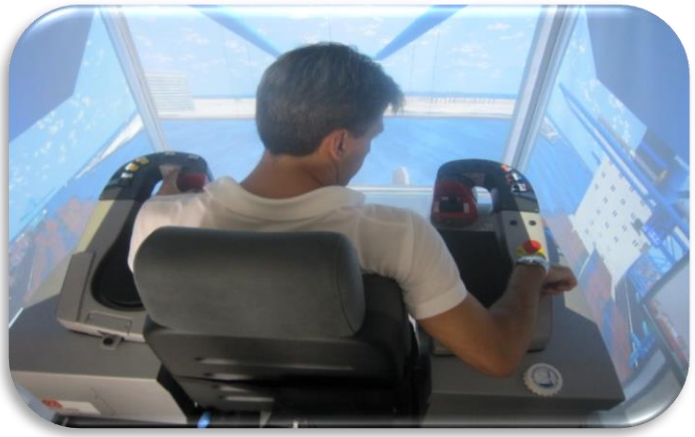
Interoperable Virtual Simulators

The Simulators developed by Simulation Team are an important support in Training both for Operative Resources and Decision Makers.
Interoperability is one key point of our Simulators and it is based on state of art on standards (i.e. HLA High Level Architecture). HLA is the basis for the Creation of federation with models, Real equipment and simulators.
In this way it is possible to train people in Stand-alone mode as well as in by Concurrent Collective and Cooperative Training on Operations and Policies.

Simulation Team

Virtual Solutions for Marine Operations

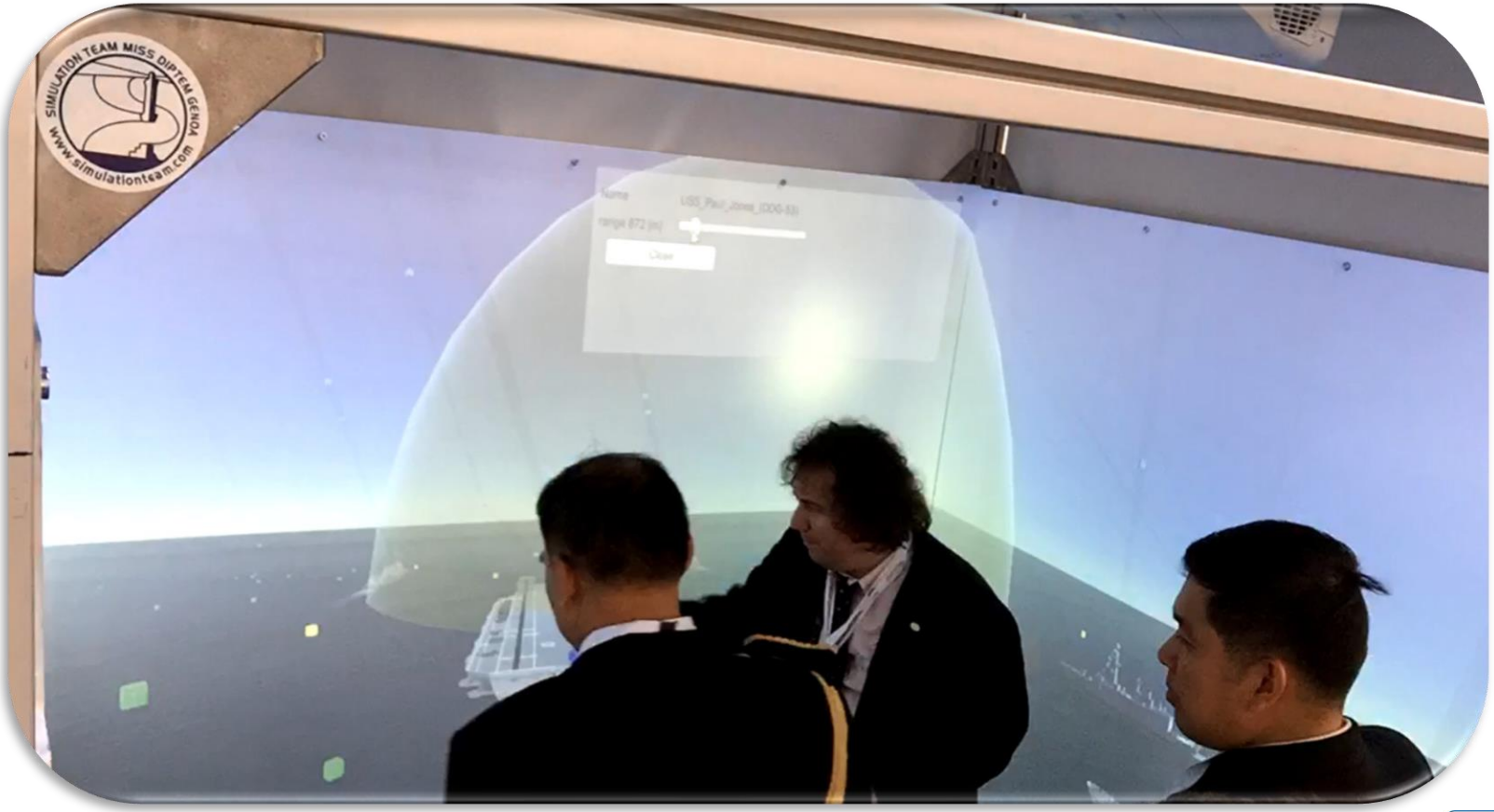
One important implementation has been the Virtual Marine Solution that supports real-time, interoperable simulation. ST-Virtual Marine enables collective, distributed & mobile training in a scalable synthetic environment able to reproduce extensively complex scenarios, multiple port configuration, operations, interactions and interferences among many different systems & platforms operated by different people.



Examples of Different Simulators

Simulation Team

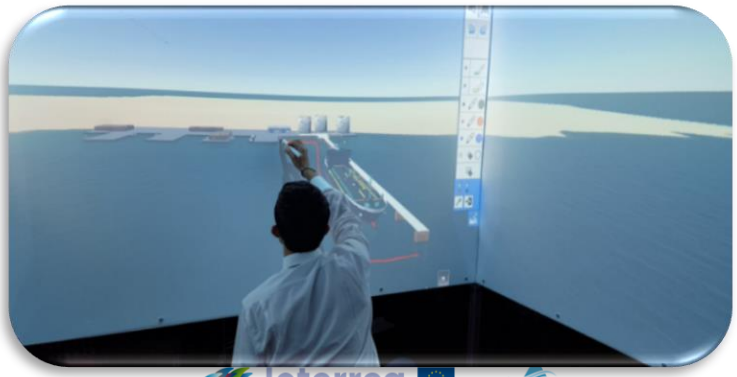
The SPIDER Evolution

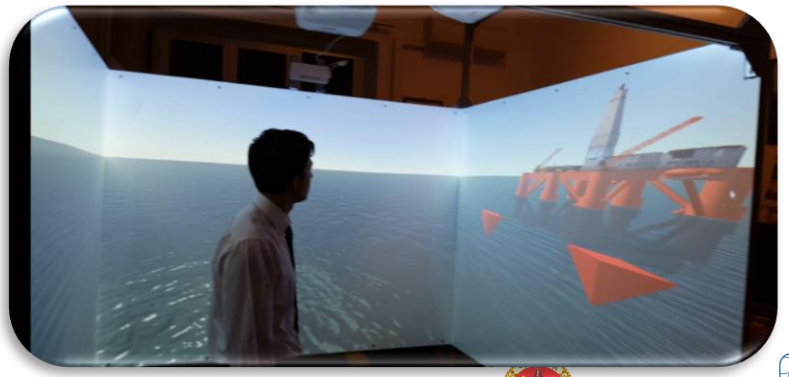


SPIDER

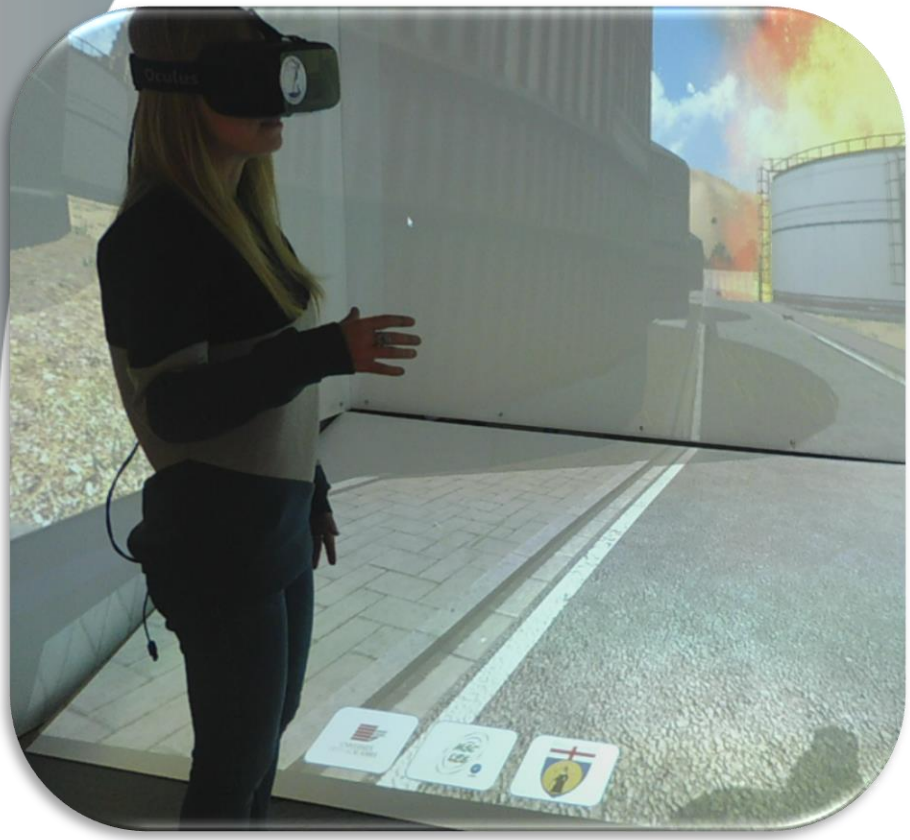
Simulation Practical Immersive Dynamic Environment for Reengineering

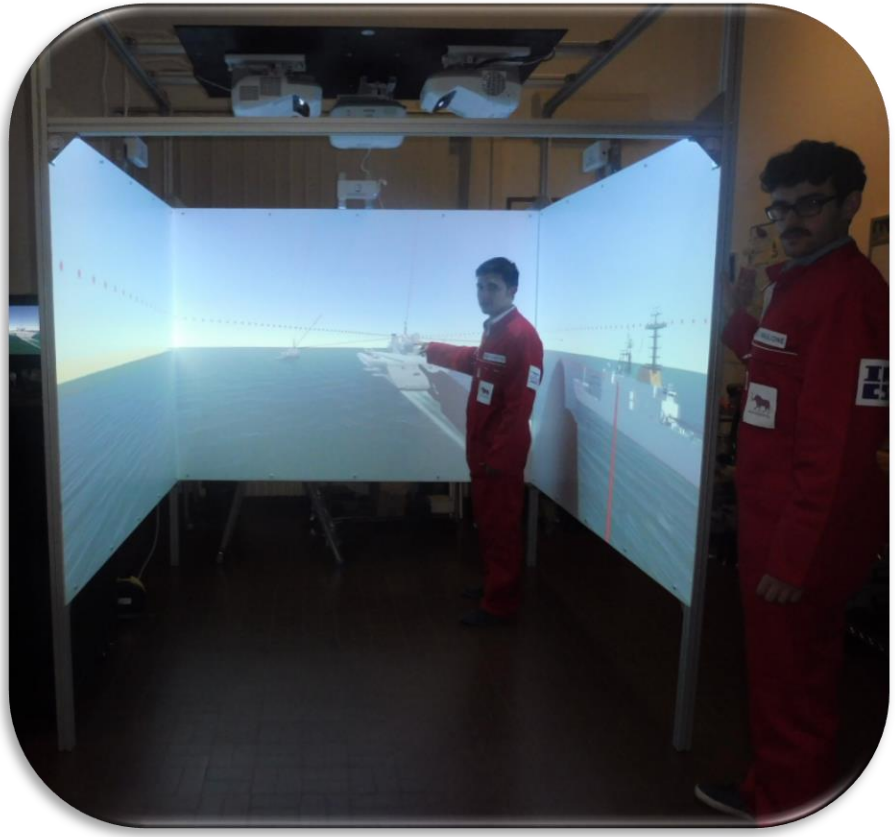
The SPIDER (Simulation Practical Immersive Dynamic Environment for Reengineering) is an innovative Interactive and Interoperable CAVE (Cave Automatic Virtual Environment) developed by Simulation Team. The basic configuration is compact (just 2m x 2m x 2.6m) and could be embedded within a Standard ISO 40' High Cube Container, integrated in IMSF & with any interoperable simulator. The SPIDER is interactive by touch screen technology and fully Immersive including sound & motion.





SPIDER: Experiencing the Simulation within an Immersive Collaborative Environment





MS2G and IA-CGF in SPIDER

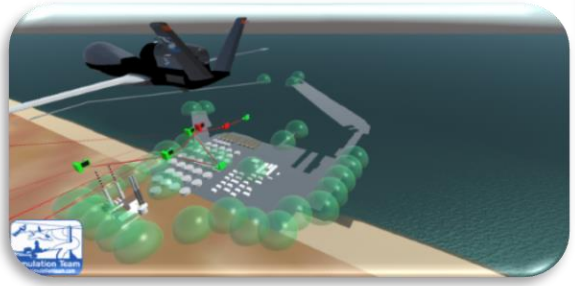
The innovative concept of MS2G (Modeling, interoperable Simulation and Serious Games) allows to develop interoperable scalable and reusable simulators with benefits of new immersive solutions.

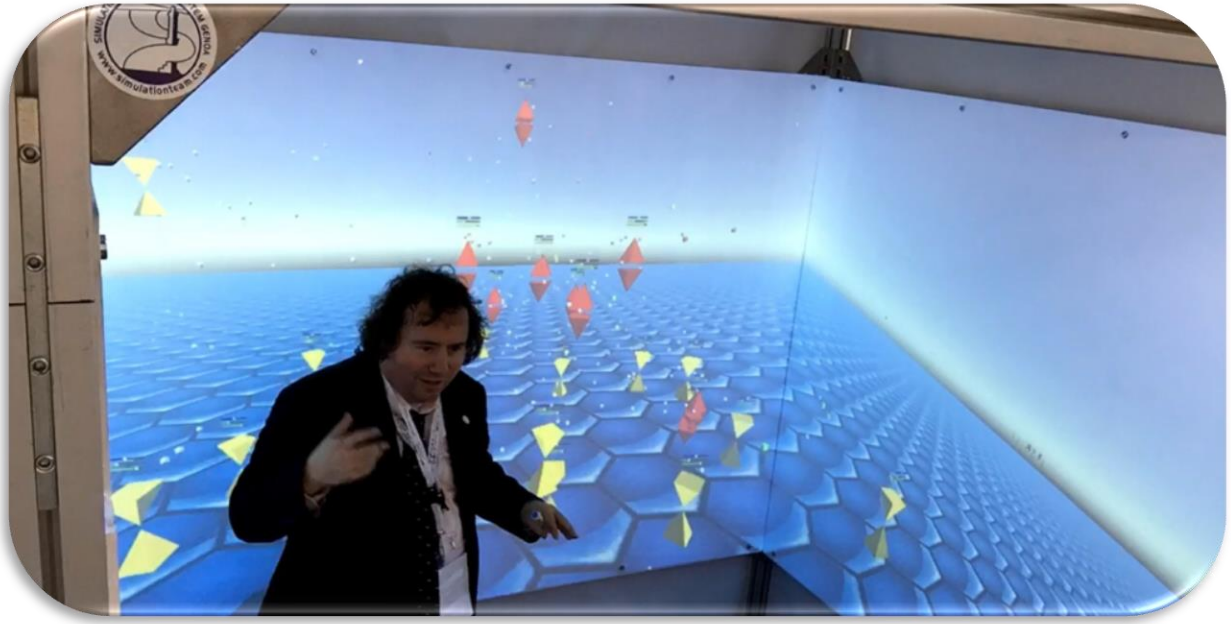
This aspect is combined in SPIDER with the use of the IA-CGF (Intelligent Agent Computer Generated Forces) that allows to automate many actions and generating complex scenarios

Simulation Team

Virtual Simulation of Real and Cyber Space

Simulations in the SPIDER allows to present Big Data and complex scenario shifting from Real to Cyber Space outlining connections and criticalities. Cyber Warfare Simulation considering Confidentiality, Availability and Integrity of Nodes was applied to scenarios, analyzed by Subject Matter Experts on SPIDER





Simulation Team

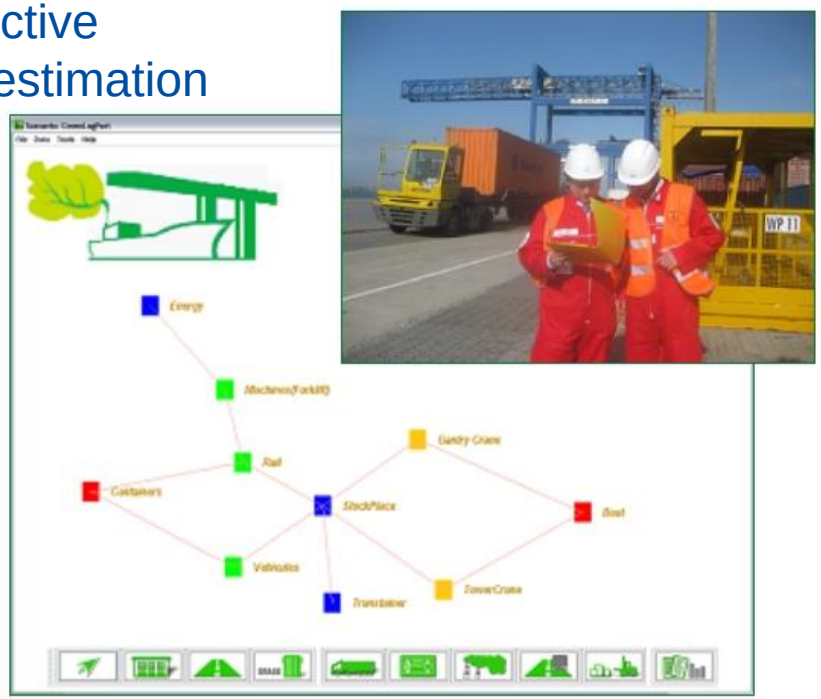
Intuitive, Immersive, Interoperable & Interactive

The Example of GREENLOG Port...

GreenLog Port Simulator

The analysis of Port Environment is strongly related to the possibility to develop effective Simulation Module devoted to support estimation of its Environmental Impacts such as

- Garbage & Port Waste
- Dredging
- Dust
- Noise
- Ship Air Emissions
- Air Quality
- Hazardous cargo
- Bunkering
- Port development
- Ship Discharge



Developed in Cooperation with Simulation Team & DIPTEM

… and GREENLOG Ship

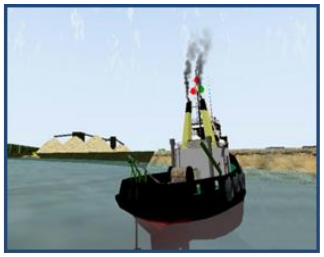
GreenLog Ship Simulator

GreenLog Ship is another example of specific Simulation Module devoted to analyze the Environmental Impact of the Ship for supporting monitoring, alternative evaluation, saving and benefits from different solution in use, handling, operating as well as in Ship Design GreenLog Ship Includes Air Emission,
Consumption, Ship Paints, Garbage/Waste Disposal, Noise, Ship Discharges,
Hazardous Cargo, Spills

Mega Ecologic Disaster Model


OIL PLATFORM

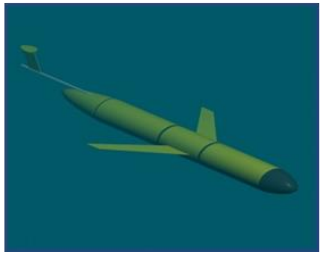

HELICOPTER


TUG

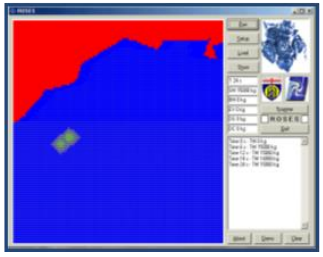

FIRE FIGHTING

RTI

AUV



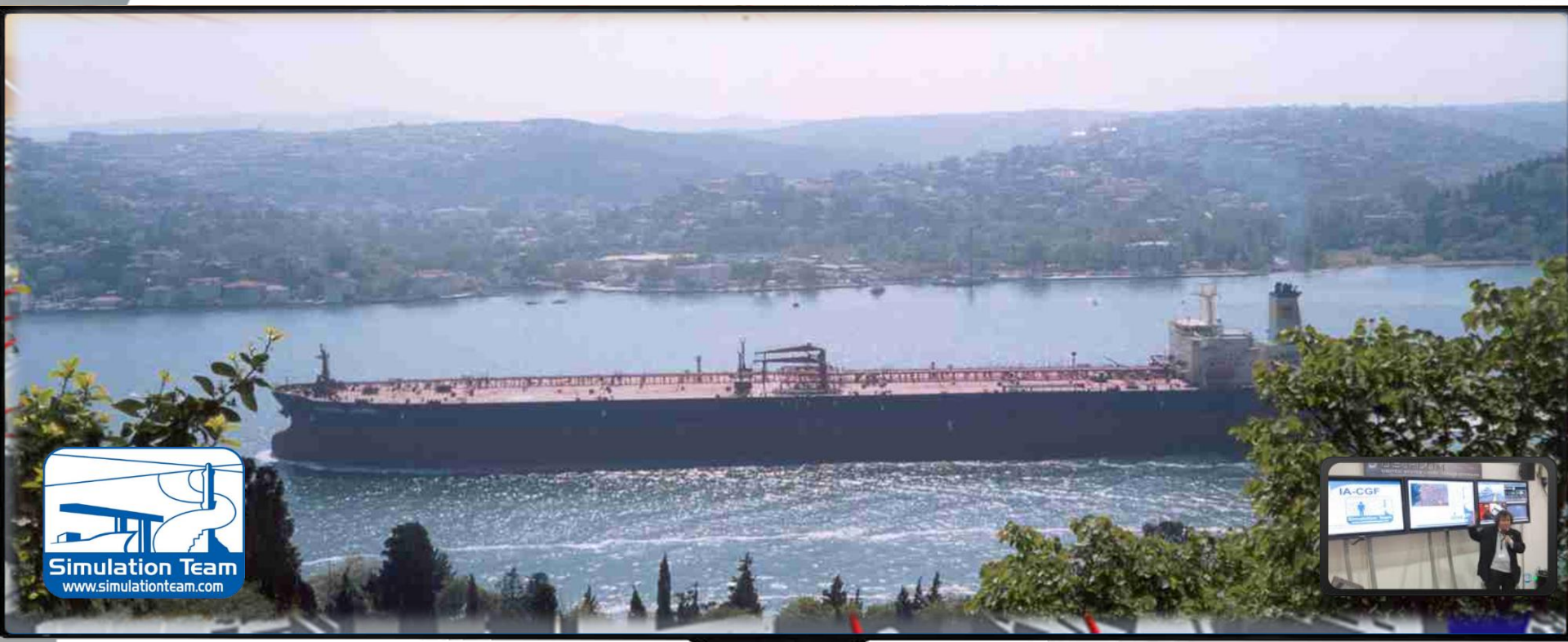
OIL SPILL



SCUBA DIVER

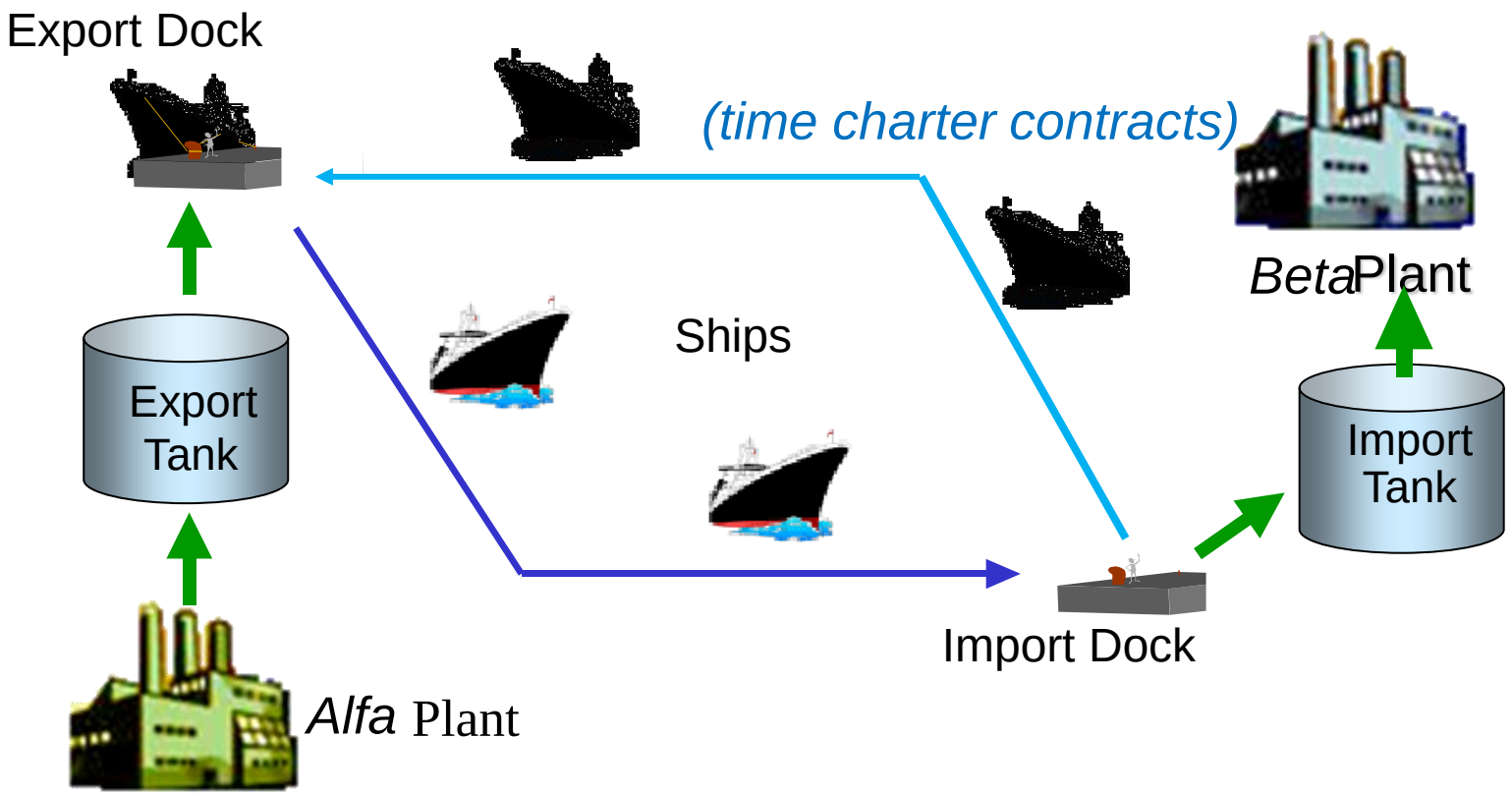
Simulation Team

A Simple Problem not so Simple!



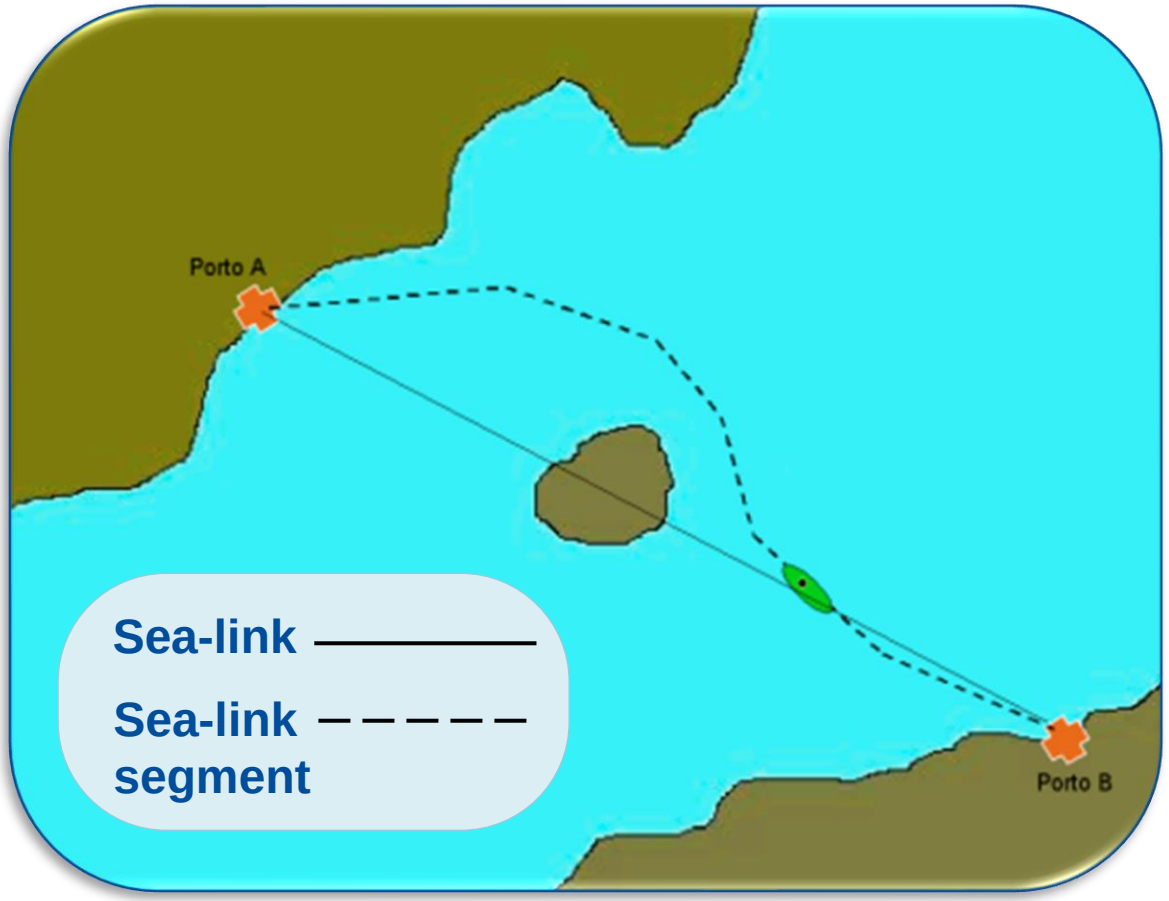
Simulation Team

Logical scheme of the Simplest Model

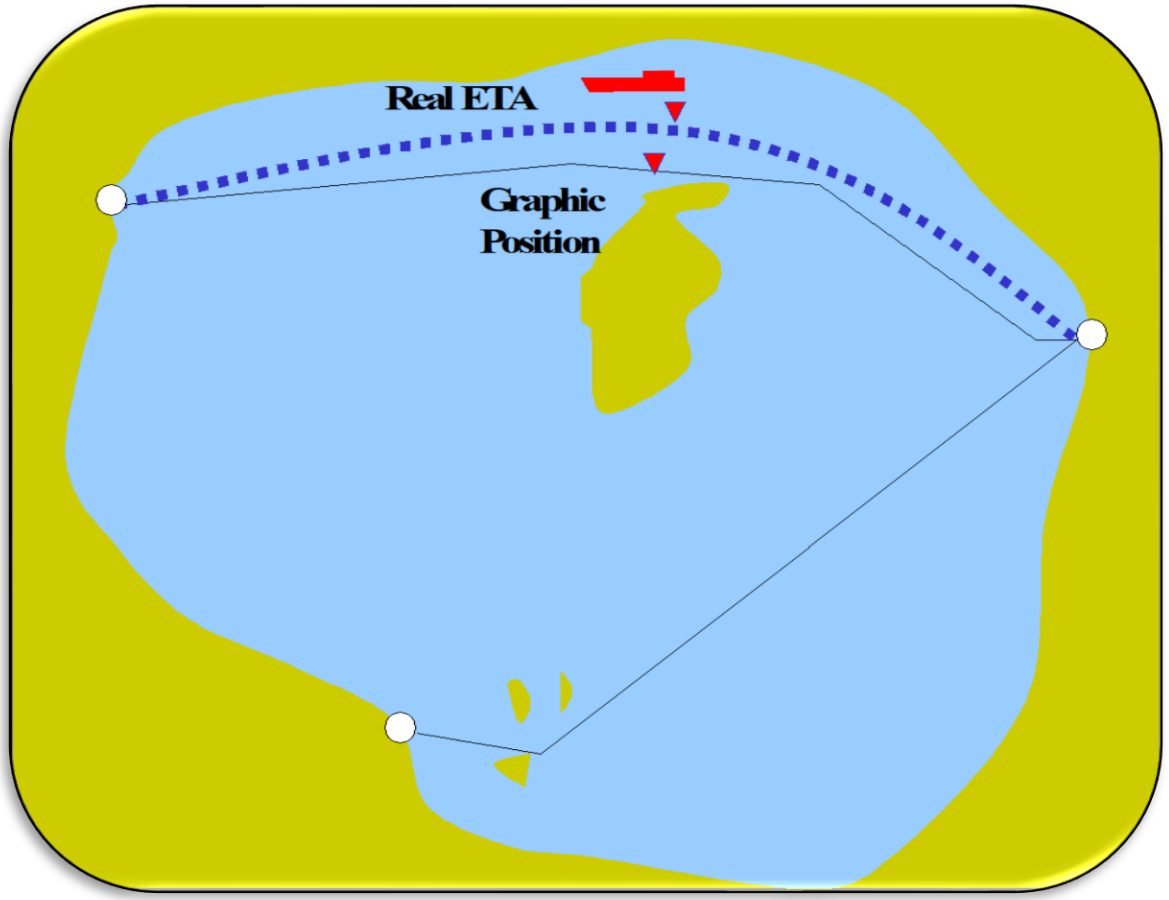


Chemical logistic flow to be analyzed

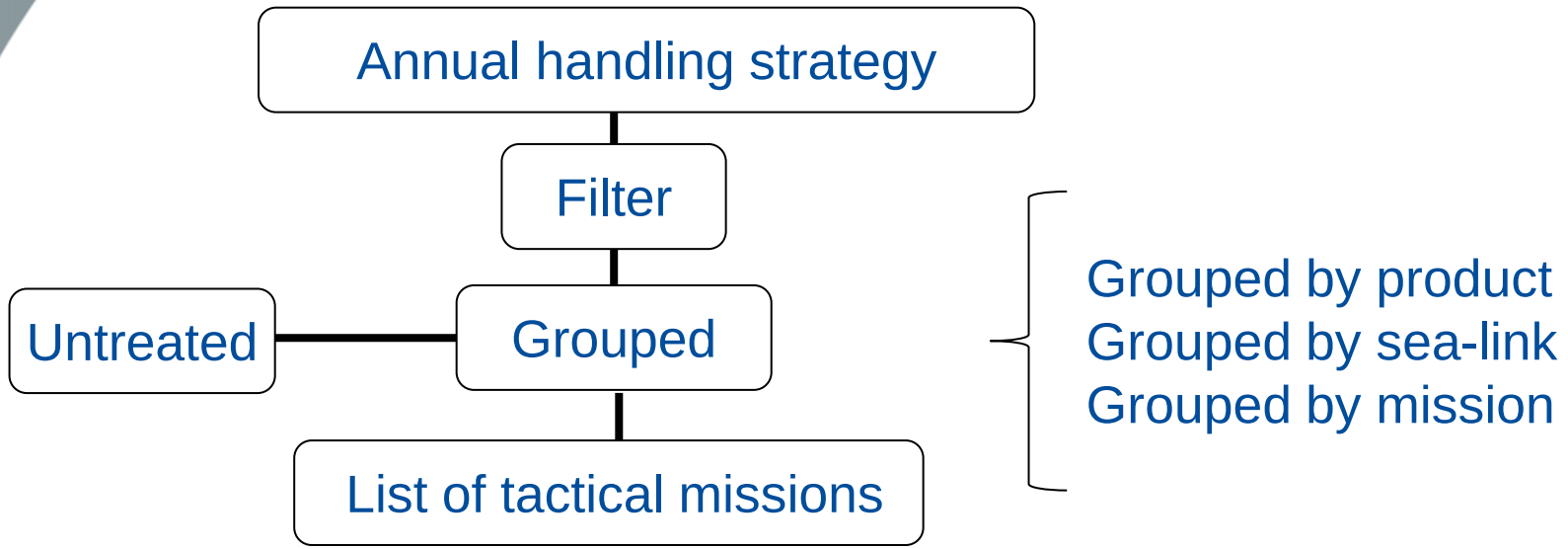
Routes and Connections



ETA: Estimated Time of Arrival



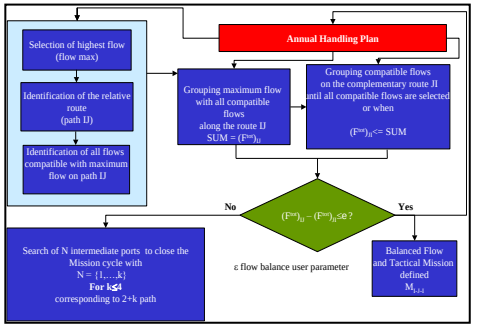
Production Logistics



List of tactical missions = subset of tactical missions;
Tactical mission = list of tactical sea-links
Tactical sea-link = connection between 2 points only; it is related to:

- **From each harbor: plant parameters, tank parameters, harbor parameters, terminal parametersd**
- **From the quantity: the amount to be handled**

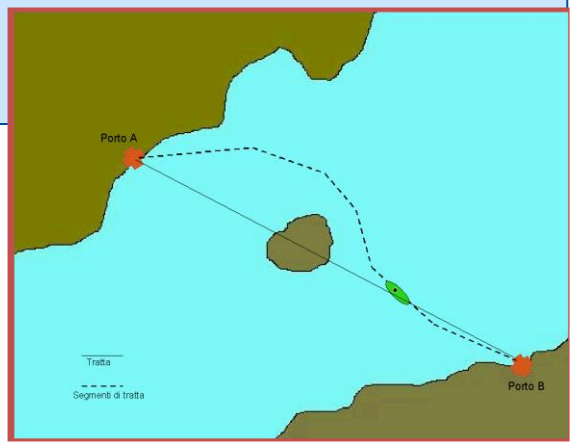
Flow Grouping



- The Flows are representing the Logistics in terms of quantities to be distributed between Chemical Plants by Import/Export operations.
- Compatible Flows on the Annual Production Plan are clustered and grouped together
- Flows should be balanced in order to optimize the fleet in terms of number of ships and capacities

Port Sequencing

- The goal of Port Sequencing consists of choosing the best sequence of harbours for a Tactical Mission.
- Parameters:
  - The harbors to be reached
  - The Flows to be fulfilled
  - The costs of Tactical Missions



Sequence 1):

α – β – γ – δ

α

β

γ

δ

Sequence 2):

α – γ – β– δ

α

γ

β

δ

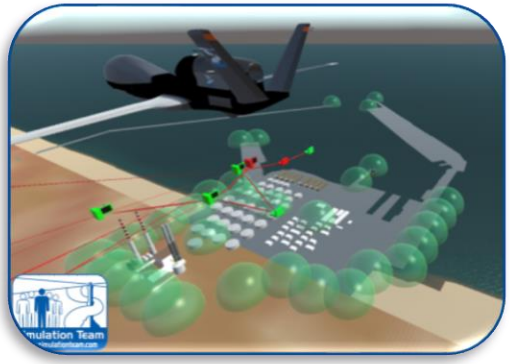
Simulation Team

Objects

- Global route
- Sea-link
- Port
- Sea-link segment
- Dock
- Calendar
- Meteo Area
- Piping Lines
- Product
- Product Flow
- Equipment
- Tactical Mission
- Ship Tank
- Ship Mission
- Factory Tank
- Ship
- Order

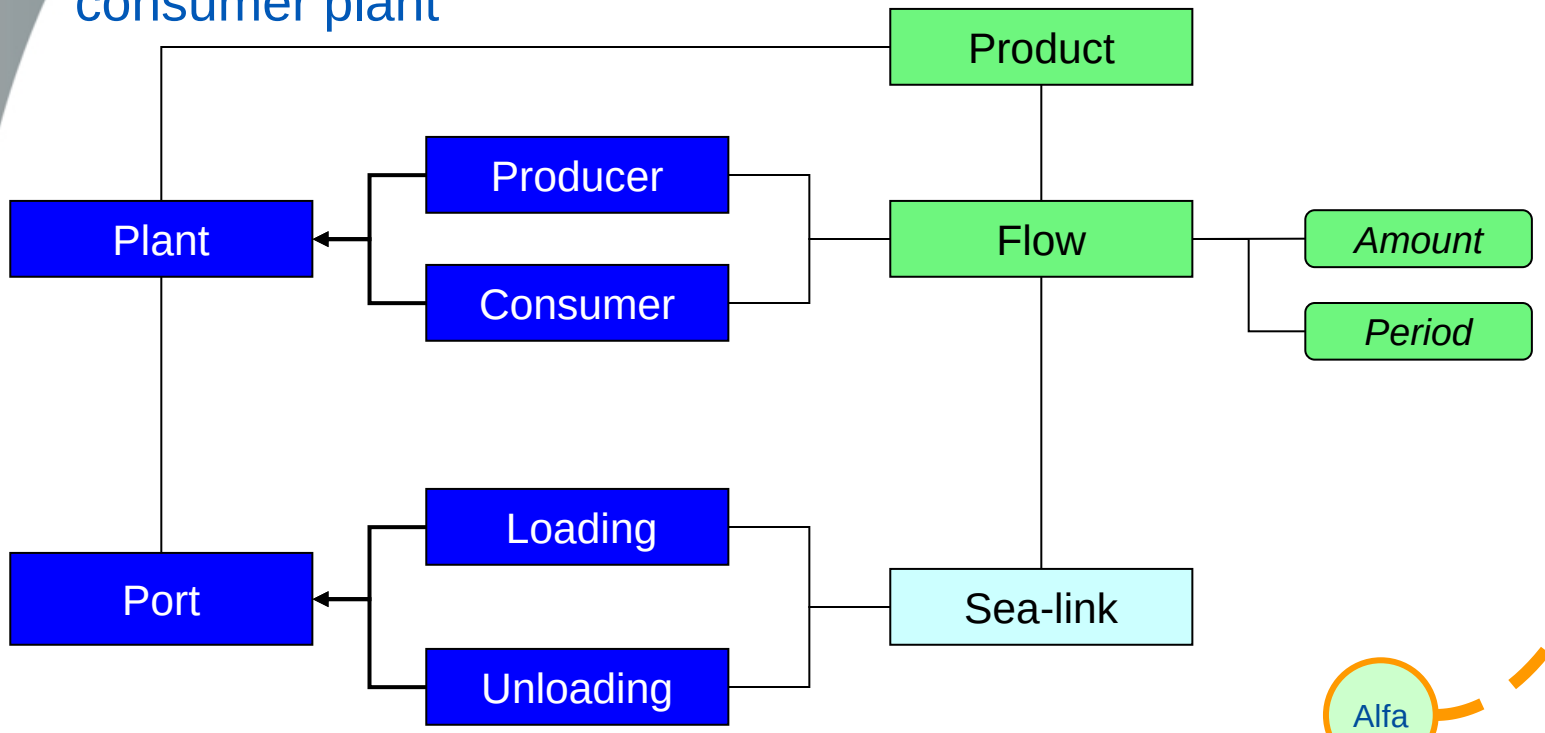
Port

- Dock
- Tank
- Piping
- Storage
- Equipment
- **Port**
  - *Geo-position*
  - Operativity
  - *Regulatory constraints*
  - *Operation Times*
  - *Harbor costs*



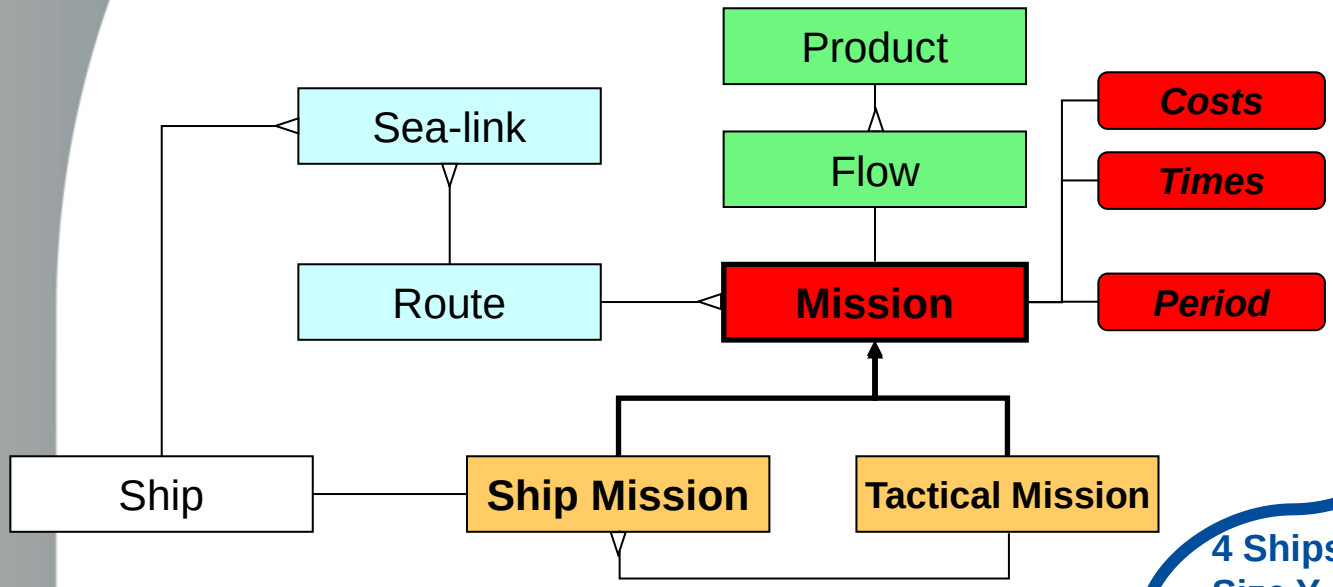
Flow

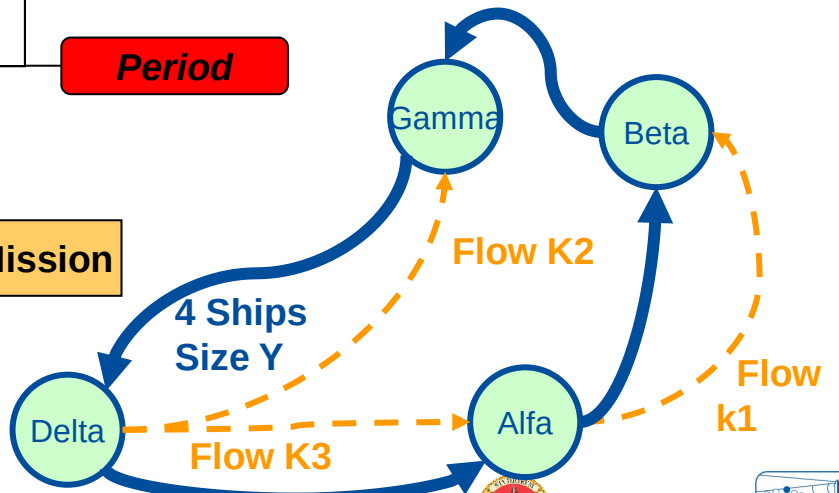
Flow is the amount of product to be transferred by sea, following a prefixed **Sea-link**, in a certain time **Period**, from a producer plant to a consumer plant



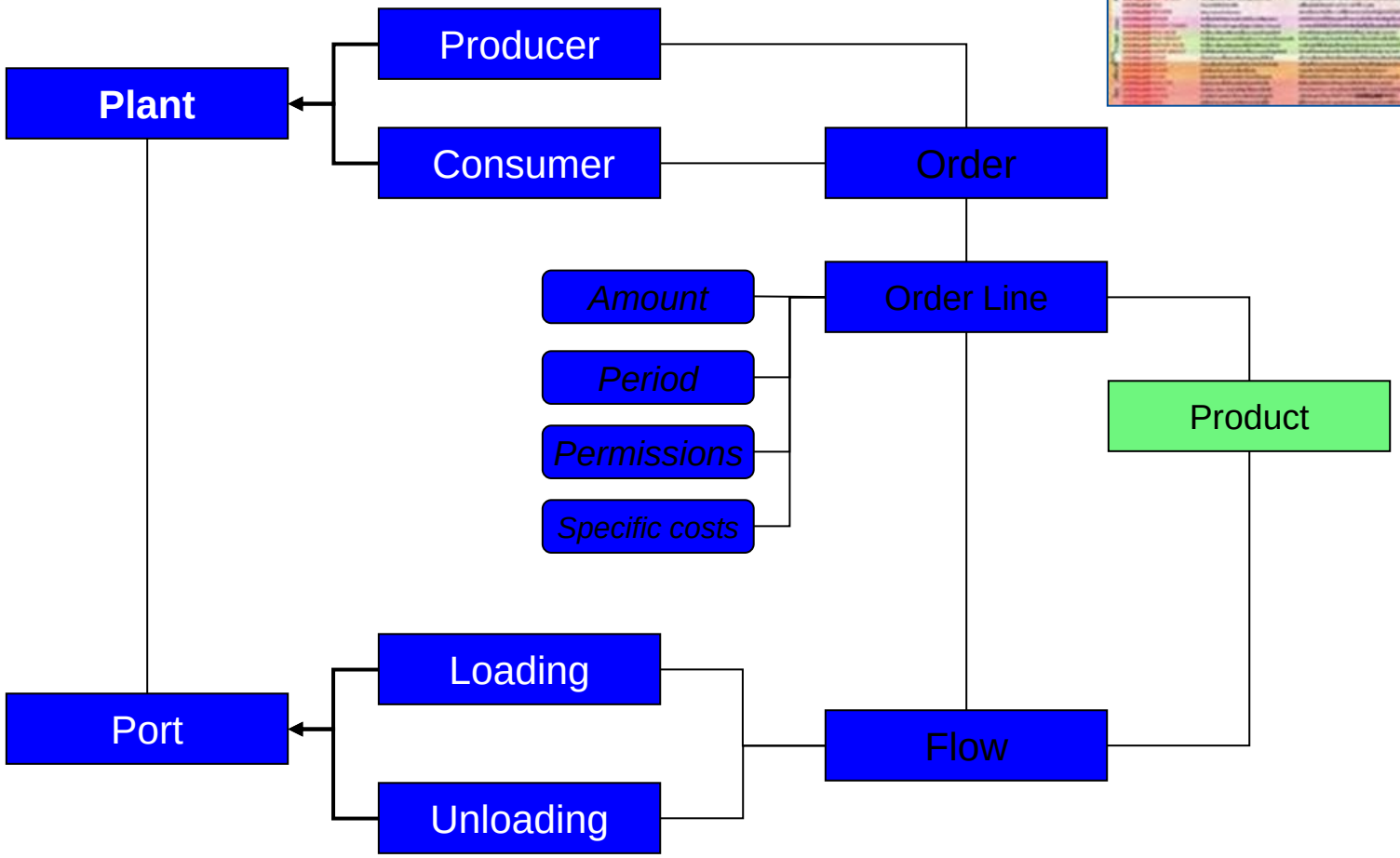
Mission

Mission is a predefined set of **Flows** (of one or more products) to be realized in a prefixed time **Period**, comprising one or more **Sea-links**, using one or more **Ships**, with **Costs** and **Times** to be determined





Order



Simulation Team

Sea-link/Segments

Forecast

Period

Meteo Area

Coordinates

Segment

Start/End

Distance

Arrival

Port

Departure

Sea-link

Distance

Segment list

Validity period

Global distance

Sea-link list

Global route

Mission

Ship Object

Contract

Ship type

Ship costs

Position

Ship

Registration data

Characteristics

Operational constraints

Setup times

Operational times

Reliability

Tank

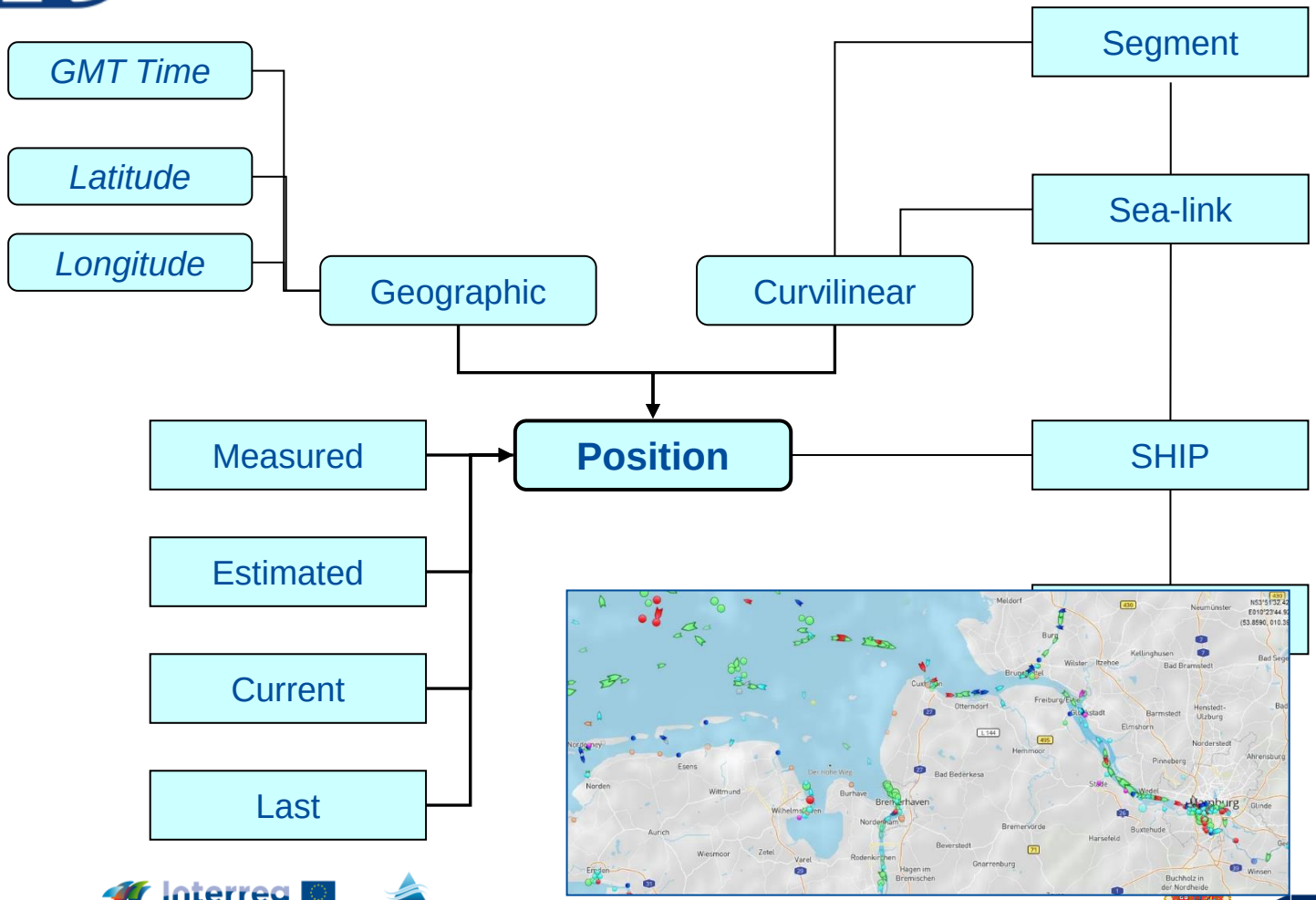
compatibile con

Load

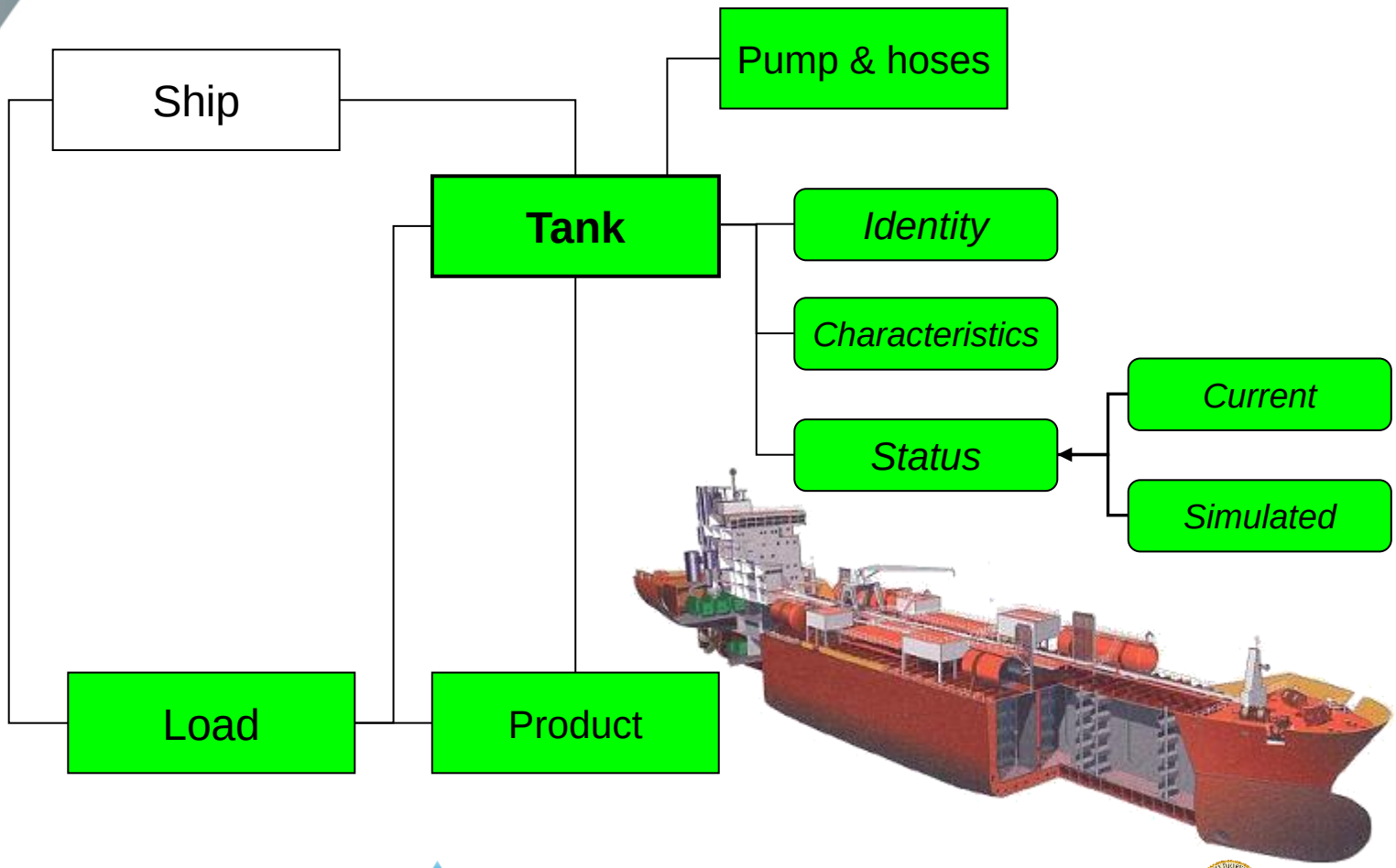
Product

Simulation Team

Ship Position

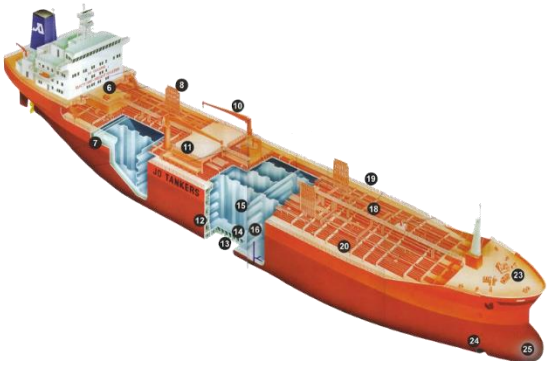


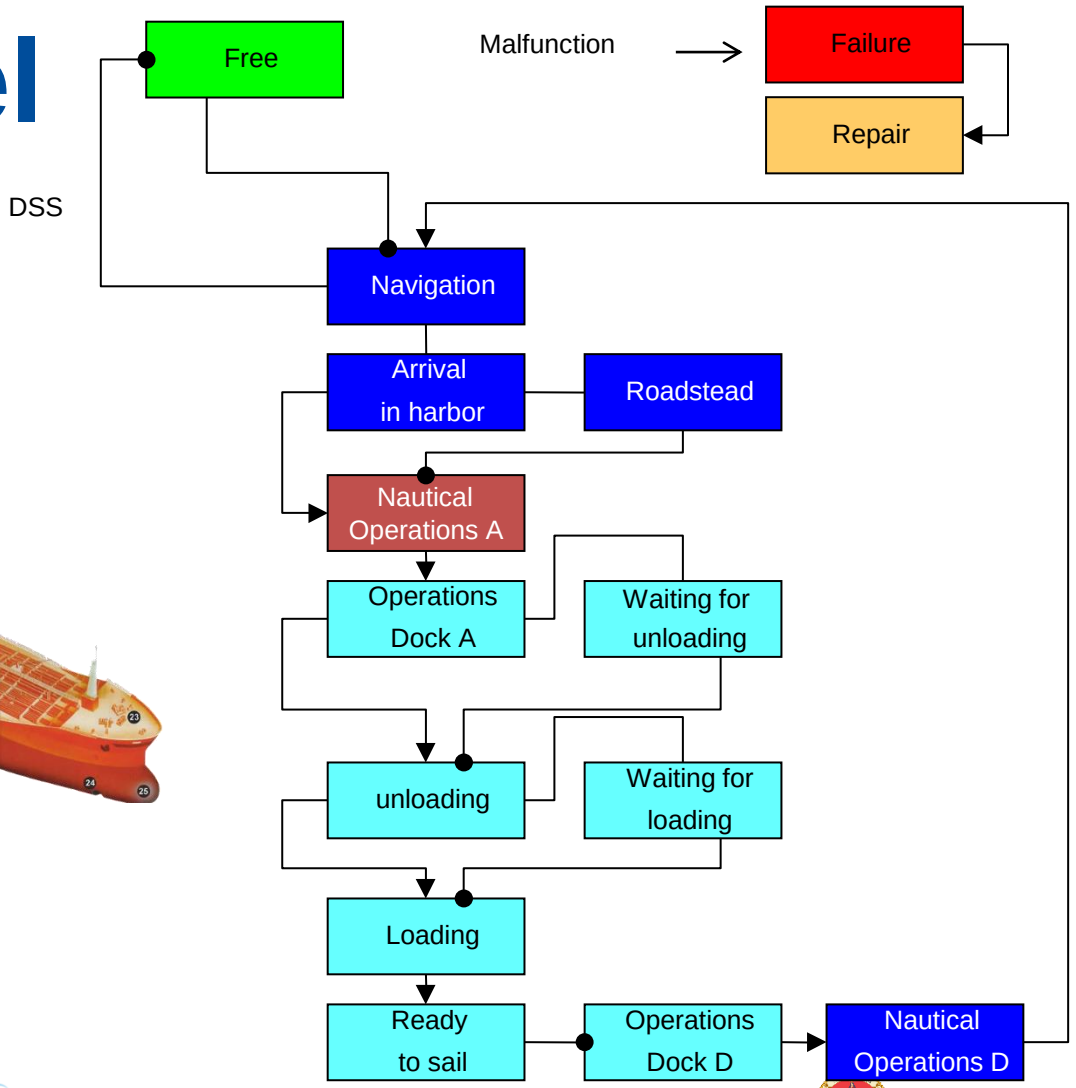
Ship Tank



Simulation Team

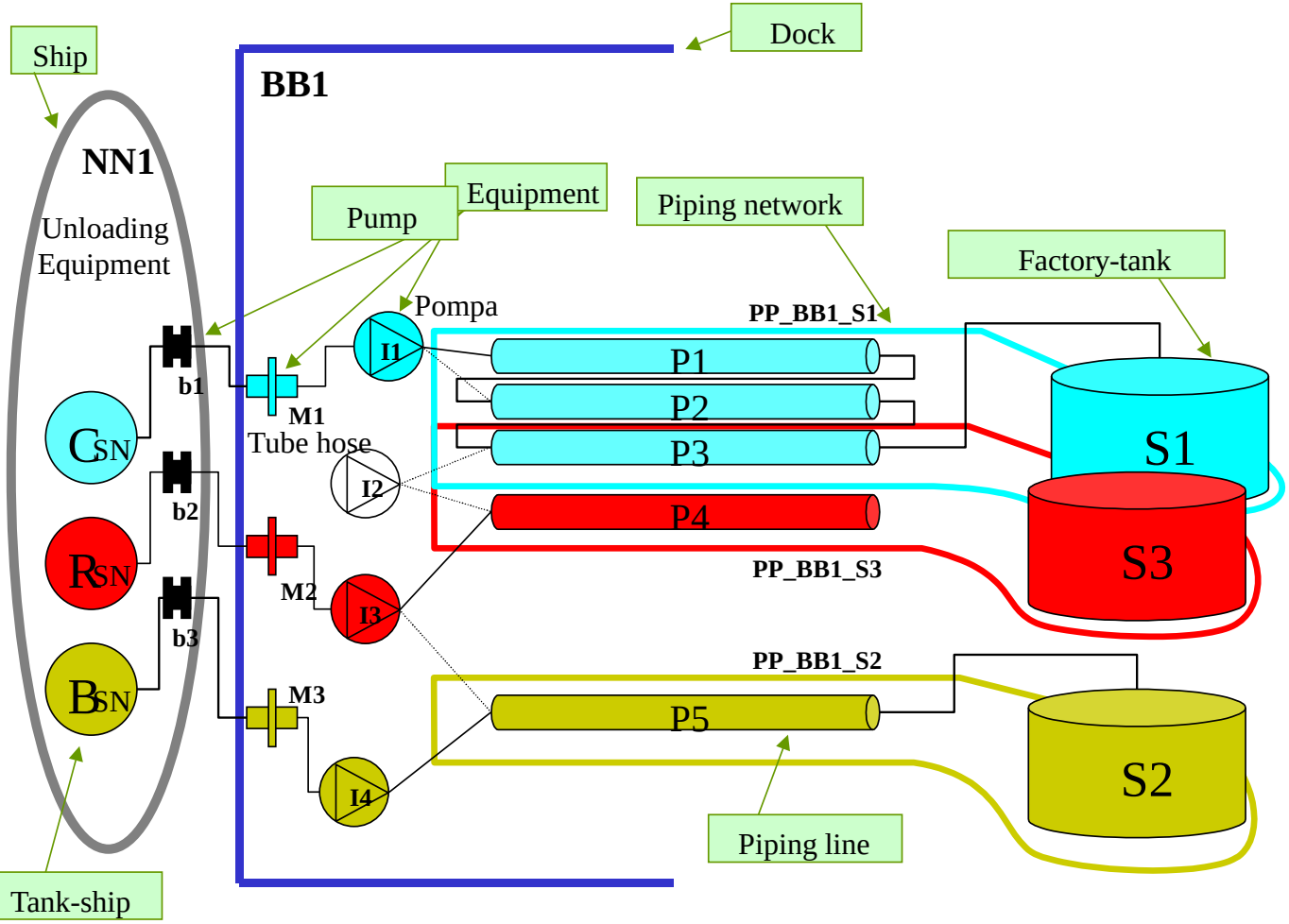
Vector Model





Simulation Team

Terminal Model



Example: the unloading of R (Red) is blocked by the piping line (P3) required by The piping network PP_BB1_S3, which is already used to unload C (cyan)

Cost of the Mission

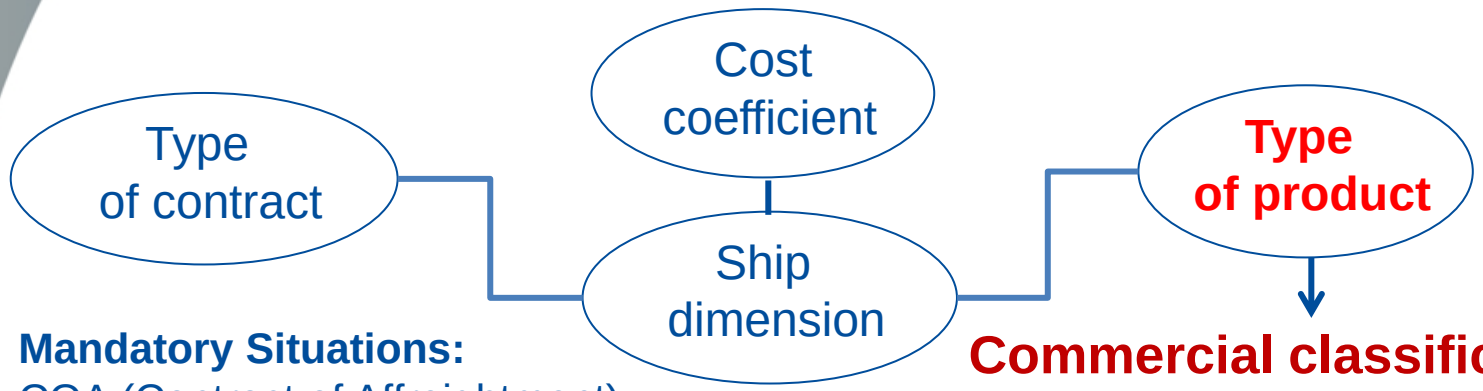
- It is evaluated as a combination of the time required by the mission cycle, of the engaged capacity (Q_{max}) during this period and a coefficient of cost:

$$Mission\ cost = Cost\ Coeff \cdot Q_{max} \cdot (time\ of\ mission\ cycle)$$

- Cost Coeff [$/t·day] depends on the type of product to be transported, on its inherent risk, on the dimensions of the ship and on the type of stipulated contract (COA, Spot and Time Charter)
- Q_{max}= Max($Q_{j\text{-th sea-leg}}$) with (j=1,….,s), where $Q_{j\text{-th sea-leg}}$ is the sum of the Flows pertaining to the j-th path
- The time of mission cycle depends on the navigation time, on the *impact factors* typical of the ports, of the sea and of the docks, and on the time required for the uploading/downloading operations.

Factors influencing the coefficient of cost:

Mission cost = Cost Coeff · Q_{max} · (time of mission cycle)



Mandatory Situations:
COA (Contract of Affreightment)
Ship owner undertakes the obligation to carry specified cargoes between specified ports

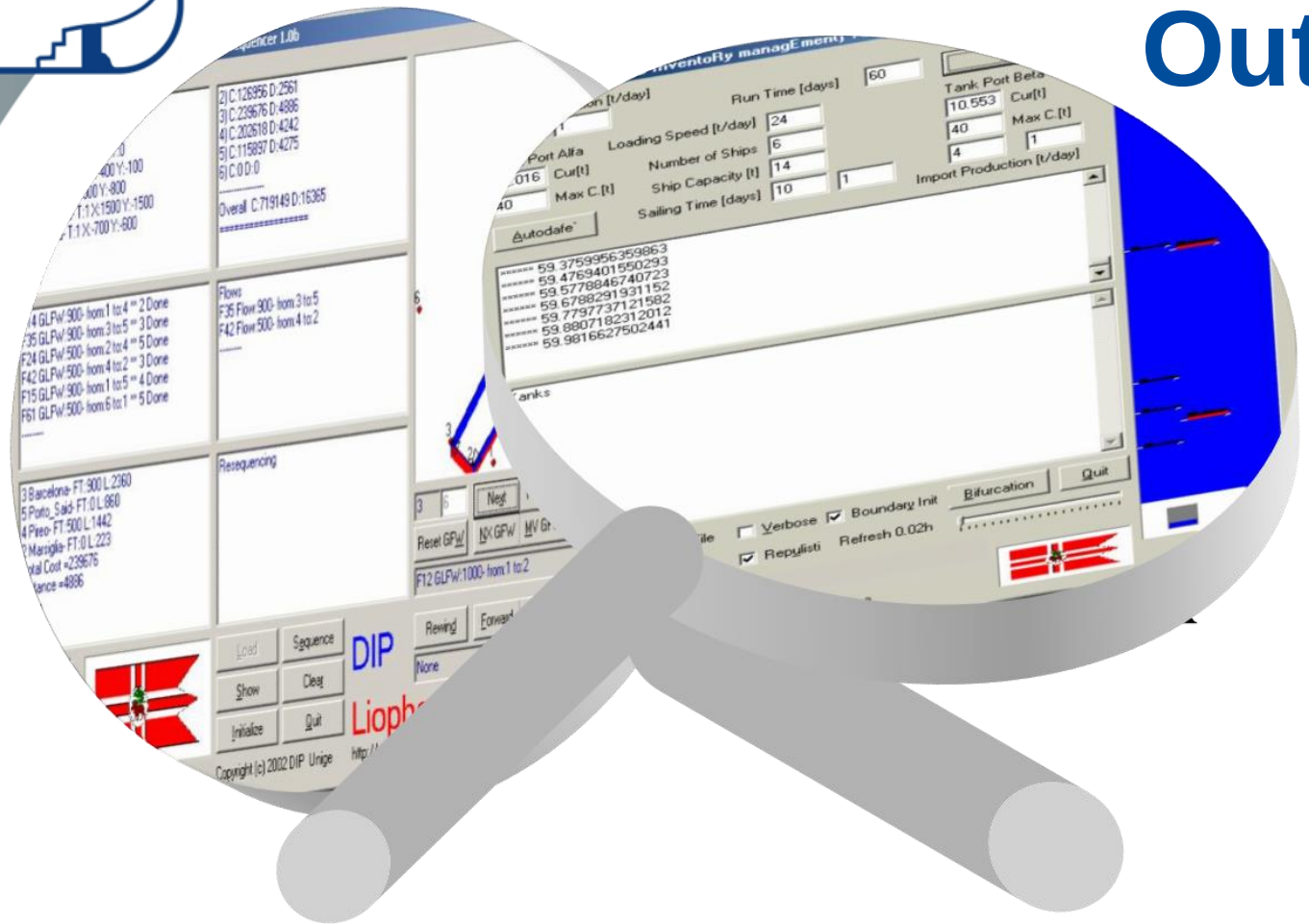
Optional Contract:
-Spot charter terms
-Flexible combinations

Commercial classification of chemical products
Commodity chemicals
Specialties
Fine chemicals

Risk factors for chemicals:
Inherent hazard of chemicals
Chemical industry supply chain transportation risk

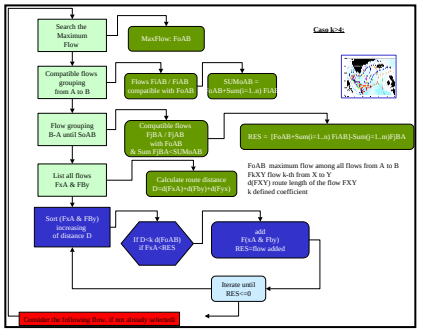
Simulation Team

Reference Models Worked Out



Petrochemical Logistics DSS

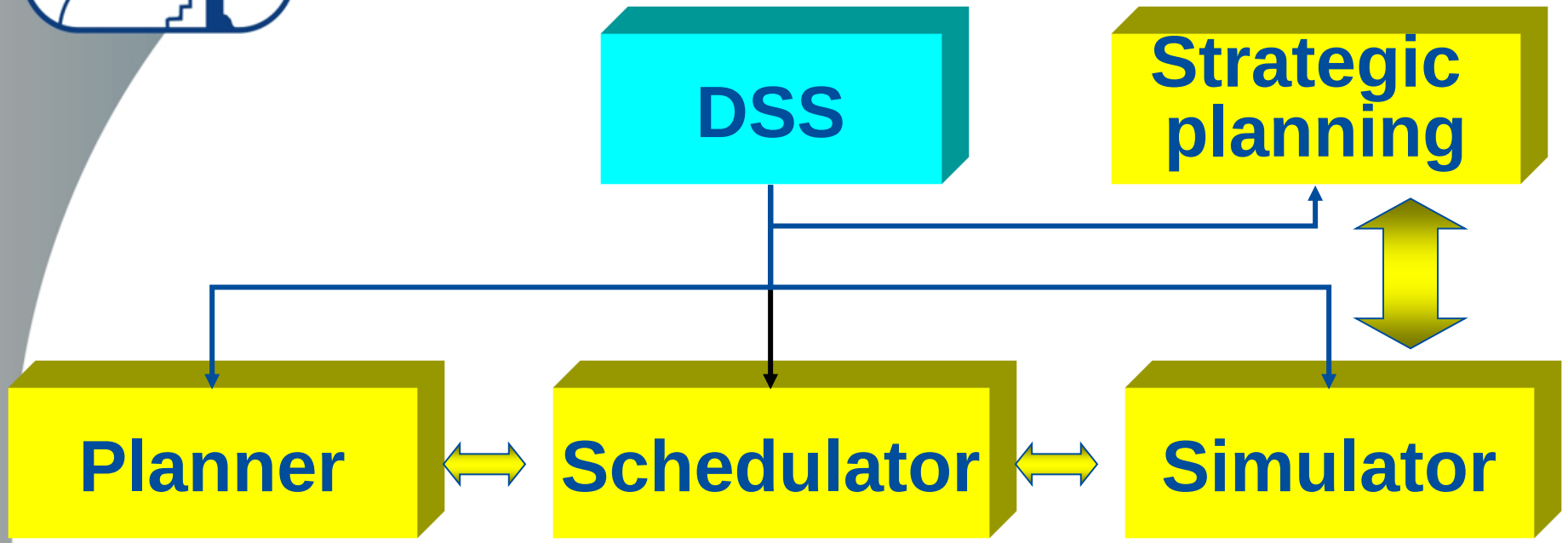
- Working out methods for the development of an innovative Decision Support System (DSS) for the maritime logistic management of a Petrochemical Industry
- Developing alternative Systems of Analysis and Optimization Techniques for a Maritime Petrochemical Logistic System
- Validating and integrating the DSS in the holding system (i.e. Processes and ERP)



DSS Objectives

- Making the decision process independent of the role of a single expert person in the logistic sector
- Realizing a real time monitoring of the tank levels, of the ship positions by GPS and calculating the relevant ETA (*Estimated Time of Arrival*)
- Supplying methods, tools and basic information to obtain:
  - ★ *Strategic choices about the plants*
  - ★ *Optimal fleet configuration*
  - ★ *Better assessment, selection and trading of ship charter agreement*
  - ★ *Better operative choices on ship Planning/Scheduling*

DSS Architecture



- Being a Complex System, it is essential to develop a campaign of tests for platform assessment and validation.
- The approach here proposed refers to the Directive 5000.61 and RPG enforced as Standard VV&A by DoD USA

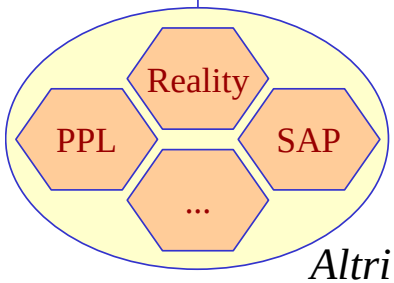
Simulation Team

DSS

Function and field constraints

Aggiornamento

Other information Systems



Altri Sistemi Informativi

Data Sharing

Optmizing

Metamodels

Optimizer

Fine Tuning

Simulator

Quick Evaluation for Optmizing

Manual User

Manual planner

Planner

SemiAutomatic

Heuristic planner

Automatic Generation

Plan

Simulation Scenario

Optmizing Process

Fast Generation of Simulation Scenario

Manual User

Manual Schedulator

Schedulator

SemiAutomatic

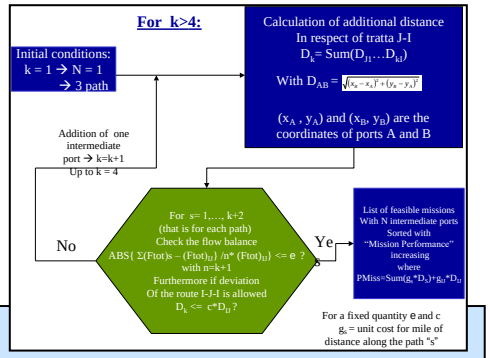
Heuristic Schedulator

Automatic Generation

Schedule

Optmizing Process

CHARME Sequencer Utilities

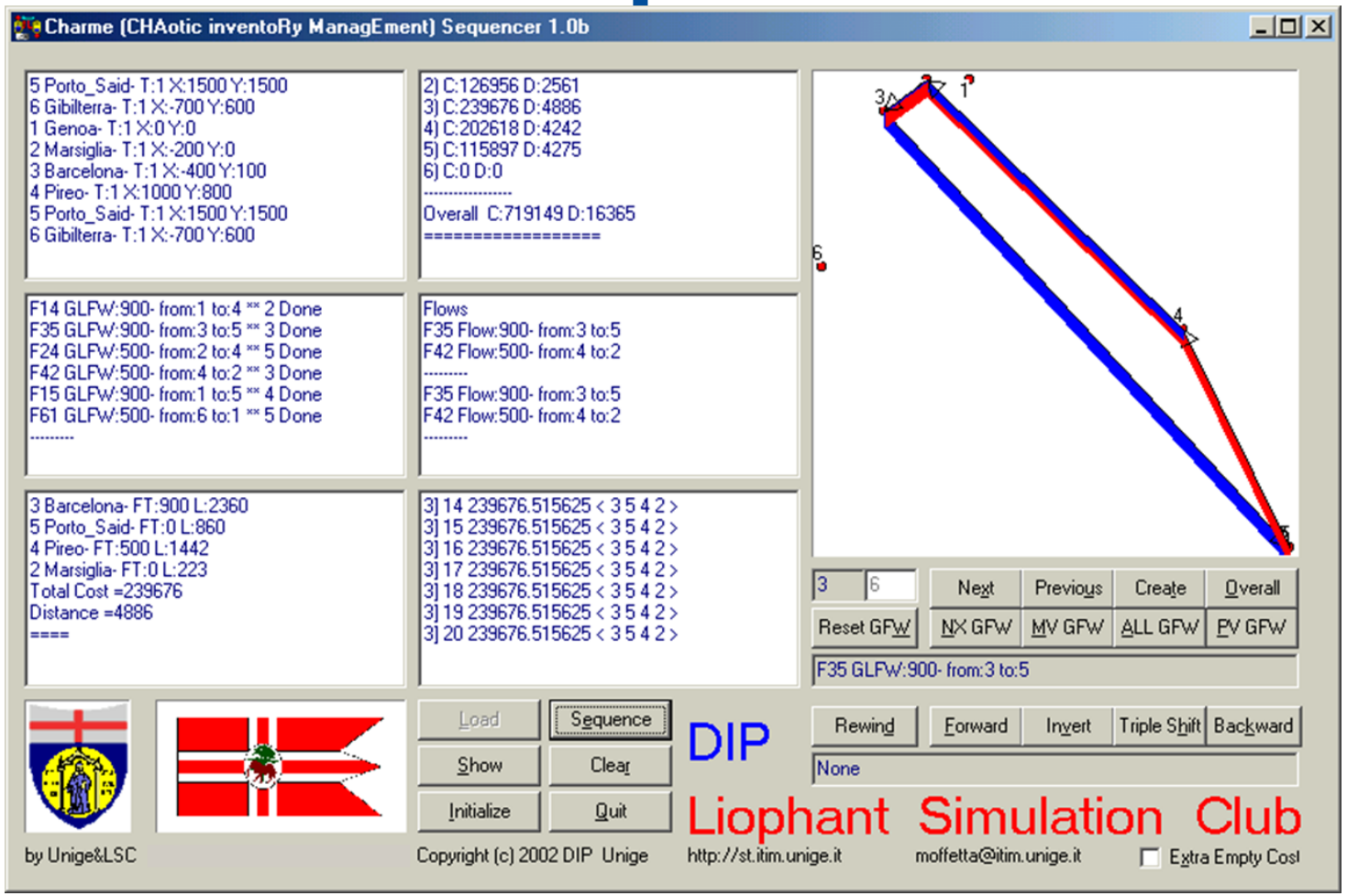


- **Simulation of:**
  - **Navigation (Stochastic Estimated Time of Arrival)**
  - **Docks Upload/Download**
  - **Saturation level in ships**
- **Tactical mission management**
- **Evaluation of different port sequences**
- **Evaluation of different grouping choices between Flows**
- **Evaluation of the cost function of the tactical missions**

Simulation Team

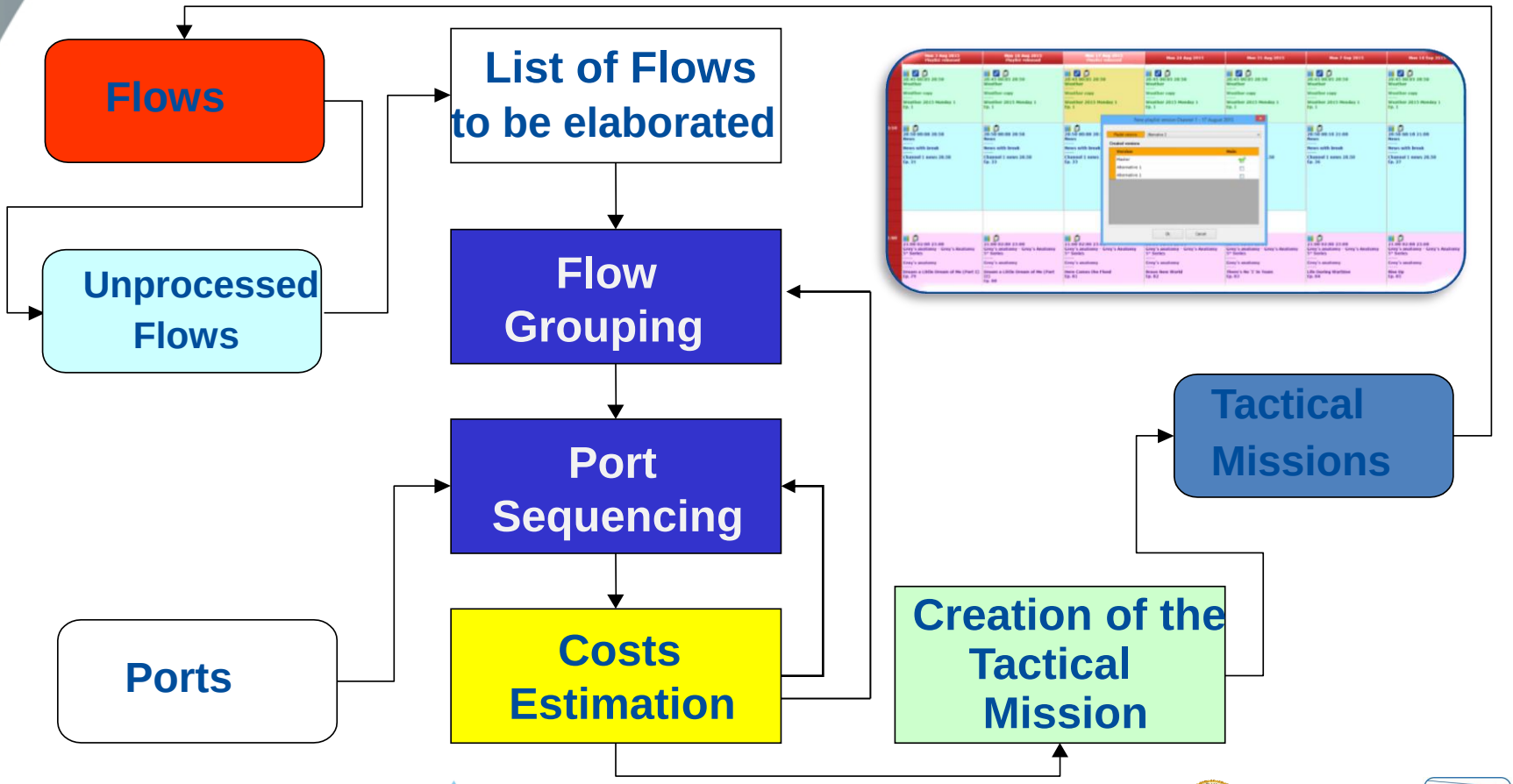
Charme Sequencer

Smart Optimizer & Simulator



Simulation Team

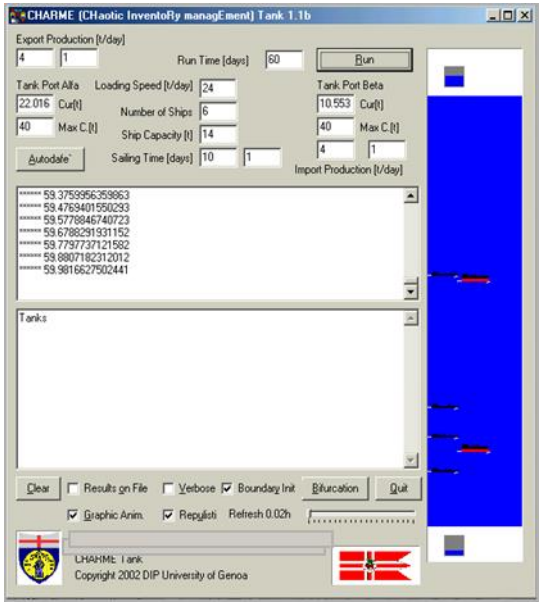
CHARME Procedure Sequencer



Simulation Team

CHARME Tank Objectives:

- Identifying the critical aspects in the management of the ships transporting chemical products;
- Setting out a support methodology aiming at validating Complex Systems;
- Applying the fundamentals of the Theory of Chaos to stochastic problems of the maritime logistic system

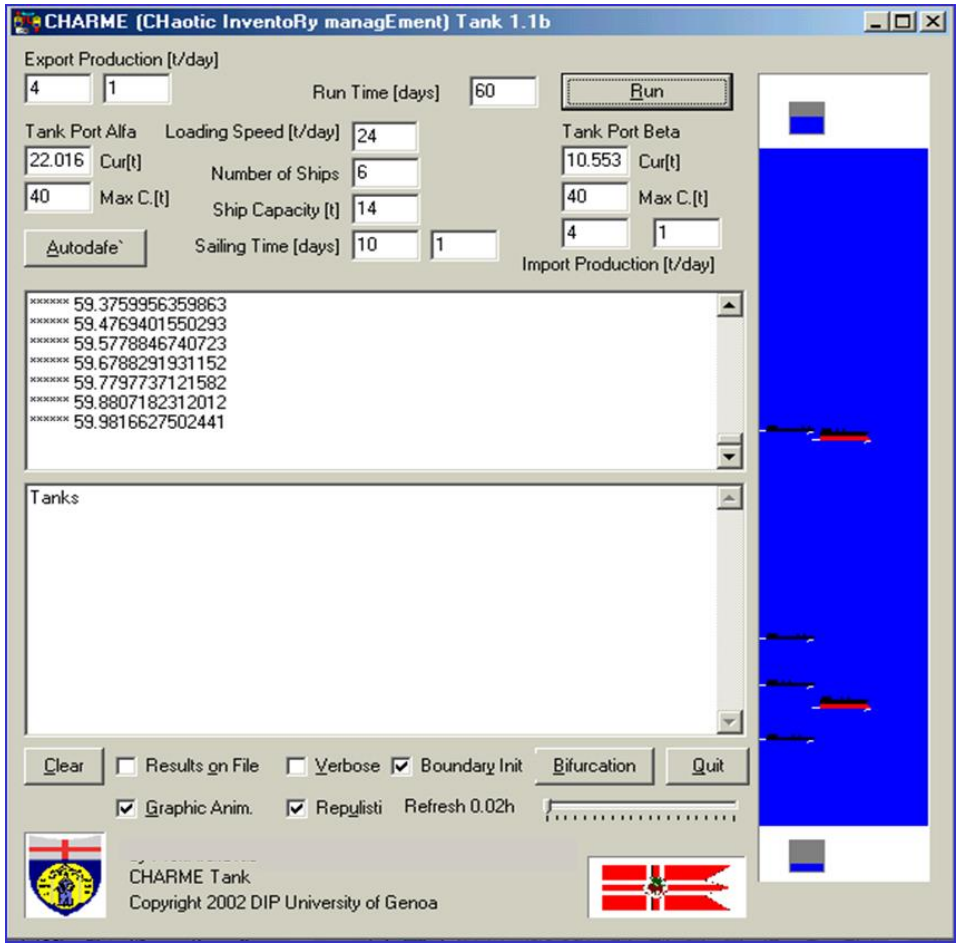


Charme Thank Simulator

Simulation Team

Charme Tank with 6 Ships

CHAotic inventoRy ManagEment



Discrete Event Stochastic Simulation

It is very important to conduct Validation, Verification and Accreditation of the model and to measure Experimental Error

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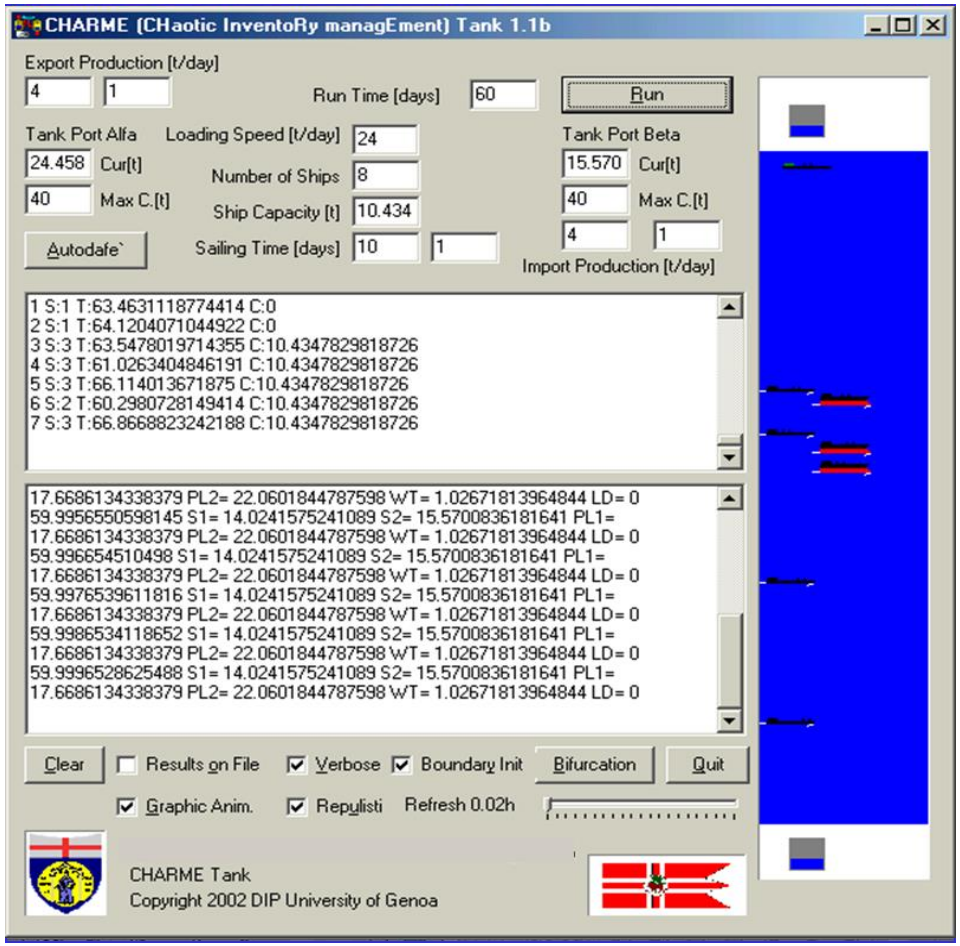
Charme Tank with 8 Ships

CHAotic inventoRy ManagEment



Discrete Event Stochastic Simulation

It is very important to conduct Validation, Verification and Accreditation of the model and to measure Experimental Error

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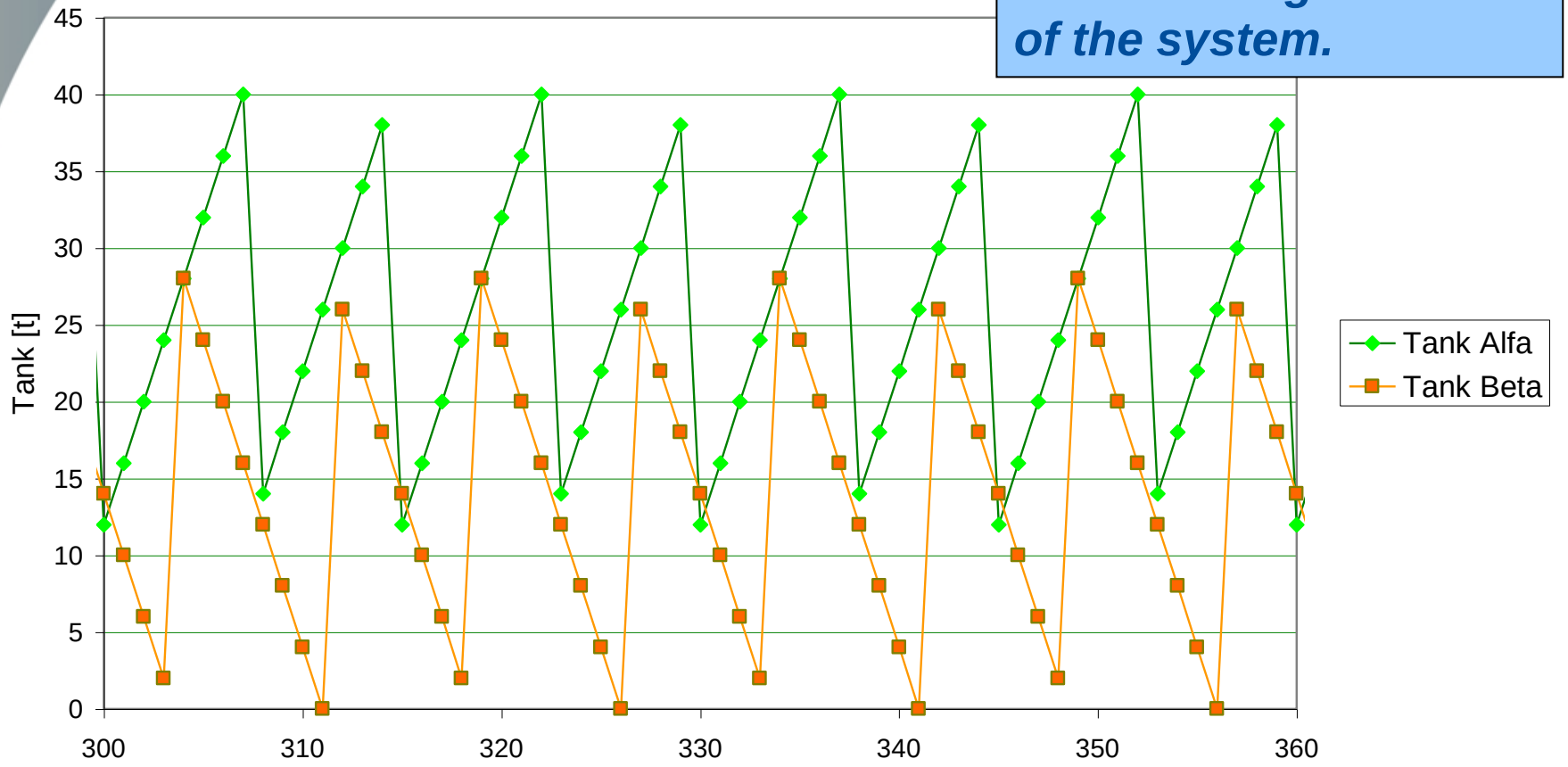
Simulation Team

Deterministic Model

Tank Behaviour

The deterministic model with 3 ships shows a regular trend of the system.



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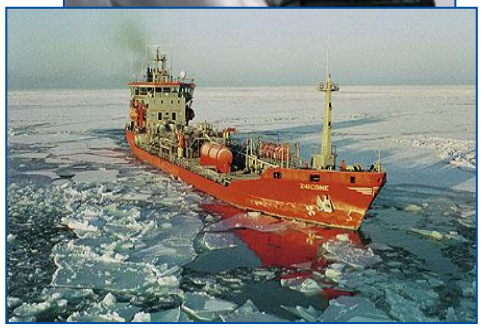
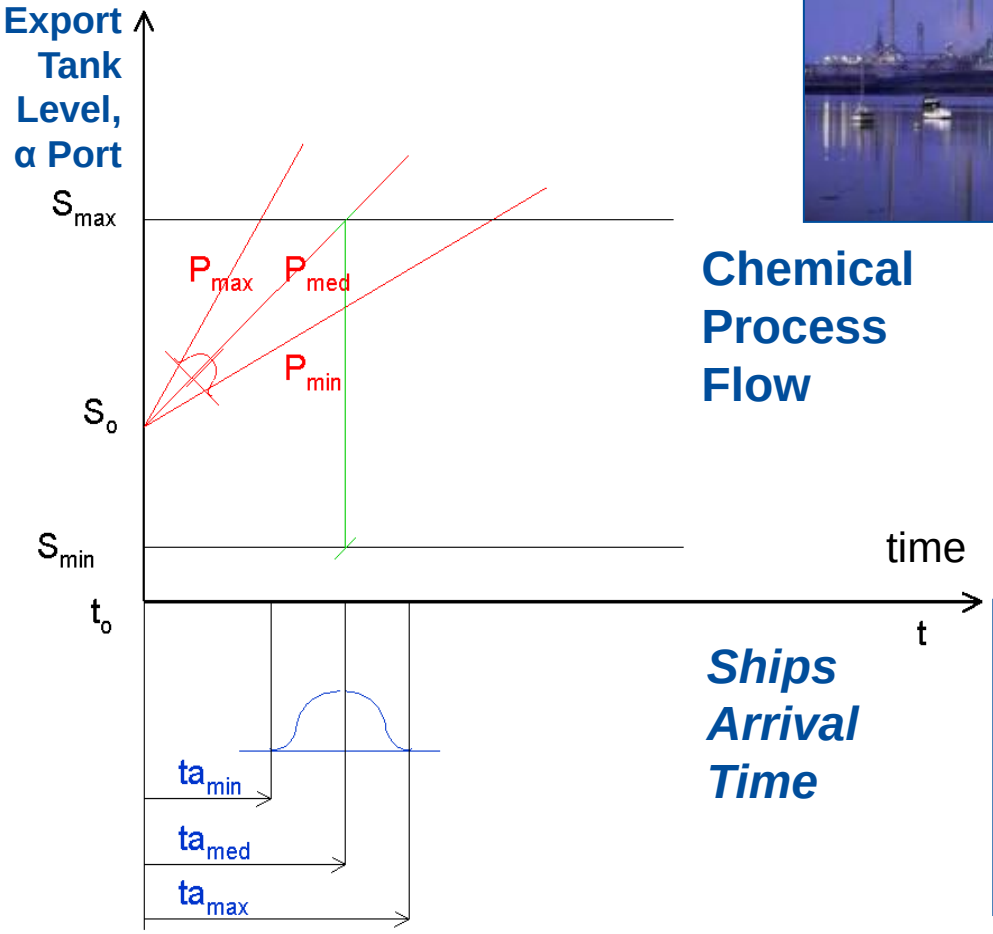
The role of Stochasticity (1/2)



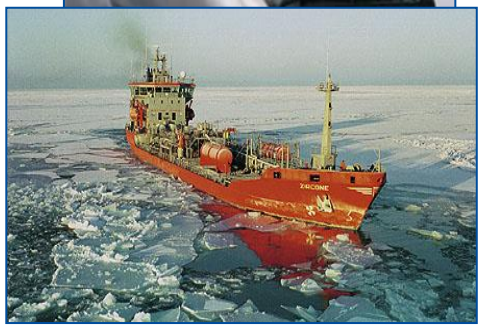


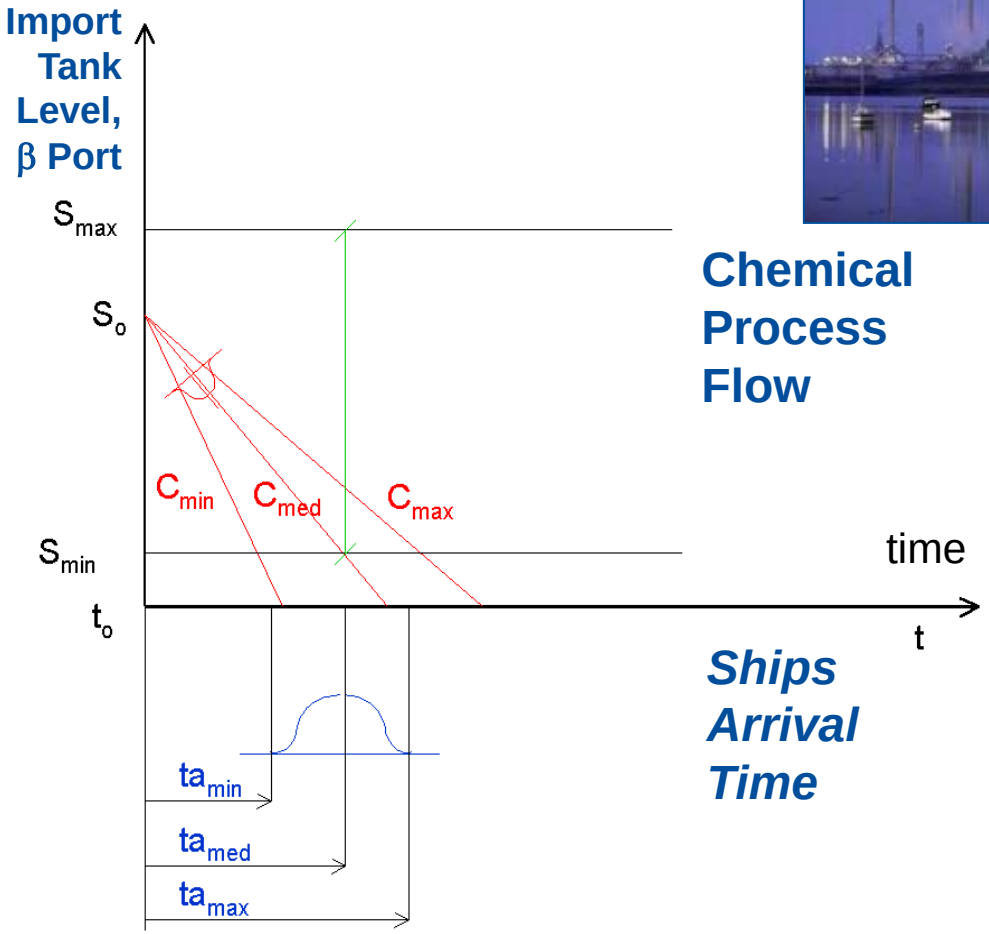
Chemical Process Flow

Ships Arrival Time

Simulation Team

The role of Stochasticity (2/2)





Chemical Process Flow

Ships Arrival Time

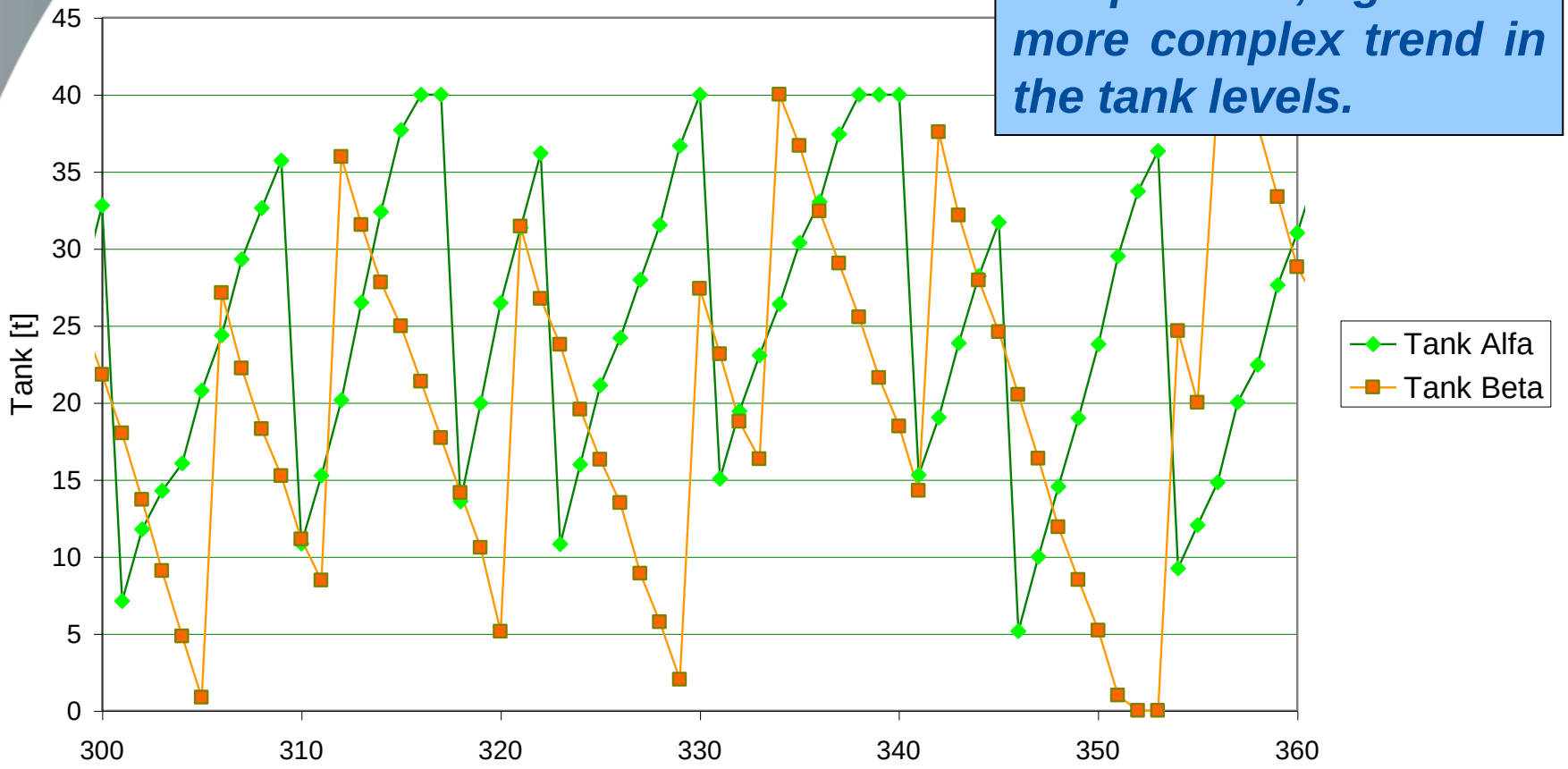
Simulation Team

Stochastic regime

with a limited number of ships

Tank Behaviour

A model with 3 ships, with some stochastic components, gives a more complex trend in the tank levels.



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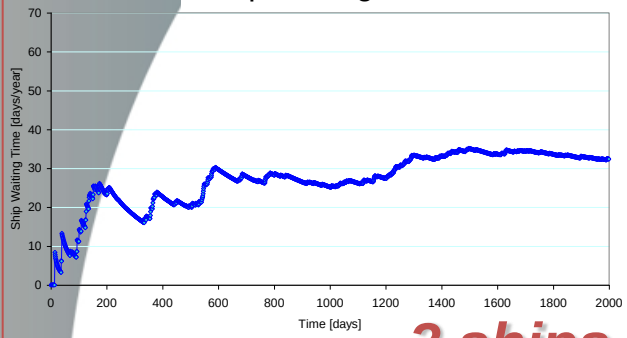
Risks and Interferences

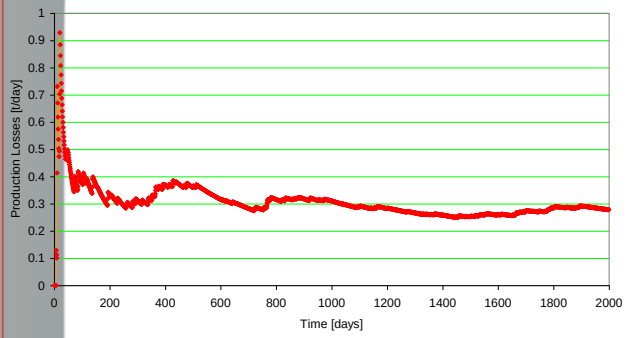
For a growing number of ships, there is a decrease in production losses & in the relevant risk levels, but the interference & the costs of Demourrages increase

Ship waiting time

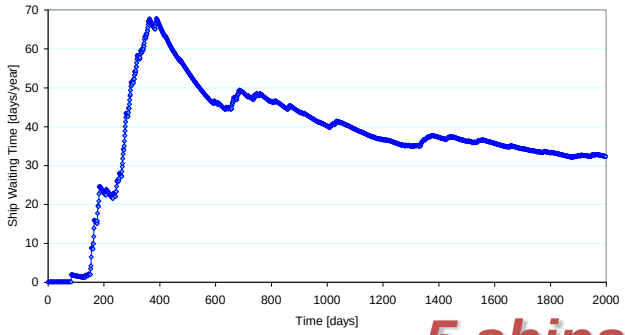


3 ships

Production losses

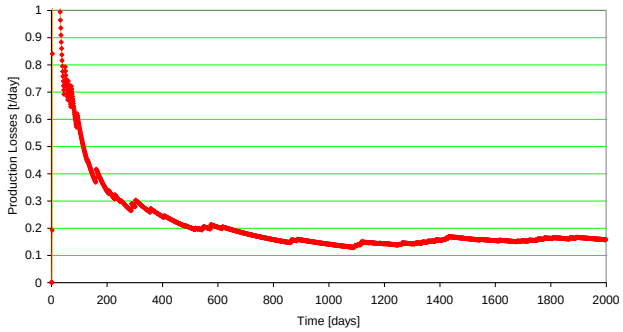


Ship waiting time

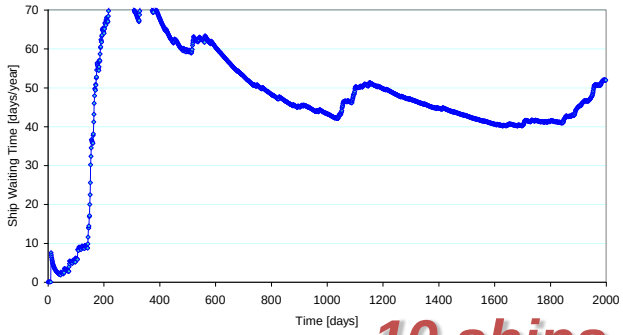


5 ships

Production losses

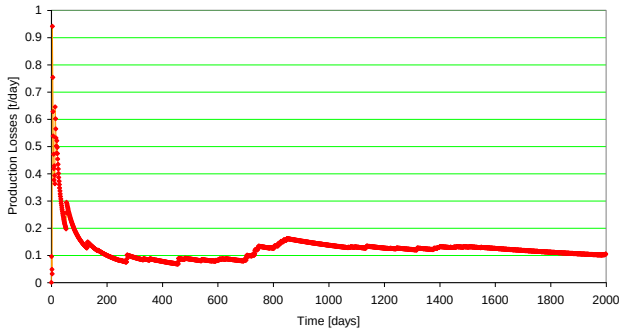


Ship waiting time



10 ships

Production losses

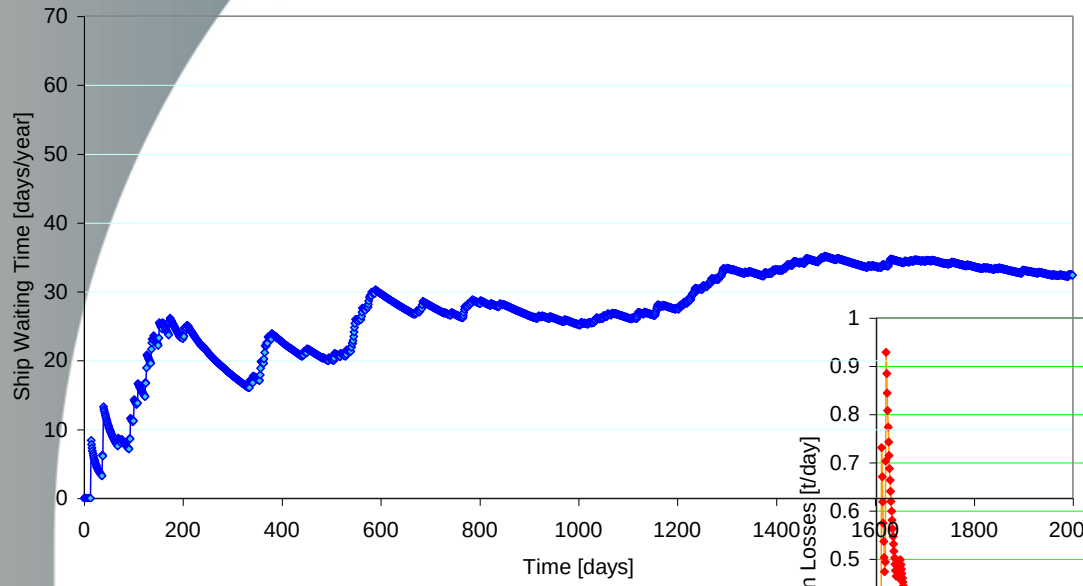


Simulation results obtained with Charme Tank on the same plant scenario

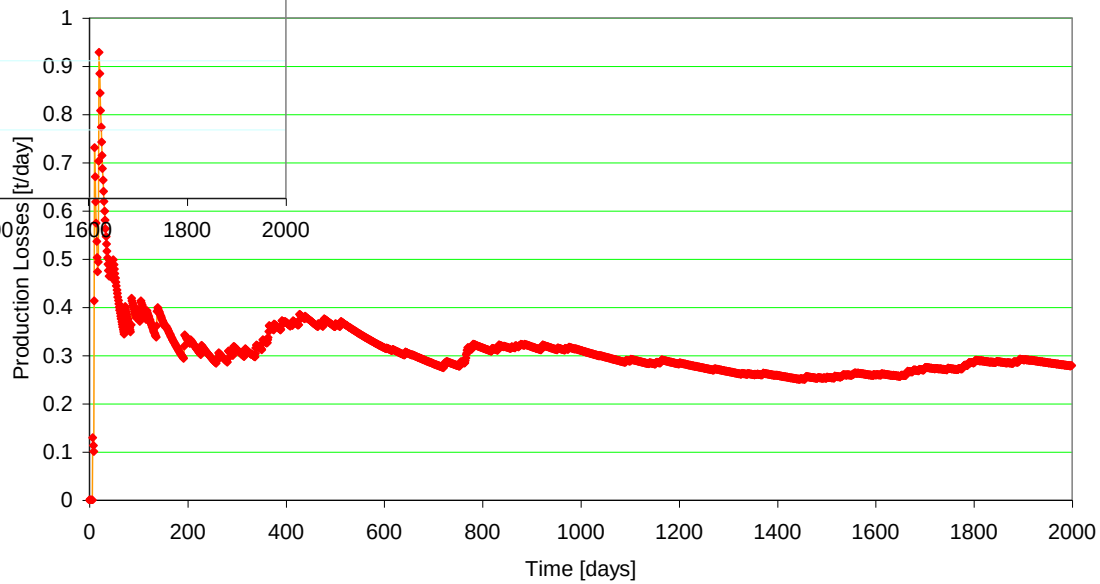
Simulation Team

Case with 3 ships

Ship Waiting Time



Production Losses



3 Ships

Simulation results obtained with Charme Tank on the same plant scenario

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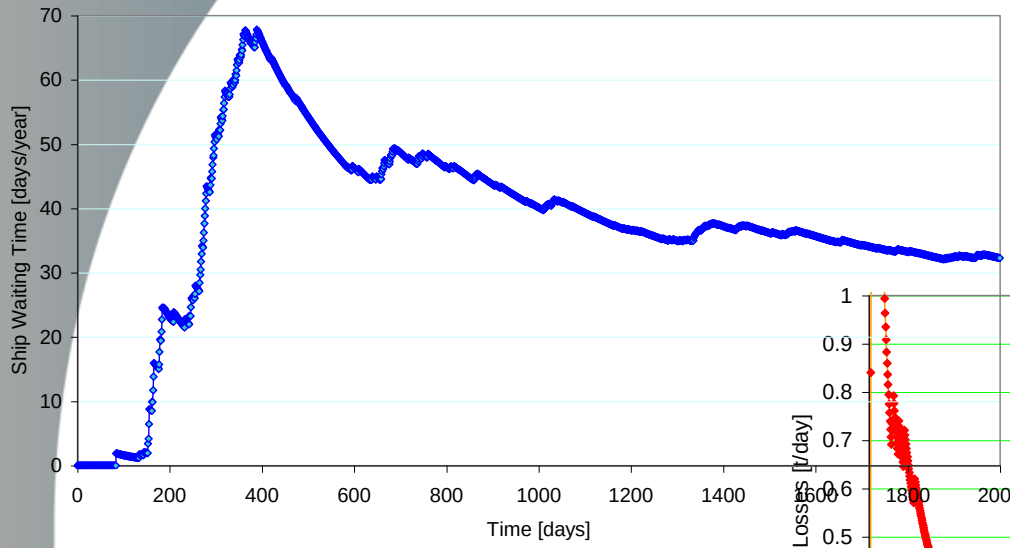
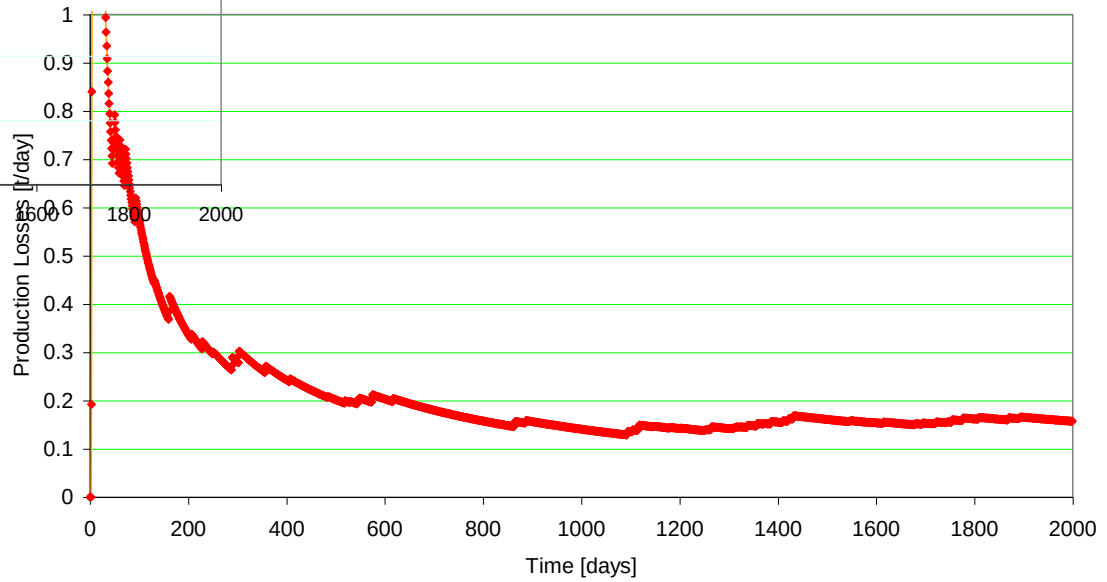
Risks and interferences

5 ship

Ship Waiting Time



Production Losses



5 Ships

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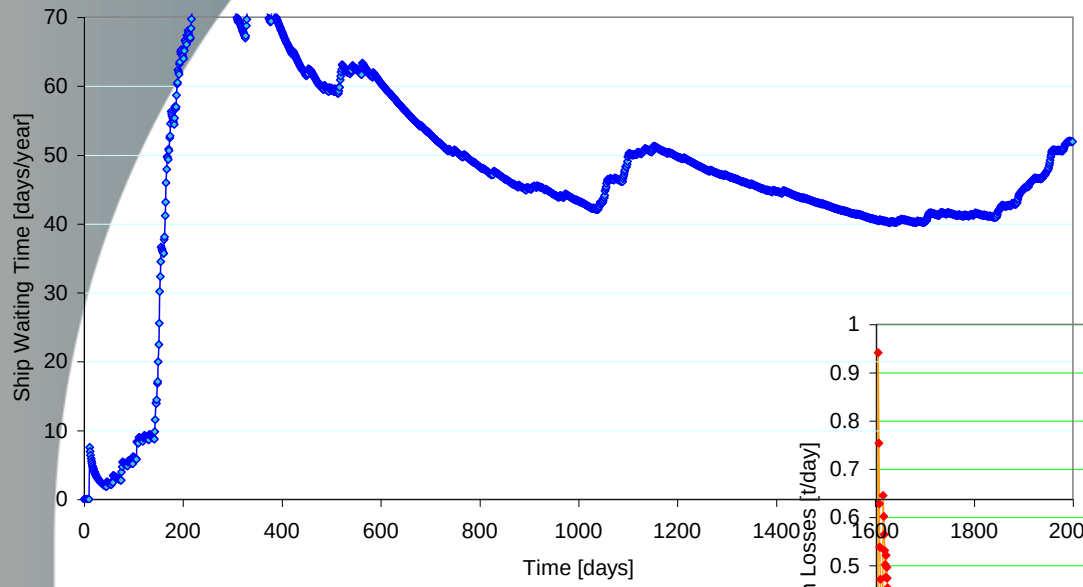
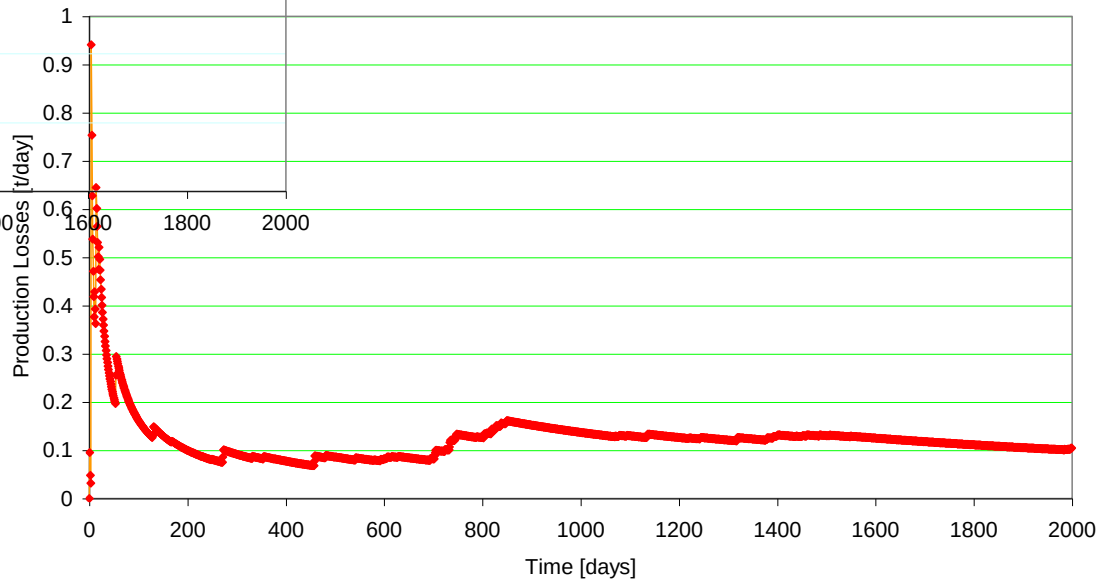
Risks and interferences

10 ship

Ship Waiting Time



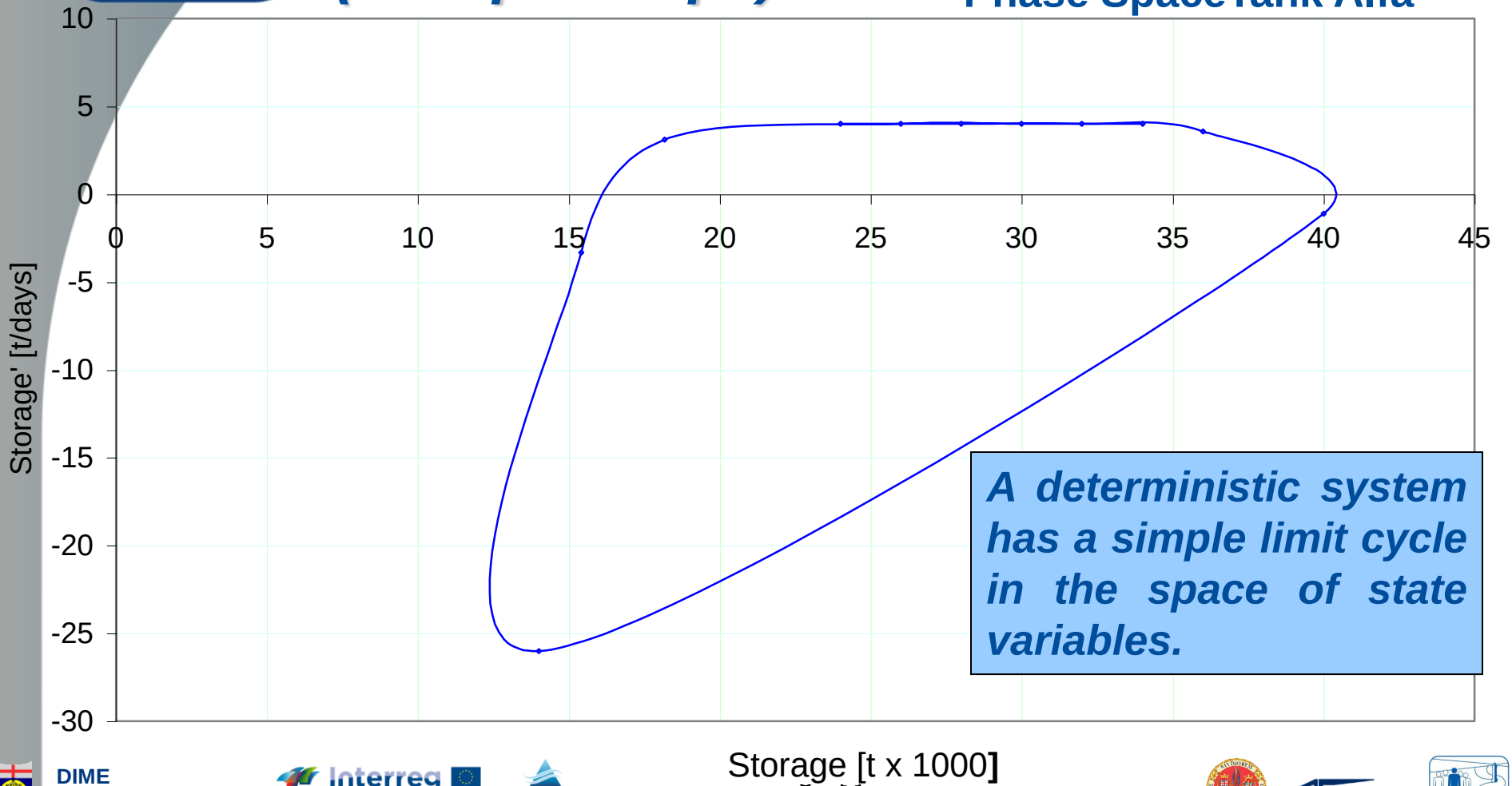
Production Losses



10 Ships

Space of the state variables of the Export Tank in a deterministic regime *(Multiple Ships)*

Phase SpaceTank Alfa



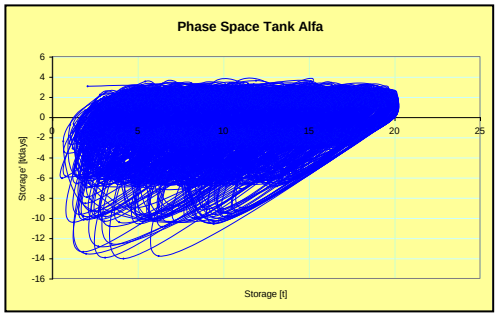
A deterministic system has a simple limit cycle in the space of state variables.

Chaos Analysis Techniques

The methodology of analysis is based on:

- Time trend of the objective functions
- Phase Space Analysis of the objective functions
- Poincaré Map of the objective functions
- Lyapunov Exponent calculation on times for the classification of Chaotic Attractors

- Chaotic Threshold Identification by bifurcation diagrams



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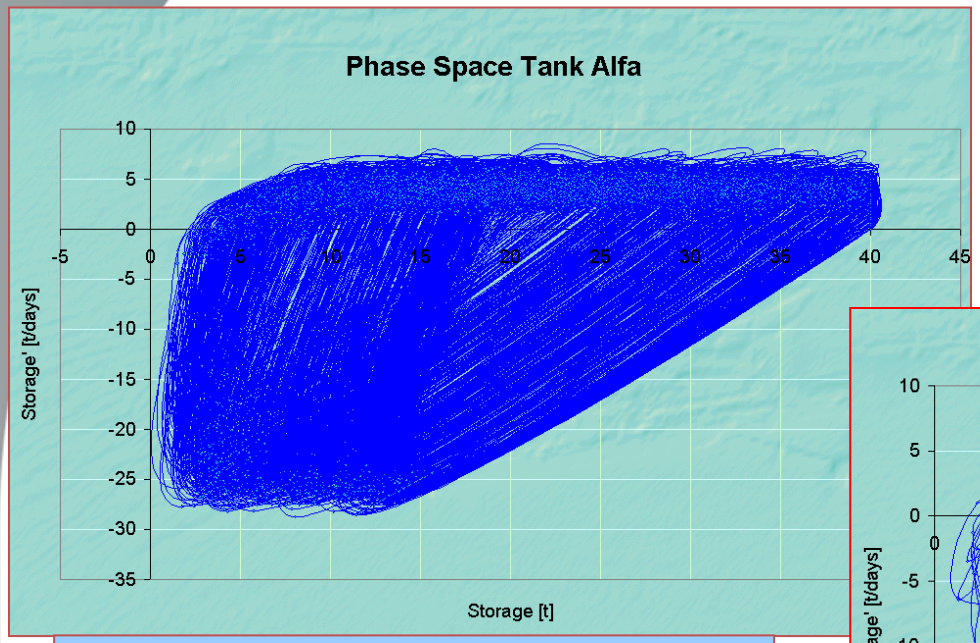
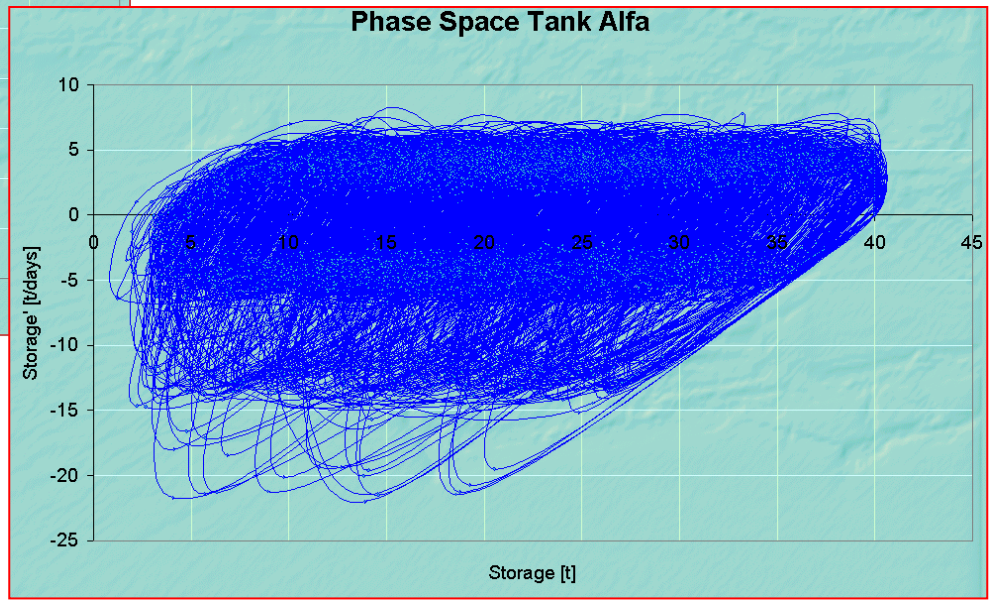
Space of the state variables of the Export Tank in Stochastic Regime



If many ships are affected by a stochastic forcing, the space of state variables has a greater complexity.



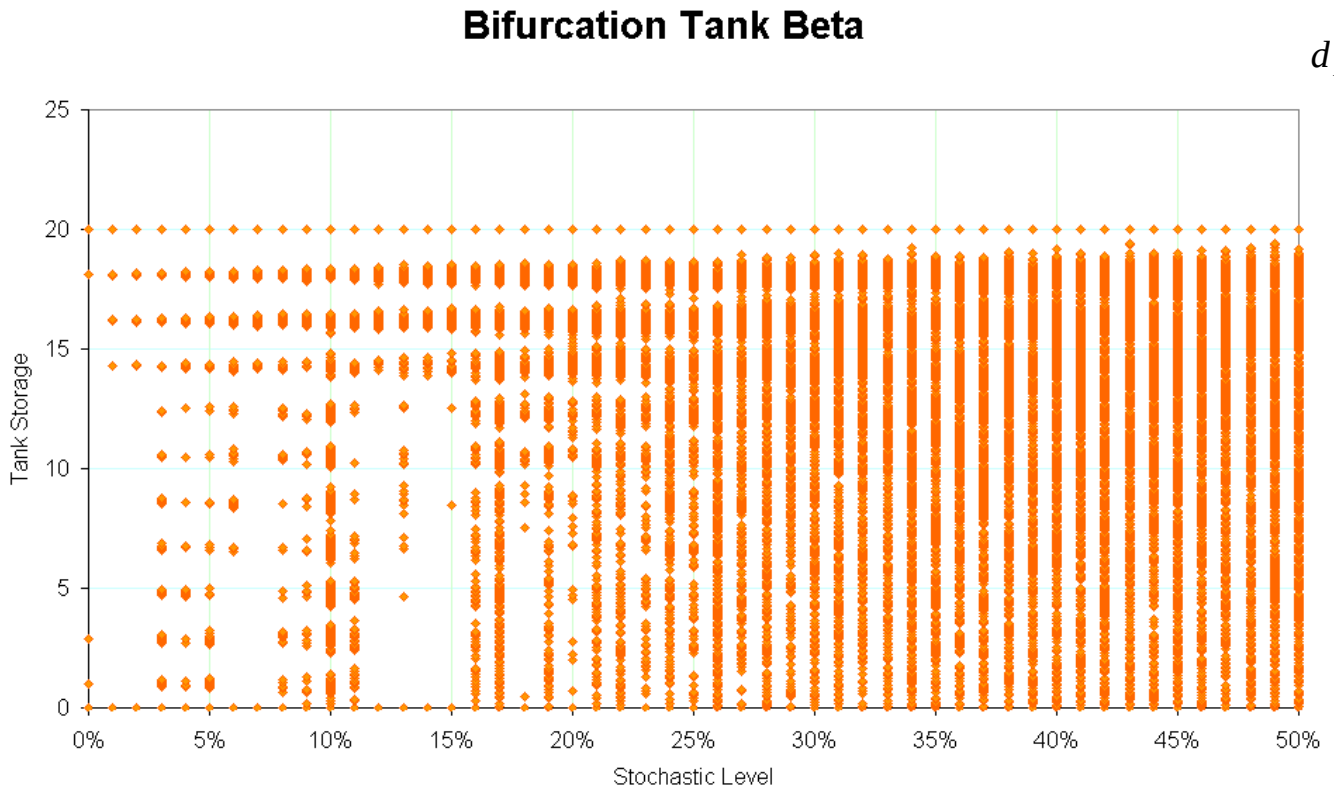
In a stochastic regime, with a limited number of ships, the space of the state variables gets progressively complex, but the map has still sharp contours.

Bifurcation Diagram

$$D' = D \cdot e^{\lambda(t'-t)}$$

$$d_L = k + \frac{\log\left(\prod_{i=1}^{k} \lambda_i\right)}{\log \frac{1}{\lambda_{k+1}}}$$

$$d_L = 1 + \frac{\lambda_1}{\lambda_2}$$



It can be observed that, even with a minimum level of stochasticity, a "chaotic" trend is easily generated.

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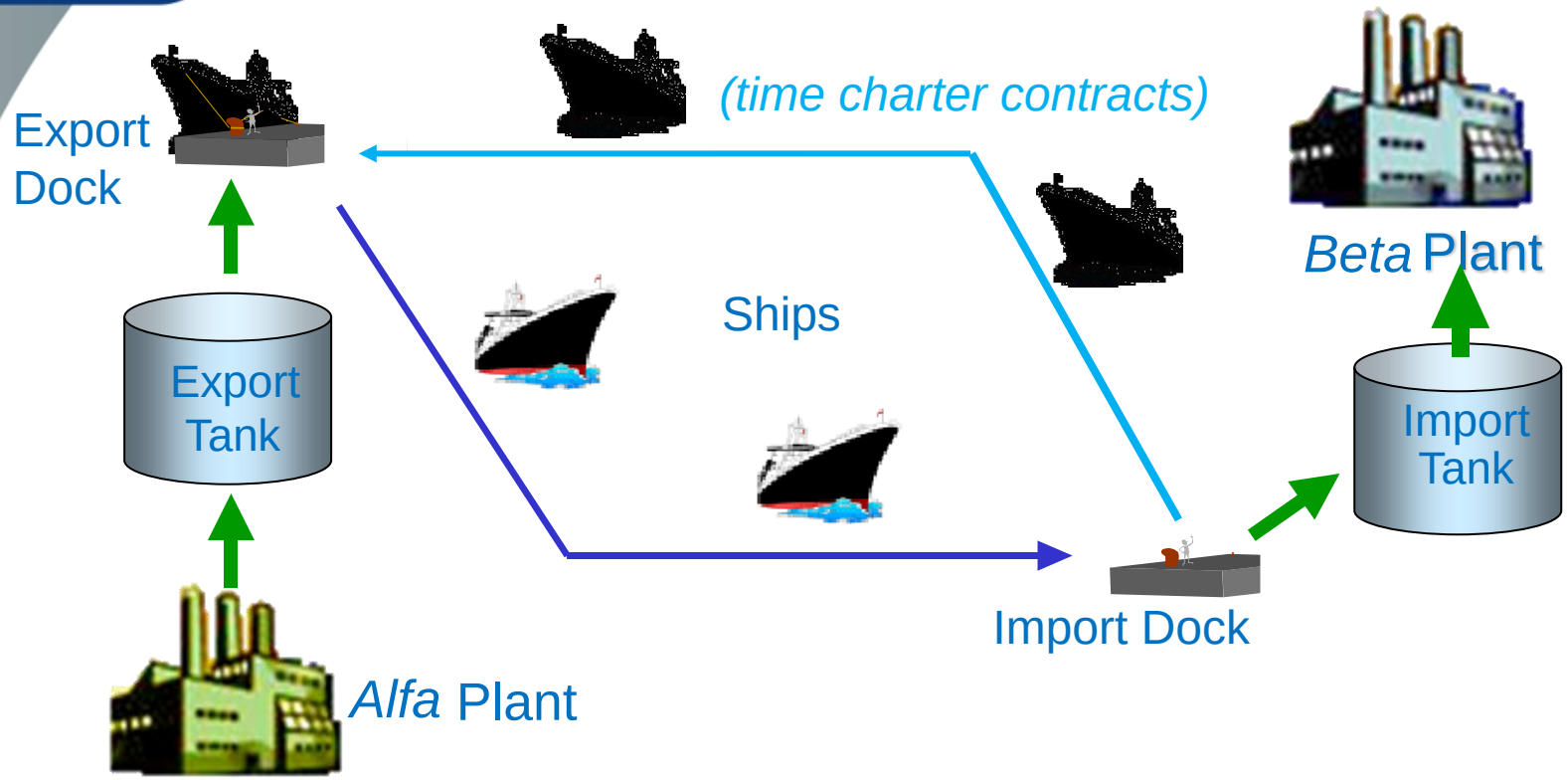
Chemical Logistics: Exerise



We will focuse on Simplest Case that could be further generalized to more ports & flows

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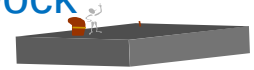
Logistics Case Basic Numbers

Time Charter Contracts

Production: 2’500 tons/day

Ship Loading Speed: 2’000 tons/h

Export Dock



(time charter contracts)

Beta Plant

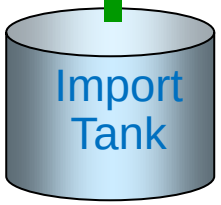
Capacity: 32’000 tons

Ships

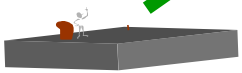
Export Tank

Capacity: 28’000 tons

Navigation Time: 6 days



Import Tank



Import Dock

Ship Unloading Speed: 3’000 tons/h

Alfa Plant

Production: 4’500 tons/day

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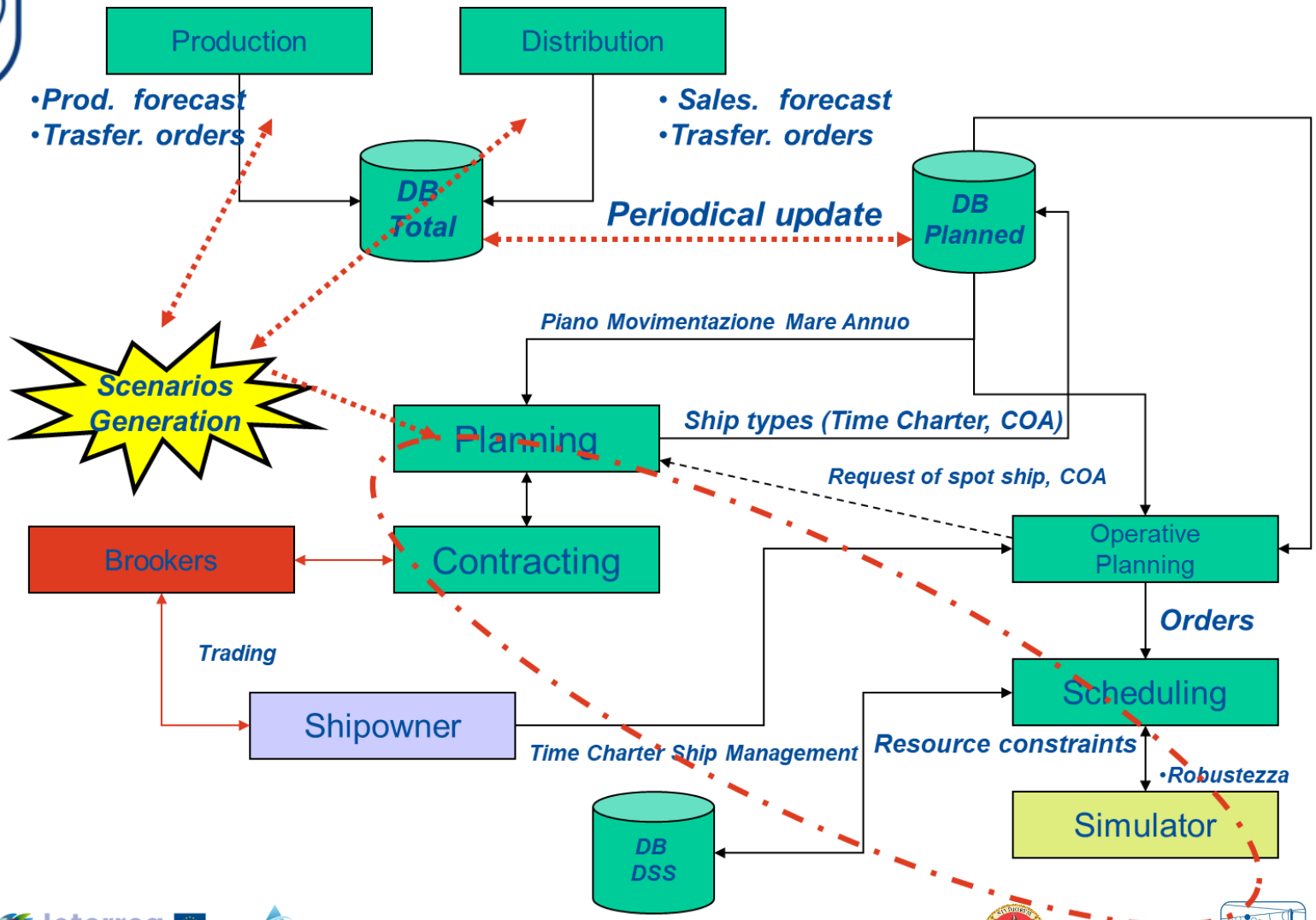
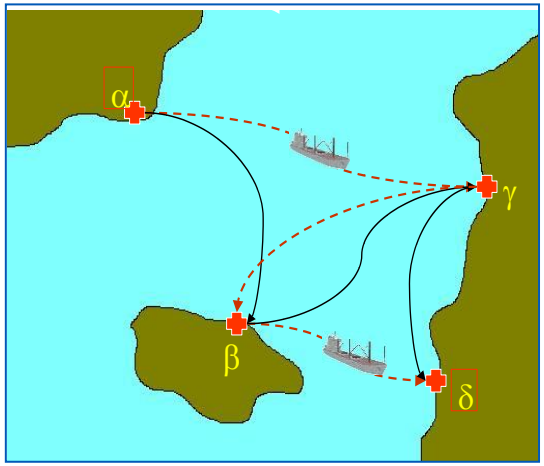
DSS General Architecture



Interactions: Data & Knowledge

- The DSS database updates the holding information system in real-time
- The working scenarios may be created without affecting the current operative database
- Each *user* may modify the scenarios provided he is duly autorized

- A hierarchical Authorization System maintains the reference system, representative of the current state, to perform the Planning and the operative Scheduling. In general it is crucial to coordinate strategic investments, planning and operational schedule



Simulation Team

Expected benefits

- Helping in restructuring of port and production facilities with quantitative analyses

- Reduction of Stock-Out and Over-Stock risk in the production plants

- Reduction of Maritime-Logistical costs of chemical products

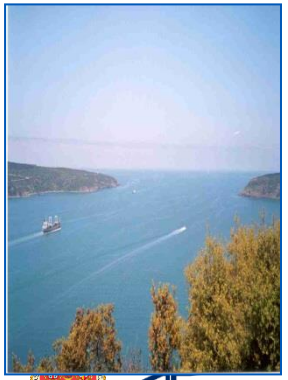
Simulation Team

Summarizing

- The use of DSS allows a better planning and management of the resources for the shipping of chemicals, with respect to the traditional techniques, reducing the global cost of transport and the relevant risks

- The CHARME models supply valid tools to perform tests for assessment, validation and accreditation of the Decision Support System here developed. In this way it becomes possible to finalize strategic decisions even in problem of difficulties

- The Theories of Caos can be applied in the study of maritime transport problems
- The specific worked-out procedures allow the integration of the DSS in the Holding



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Simulation Team

Conclusions

The Simulation Team is acting at international level as a reference point between users and providers in simulation area.

The integration of experts, technicians is providing very good results on real case studies and complex projects.

An active area of development is related to distributed simulation and web-based modeling for extending the impact and exploitation of these proposed systems.

Every year Simulation Team - MITIM DIME and Liophant organize major Conferences and International Workshops focusing on application of Modelling & Simulation.

For instance the I3M2019 was in Lisbon, SummerSim2019 in Berlin, WAMS will be in Singapore and other events have been organized worldwide

There is a constant interest in fostering joint cooperation and exchanges with international Excellence Centers working on simulation.

In 2020 Prof.Bruzzone serves as General Chair of WAMS in Linz as well as of I3M in Athens: this last conference represent one of the major scientific event worldwide in simulation: i.e. the I3M2011 organized in Rome, joint to CAX Forum, probably was the largest scientific event in M&S worldwide, involving over 500 speakers from 56 countries and over 30 live demonstrations (including Distributed simulation connecting NASA, MIT and Genoa University)

SPECTS

Summer Computer Simulation Conference

Berlin

WISH

MAS Modeling & Applied Simulation

EMSS

I3M

HMS

Lisbon

IMAACA

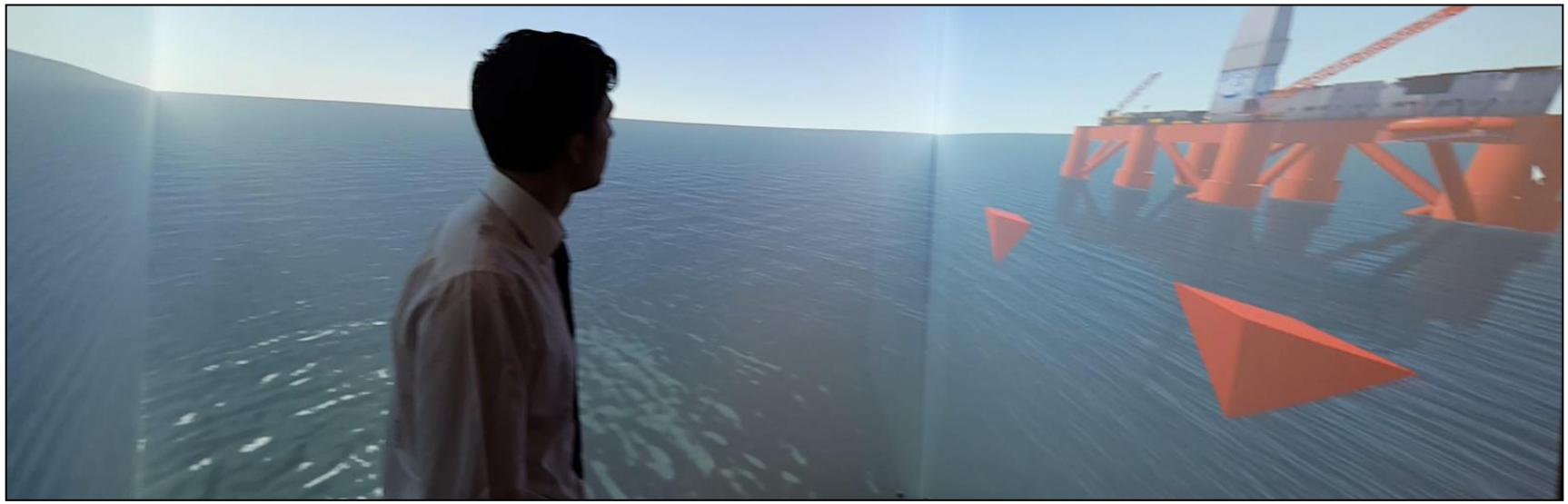
Springsim

Tucson

DHSS

Don’t Worry…

… just Simulate and Solve!



Simulation Team

References

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DIME