Simulation Team

Modeling & Design of Complex System

Intro to Case Studies

Liophant Simulation

M&S Net

McLeod Institute of Technology and Interoperable M&S Genoa Center

Agostino G. Bruzzone

agostino@itim.unige.it

www.simulationteam.com
www.liophant.org
www.itim.unige.it/strategos

www.itim.unige.it/cs/strategos/edu/complexsystems

DIPTEM
University of Genoa

Simulation Team

Who's Who
Agostino G.Bruzzone

- Basic Engineering Studies in Italian Naval Academy, Pisa and Genoa University
- Mechanical Engineer
- Expert in Modelling & Simulation, Project Management, Operation Management, AI & IA, Industrial Plants &Logistics
- Expertise as Freelance Consultant for Industries, Companies, Ports, etc.
- Experience in Projects with Major Companies (i.e. IBM, LMC, Boeing, FCA, Ansaldo, Leonardo, Solvay) & Agencies (i.e. EDA, NASA, NATO, DGA, DoD, Navy, etc.).
- Full Professor in DIME, 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
- Founder & former Leader of the Simulation Program of the NATO STO CMRE
- Project and Program Manager in R&D Initiatives & Joint Ventures with Industries & Agencies for several MUSD along last years
- Director of the Master Program in Industrial Plants & MSc STRATEGOS in Strategic Engineering of Genoa University
- President of Liophant and Simulation Team
- General Chair of major conferences (e.g.I3M)

Simulation Team

Simulation Team
www.simulationteam.com

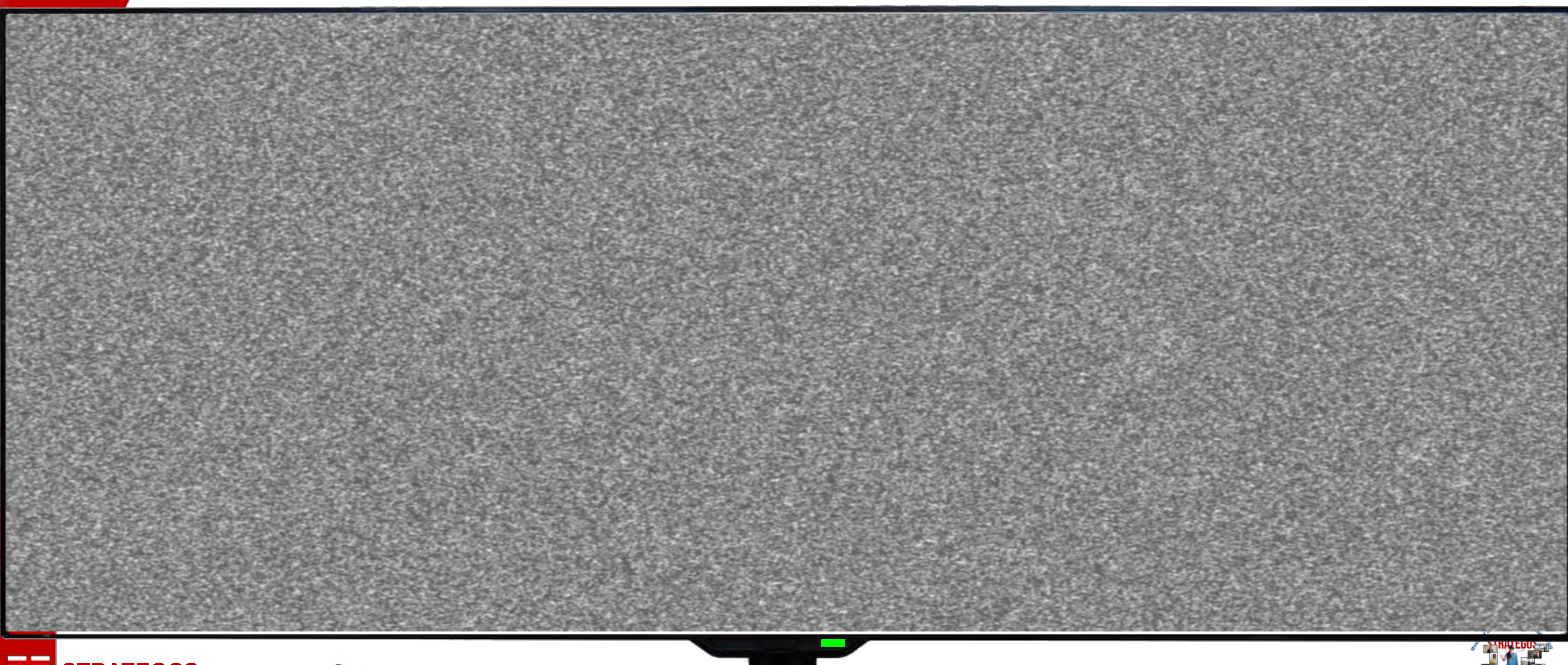
Examples

Lets look at some Examples…

Lets look at some Examples…

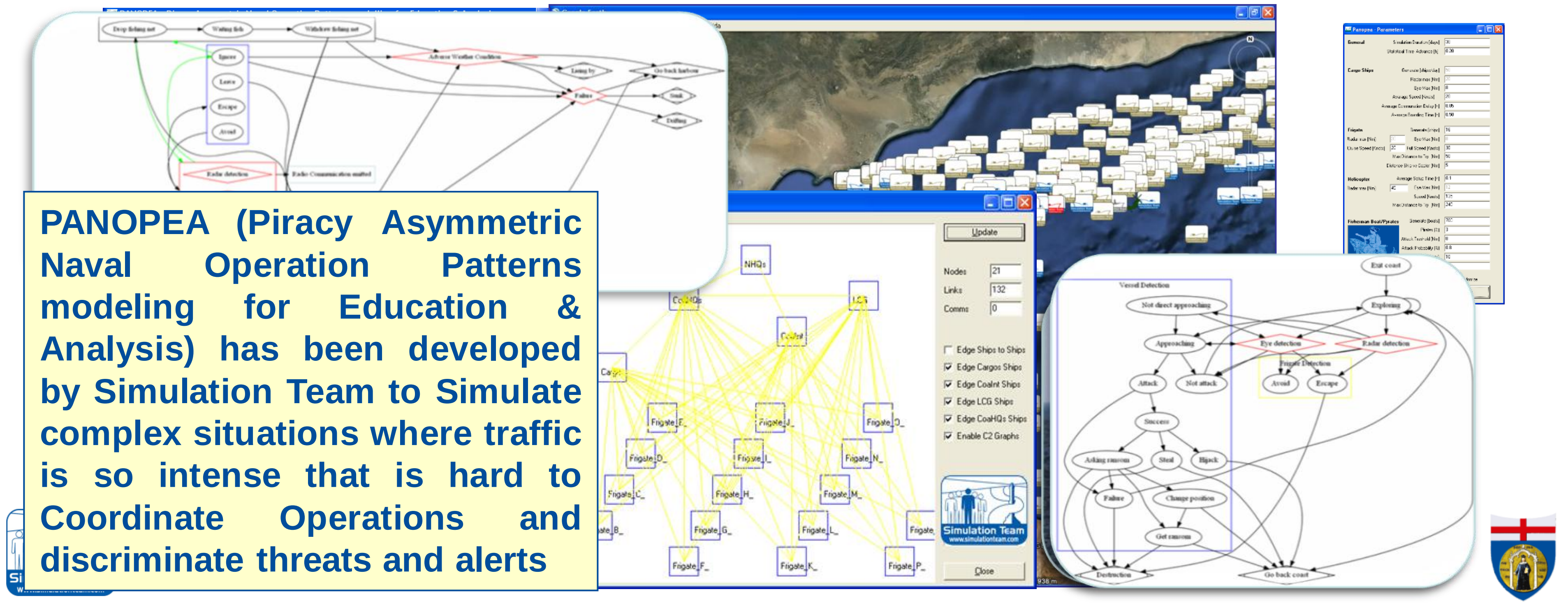
Lets look at some Examples…

We Rebuild the Bridge! Go Great Genoa!
LIBERTAS
Che l'inse?



Working on Real Virtual Worlds

IA-CGF for Large Systems & Huge Interactions



PANOPEA (Piracy Asymmetric Naval Operation Patterns modeling for Education & Analysis) has been developed by Simulation Team to Simulate complex situations where traffic is so intense that is hard to Coordinate Operations and discriminate threats and alerts

Haiti Humanitarian Support Demonstration

The demonstration was devoted to show the potential of interoperability in combining different simulators for full coverage of a complex problem such as that one of Haiti. Simulation Team was involved by using his interoperable IACGF reproducing Population Behavior, Human Factors (famine, stress, diseases, fear, aggressiveness), Riots and Gang Activities as well as the impact of the Simulation Earthquake




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

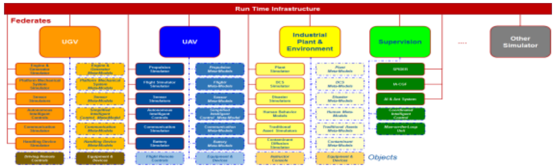
UxV & Plants…
…and more!

We Rebuild the Bridge! Go Great Genoa! Che l'inse?

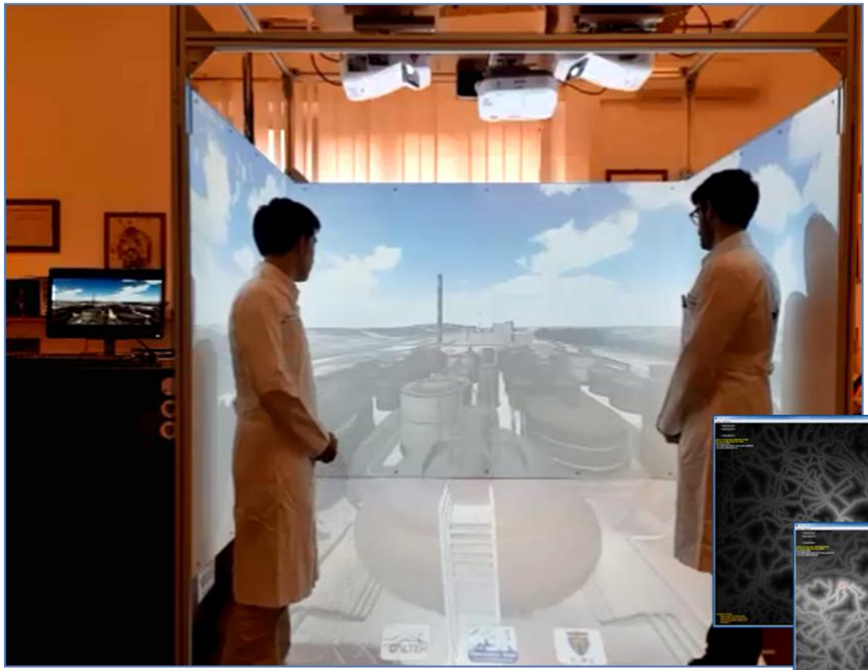
Inspection Outside

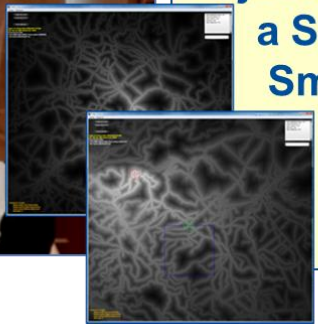
Inspection Inside

UxV Unmanned any domain Vehicle



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





Humans need new ways to interact with Intelligent Systems.

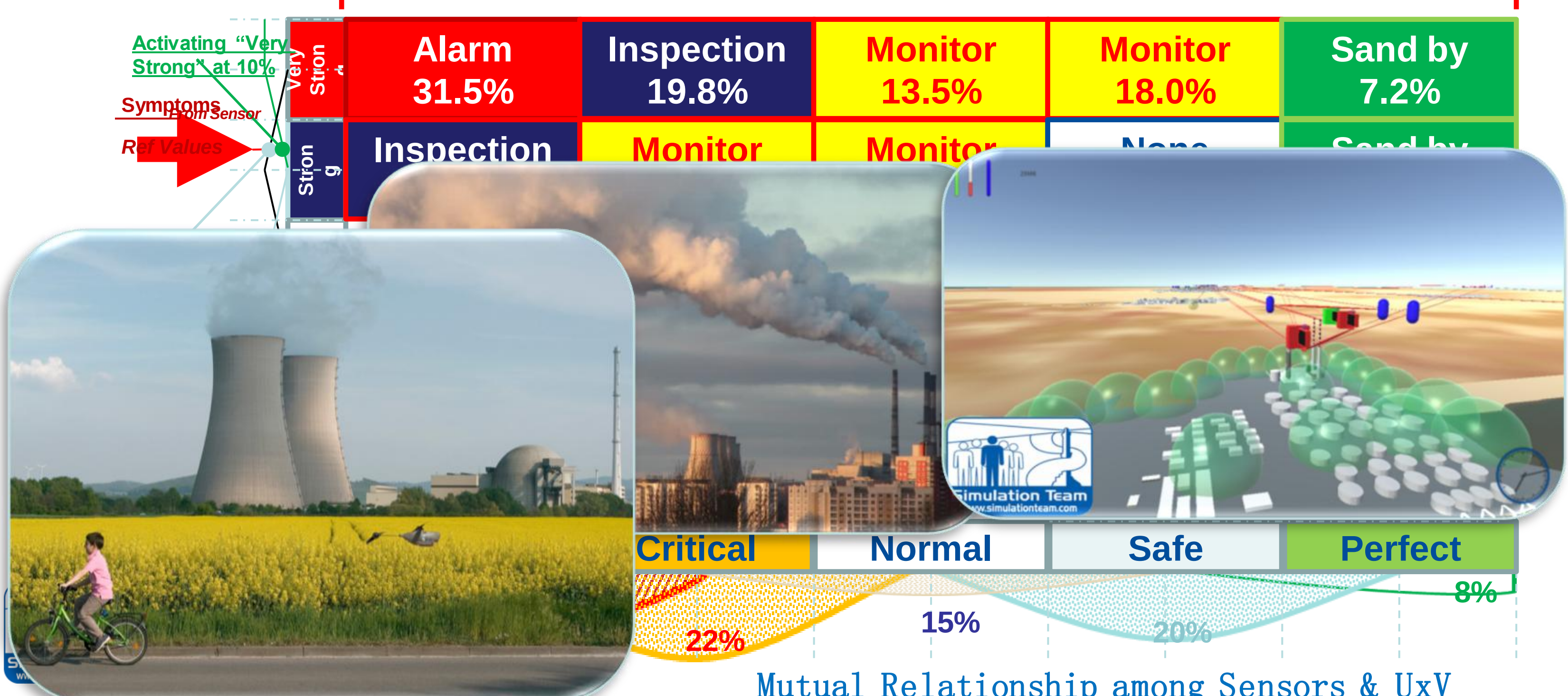
Today we need to pass from driving and piloting a single UAV to assigning high level task and objectives to a Wing or a Swarm of Uxv.

Smart Simulation allows to Design, Experiment & Test these new Solution

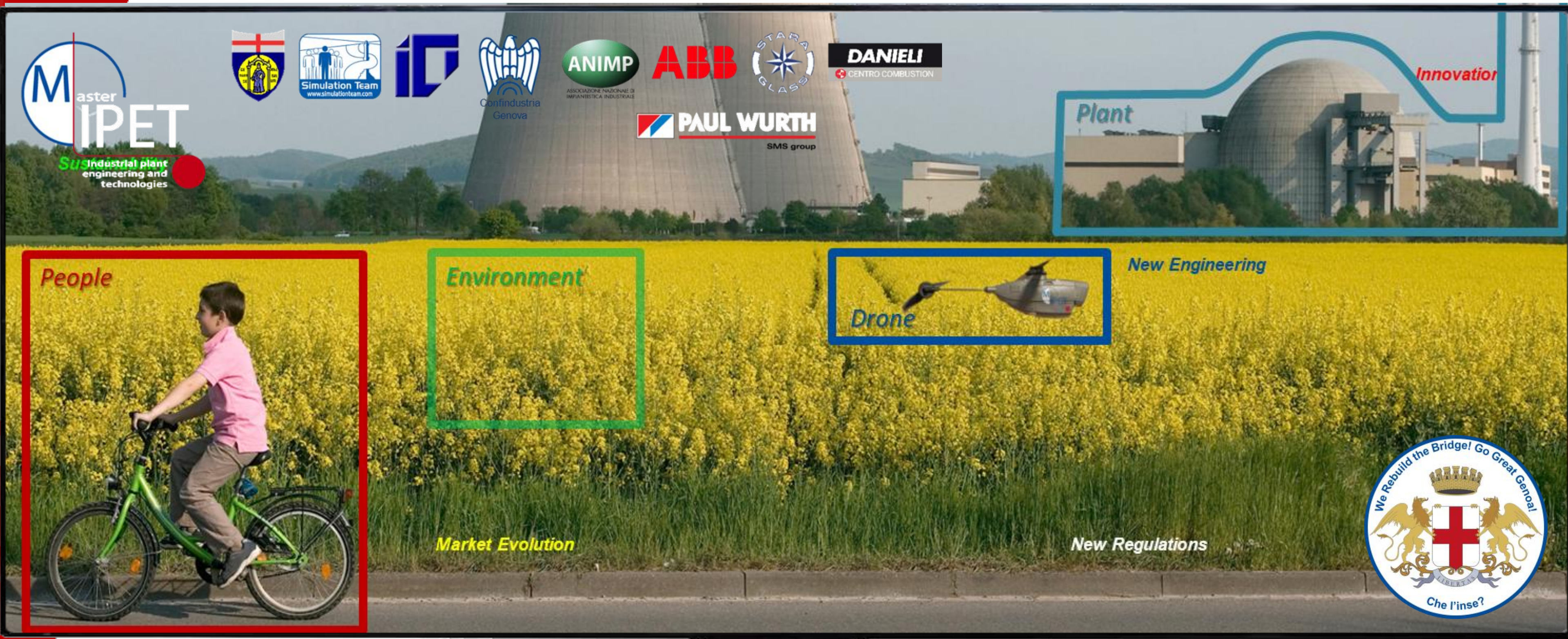
AI… Artificial Intelligent for Awareness driven Initiatives

Danger	31.5%
Inspect	35.2%
Monitor	23.3%
Stand by	8.0%

General Situation
on the Plant



MS2G supporting us during good times..

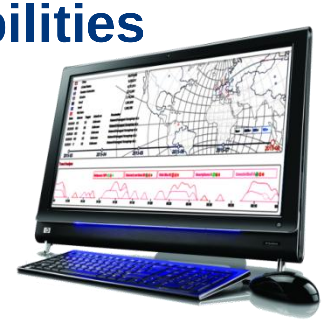


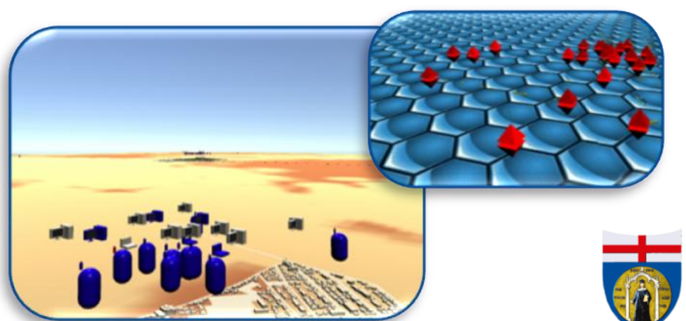
…and during Crisis and Critical Conditions

Cyber Domain: adding Spices to T-REX

Threat network simulation for REactive eXperience

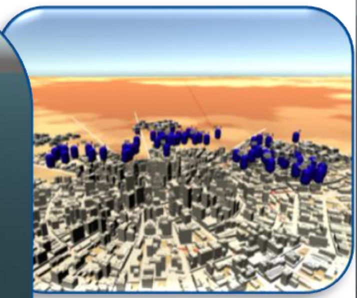
The Cyber Security is part of T-Rex environment and allows to evaluate the impacts on operations and estimates their magnitude This approach allows to considerate the Cyber Domain Complexity and the impacts on ICT process and infrastructures as well as Social Engineering elements. The MS2G (Modeling, interoperable Simulation & Serious Games) approach, make possible to raise users awareness and improve performance reducing vulnerabilities

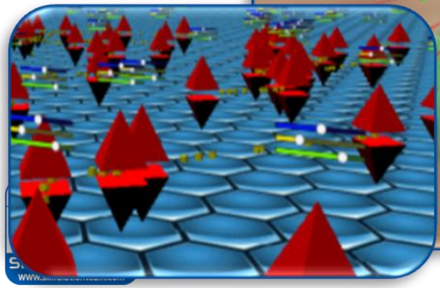




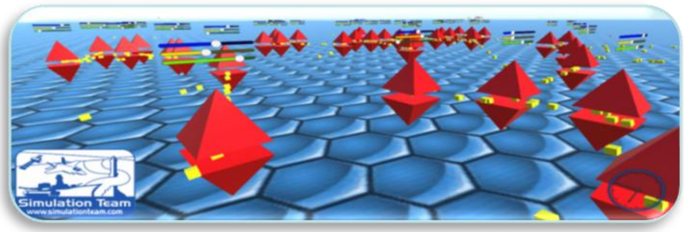
Hybrid Challenges & Autonomous Systems

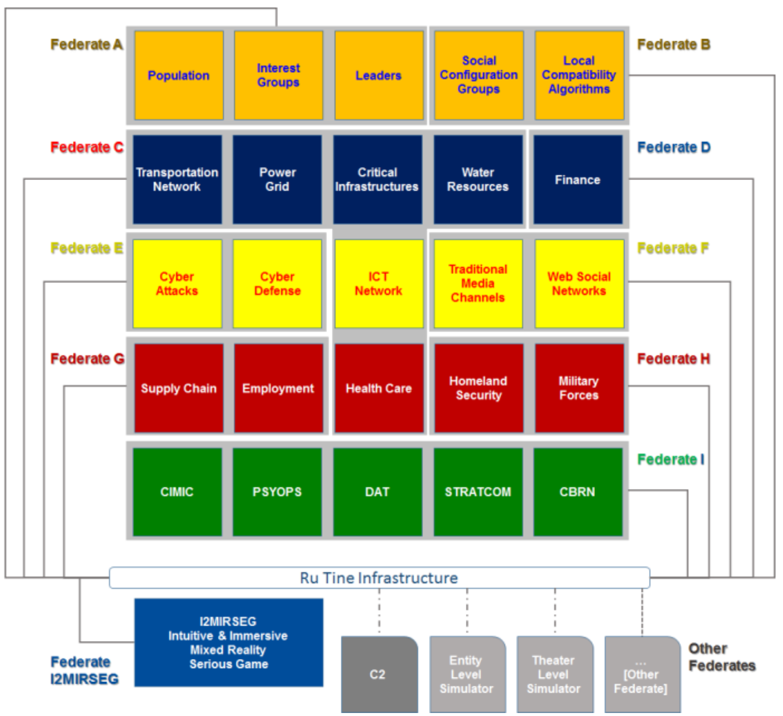
Autonomous Systems represent crucial elements for Hybrid Challenges both in terms of available Resources and Threats The T-REX simulates towns, infrastructures, people, UxV as well as Cyber & Real coordinated actions that affect whole System





Creating Comprehensive Environments

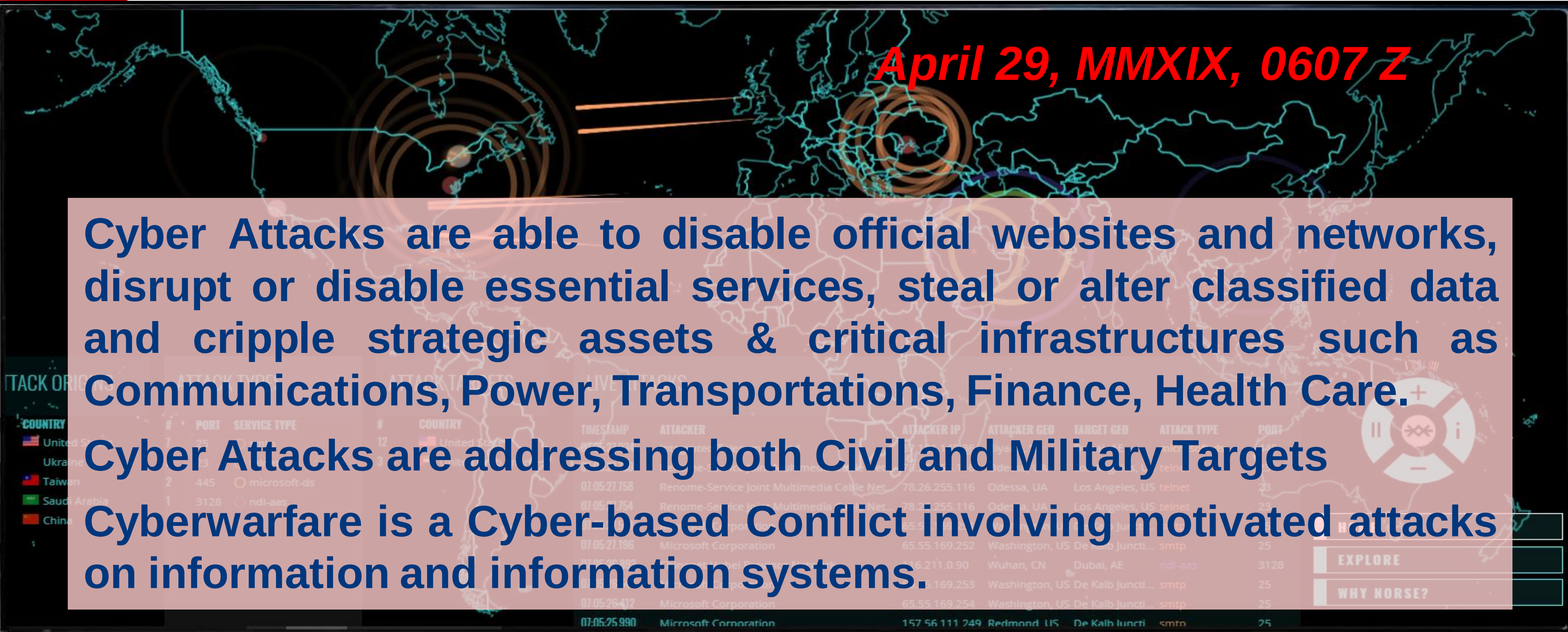




New Frontiers &…

New Frontiers &…
…New Engineers

Problems are know but Often Decision Makers are not ready!



April 29, MMXIX, 0607 Z

Cyber Attacks are able to disable official websites and networks, disrupt or disable essential services, steal or alter classified data and cripple strategic assets & critical infrastructures such as Communications, Power, Transportations, Finance, Health Care.

Cyber Attacks are addressing both Civil and Military Targets

Cyberwarfare is a Cyber-based Conflict involving motivated attacks on information and information systems.

Real Crises were there in Real World

Big Data are a resources also for Attackers in Cyberspace

- Yahoo 2013 & 2014, Over 1 billion accounts
- TJX, 2003, 45.7 million credit/debit cards, driver's licenses
- FriendFinder, 2016, 412 million accounts on dating
- Ebay, 2014, 145 million accounts
- Heartland Pay.Syst, 2008/2009, 130 million credit cards
- Target Stores, 2013, 110 million records compromised
- Sony OE., 2011, 102 million records compromised
- Anthem, 2015, 69 million health insurer records
- Home Depot, 2014, 56 million credit and debit cards 10.5 GUSD (~194 USD/card)
- LinkedIn, 2012, 6.5 million accounts (4%), password cracking in 72h for 90% cases

Attacking not C2… but your Plug




MiTM Man in The Middle   Dsniff Dug Song Sniff through SSH & HTML by MiTM

It is not necessary to attack your PC or Mobile…

… new Kitchen Appliance provide new vulnerabilities:

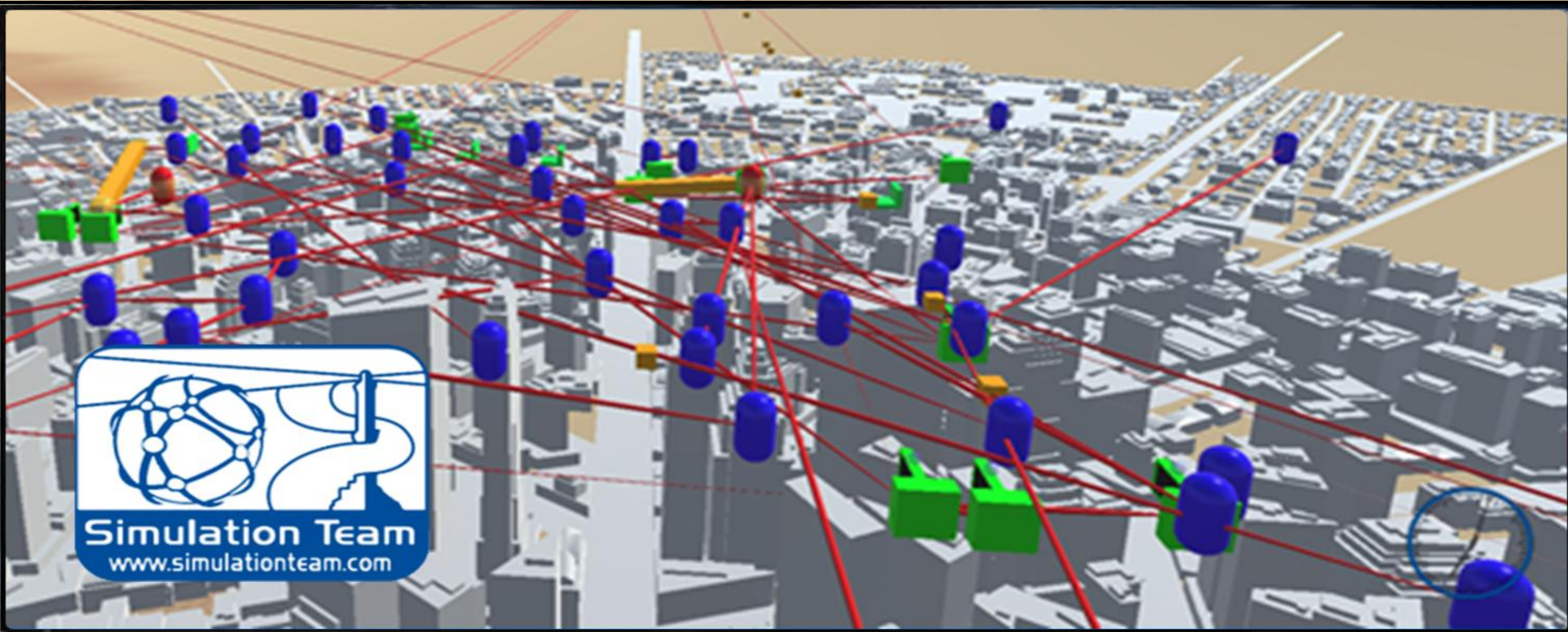
- **To get your Google Account by MiMT from a Fridge able to propose you the Google Calendar (2015)**
- **To generate a Junk Mail Campaign spamming 750’000 emails from 10’000 Home Devices (2014)**
- **To watch your home from Always On Camera from Smart TV (2015)**

Smartv Federal Trade Commission

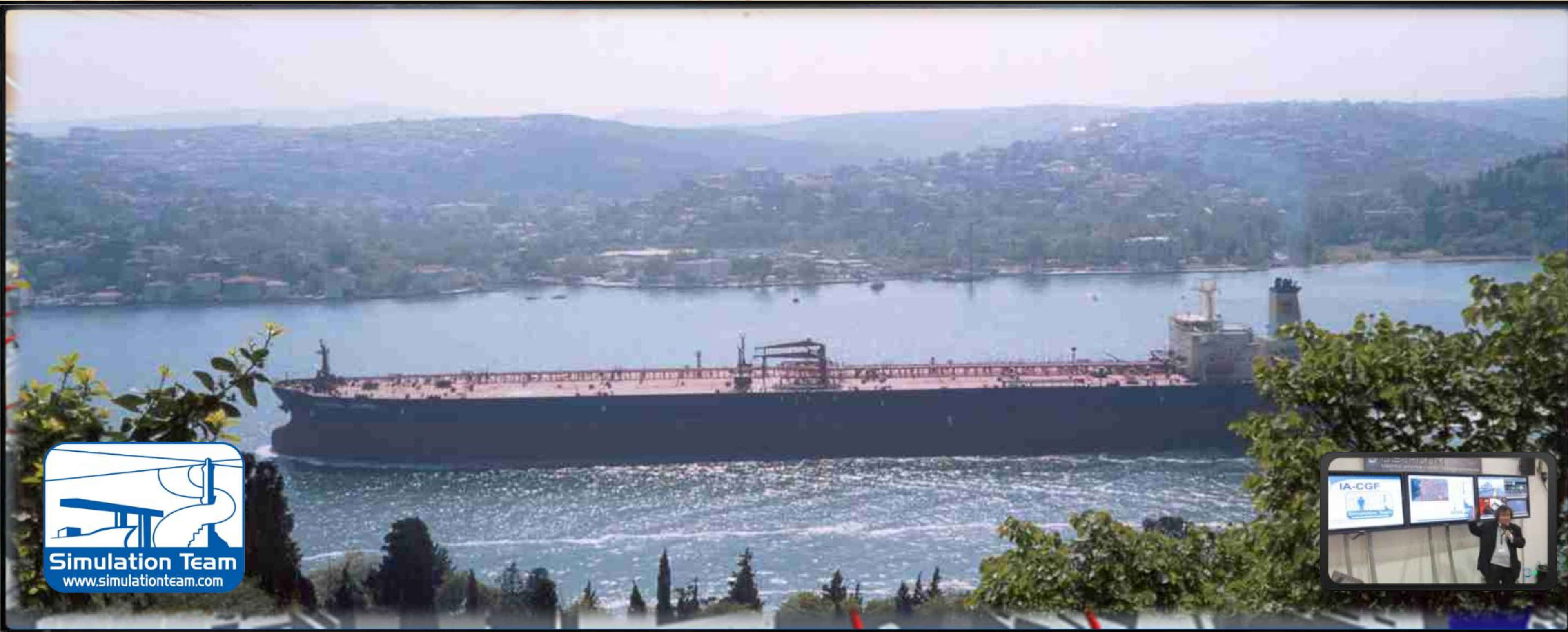
Kids want to have Fun and test Toys

- Estonia, April 26-May 23, 2007, DDS, Botnet, Ping floods: All Government, 2 Banks, Political Parties, No Parliament Email, No Credit Cards, no ATM
- Georgia, August 7-12, 2008, DDS, Botnet, Web Defacement, Sql Injections, Spamming: News and Government Websites Down, Gov.Comms down with the World, Banks & Cell Phones down.
- Kyrygistan, January 18-31, 2009, DDS, ¾ IPS down, 80% internet down, mobile down
- Ukraine, 2015/2017, SCADA,Blackouts 1 million People 2h

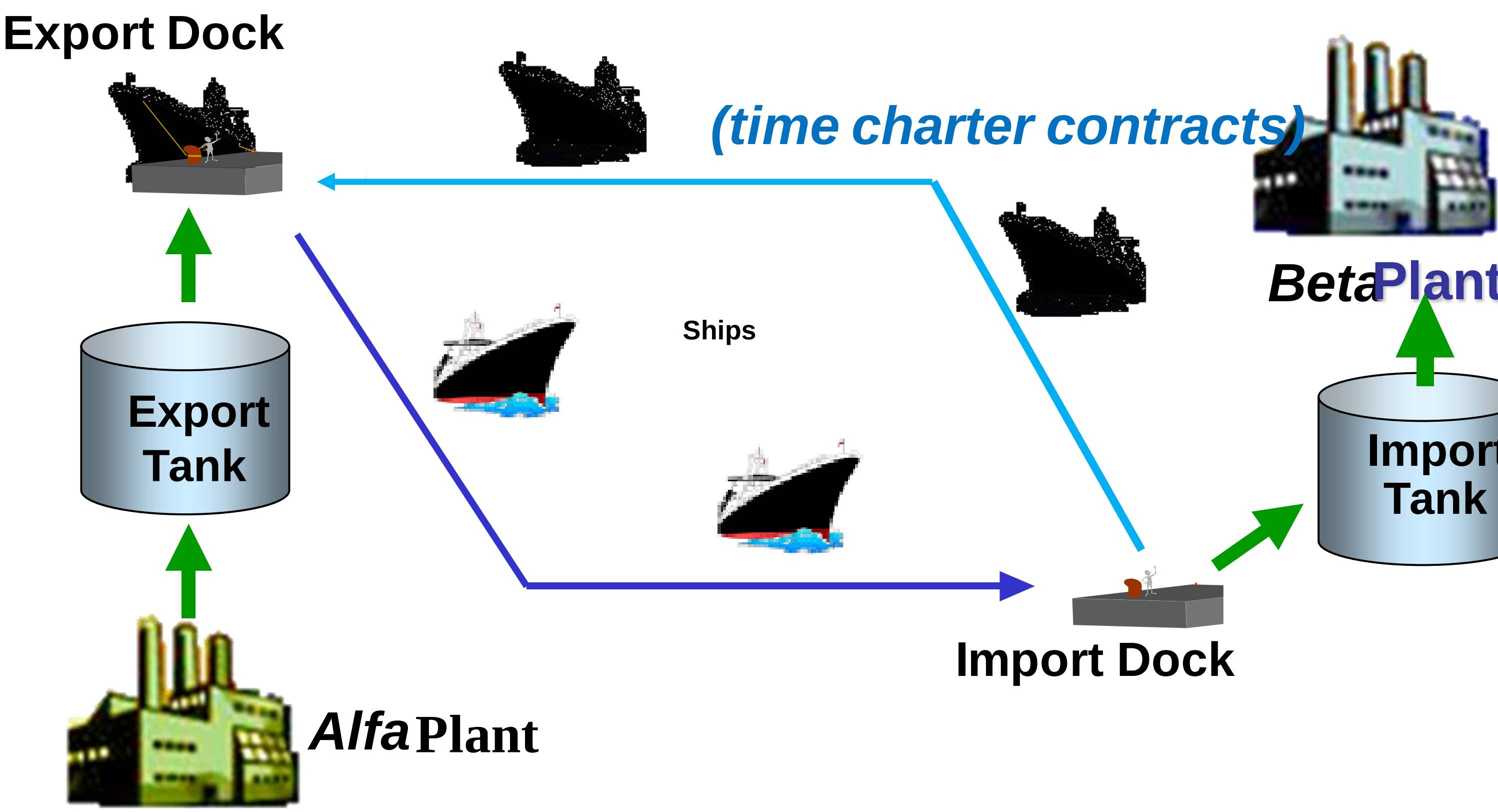
New Paradigms are emerging… Hybrid Warfare is just one!



A Simple Problem not so Simple!

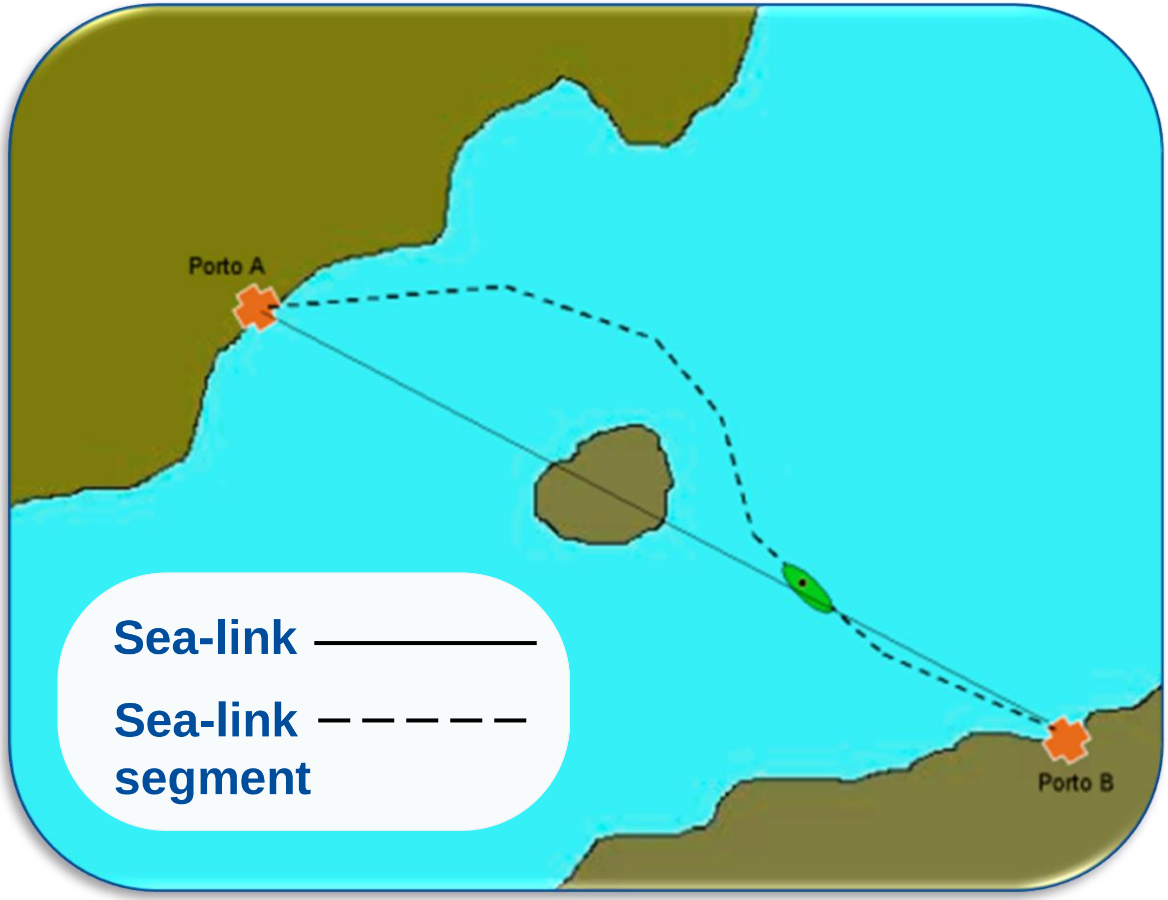


Logical scheme of the Simplest Model

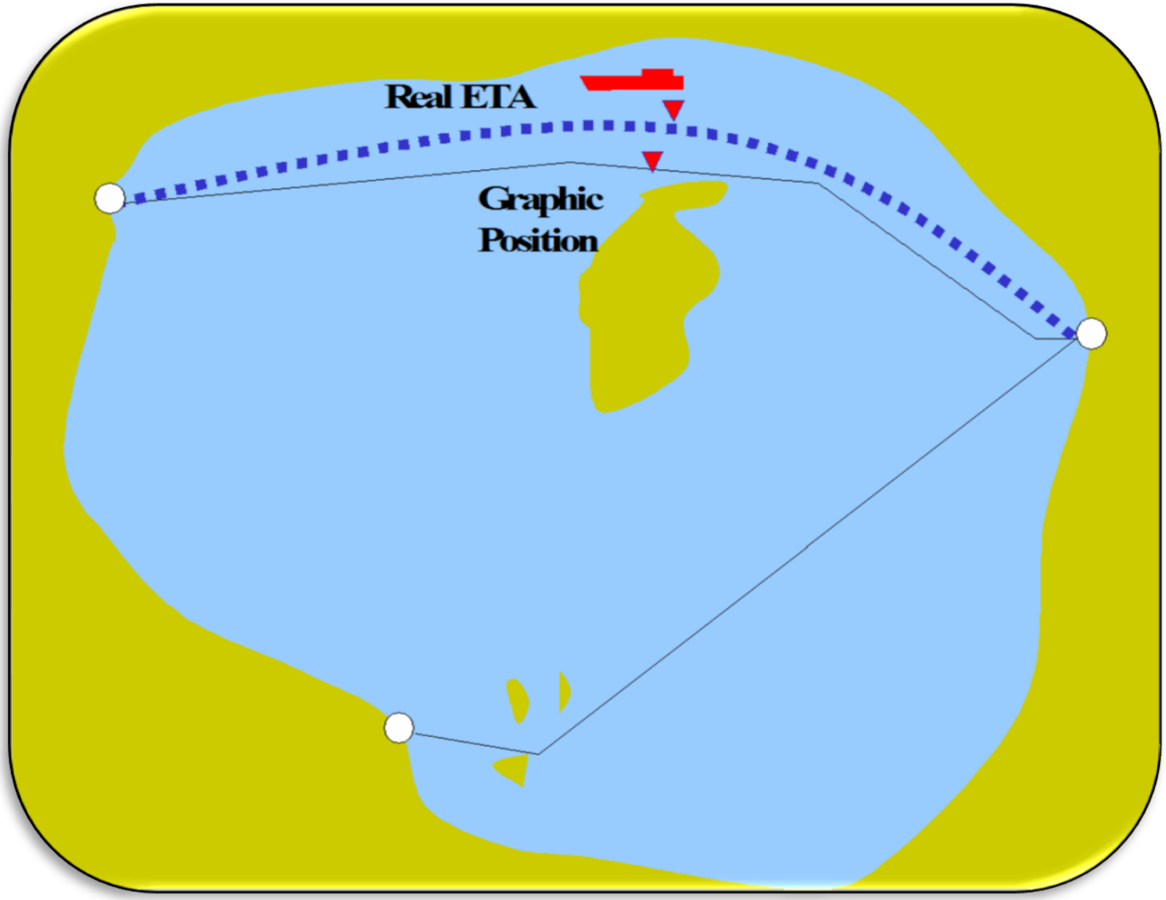


Chemical logistic flow to be analyzed

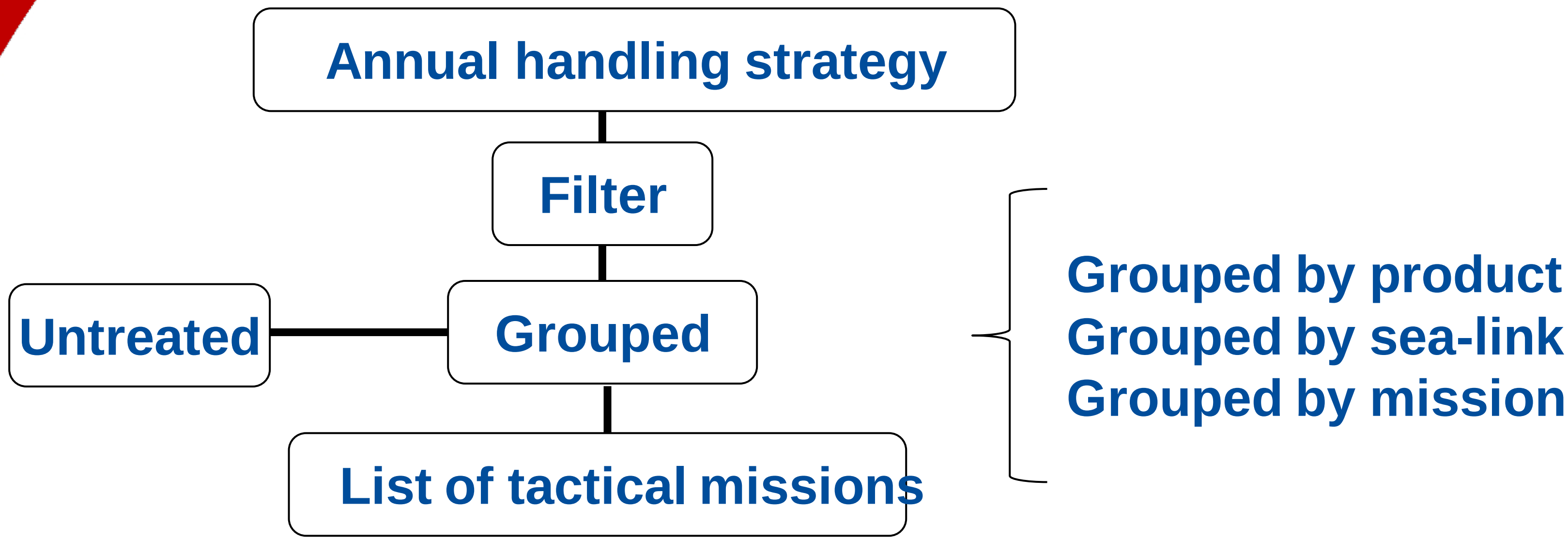
Routes and Connections



ETA: Estimated Time of Arrival



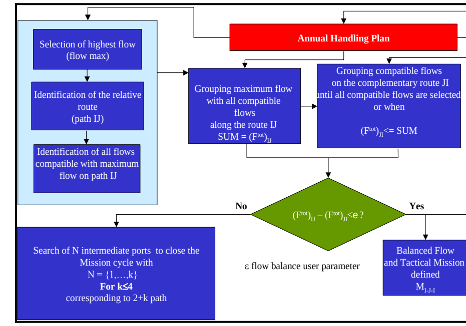
Production Logistics



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

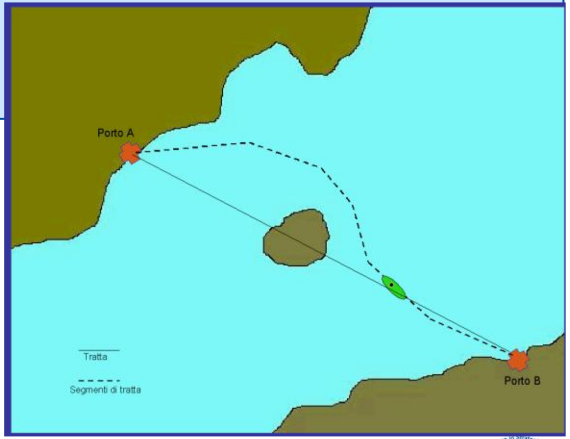
Flow Grouping



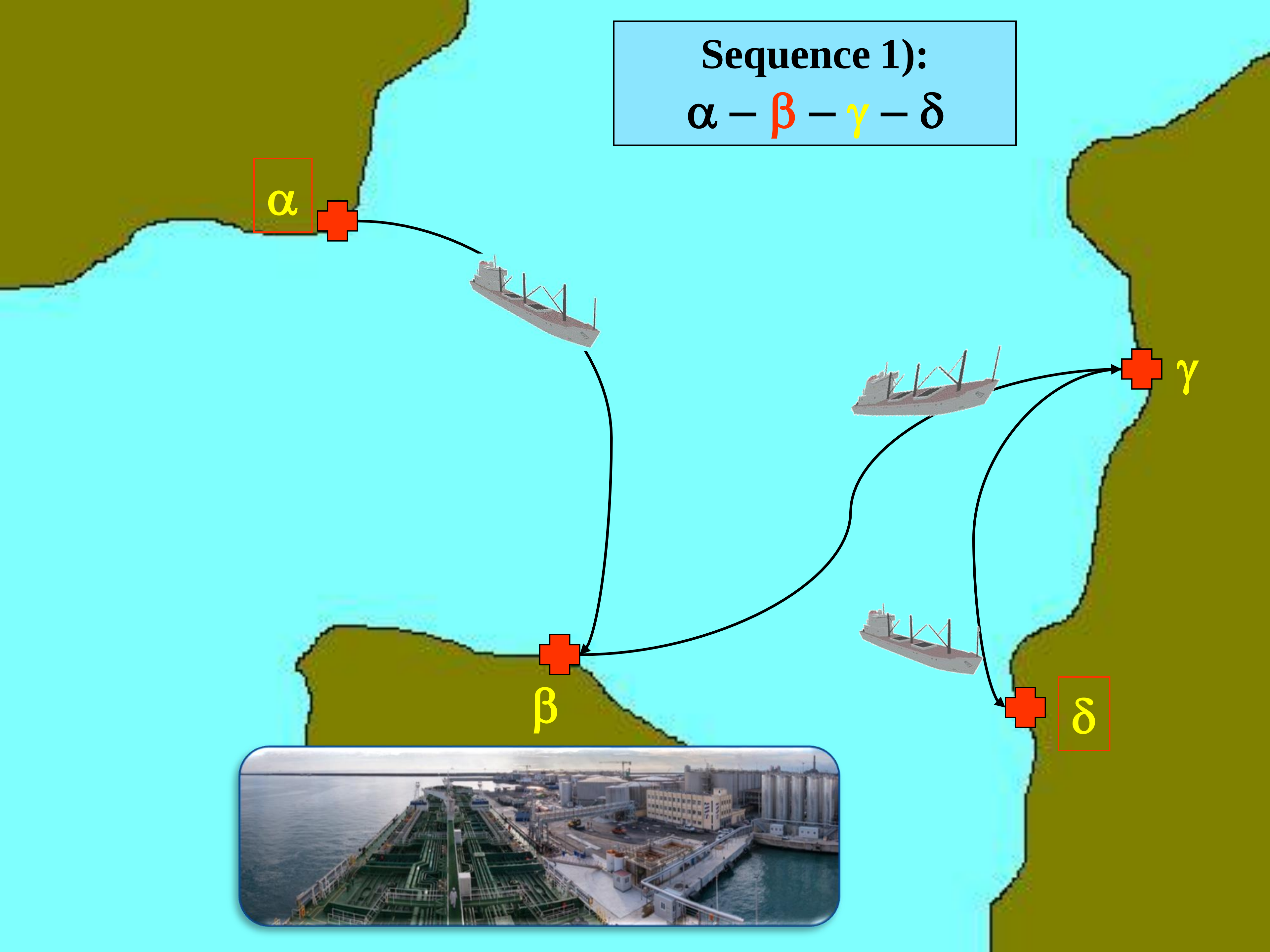
- **The Flows are representing the Logistics in terms of quantities to be distributed between Chemical Plants by Import/Export operations.**
- **Compatible Flows on the Annual Production Plan are clustered and grouped together**
- **Flows should be balanced in order to optimize the fleet in terms of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

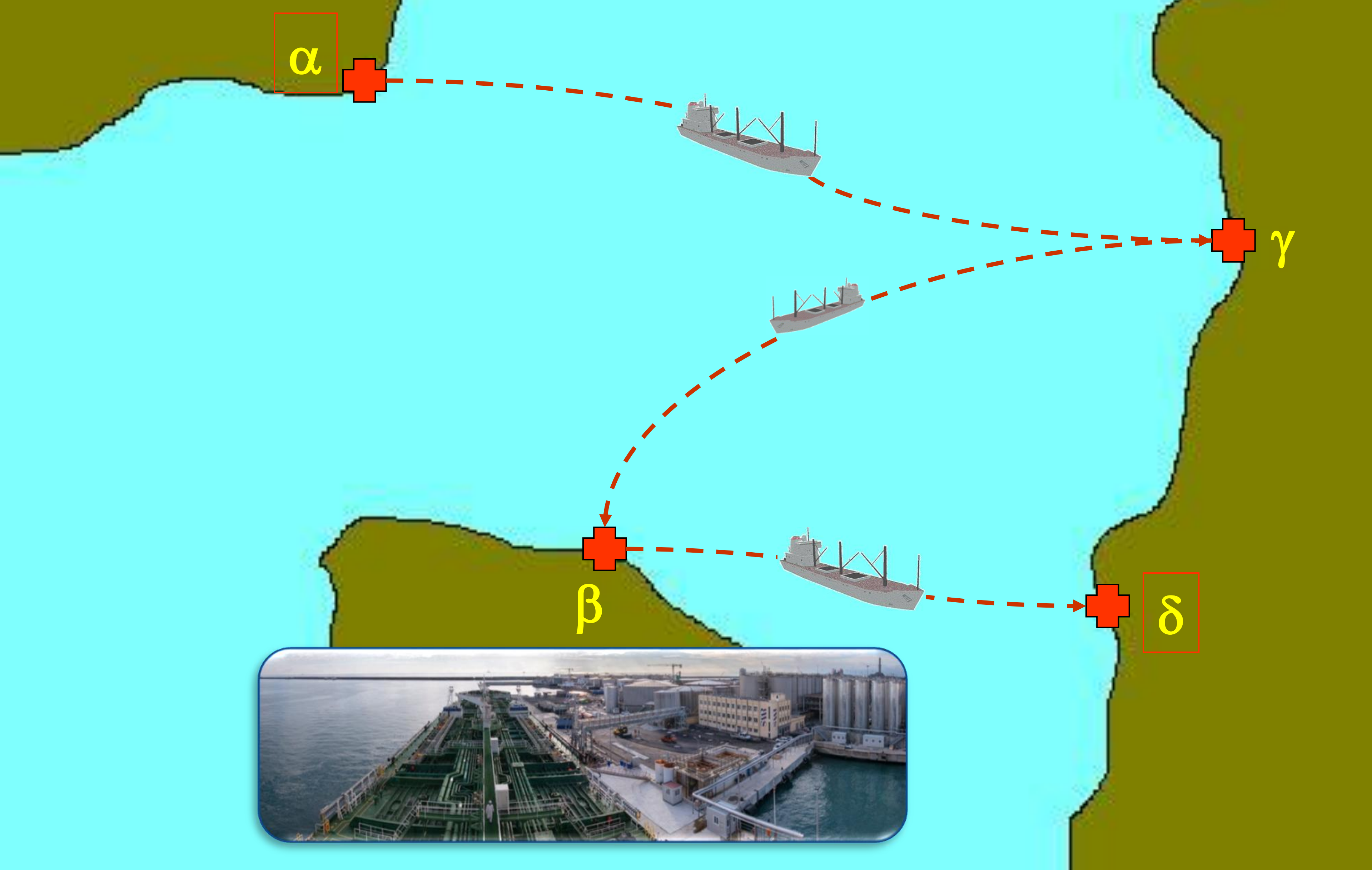


Sequence 1):
$\alpha - \beta - \gamma - \delta$

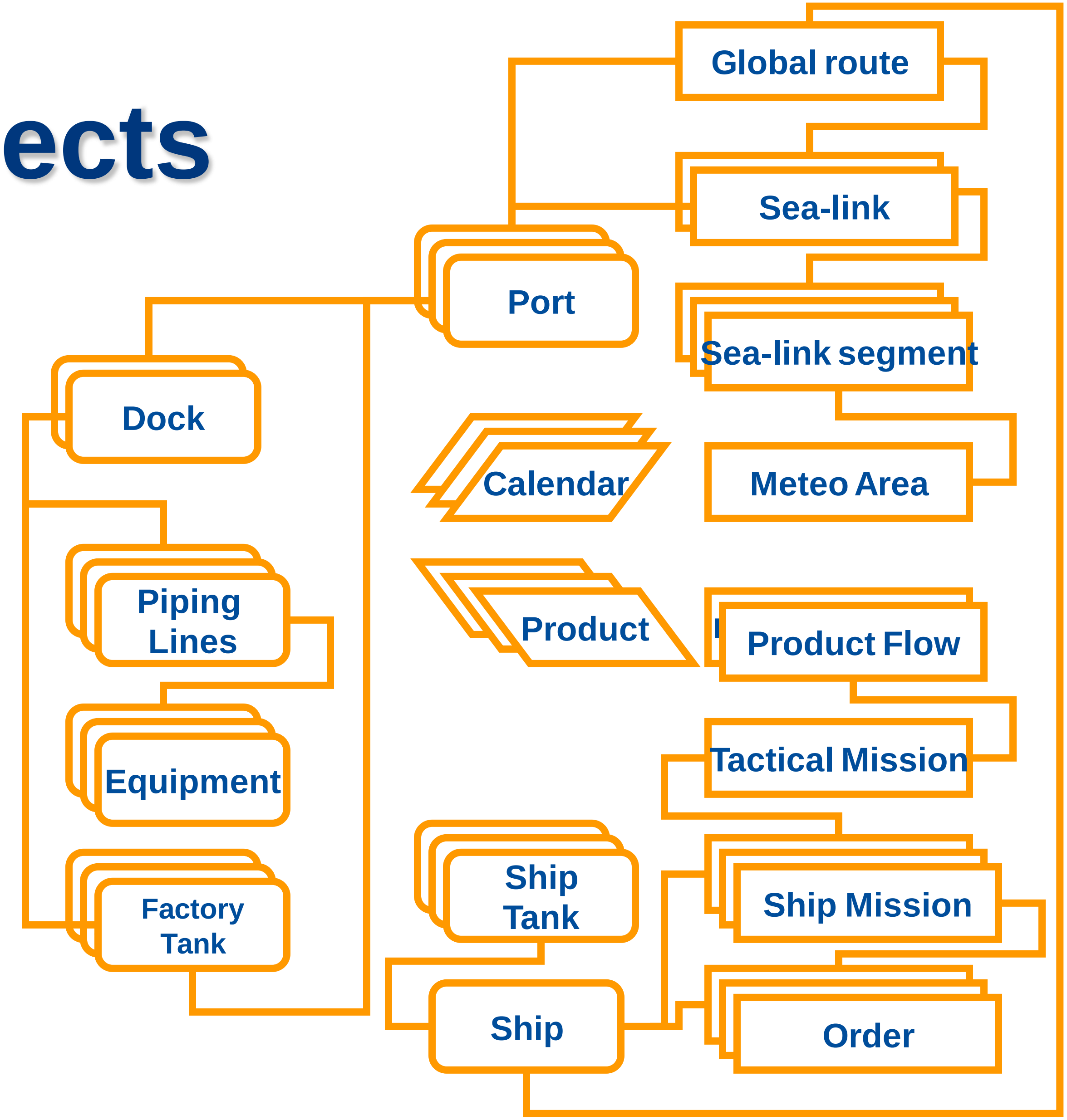


Sequence 2):

$\alpha - \gamma - \beta - \delta$



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

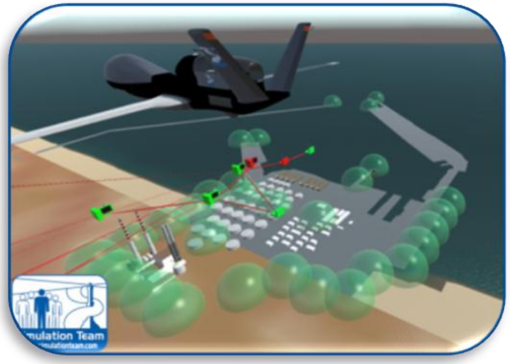
Port

Dock — Tank

Piping — Storage

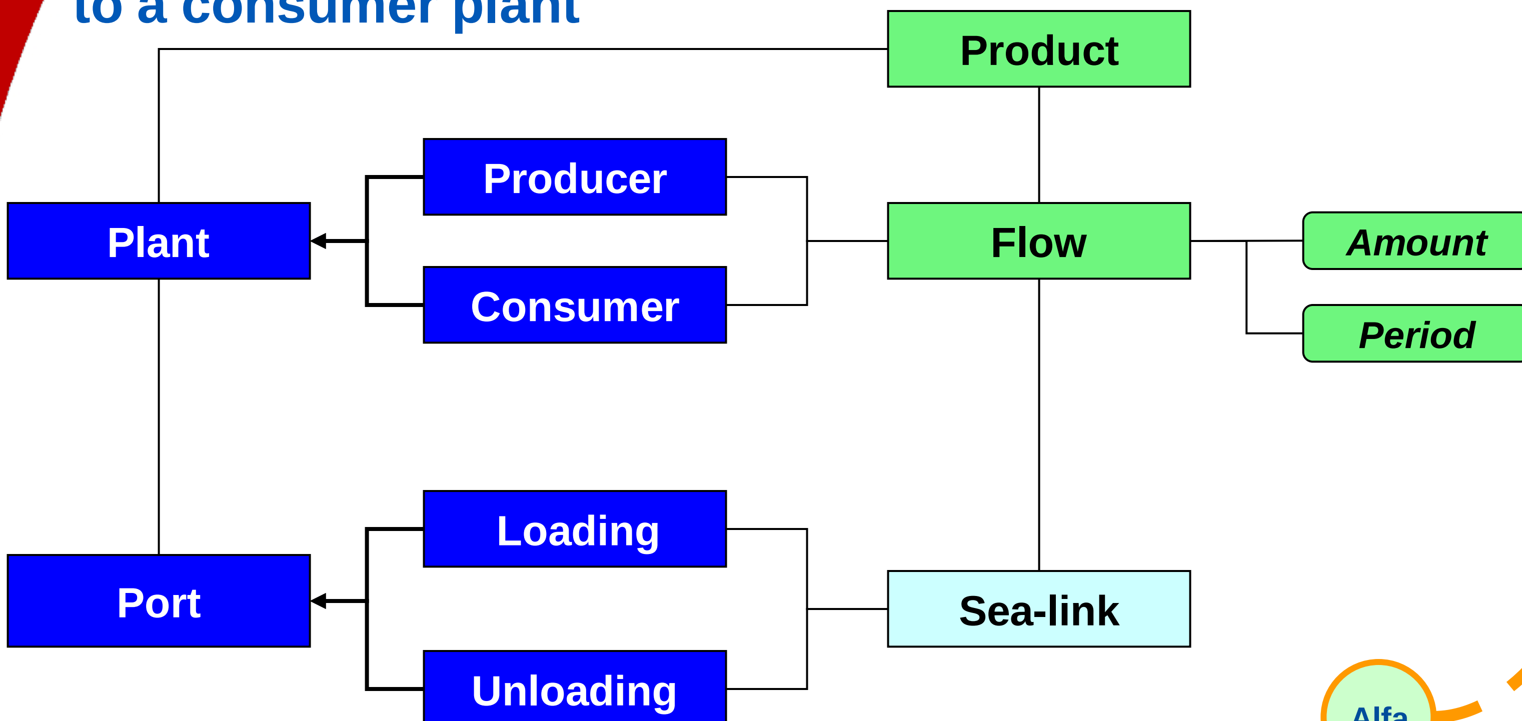
Equipment — **Port**

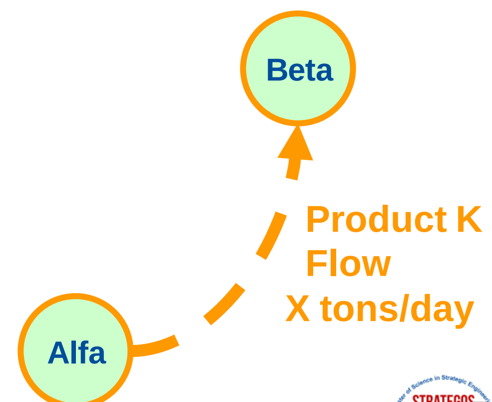
Port:
- *Geo-position*
- Operativity
- *Regulatory constraints*
- *Operation Times*
- *Harbor costs*



Flow

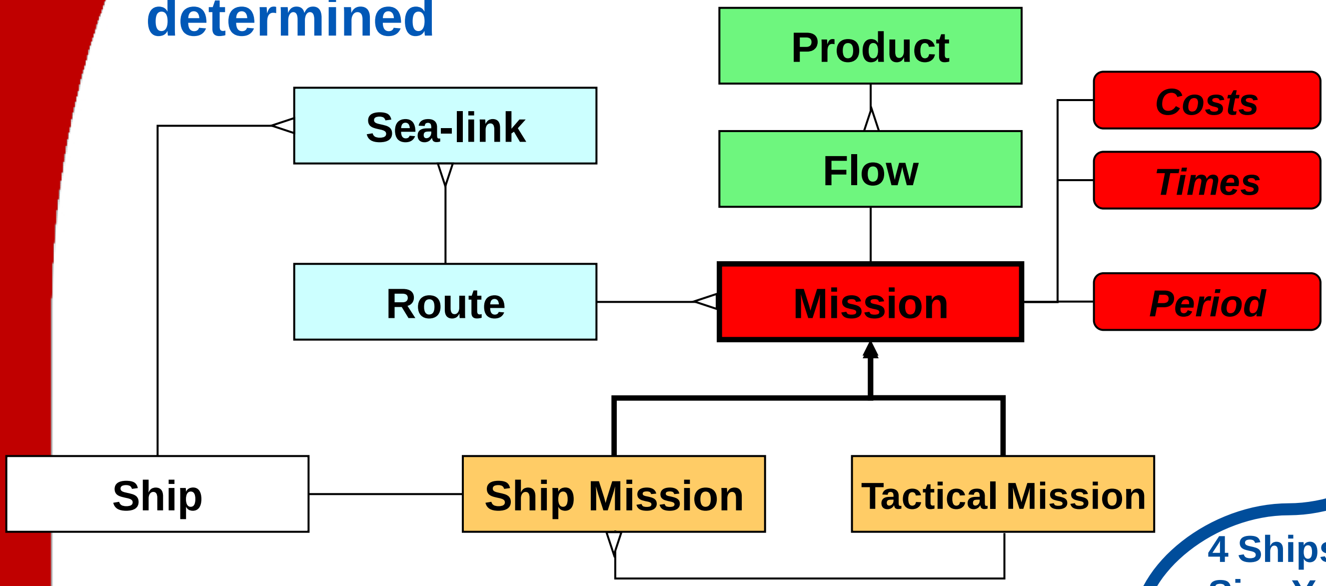
Flow is the amount of product to be transferred by sea, following a prefixed **Sea-link**, in a certain time **Period**, from a producer plant to a consumer plant

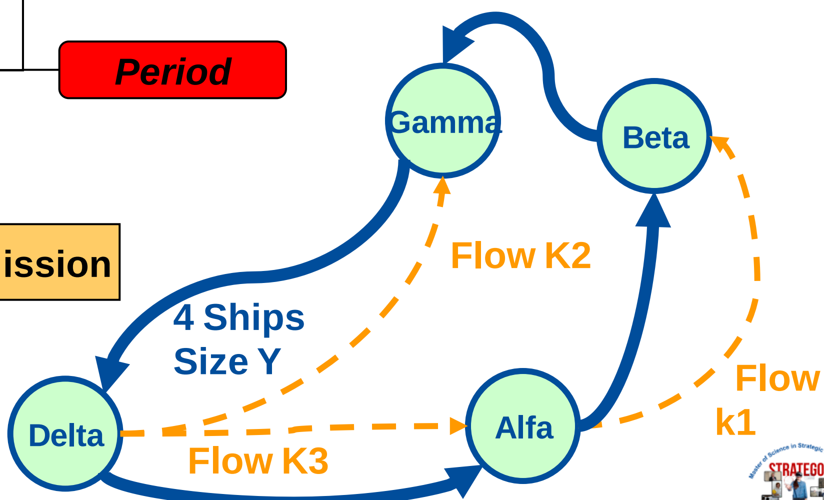




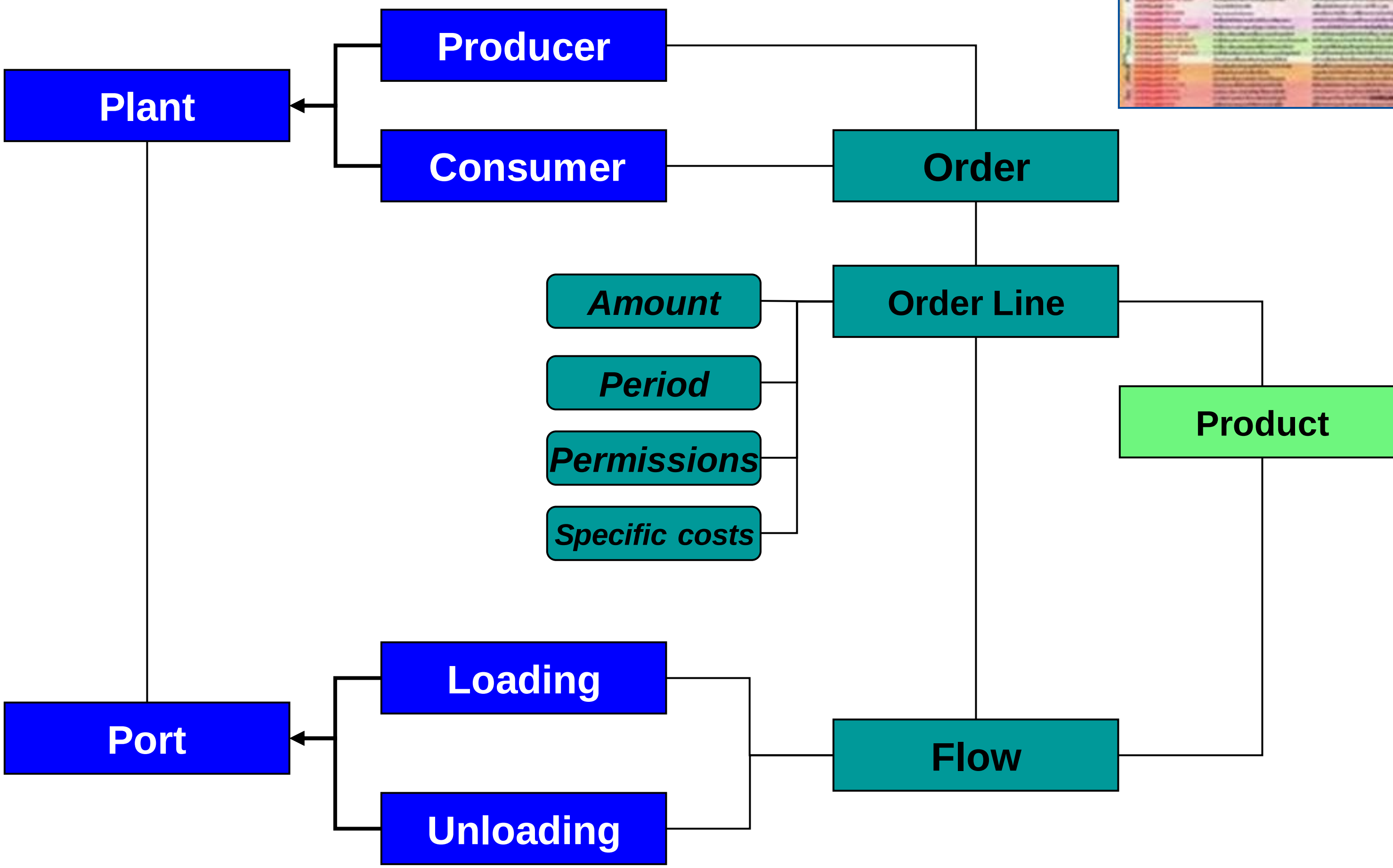
Mission

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


Producer
Plant
Consumer
Order
Amount
Order Line
Period
Product
Permissions
Specific costs
Loading
Port
Flow
Unloading

Sea-link/Segments

Forecast

Period

Meteo Area

Coordinates

Segment

Start/End

Distance

Arrival

Port

Sea-link

Distance

Departure

Segment list

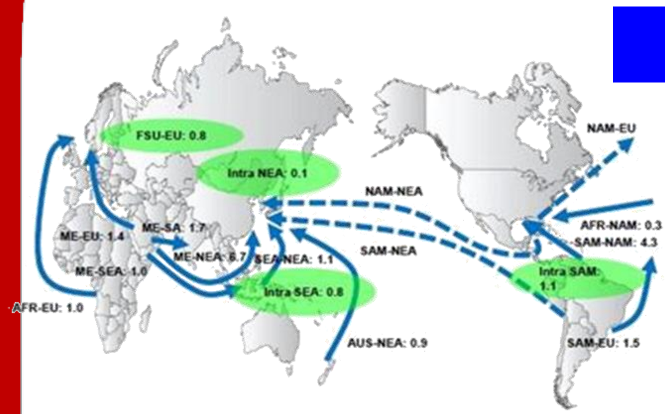
Validity period

Global distance

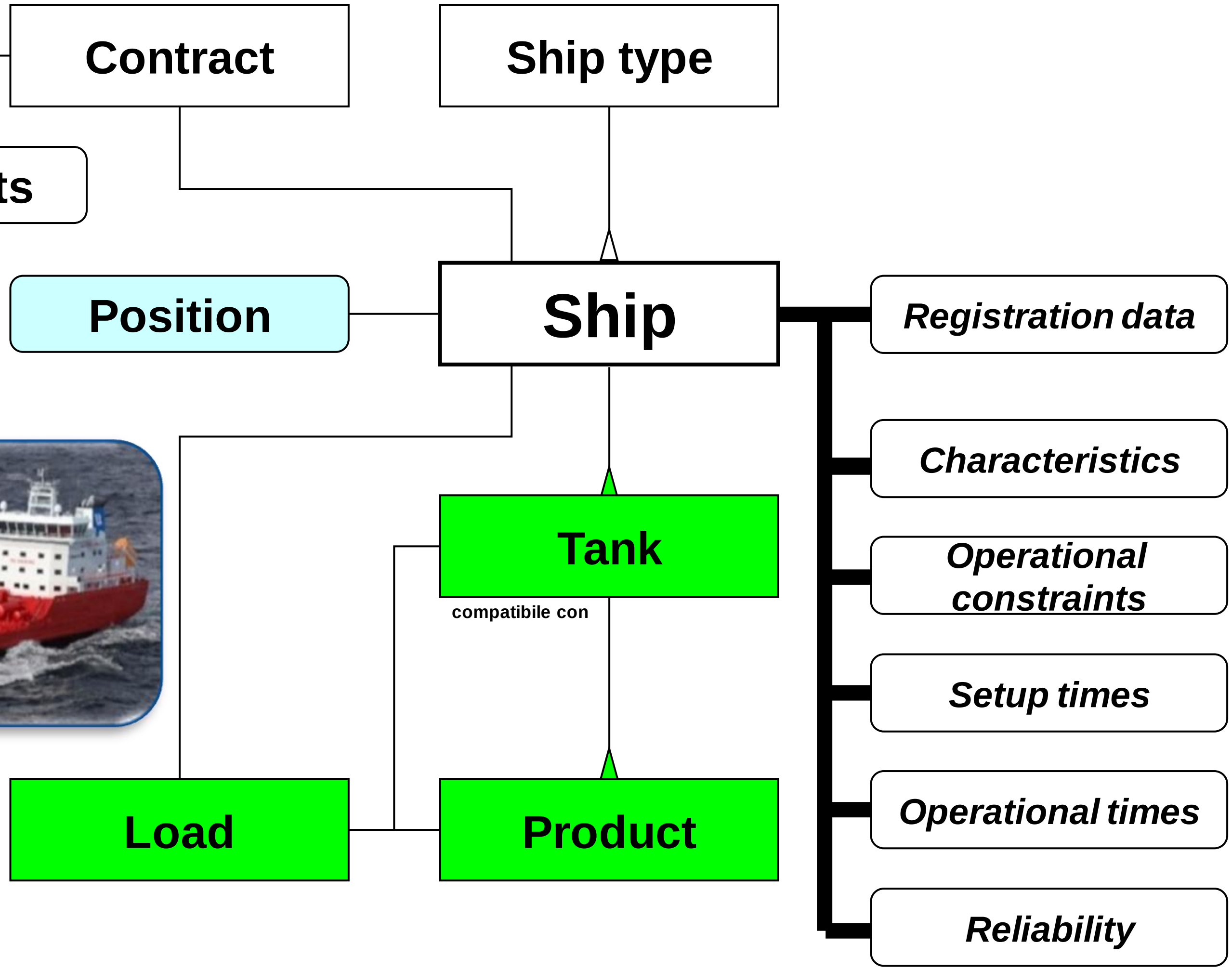
Global route

Mission

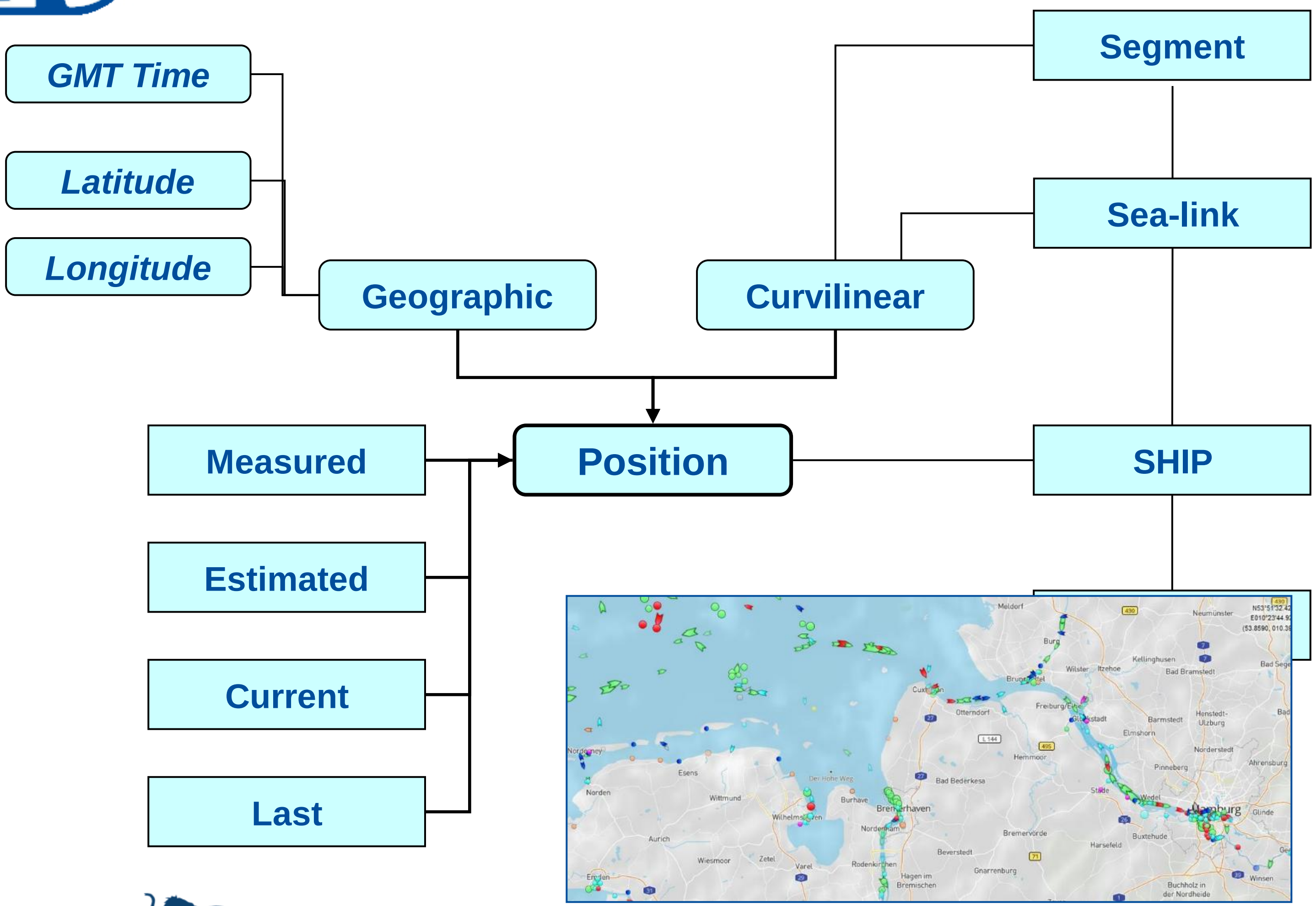
Sea-link list



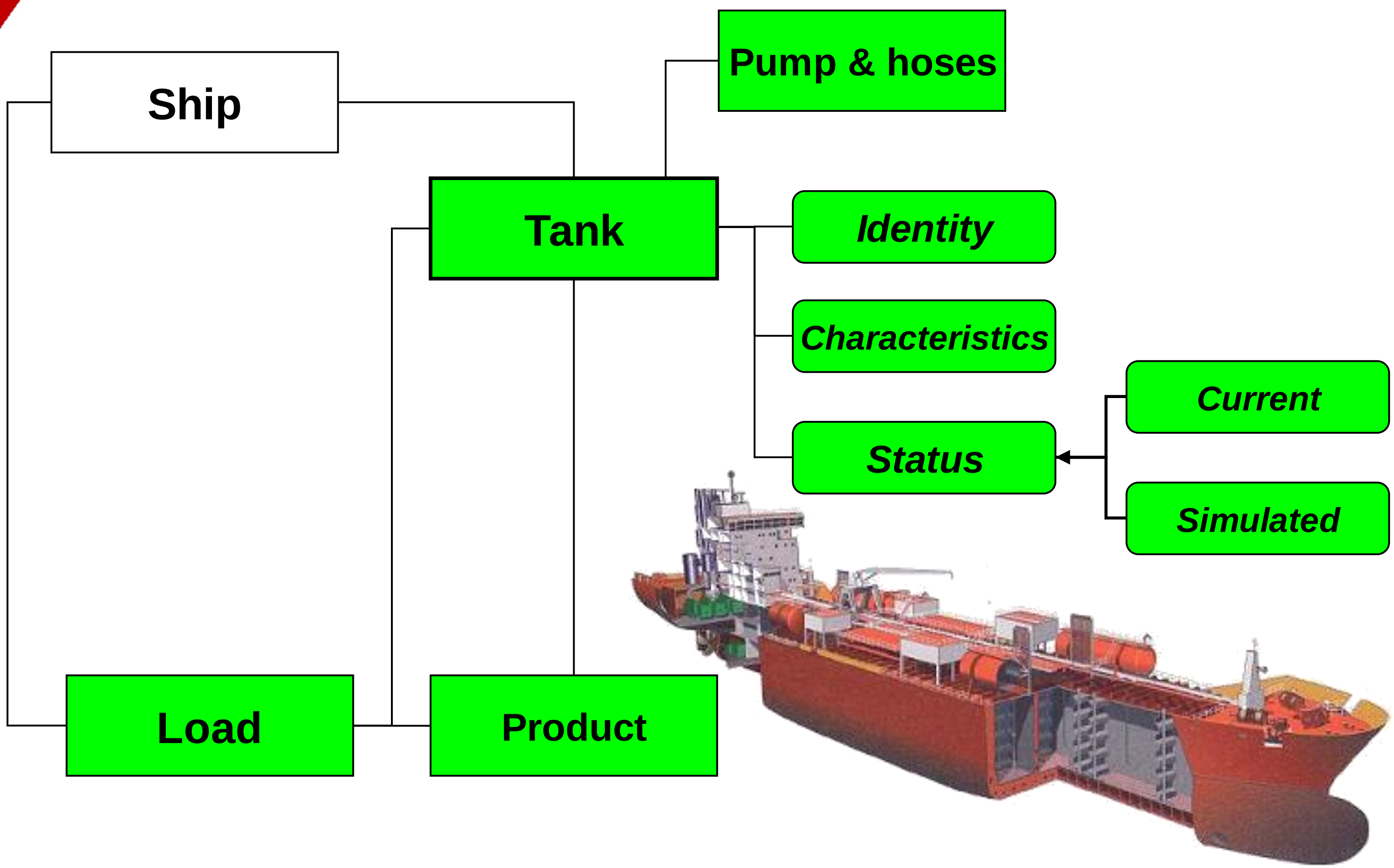
Ship Object


Contract
Ship type
Ship costs
Position
Ship
Registration data
Characteristics
Operational constraints
Setup times
Operational times
Reliability
Tank
compatibile con
Load
Product

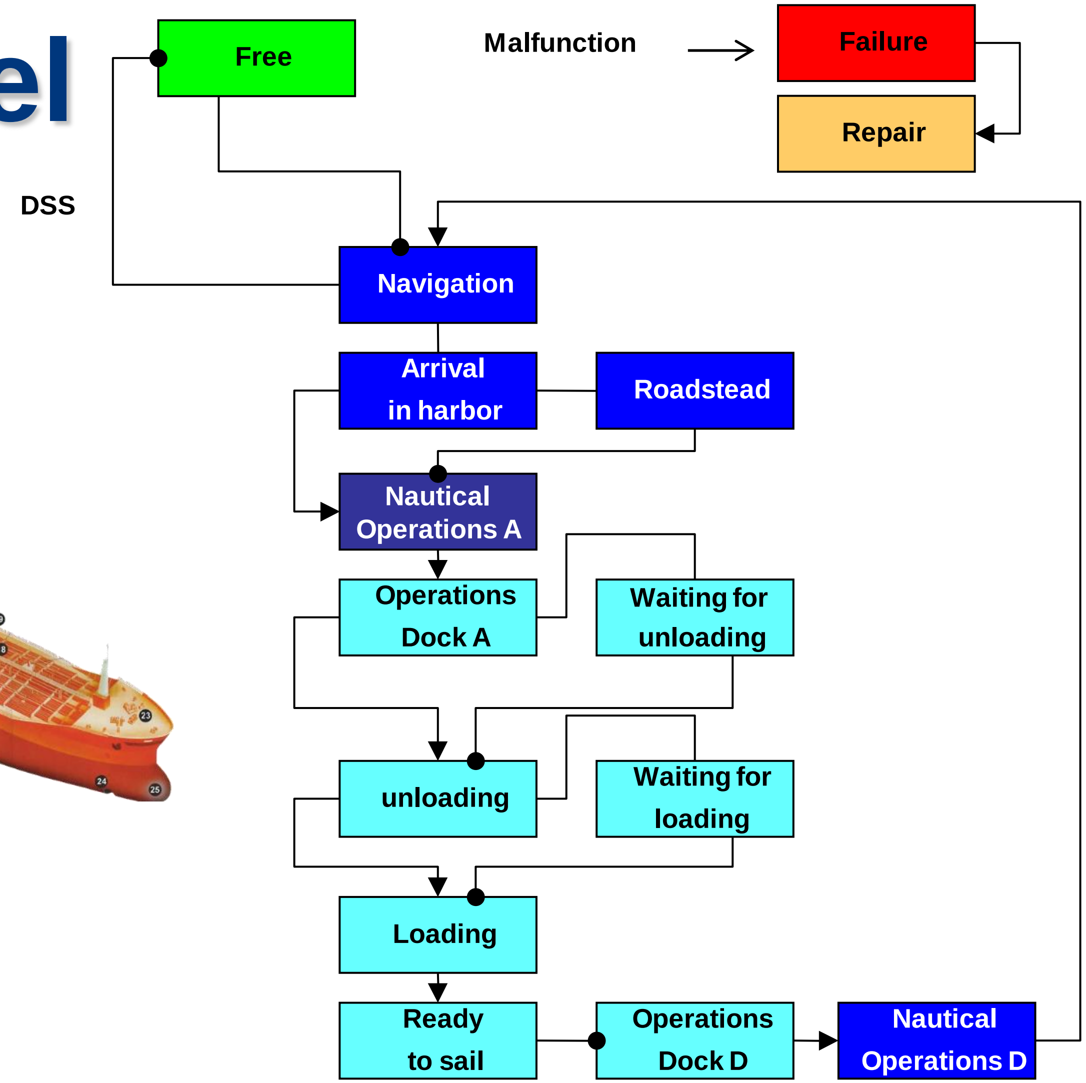
Ship Position

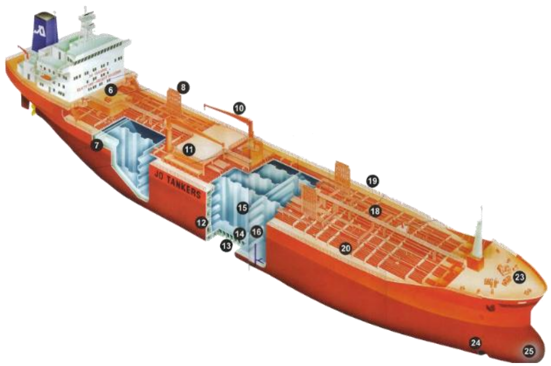


Ship Tank

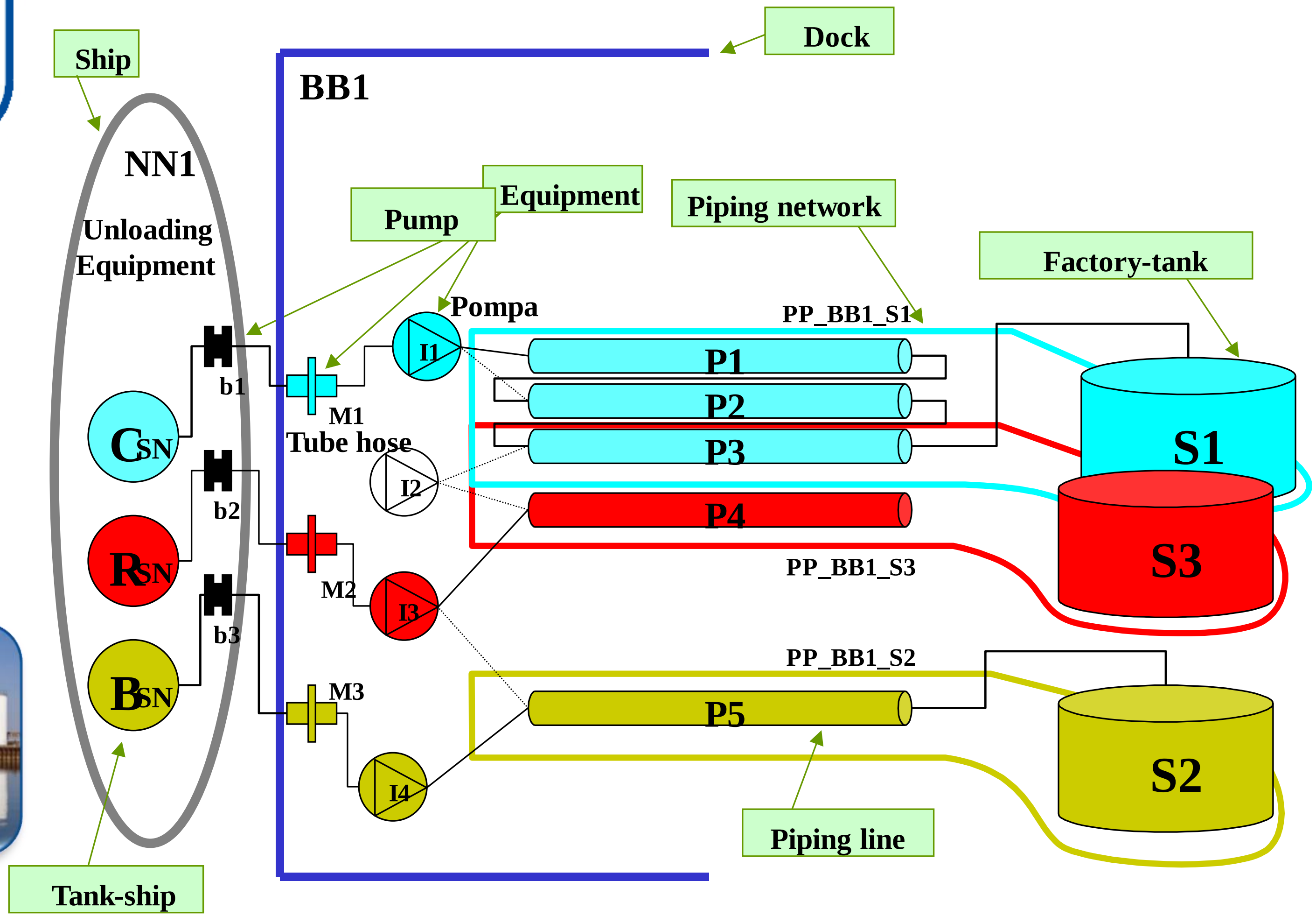

Pump & hoses
Ship
Tank
Identity
Characteristics
Current
Status
Simulated
Load
Product

Vector Model





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 ($j=1,\ldots,s$), 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)

Type of contract

Cost coefficient

Ship dimension

Type of product

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

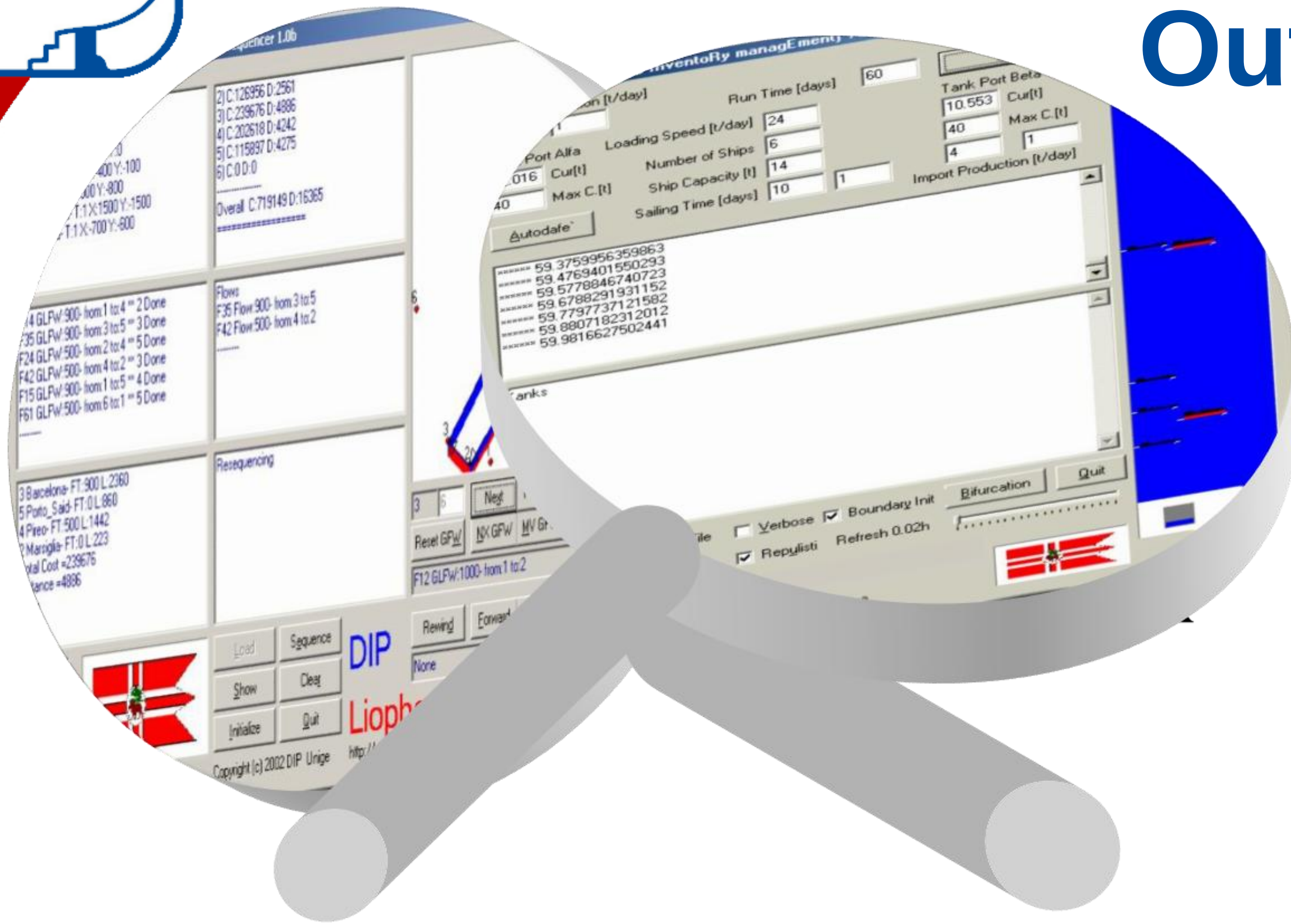
Commercial classification of chemical products

Commodity chemicals
Specialties
Fine chemicals

Risk factors for chemicals:

Inherent hazard of chemicals
Chemical industry supply chain transportation risk

Reference Models Worked Out

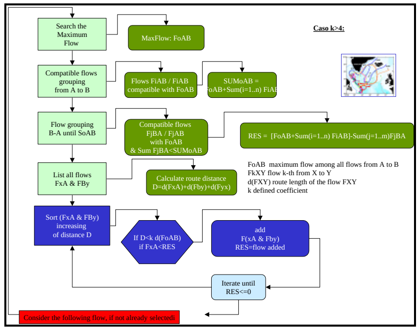


Petrochemical Logistics DSS

- **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**

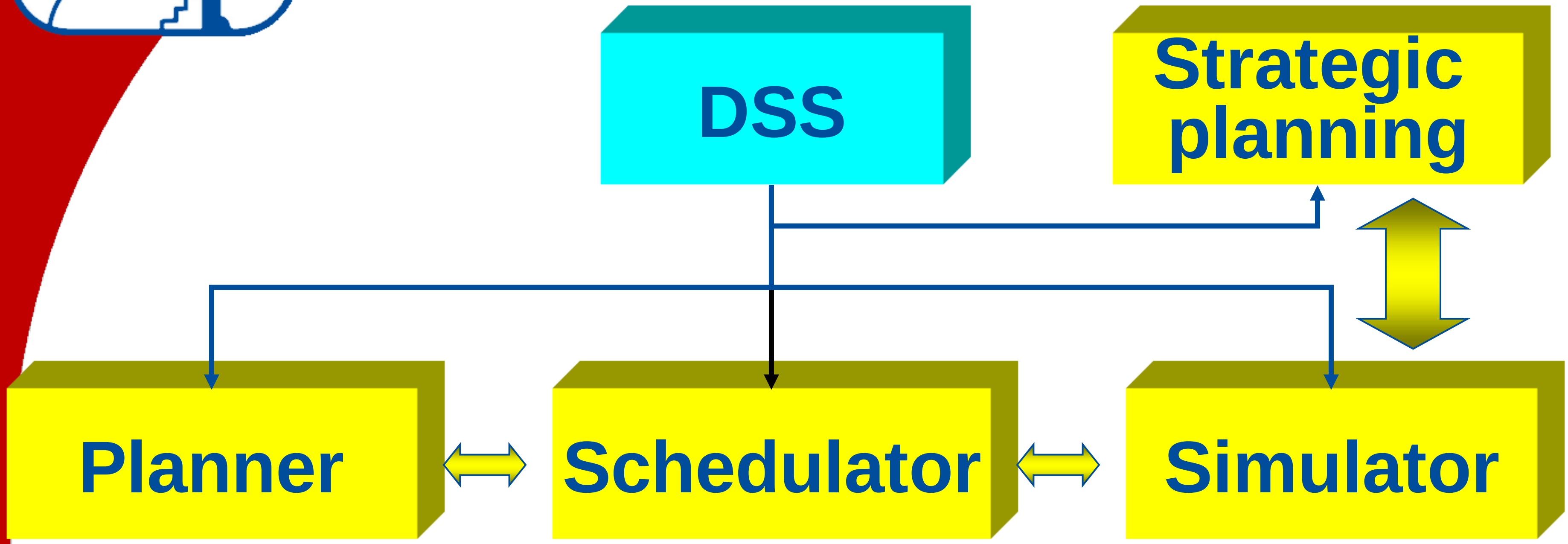
- **Validating and integrating the DSS in the holding system (i.e. Processes and ERP)**



DSS Objectives

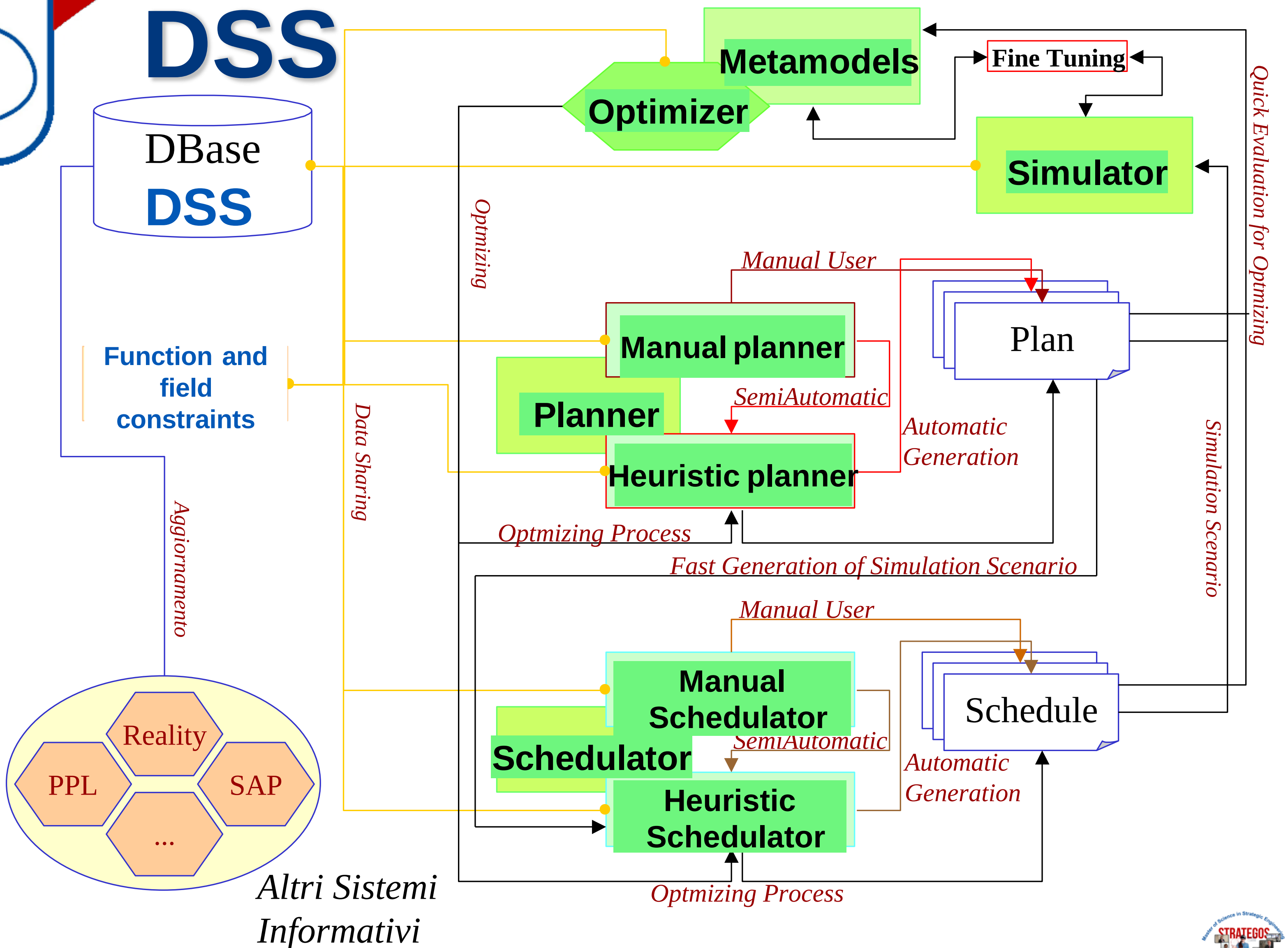
- Making the decision process independent of the role of a single expert person in the logistic sector
- Realizing a real time monitoring of the tank levels, of the ship positions by GPS and calculating the relevant ETA (*Estimated Time of Arrival*)
- Supplying methods, tools and basic information to 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

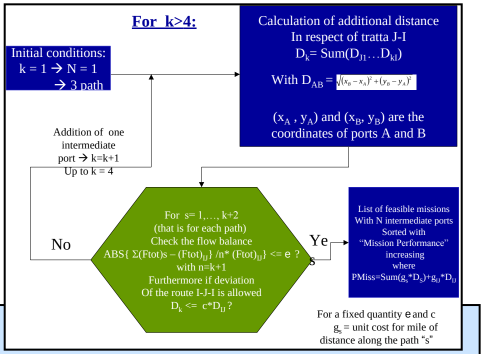


- Being a Complex System, it is essential to develop a campaign of tests for platform assessment and validation.
- The approach here proposed refers to the Directive 5000.61 and RPG enforced as Standard VV&A by DoD USA

DSS


DBase
DSS
Function and field constraints
Aggiornamento
Data Sharing
Optmizing
Metamodels
Optimizer
Fine Tuning
Simulator
Quick Evaluation for Optmizing
Manual User
Plan
Manual planner
Planner
SemiAutomatic
Heuristic planner
Automatic Generation
Optmizing Process
Fast Generation of Simulation Scenario
Simulation Scenario
Manual User
Schedule
Manual Schedulator
Schedulator
SemiAutomatic
Heuristic Schedulator
Automatic Generation
Optmizing Process
Other information Systems
Reality
PPL
SAP
...
Altri Sistemi Informativi

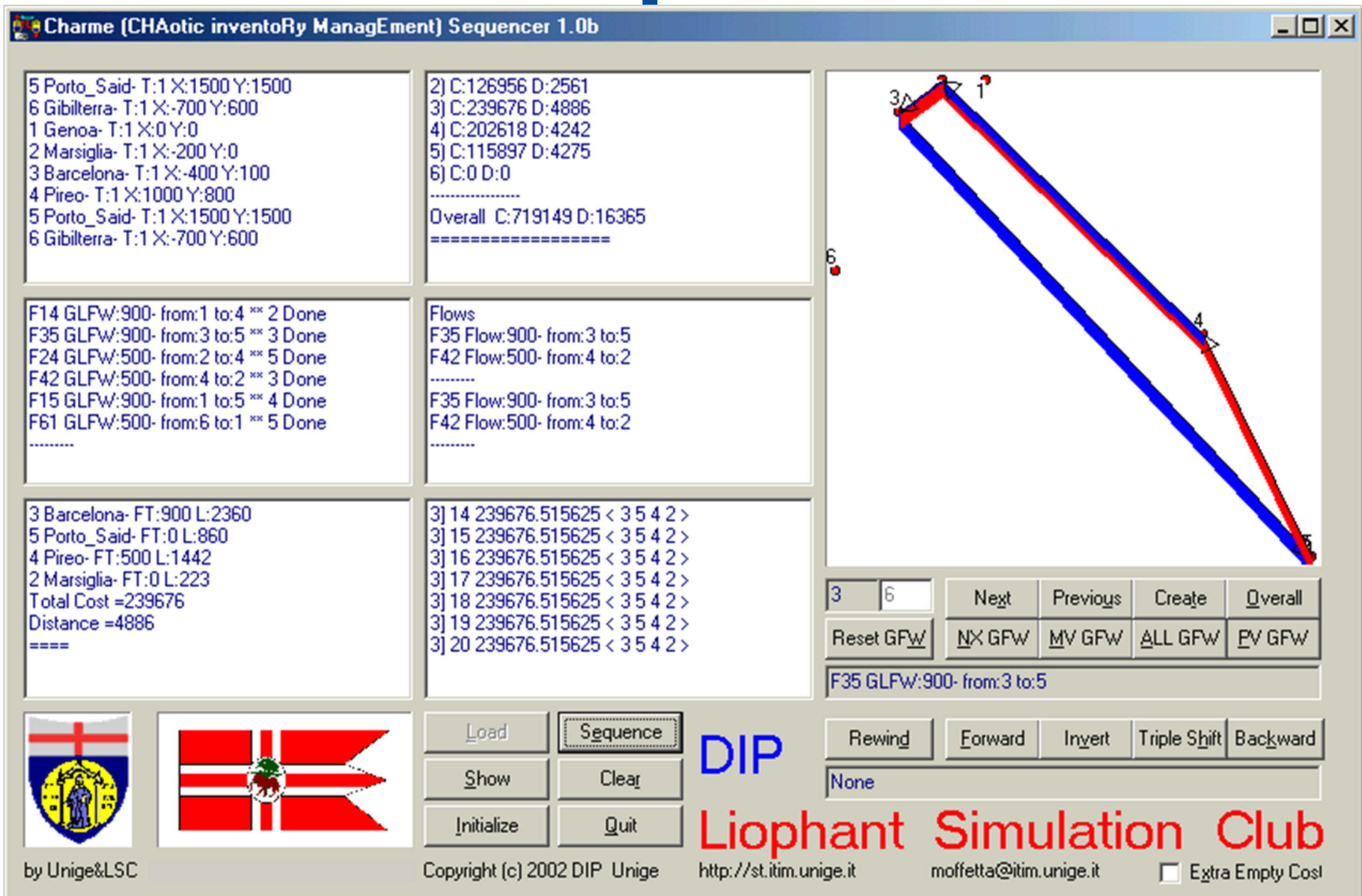
CHARME Sequencer Utilities



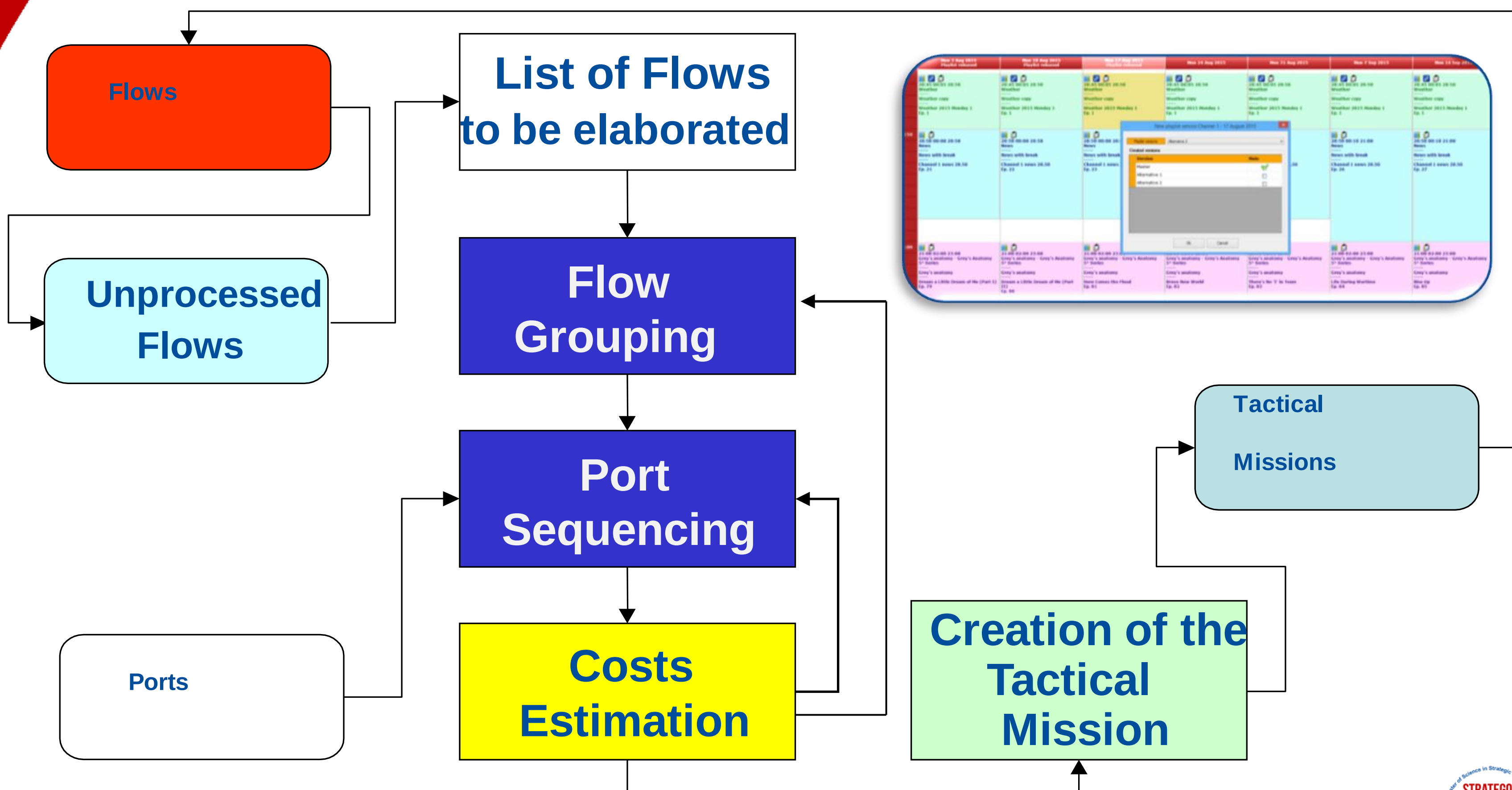
- Simulation of:
  - Navigation (Stochastic Estimated Time of Arrival)
  - Docks Upload/Download
  - Saturation level in ships
- Tactical mission management
- Evaluation of different port sequences
- Evaluation of different grouping choices between Flows
- Evaluation of the cost function of the tactical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

Charme Sequencer

Smart Optimizer & Simulator

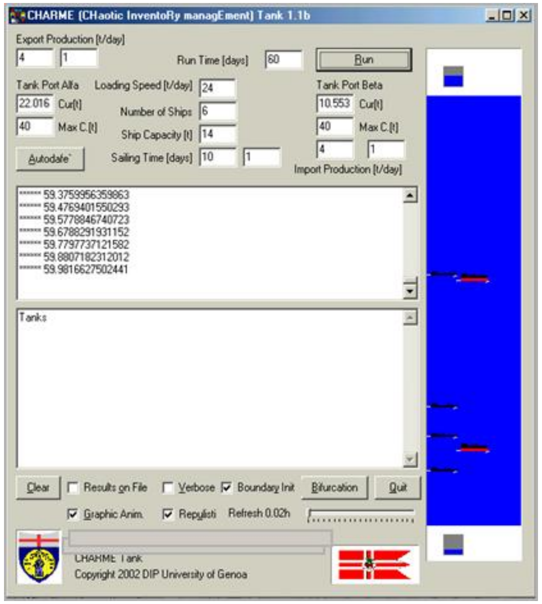


CHARME Procedure Sequencer



CHARME Tank Objectives:

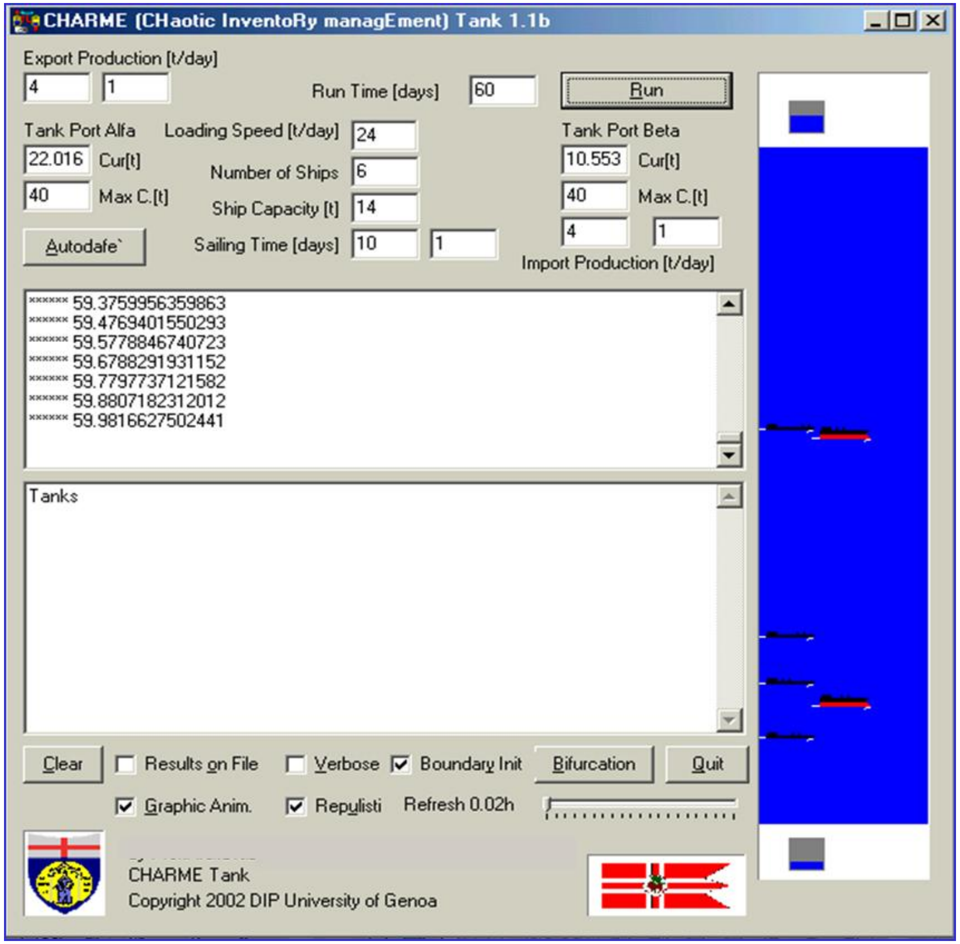
- **Identifying the critical aspects in the management of the ships transporting chemical products;**
- **Setting out a support methodology aiming at validating Complex Systems;**
- **Applying the fundamentals of the Theory of Chaos to stochastic problems of the maritime logistic system**



Charme Thank Simulator

Charme Tank with 6 Ships

CHAotic inventoRy ManagEment



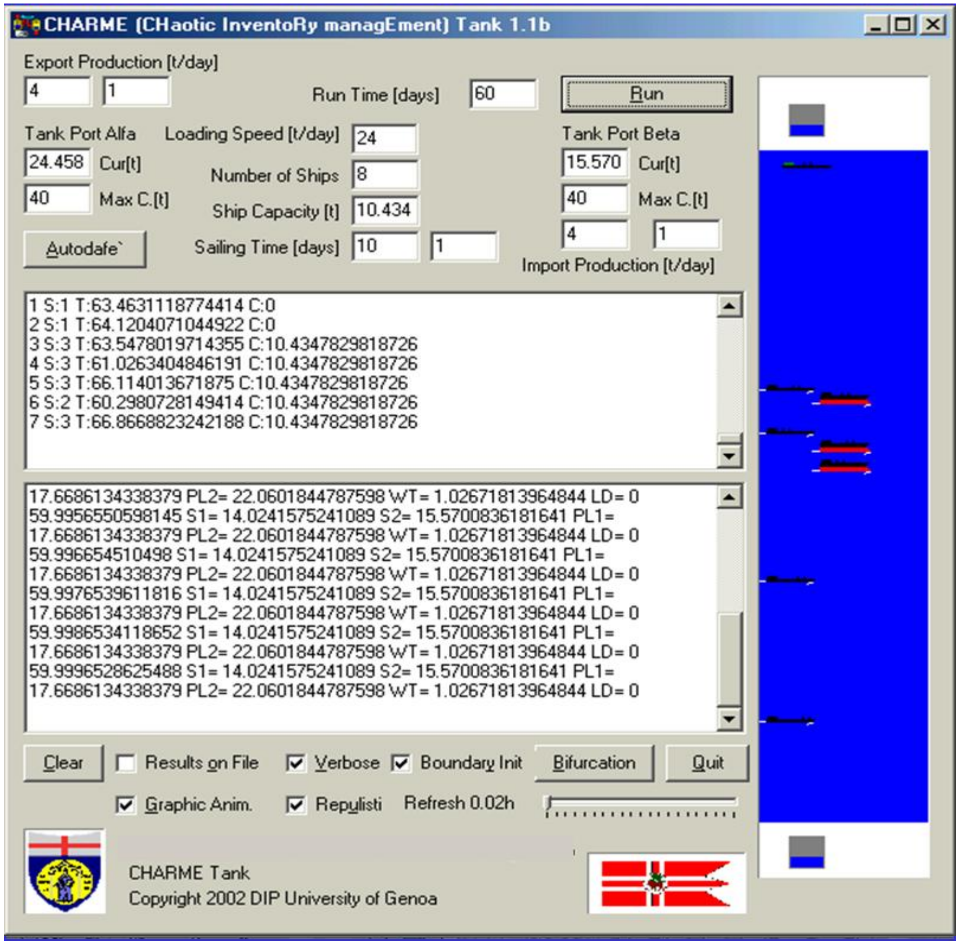
It is very important to conduct Validation, Verification and Accreditation of the model and to measure Experimental Error

Discrete Event Stochastic Simulation

www.liophant.org/projects

Charme Tank with 8 Ships

CHAotic inventoRy ManagEment



Discrete Event Stochastic Simulation

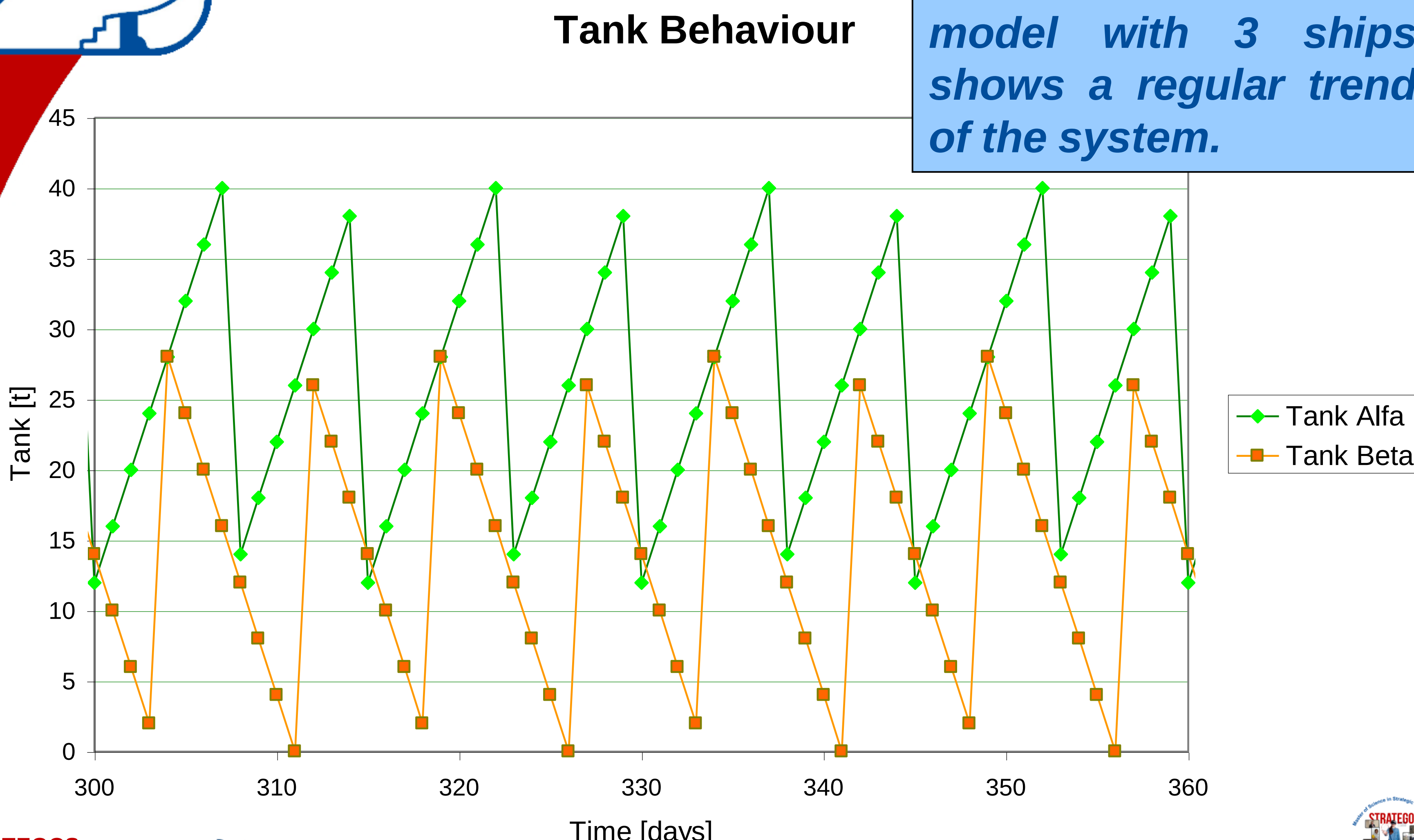
It is very important to conduct Validation, Verification and Accreditation of the model and to measure Experimental Error

Simulation Team
www.simulationteam.com

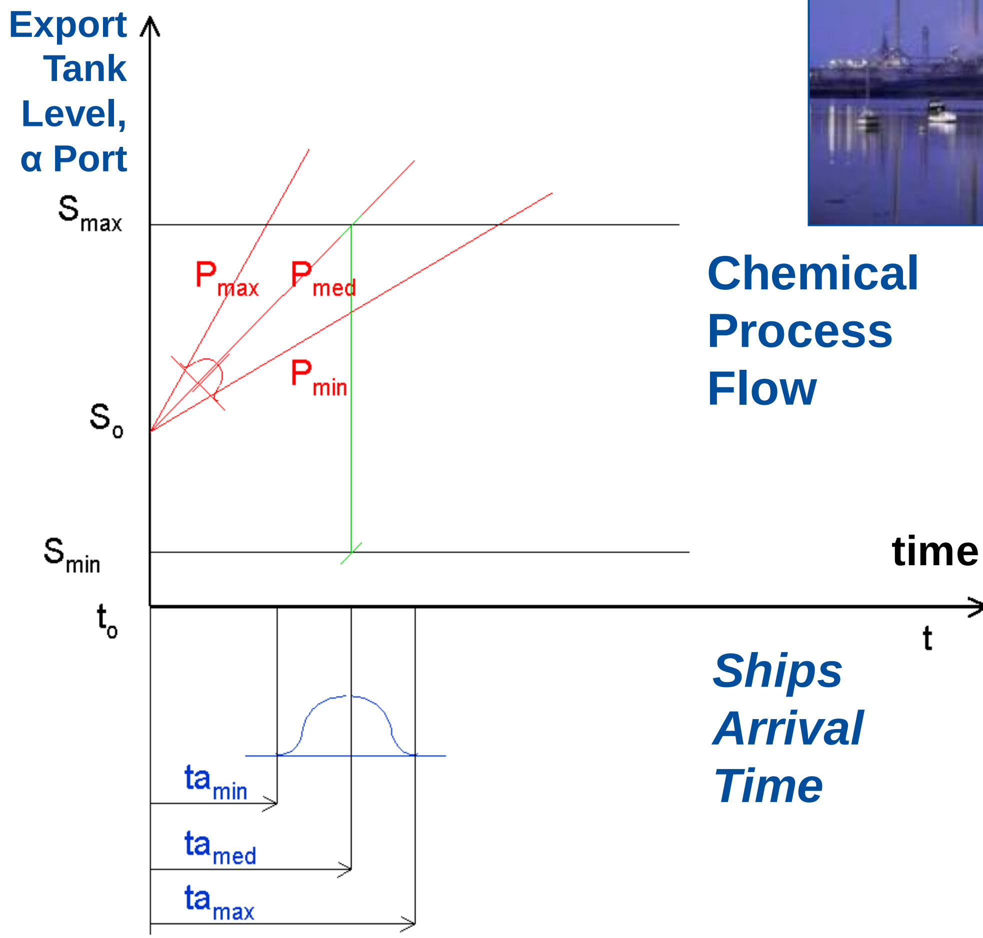
www.liophant.org/projects

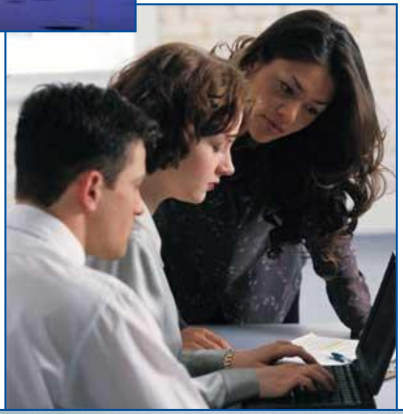
Deterministic Model

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

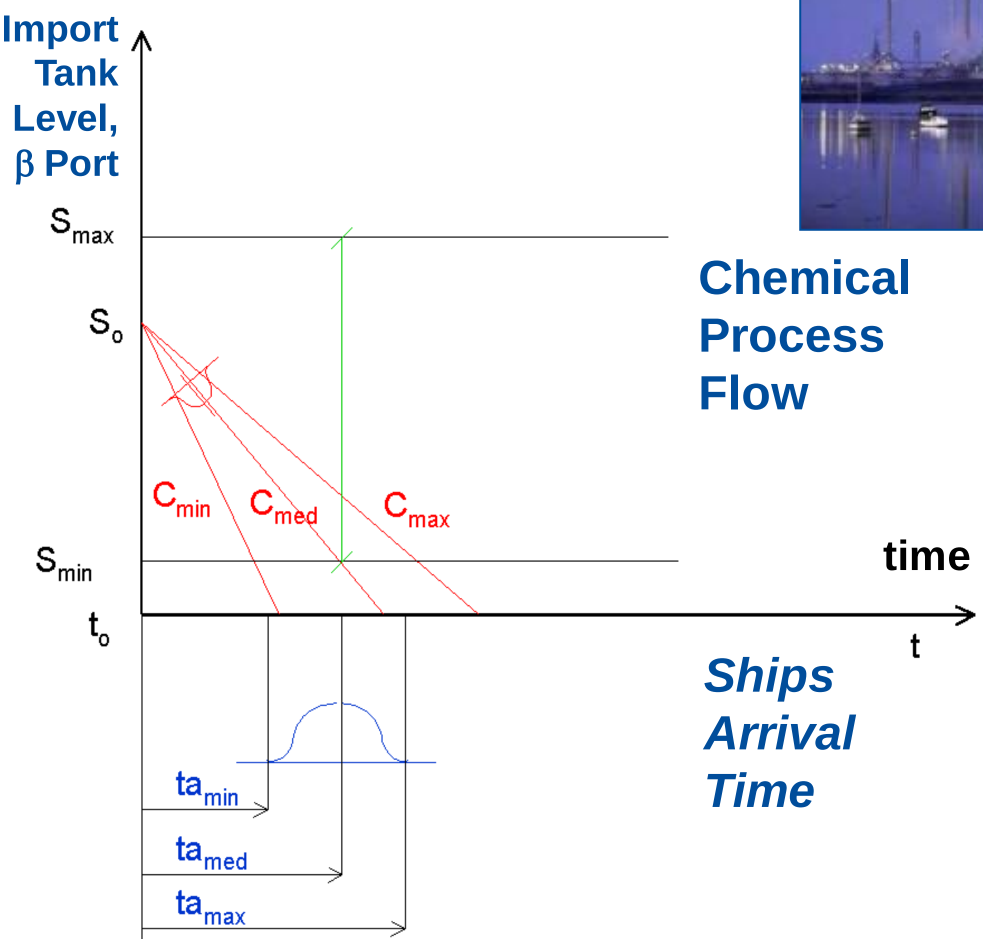


The role of Stochasticity (1/2)

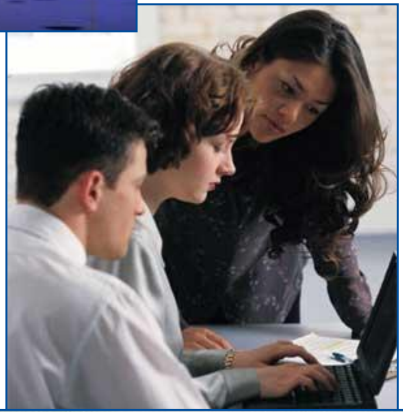




The role of Stochasticity (2/2)



Chemical Process Flow



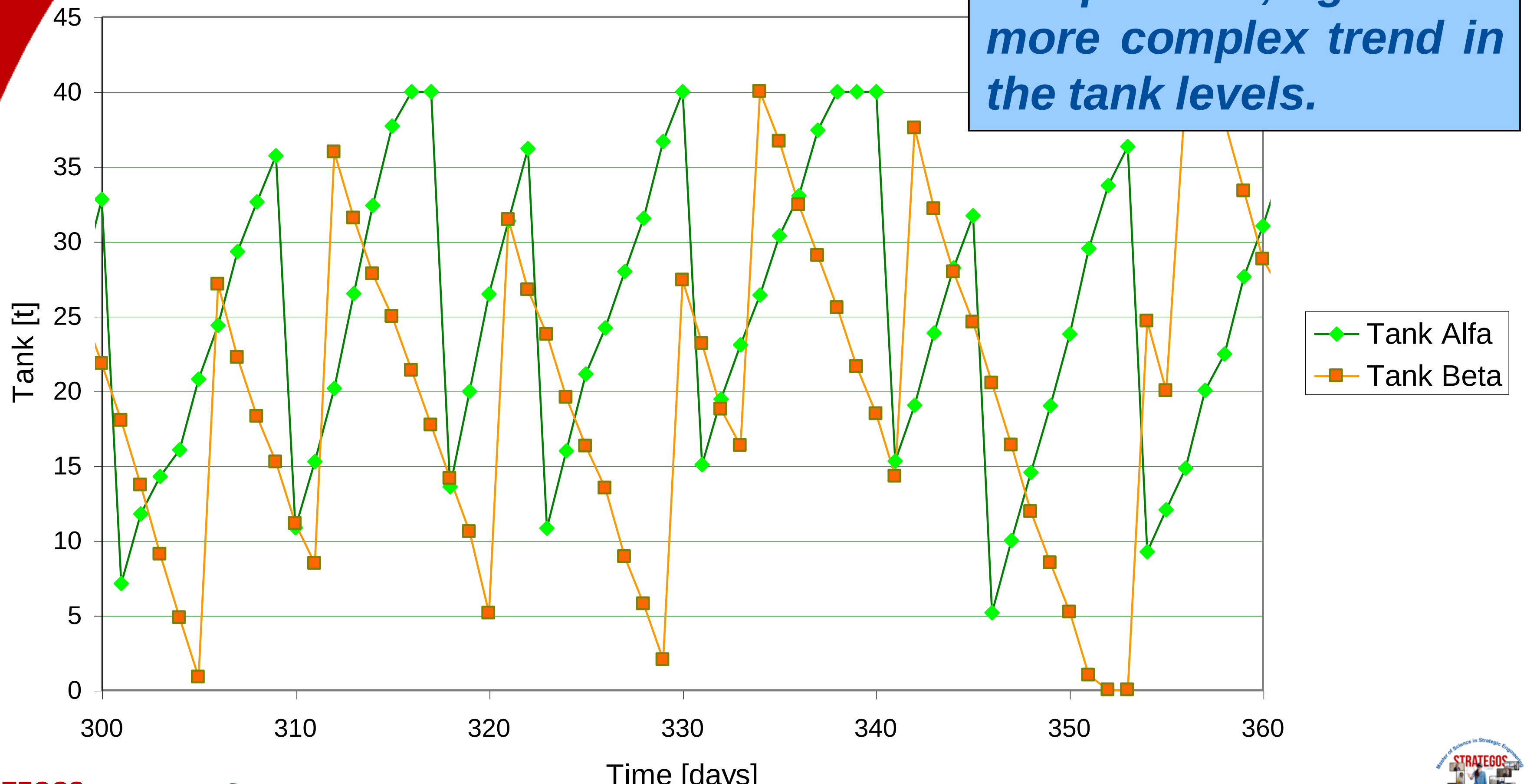
Ships Arrival Time

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.

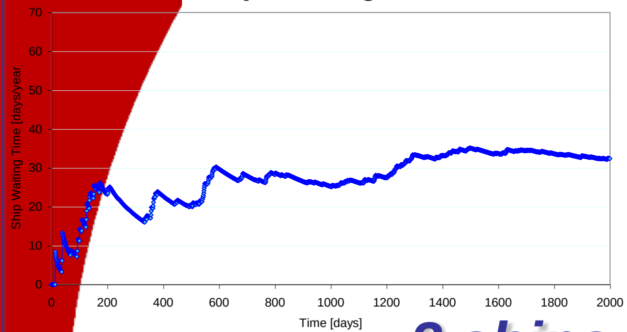


Simulation Team

Risks and Interferences

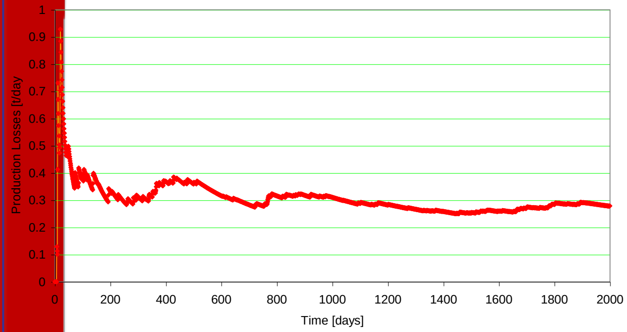
For a growing number of ships, there is a decrease in production losses & in the relevant risk levels, but the interference & the costs of Demourrages increase

Ship waiting time

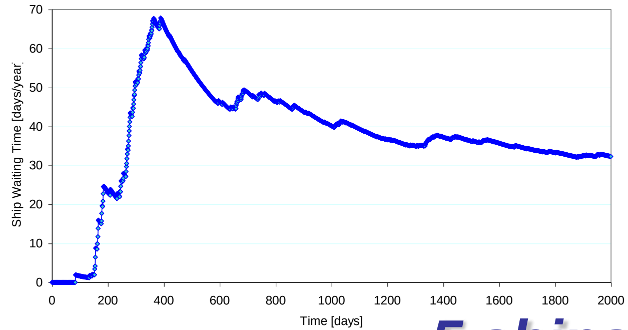


3 ships

Production losses

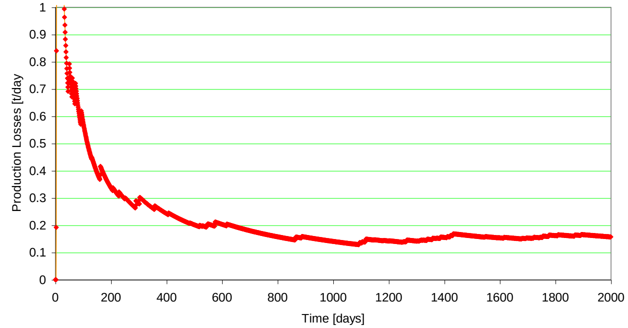


Ship waiting time

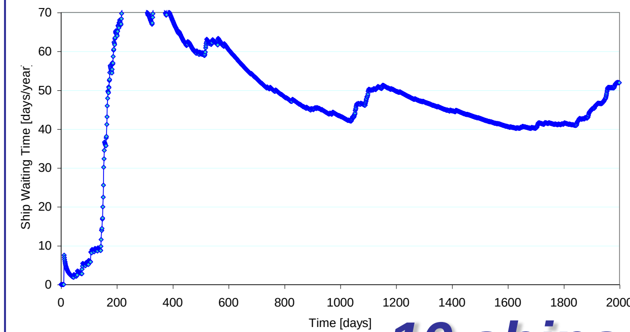


5 ships

Production losses

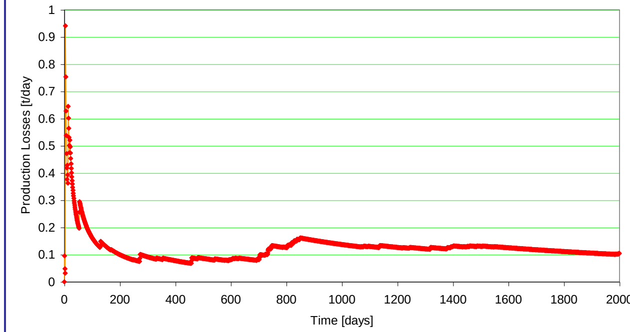


Ship waiting time



10 ships

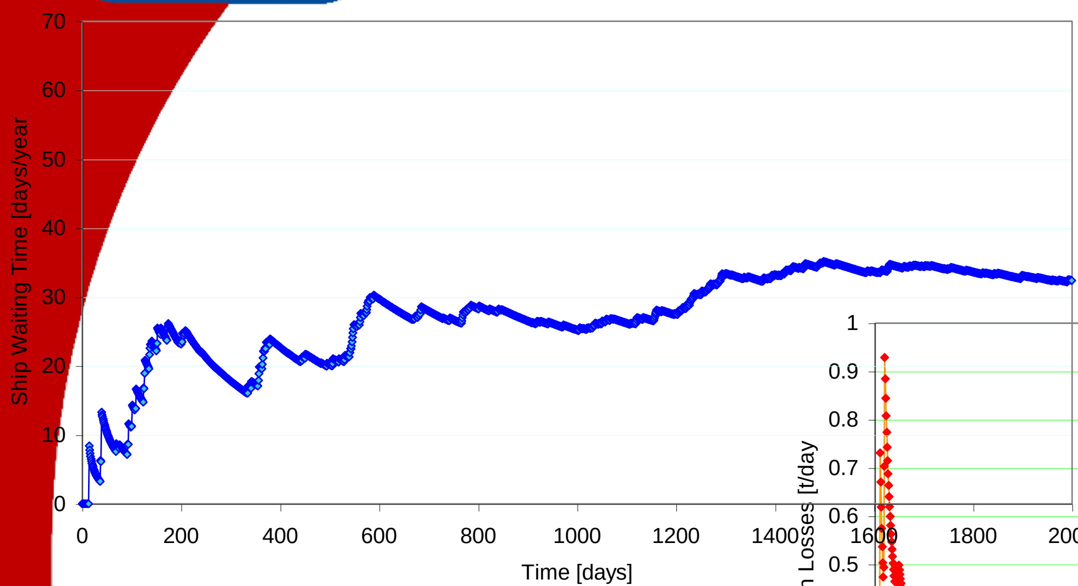
Production losses



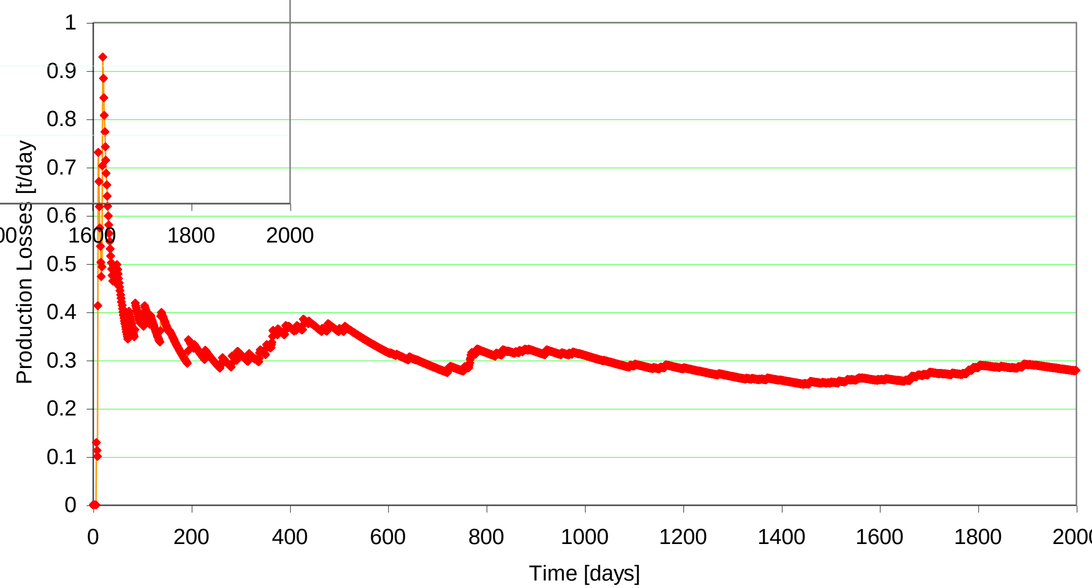
Simulation results obtained with Charme Tank on the same plant scenario

Case with 3 ships

Ship Waiting Time



Production Losses



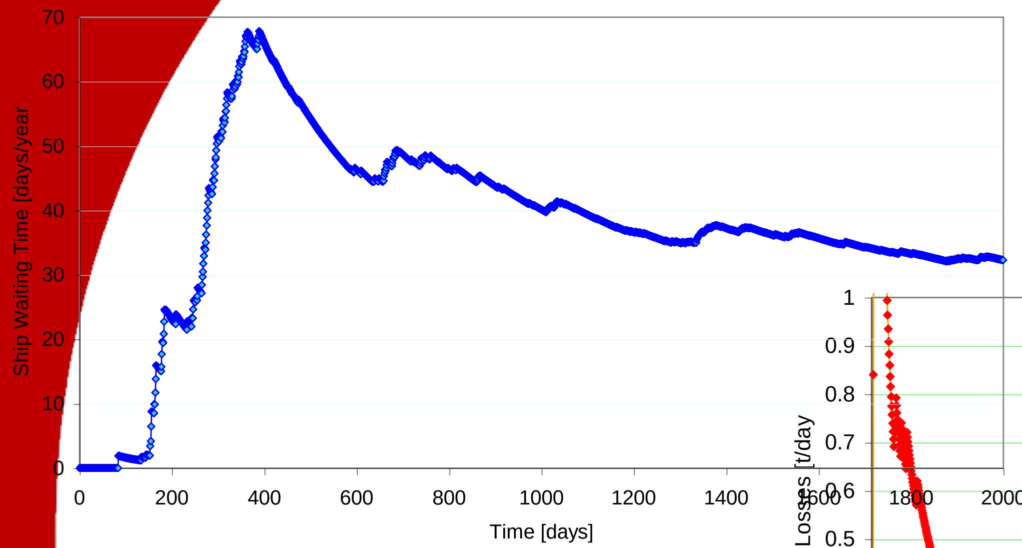
3 Ships

Simulation results obtained with Charme Tank on the same plant scenario

Risks and interferences

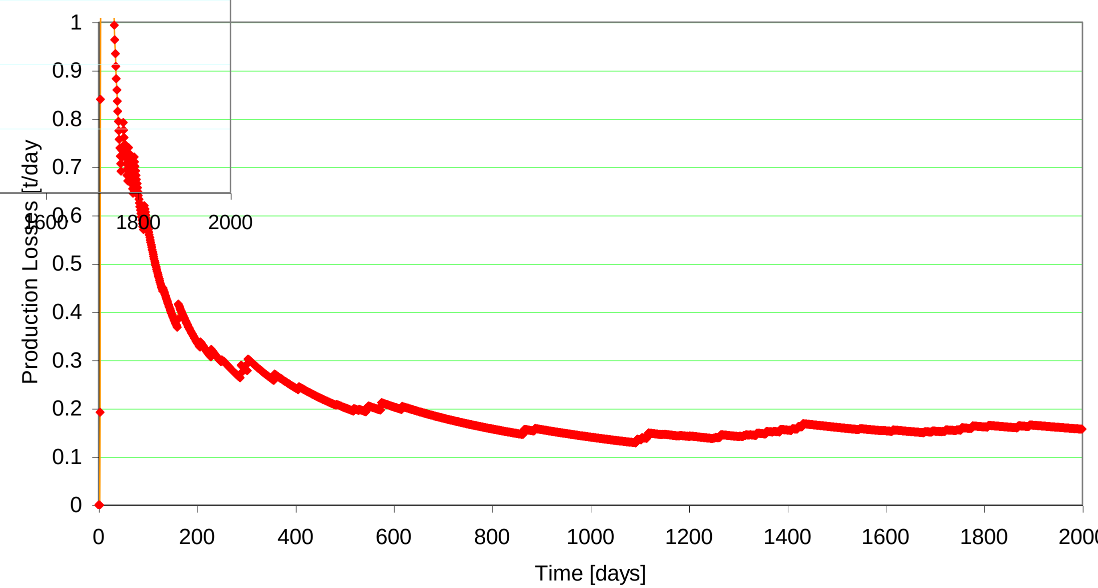
5 ship

Ship Waiting Time



5 Ships

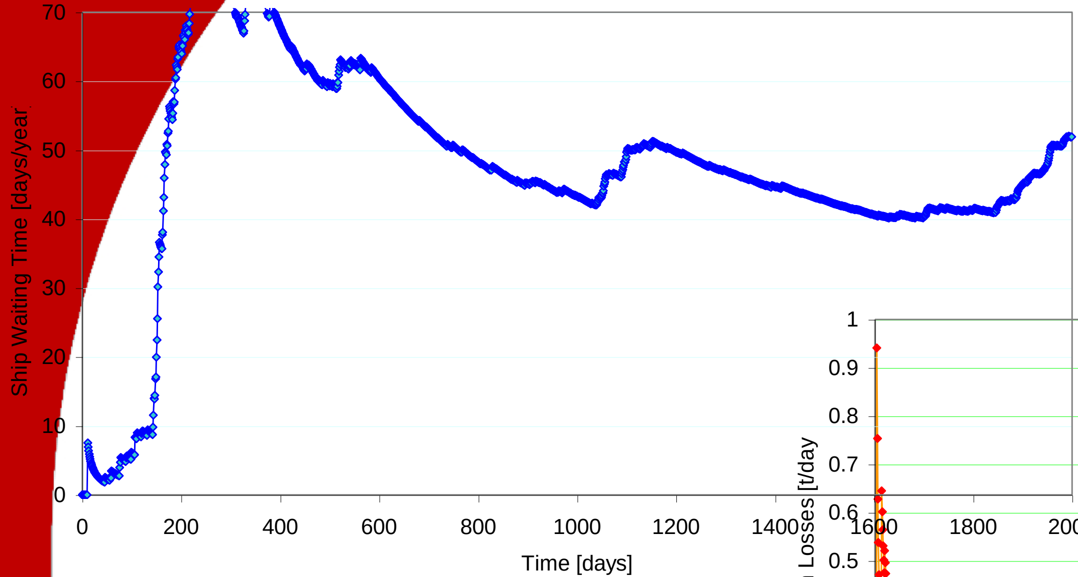
Production Losses



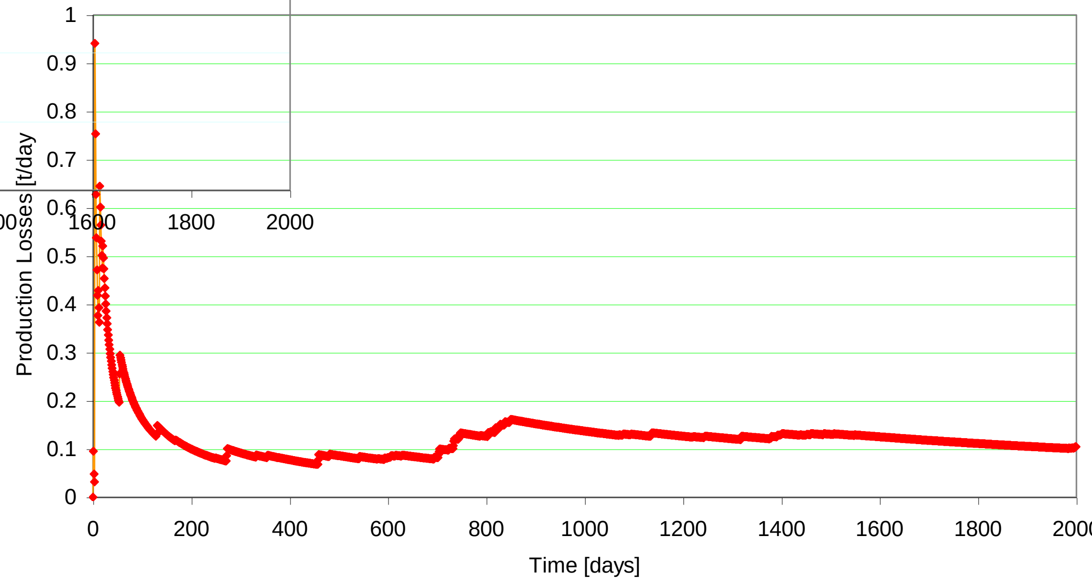
Risks and interferences

10 ship

Ship Waiting Time

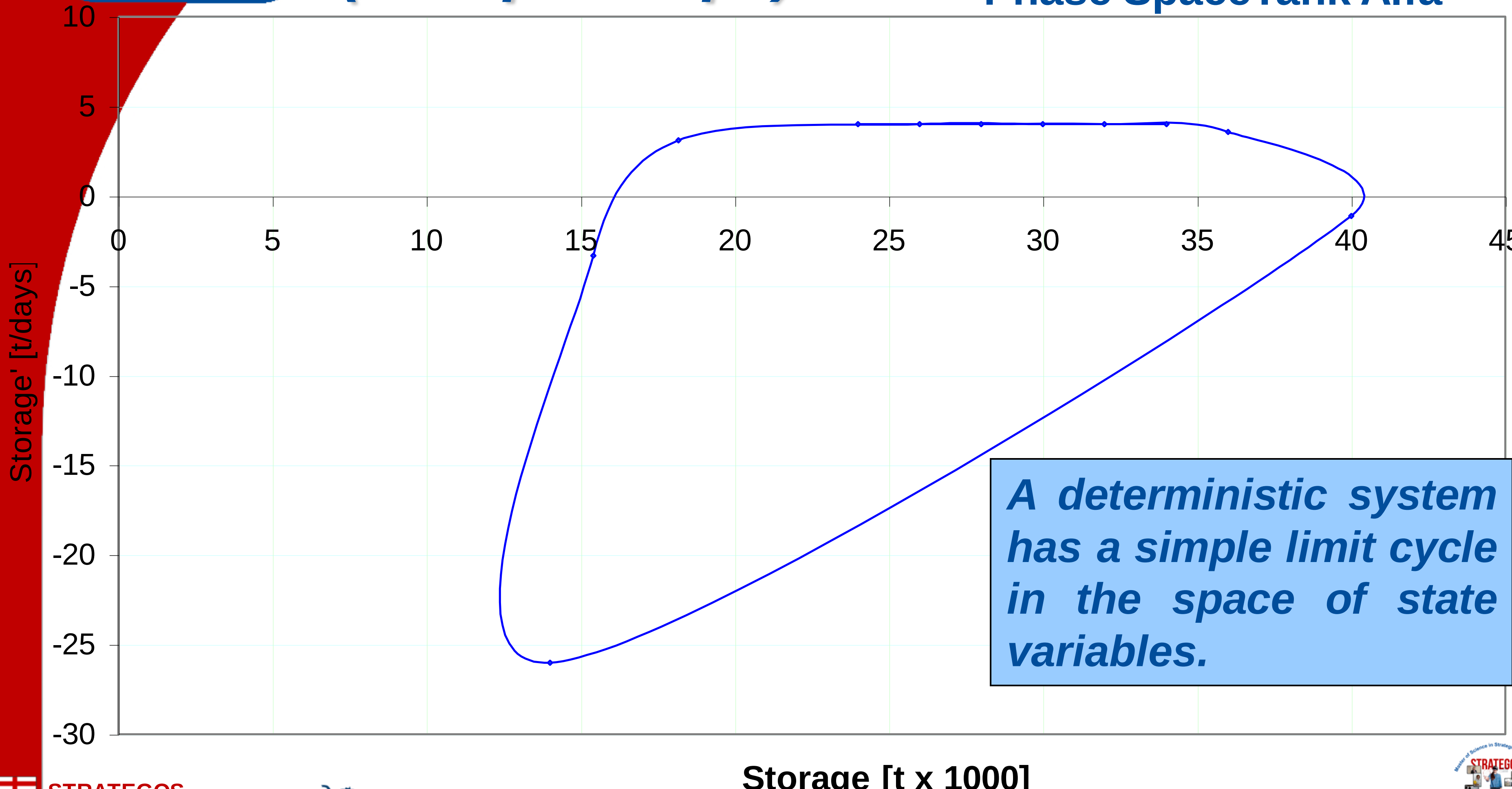


Production Losses



10 Ships

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



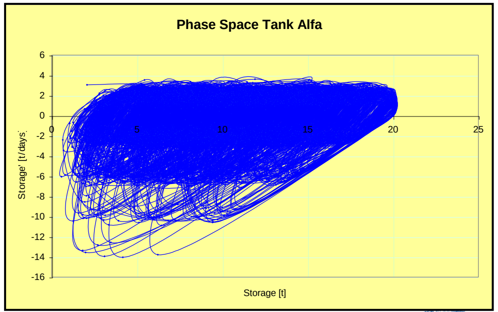
A deterministic system has a simple limit cycle in the space of state variables.

Chaos Analysis Techniques

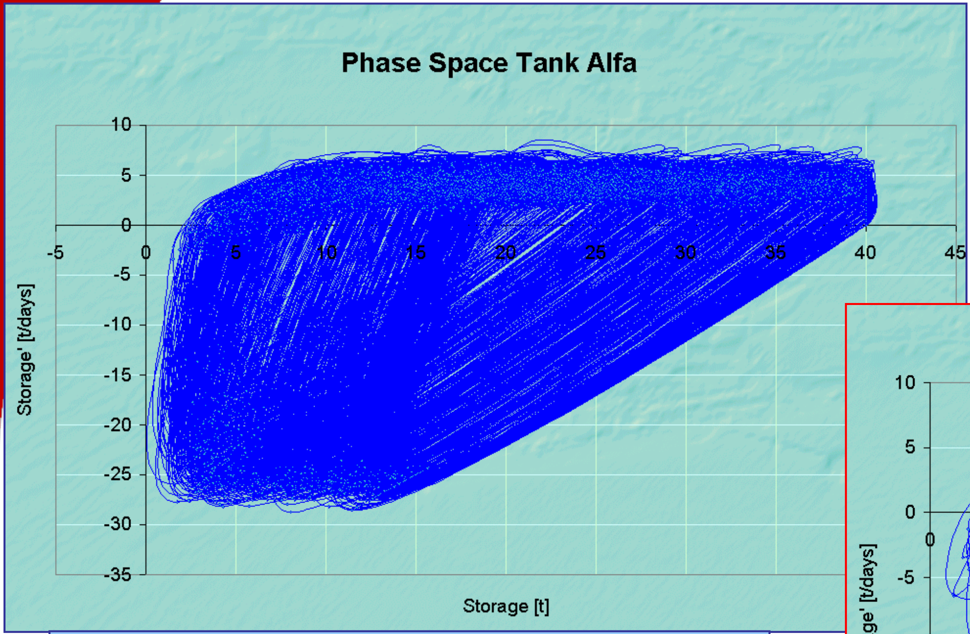
The methodology of analysis is based on:

- 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

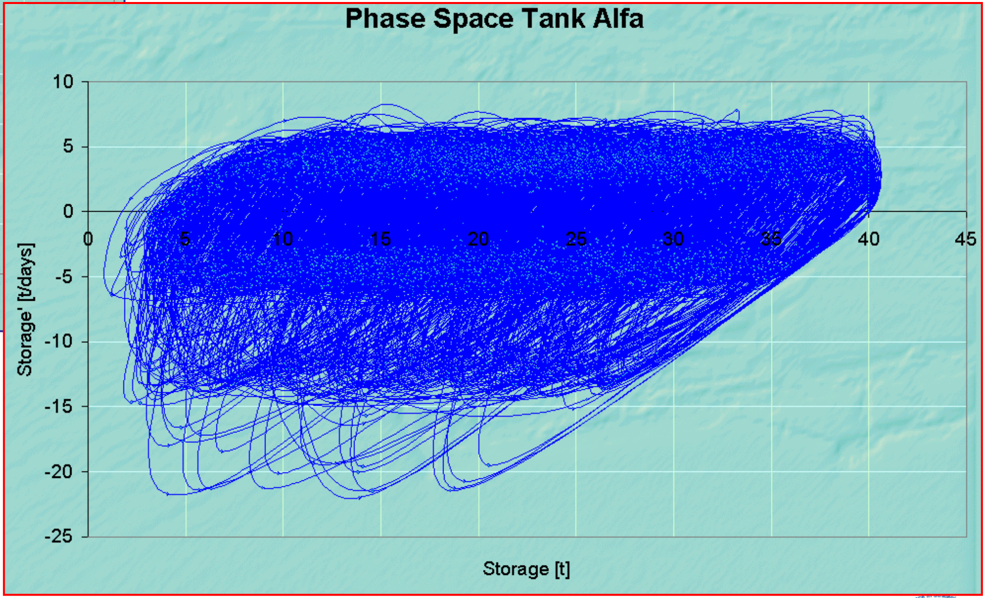


Space of the state variables of the Export Tank in Stochastic Regime



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.

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

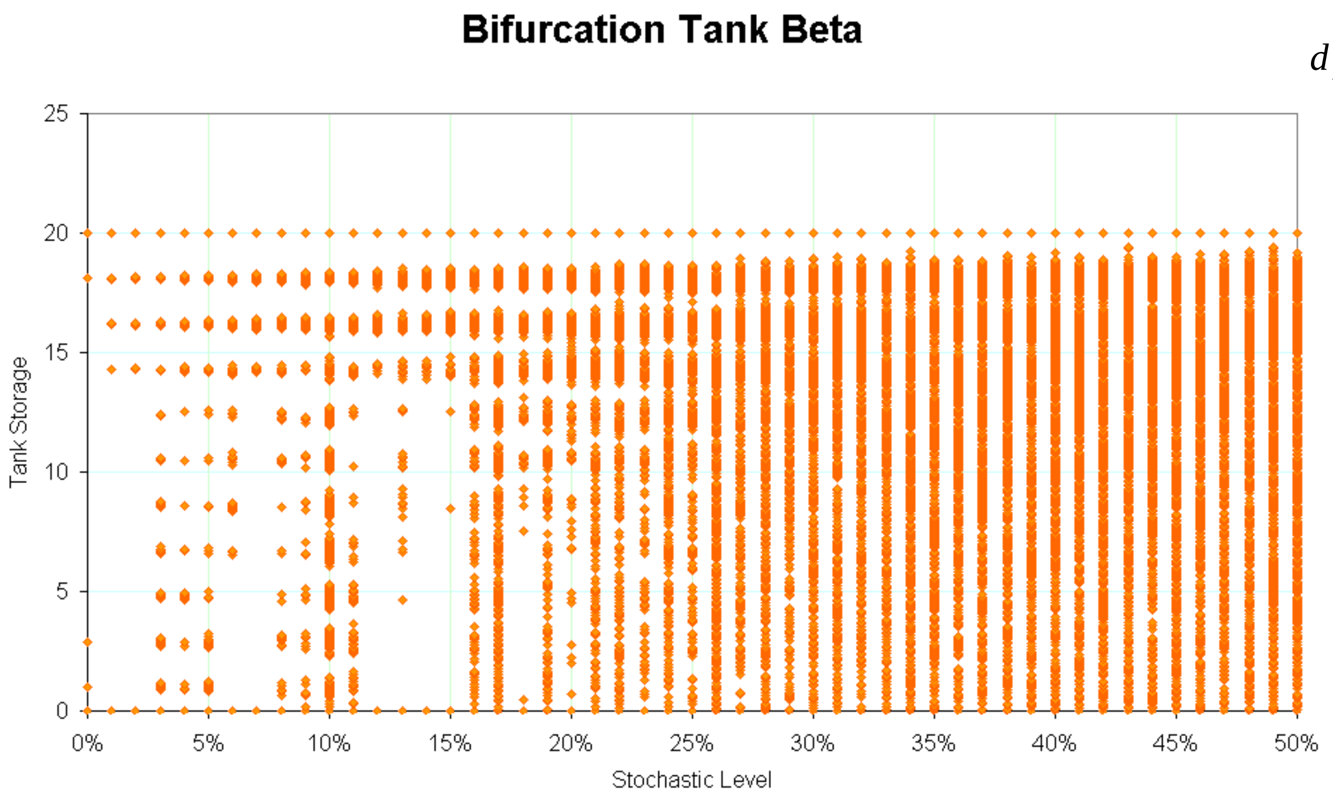


Bifurcation Diagram

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

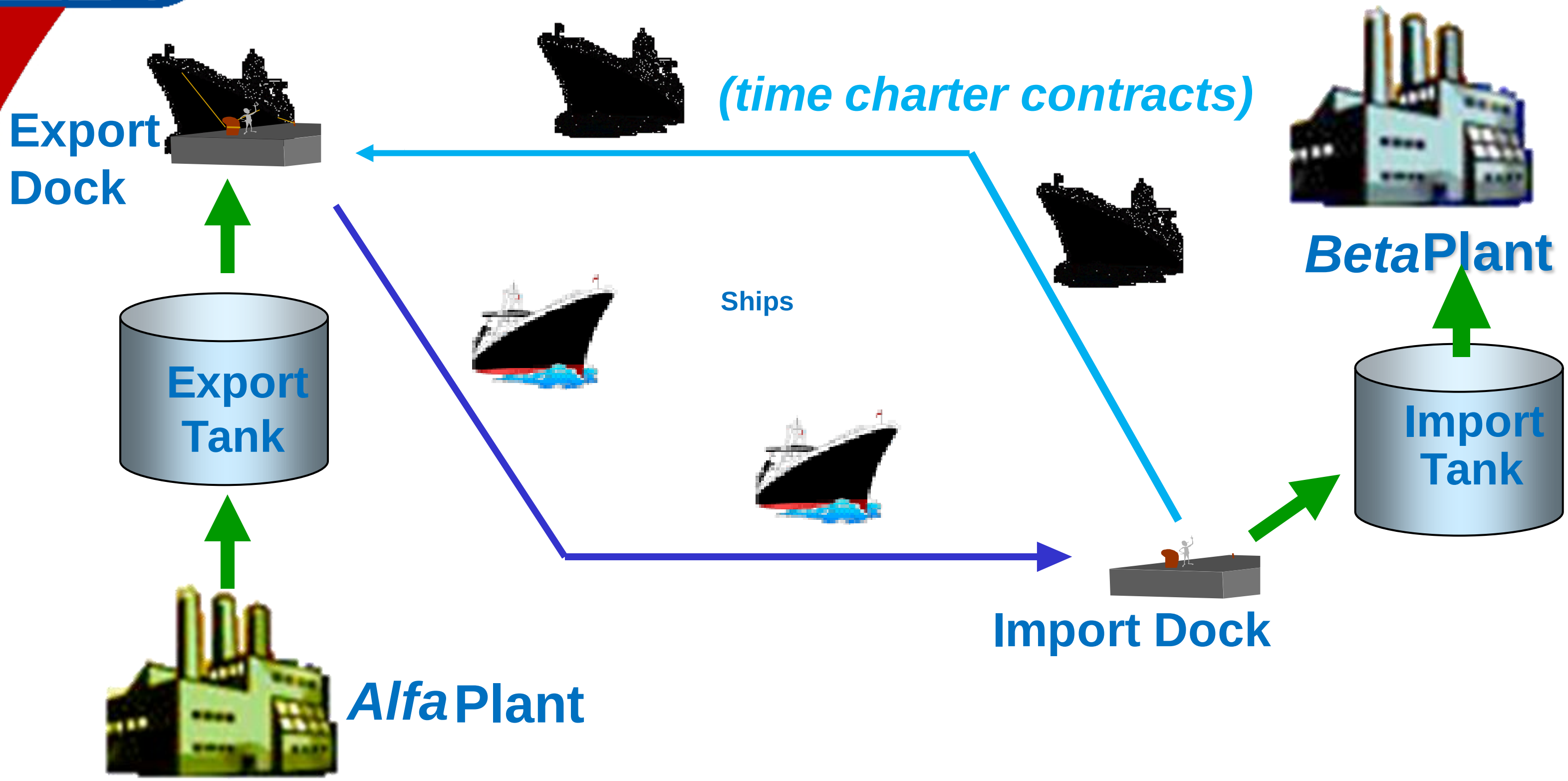
$$d_L = k + \frac{\log\left(\prod_{i=1}^{k} \lambda_i\right)}{\log \frac{1}{\lambda_{k+1}}}$$

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



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

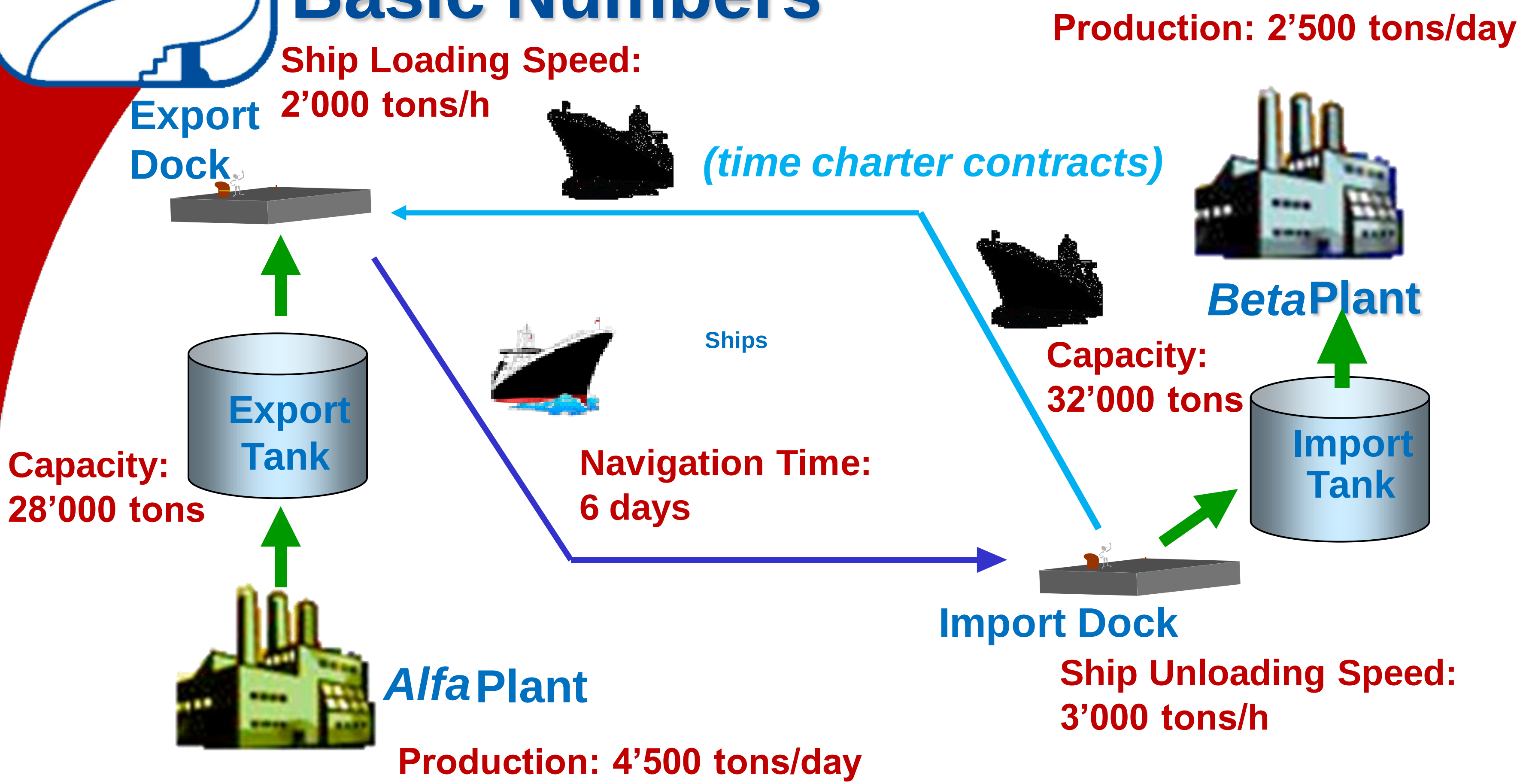
Chemical Logistics: Exerise



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

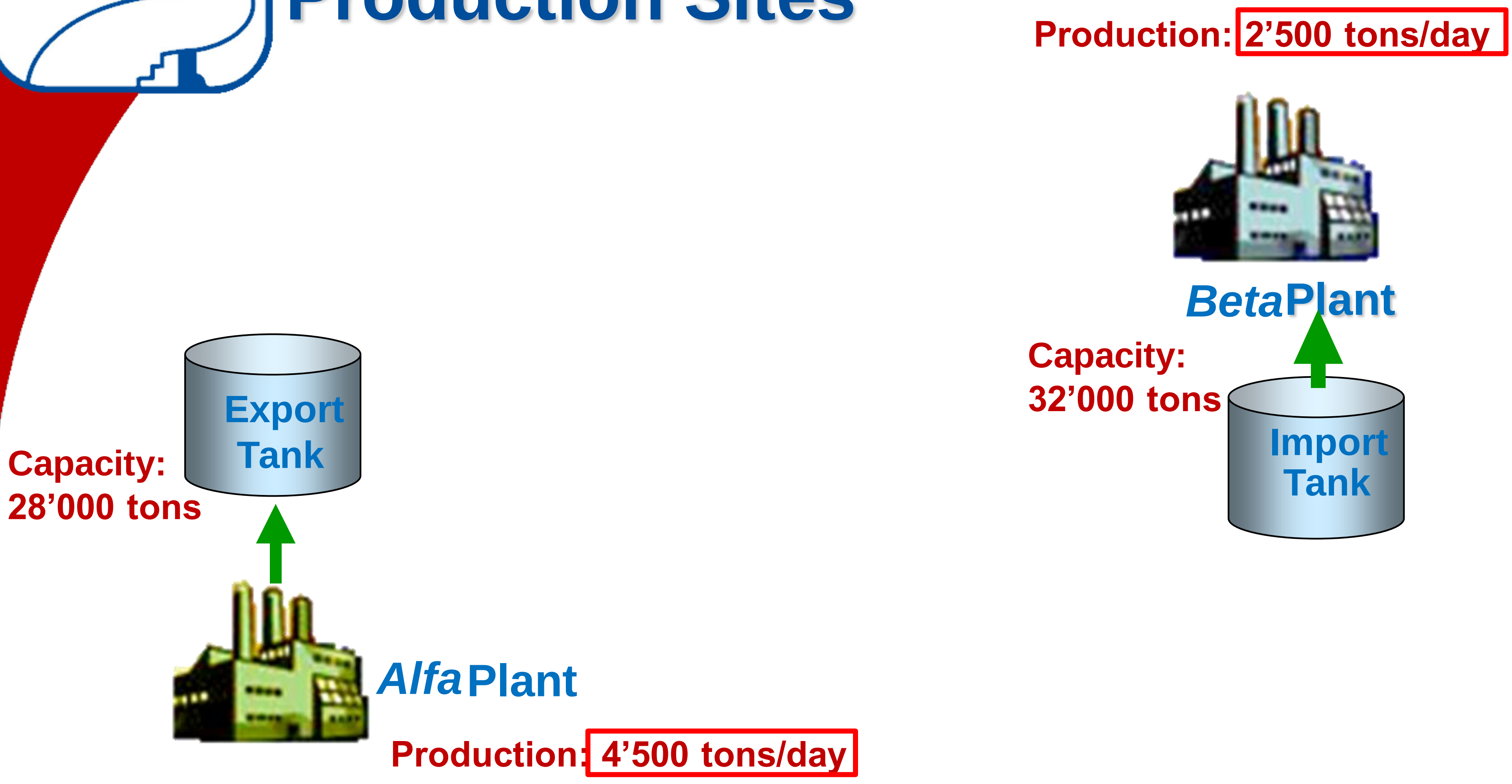
Logistics Exerise Basic Numbers

Time Charter Contracts



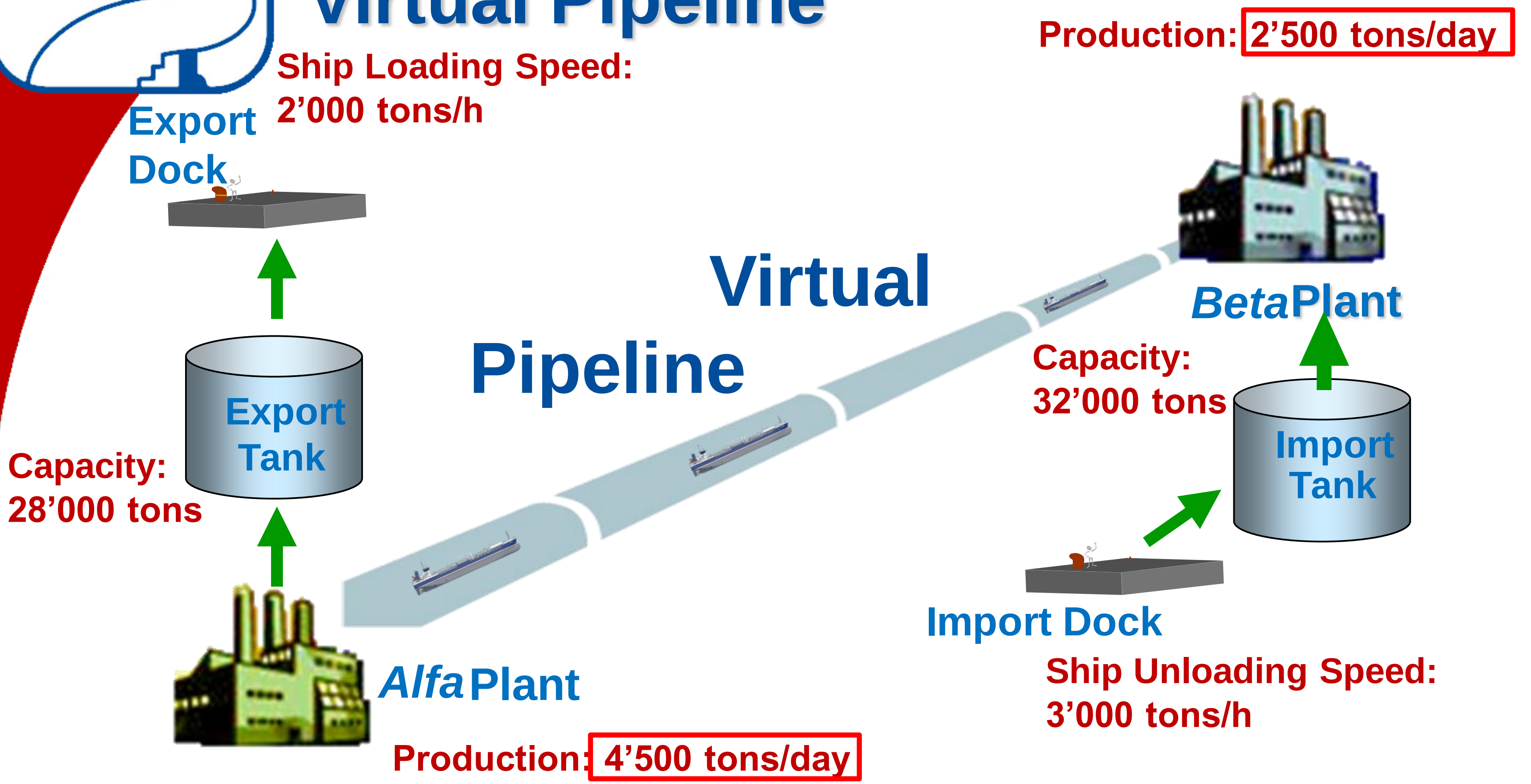
Production Sites

Time Charter Contracts



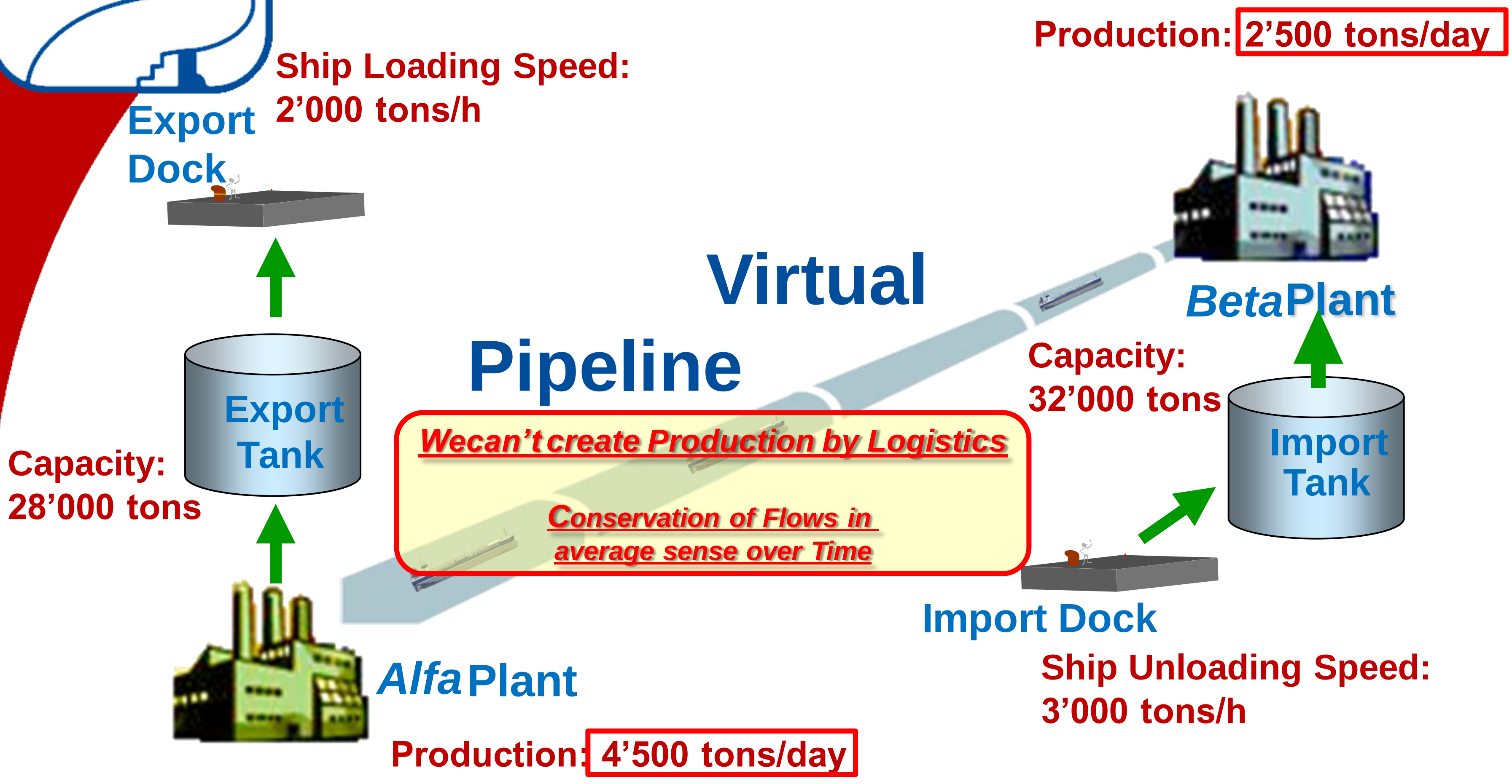
Logistics as Virtual Pipeline

Time Charter Contracts



Balancing Flows

Time Charter Contracts



Chemical Flows & Production

Time Charter Contracts

Production: 2’500 tons/day

Ship Loading Speed:
2’000 tons/h

Export Dock

Export Tank

Capacity:
28’000 tons

Alfa Plant

Virtual Pipeline

Wecan’t create Production by Logistics

Conservation of Flows in average sense over Time

So

Production: 2’500 tons/day

2’000 tons/day → To other Customers

Beta Plant

Capacity:
32’000 tons

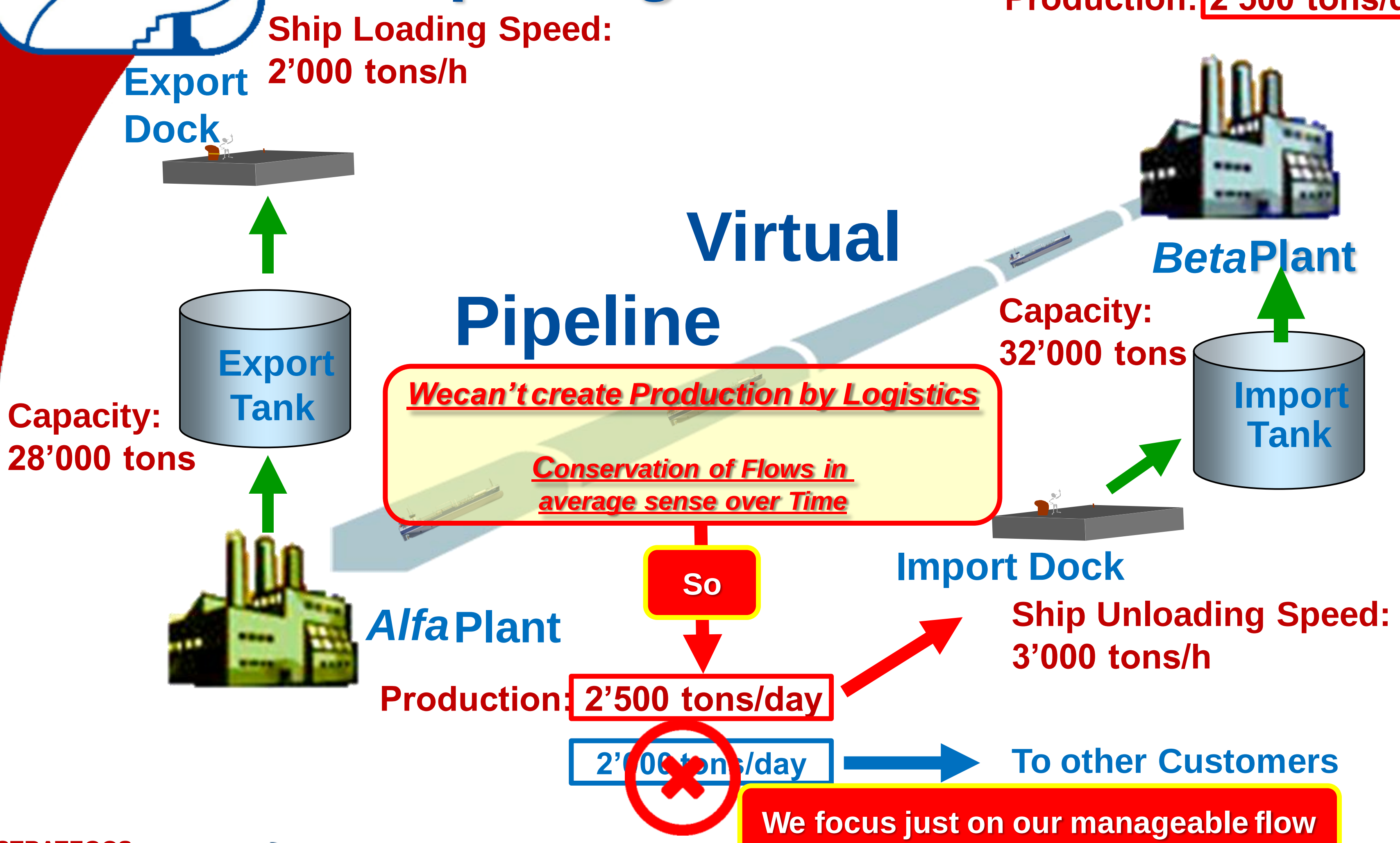
Import Tank

Import Dock

Ship Unloading Speed:
3’000 tons/h

Out Exercise: Demposing

Time Charter Contracts



From Continuous Flow to Discrete

Time Charter Contracts

Production: 2’500 tons/day

Ship Loading Speed:
2’000 tons/h

Export Dock

Beta Plant

Virtual Pipeline

Capacity:
32’000 tons

Export Tank

Import Tank

Capacity:
28’000 tons

Our Virtual Pipeline is an echelon in Supply Chain, but flow is discontinuous

So we need Autonomy to operate

Import Dock

Alfa Plant

Ship Unloading Speed:
3’000 tons/h

Production: 2’500 tons/day

$$A_{beta} = \frac{32'000}{2'500} = 12.8 \text{ days}$$

$$A_{alfa} = \frac{28'000}{2'500} = 11.2 \text{ days}$$

$$\text{Autonomy: } \frac{\text{Tank Capacity}}{\text{Production Flow}} \text{ [days]}$$

Time Charter Contracts

Autonomy Concept

Production: 2'500 tons/day

Ship Loading Speed:
2'000 tons/h

Export Dock

Virtual Pipeline

BetaPlant

Capacity:
32'000 tons

Export Tank

Capacity:
28'000 tons

Import Tank

Most Critical Autonomy Determines the Frequency of Ship Arrival

Import Dock

AlfaPlant

Ship Unloading Speed:
3'000 tons/h

Production: 2'500 tons/day

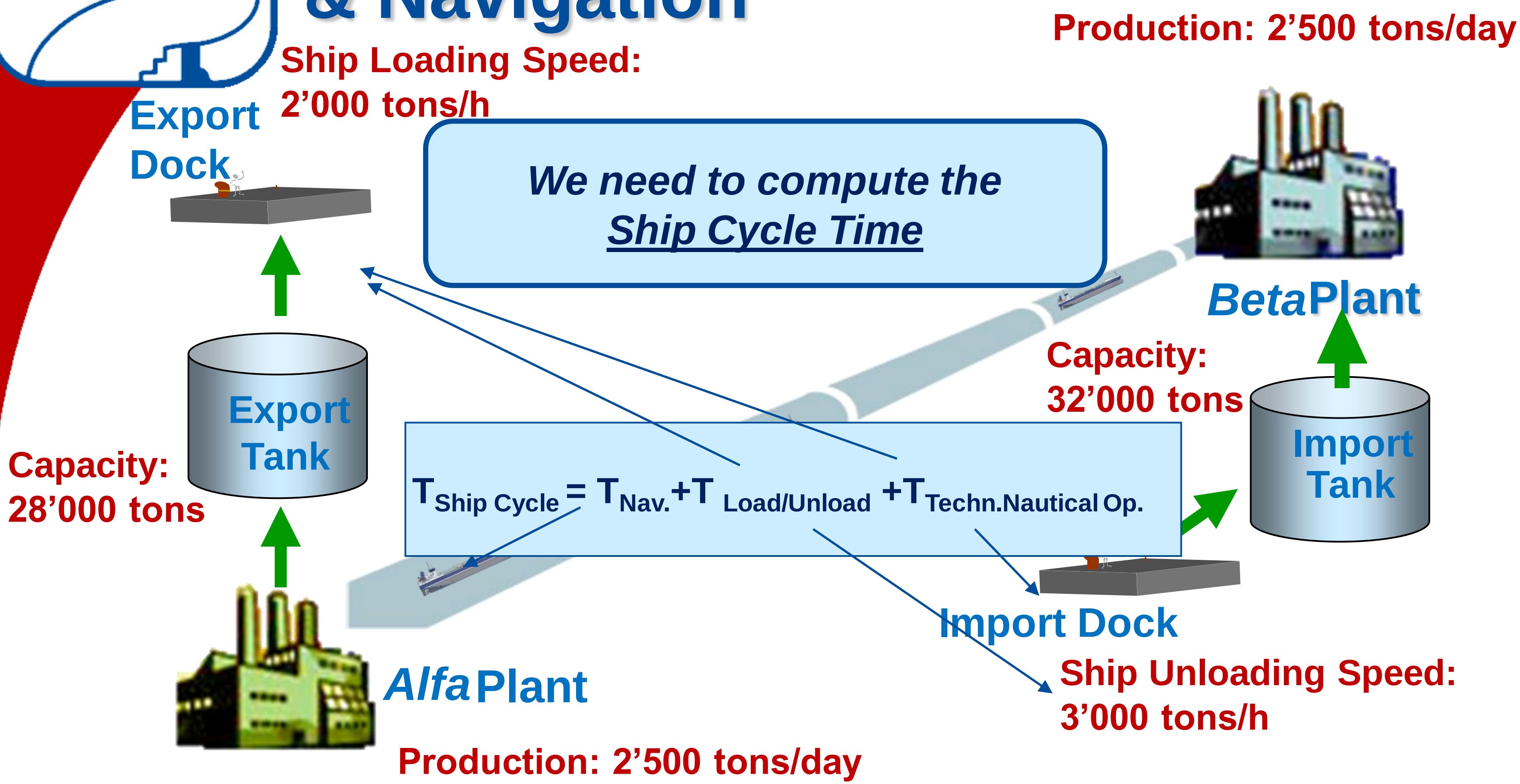
$$A_{beta} = \frac{32'000}{2'500} = 12.8 \text{ days}$$

$$A_{alfa} = \frac{28'000}{2'500} = 11.2 \text{ days}$$

$$A_{critical} = A_{min} = A_{alfa}$$

Ship Cycle Time & Navigation

Time Charter Contracts



$A_{critical} = 11.2$ days

Ship Size: 1st Tentative

Time Charter Contracts

Ship Loading Speed: 2’000 tons/h

Export Dock

We need to estimate a Ship Size to compute Loading Time: Biggest Ship should be ≤ Min Tank So in our case 28’000 tons capacity

Production: 2’500 tons/day

Beta Plant

Capacity: 32’000 tons

Import Tank

Export Tank

Capacity: 28’000 tons

$$T_{\text{Ship Cycle}} = T_{\text{Nav.}} + T_{\text{Load/Unload}} + T_{\text{Techn.Nautical Op.}}$$

Import Dock

Ship Unloading Speed: 3’000 tons/h

Alfa Plant

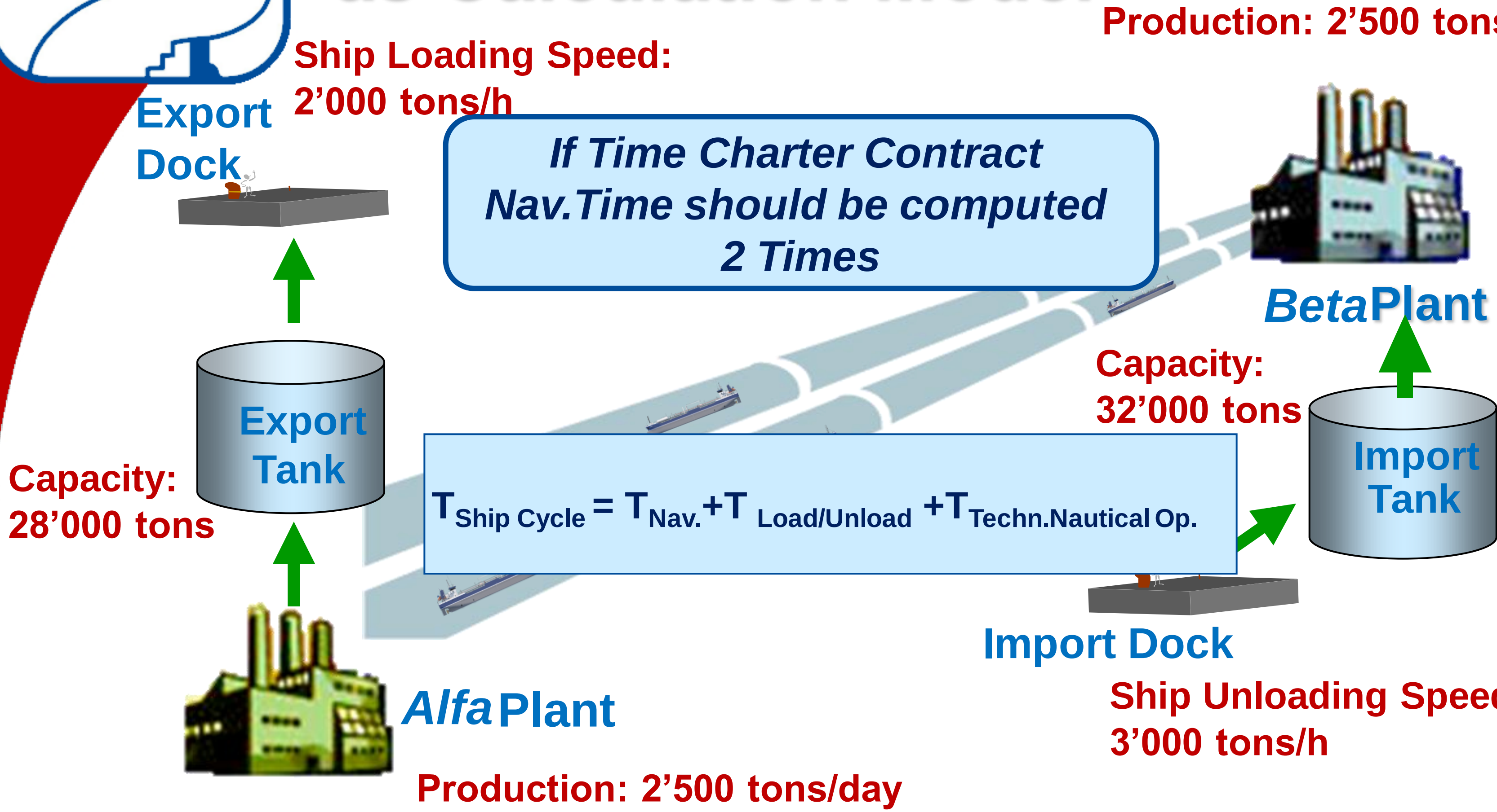
Production: 2’500 tons/day

ritical = 11.2 days

$$T_{\text{Ship Cycle}} = 2 \times 6 + \frac{28'000}{2'000 \times 24} + \frac{28'000}{3'000 \times 24} + 4 \times \frac{45'}{24 \times 3600}$$

Logistics as Calculation Model

Time Charter Contracts



$$T_{Ship\ Cycle} = T_{Nav.} + T_{Load/Unload} + T_{Techn.Nautical\ Op.}$$

$A_{critical} = 11.2$ days

$T_{Ship\ Cycle} = 12^{\ days}\ 23^{h}\ 23'$

Number of Ships

We need to determine Interval of Arrivals and compare With Critical Autonomy

$$T_{\text{Ship Cycle}} = T_{\text{Nav.}} + T_{\text{Load/Unload}} + T_{\text{Techn.Nautical Op.}}$$

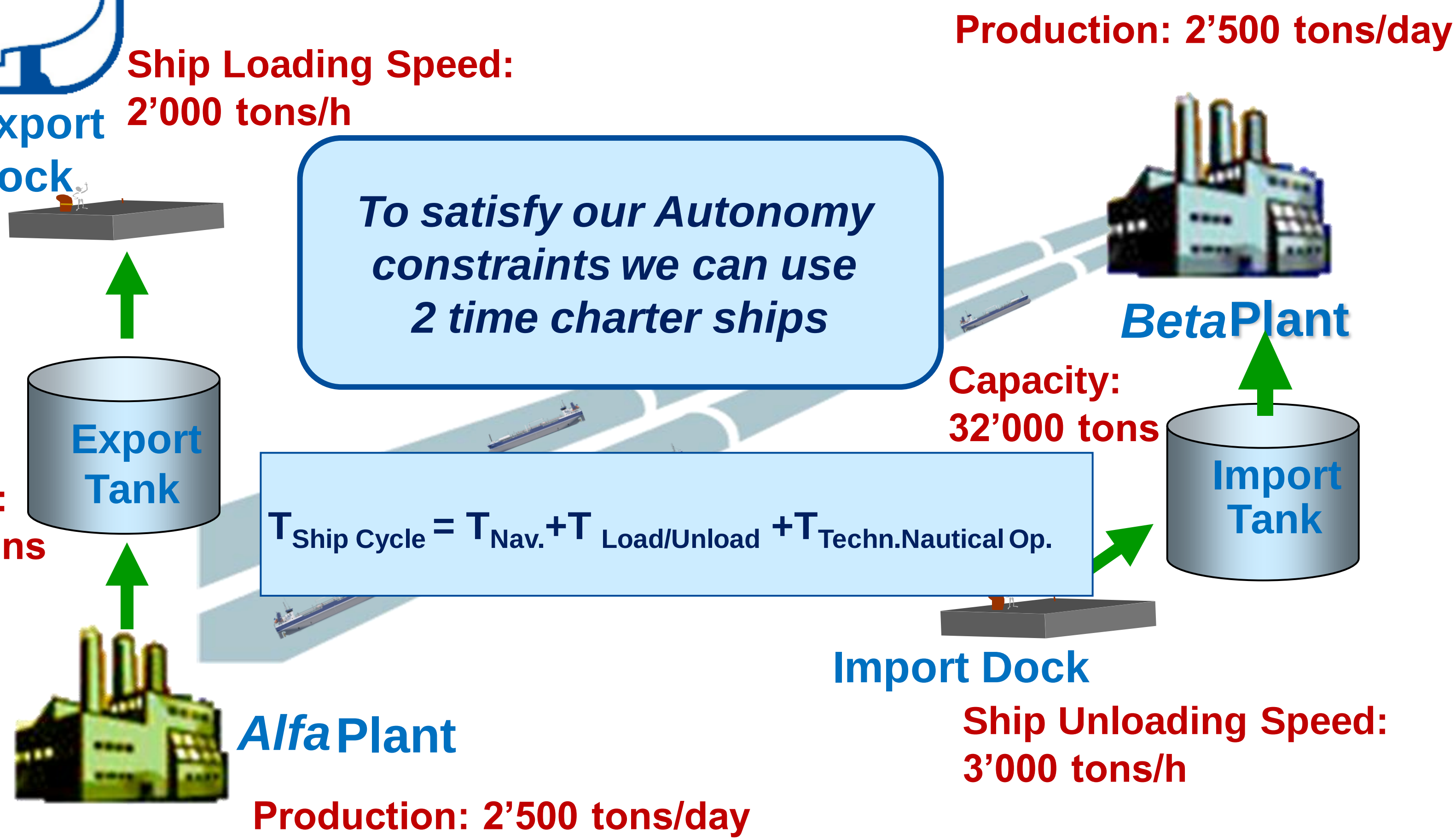
$A_{critical} = 11.2$ days

$$\text{Interval}_{\text{Arrivals n}} = T_{\text{Ship Cycle}} / N_{\text{Ships}} \leq A_{critical}$$

Simulation Team

Checking Times vs. Autonomy

Time Charter Contracts



To satisfy our Autonomy constraints we can use 2 time charter ships

$T_{Ship\ Cycle} = T_{Nav.} + T_{Load/Unload} + T_{Techn.Nautical\ Op.}$

$A_{critical} = 11.2$ days

$Interval_{Arrivals\ 2} = T_{Ship\ Cycle} / 2 \leq A_{critical}$

Simulation Team

2 Ships are enough Here

Time Charter Contracts

Export Dock

Ship Loading Speed: 2'000 tons/h

Production: 2'500 tons/day

Ship Cycle Time is > of Critical Autonomy so we can Add Ships to increase <u>Frequence of Arrivals</u>

Beta Plant

Export Tank

Capacity: 28'000 tons

Capacity: 32'000 tons

Import Tank

$$T_{Ship\ Cycle} = T_{Nav.} + T_{Load/Unload} + T_{Techn.Nautical\ Op.}$$

Import Dock

Alfa Plant

Ship Unloading Speed: 3'000 tons/h

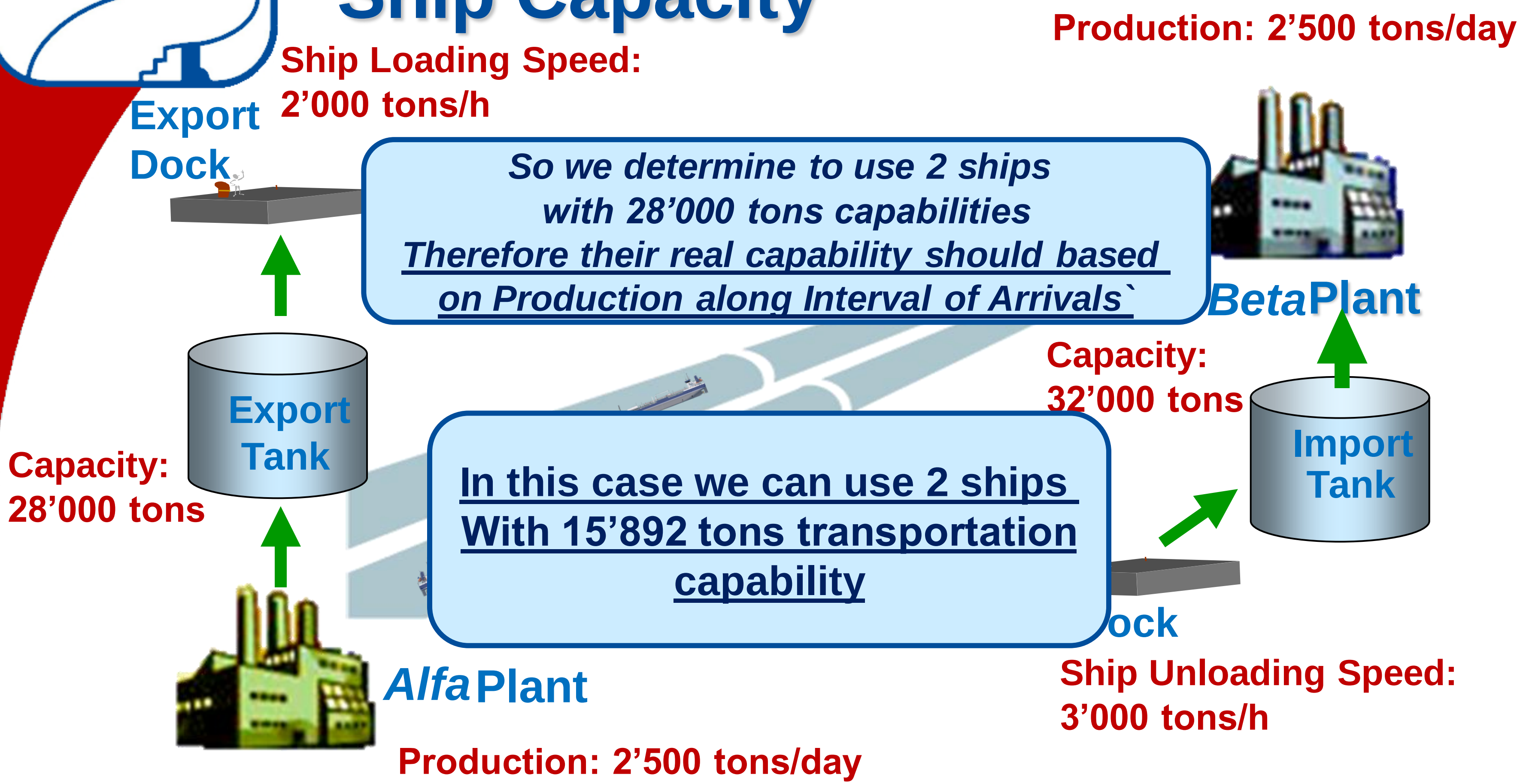
Production: 2'500 tons/day

$A_{critical}$ = 11.2 days

$$\text{Interval}_{Arrivals\ 2} = 12^{days}\ 23^{h}\ 23' / 2 = 6^{days}\ 11^{h}\ 41' \leq A_{critical}$$

Recomputing Ship Capacity

Time Charter Contracts



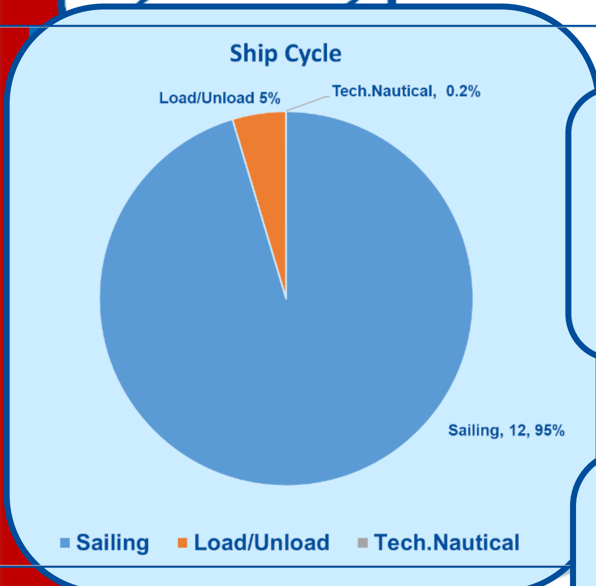
$A_{critical}$ = 11.2 days

$SC_{size\ 2nd\ tentative}$ = Interval $_{Arrivals\ 2}$ x Production = 15’792 tons

Updating our Solution

Time Charter Contracts

Production: 2’500 tons/day



We could check, with
New Ship Size, if it could be
Possible to reduce the fleet
We recalculate the Ship Cycle Time

BetaPlant

Capacity: 32’000 tons

Import Tank

We still need two ships

$T_{Ship\ Cyle\ 2} = 12^{days}\ 14^{h}\ 00'$

$Interval_{\ Arrivals\ 2} = 6^{days}\ 7^{h}\ 00'$

$SC_{size\ 2nd\ tentative} = 15'730\ tons$

ock

ip Unloading Speed: 3’000 tons/h

Alf

Production: 2’500 tons/day

$A_{critical} = 11.2\ days$

$$T_{Ship\ Cycle\ 2} = 2 \times 6 + \frac{15'892}{2'000 \times 24} + \frac{15'892}{3'000 \times 24} + 4 \times \frac{45'}{24 \times 3600}$$

Quick & Fine Tuning

Time Charter Contracts

Ship Loading Speed: 2'000 tons/h

Export Dock

At this time we recheck, with New Ship Size for a 3rd tentative, but obviously the changes are expected to be less & less important

Production: 2'500 tons/day

*Beta*Plant

Capacity: 32'000 tons

Import Tank

Export Tank

Capacity: 28'000 tons

We still need two ships

$T_{\text{Ship Cyle 3}} = 12^{\text{days}}\ 13^{h}\ 59'$

$\text{Interval}_{\text{Arrivals 3}} = 6^{\text{days}}\ 6^{h}\ 59'$

$SC_{\text{size 3rd tentative}} = 15'728 \text{ tons}$

Alf

ock

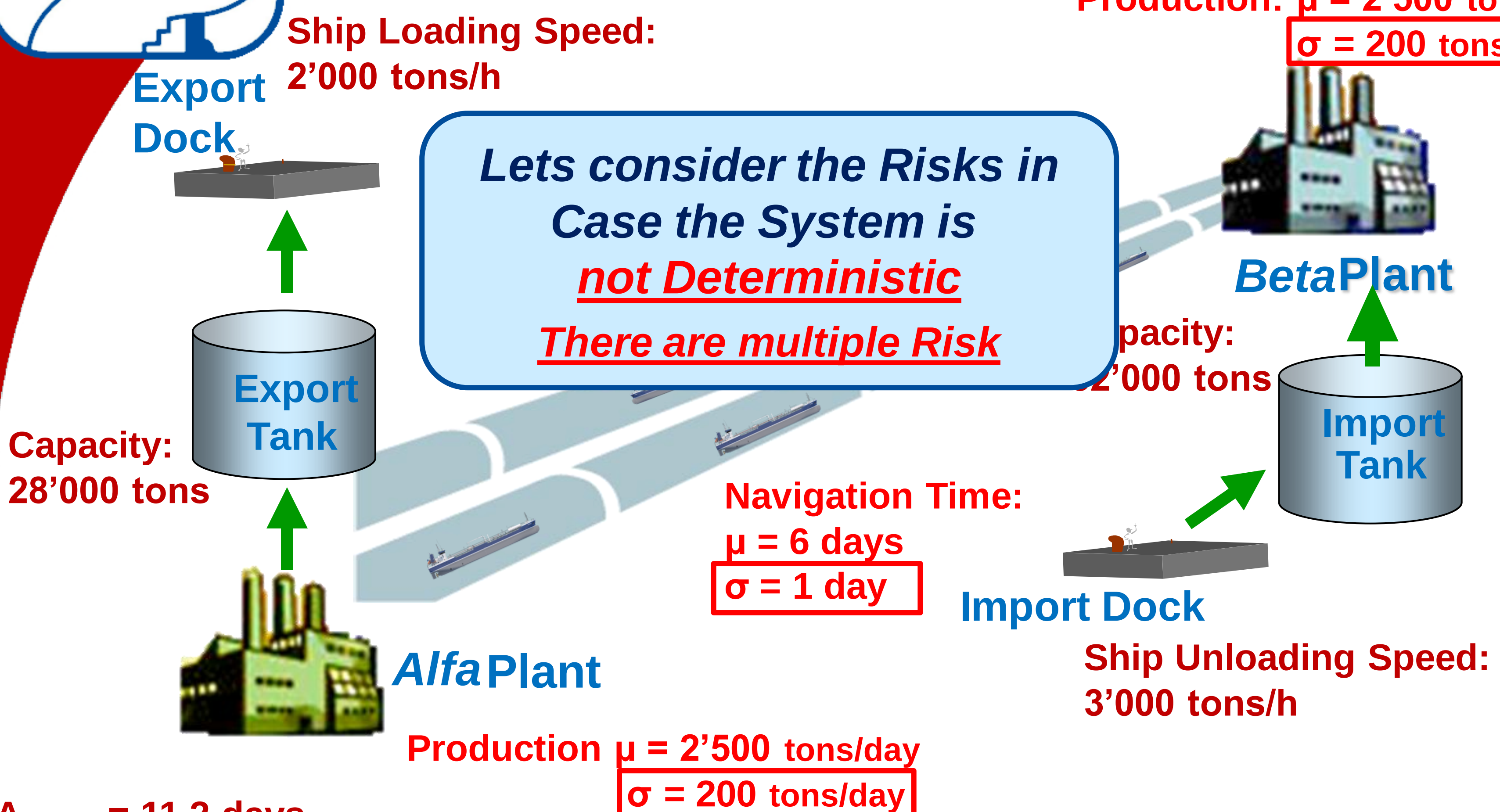
ip Unloading Speed: 3'000 tons/h

Production: 2'500 tons/day

$A_{critical} = 11.2$ days

Time Charter Contracts

Risks in Logistics



$A_{critical}$ = 11.2 days

Statistical Tables

	z	N (-oo, x)	N (x, +oo)	N (-|x|, +|x|)	N(-oo,-|x|) N(+|x|,+oo)	Agostino G. Bruzzone
0	-3.10	0.097%	99.903%	99.806%	0.194%	Gestione dei Progetti
1	-3.00	0.135%	99.865%	99.730%	0.270%	d'Impianto
2	-2.90	0.187%	99.813%	99.627%	0.373%	Distribuzione Normale
3	-2.80	0.256%	99.744%	99.489%	0.511%	Area sottesa
4	-2.70	0.347%	99.653%	99.307%	0.693%	
5	-2.60	0.466%	99.534%	99.068%	0.932%	
6	-2.50	0.621%	99.379%	98.758%	1.242%	
7	-2.40	0.820%	99.180%	98.360%	1.640%	
8	-2.30	1.072%	98.928%	97.855%	2.145%	
9	-2.20	1.390%	98.610%	97.219%	2.781%	
10	-2.10	1.786%	98.214%	96.427%	3.573%	
11	-2.00	2.275%	97.725%	95.450%	4.550%	
12	-1.90	2.872%	97.128%	94.257%	5.743%	
13	-1.80	3.593%	96.407%	92.814%	7.186%	
14	-1.70	4.457%	95.543%	91.087%	8.913%	
15	-1.60	5.480%	94.520%	89.040%	10.960%	
16	-1.50	6.681%	93.319%	86.639%	13.361%	
17	-1.40	8.076%	91.924%	83.849%	16.151%	
18	-1.30	9.680%	90.320%	80.640%	19.360%	
19	-1.20	11.507%	88.493%	76.986%	23.014%	
20	-1.10	13.567%	86.433%	72.867%	27.133%	
21	-1.00	15.866%	84.134%	68.269%	31.731%	
22	-0.90	18.406%	81.594%	63.188%	36.812%	
23	-0.80	21.186%	78.814%	57.629%	42.371%	
24	-0.70	24.196%	75.804%	51.607%	48.393%	
25	-0.60	27.425%	72.575%	45.149%	54.851%	
26	-0.50	30.854%	69.146%	38.292%	61.708%	
27	-0.40	34.458%	65.542%	31.084%	68.916%	
28	-0.30	38.209%	61.791%	23.582%	76.418%	
29	-0.20	42.074%	57.926%	15.852%	84.148%	
30	-0.10	46.017%	53.983%	7.966%	92.034%	

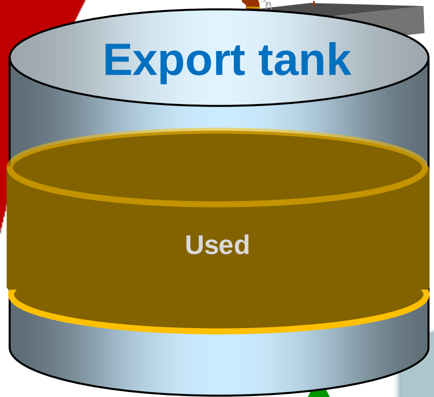
	z	N (-oo, x)	N (x, +oo)	N (-|x|, +|x|)	N(-oo,-|x|) N(+|x|,+oo)	Agostino G. Bruzzone
31	0.00	50.000%	50.000%	0.000%	100.000%	
32	0.10	53.983%	46.017%	7.966%	92.034%	
33	0.20	57.926%	42.074%	15.852%	84.148%	
34	0.30	61.791%	38.209%	23.582%	76.418%	
35	0.40	65.542%	34.458%	31.084%	68.916%	
36	0.50	69.146%	30.854%	38.292%	61.708%	
37	0.60	72.575%	27.425%	45.149%	54.851%	
38	0.70	75.804%	24.196%	51.607%	48.393%	
39	0.80	78.814%	21.186%	57.629%	42.371%	
40	0.90	81.594%	18.406%	63.188%	36.812%	
41	1.00	84.134%	15.866%	68.269%	31.731%	
42	1.10	86.433%	13.567%	72.867%	27.133%	
43	1.20	88.493%	11.507%	76.986%	23.014%	
44	1.30	90.320%	9.680%	80.640%	19.360%	
45	1.40	91.924%	8.076%	83.849%	16.151%	
46	1.50	93.319%	6.681%	86.639%	13.361%	
47	1.60	94.520%	5.480%	89.040%	10.960%	
48	1.70	95.543%	4.457%	91.087%	8.913%	
49	1.80	96.407%	3.593%	92.814%	7.186%	
50	1.90	97.128%	2.872%	94.257%	5.743%	
51	2.00	97.725%	2.275%	95.450%	4.550%	
52	2.10	98.214%	1.786%	96.427%	3.573%	
53	2.20	98.610%	1.390%	97.219%	2.781%	
54	2.30	98.928%	1.072%	97.855%	2.145%	
55	2.40	99.180%	0.820%	98.360%	1.640%	
56	2.50	99.379%	0.621%	98.758%	1.242%	
57	2.60	99.534%	0.466%	99.068%	0.932%	
58	2.70	99.653%	0.347%	99.307%	0.693%	
59	2.80	99.744%	0.256%	99.489%	0.511%	
60	2.90	99.813%	0.187%	99.627%	0.373%	
61	3.00	99.865%	0.135%	99.730%	0.270%	
62	3.10	99.903%	0.097%	99.806%	0.194%	
© 2000 DIP University of Genoa						

We can use Central Limite
Theorem and use N Distribution

Over Stock Risk in *Time Charter Contracts* Export due to the Plant

Ship Loading Speed:
2’000 tons/h

Export Dock



Capacity:
28’000 tons

Al[...]

Production μ = 2’500 tons/day

$A_{critical}$ = 11.2 days

σ = 200 tons/day

1st Risk:
Over Stock in Export Tank
respect Production Standard Devision

Safety Stock$_{alfa}$ = (Tac$_{alfa}$ – Tau$_{alfa}$)/2

Tac$_{alfa}$ = 28’000 tons

Tau$_{alfa}$ = SC$_{size}$ = 15’728 tons

Safety Stock$_{alfa}$ =12’272 / 2 = 6136 tons

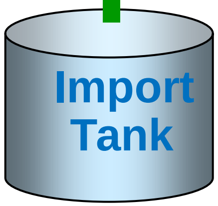
Productivy on Interval (PoI):

PoI μ = μ $_{Production}$ x Interval $_{Arrivals}$

PoI σ = $Sqrt(\sum_{Interval\ days} \sigma^2_{Production})$

*Beta*Plant

Capacity:
[...]000 tons



[...]ock

[...]ip Unloading Speed:
[...]00 tons/h

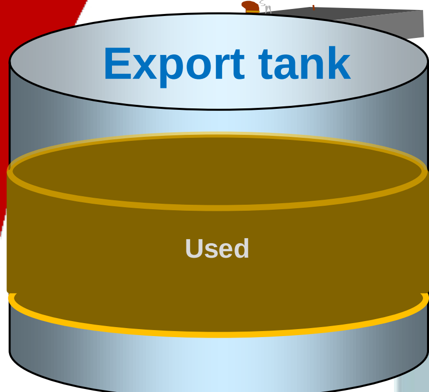
PoI μ = 2’500 x 6.291 = 15’728 tons each 6.291 days
PoI σ = 459.63 tons each 6.291 days
Zetp = *Safety Stock$_{alfa}$* / PoI σ = 13.349
=> Risk to Exceed due to Prod.= ~ 0%

Over Stock in Export due to Ships

Time Charter Contracts

Ship Loading Speed: 2'000 tons/h

Export Dock



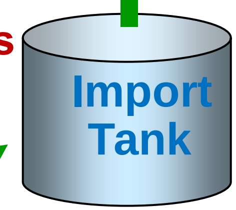
2st Risk:

Over Stock in Export Tank

respect Sailing Time

*Beta*Plant

Capacity: ...000 tons



$Safety\ Stock_{alfa} = (Tac_{alfa} - Tau_{alfa})/2$

Tac_{alfa} = 28'000 tons

$Tau_{alfa} = SC_{size}$ = 15'728 tons

$Safety\ Stock_{alfa}$ = 12'272 / 2 = 6136 tons

Ship Potential Delay

Interval $\sigma = Sqrt(\sum_{\text{Interval days}} \sigma^2_{Navigation})$

...ock

...ip Unloading Speed: 3'000 tons/h

Alfa Plant

Production μ = 2'500 tons/day

$A_{critical}$ = 11.2 days σ = 200 tons/day

Interval σ = 2.30 days

Zetp = (*$Safety\ Stock_{alfa}$*/ μ_{prod})/Interval σ = 1.06

=> Risk to Exceed due to Prod.= ~ 14%

Corresponding to 18 blocks per year

Stockout Risk in Import due to the Plant

Time Charter Contracts

Ship Loading Speed:
2’000 tons/h

Export
Dock

3rd Risk:
Stockout in Export Tank
respect Production Standard Devision

Export
Tank

Capacity:
28’000 tons

Export tank

Used

Capacity:
32’000 tons

$Safety\ Stock_{beta} = (Tac_{beta} – Tau_{beta})/2$

Tac_{beta} = 32’000 tons

$Tau_{beta} = SC_{size}$ = 15’728 tons

$Safety\ Stock_{beta}$ =16’262/ 2 = 8136 tons

Productivy on Interval (PoI):

$PoI\ \mu = \mu_{Production} \times Interval_{Arrivals}$

$PoI\ \sigma = Sqrt(\sum_{Interval\ days} \sigma^2_{Production})$

...ock

...ip Unloading Speed:
...00 tons/h

Al...

Production μ = 2’500 tons/day
$A_{critical}$ = 11.2 days σ = 200 tons/day

PoI μ = 2’500 x 6.291 = 15’728 tons each 6.291 days
PoI σ = 459.63 tons each 6.291 days
Zetp = *$Safety\ Stock_{beta}$* / PoI σ = 17.700
=> Risk to Exceed due to Prod.= ~ 0%

Simulation Team

Time Charter Contracts

Stockout Risk in Import due to Ships

Ship Loading Speed:
2'000 tons/h

Export Dock

4th Risk:
Stockout in Export Tank
respect Sailing Time

Export Tank

Capacity:
28'000 tons

$\text{Safety Stock}_{beta} = (\text{Tac}_{beta} - \text{Tau}_{beta})/2$

$\text{Tac}_{beta} = 32'000$ tons

$\text{Tau}_{beta} = \text{SC}_{size} = 15'728$ tons

$\text{Safety Stock}_{beta} = 16'262/2 = 8136$ tons

Ship Potential Delay

$\text{Interval } \sigma = \text{Sqrt}\left(\sum_{\text{Interval days}} \sigma^2_{\text{Navigation}}\right)$

Alfa Plant

Export tank

Used

Capacity:
32'000 tons

Dock

Ship Unloading Speed:
3'000 tons/h

Production μ = 2'500 tons/day

$A_{critical}$ = 11.2 days

σ = 200 tons/day

Interval σ = 2.30 days
Zetp = (*$\text{Safety Stock}_{alfa}$*/ μ_{prod})/Interval σ = 1.41
=> Risk to Exceed due to Prod.= ~ 8%
Corresponding to 4.64 blocks per year

STRATEGOS
Genoa University

Demourrages on Ships

Time Charter Contracts

Production: μ = 2'500 tons/day
σ = 200 tons/day

Ship Loading Speed:
2'000 tons/h

Export Dock

5th Risk:
Interference among Ships
Lets assume there is just 1 mooring slot on the Dock

BetaPlant

Capacity:
...000 tons

Export Tank

Import Tank

Capacity:
28'000 tons

Ship arrivals per Year on each site
Nsa = 365 / $Interval_{Arrivals}$ =~58 ships/year
Ship Time at Alfa Dock
STAD = 15'728 / 2'000 = 7.86 hours
Occupation of the Alfa Dock =~ 0.22%
In this case the probability to have two ships concurrently at Alfa dock ~0%

...ock

...hip Unloading Speed:
3'000 tons/h

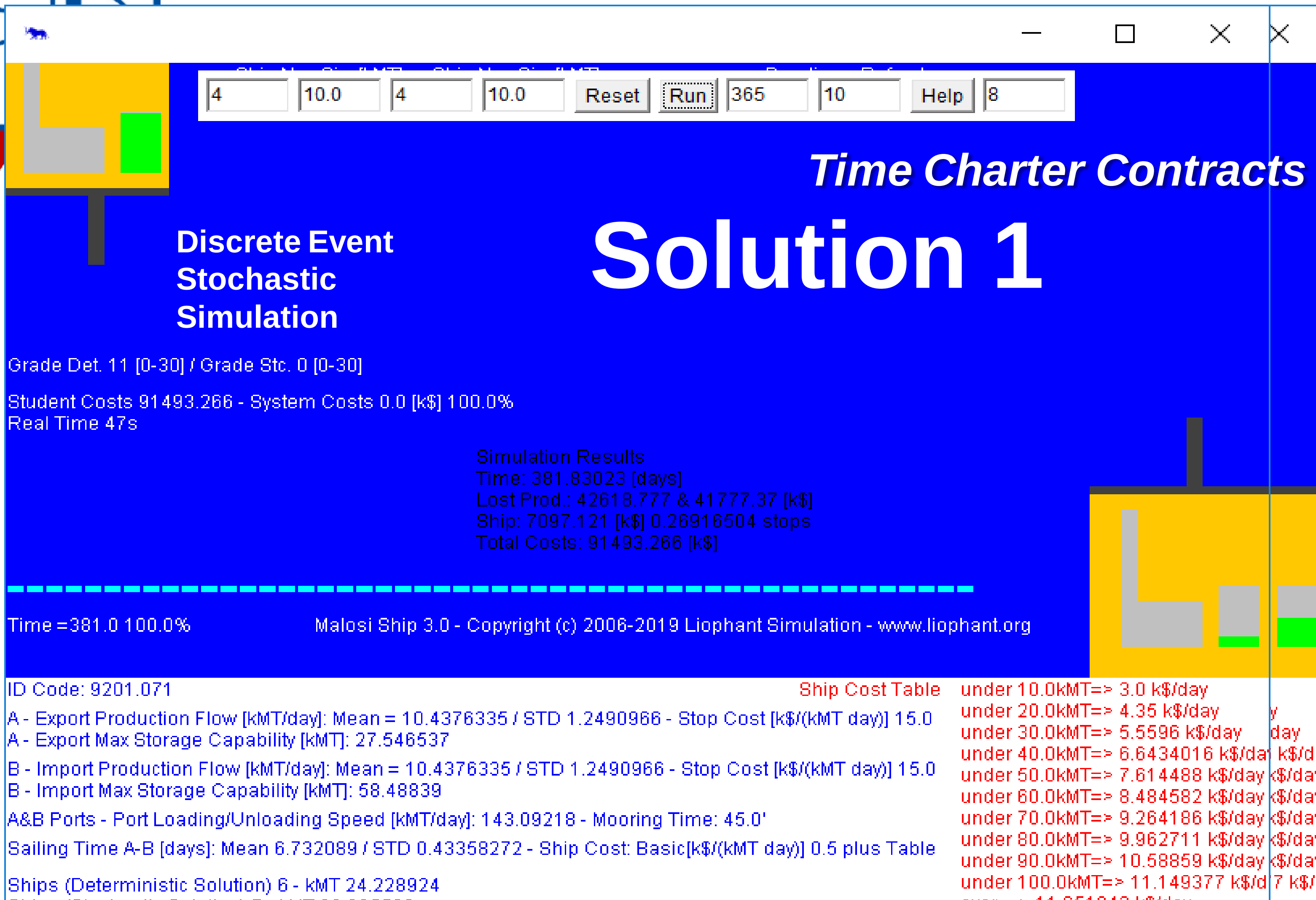
Alfa Plant

Production μ = 2'500 tons/day
σ = 200 tons/day

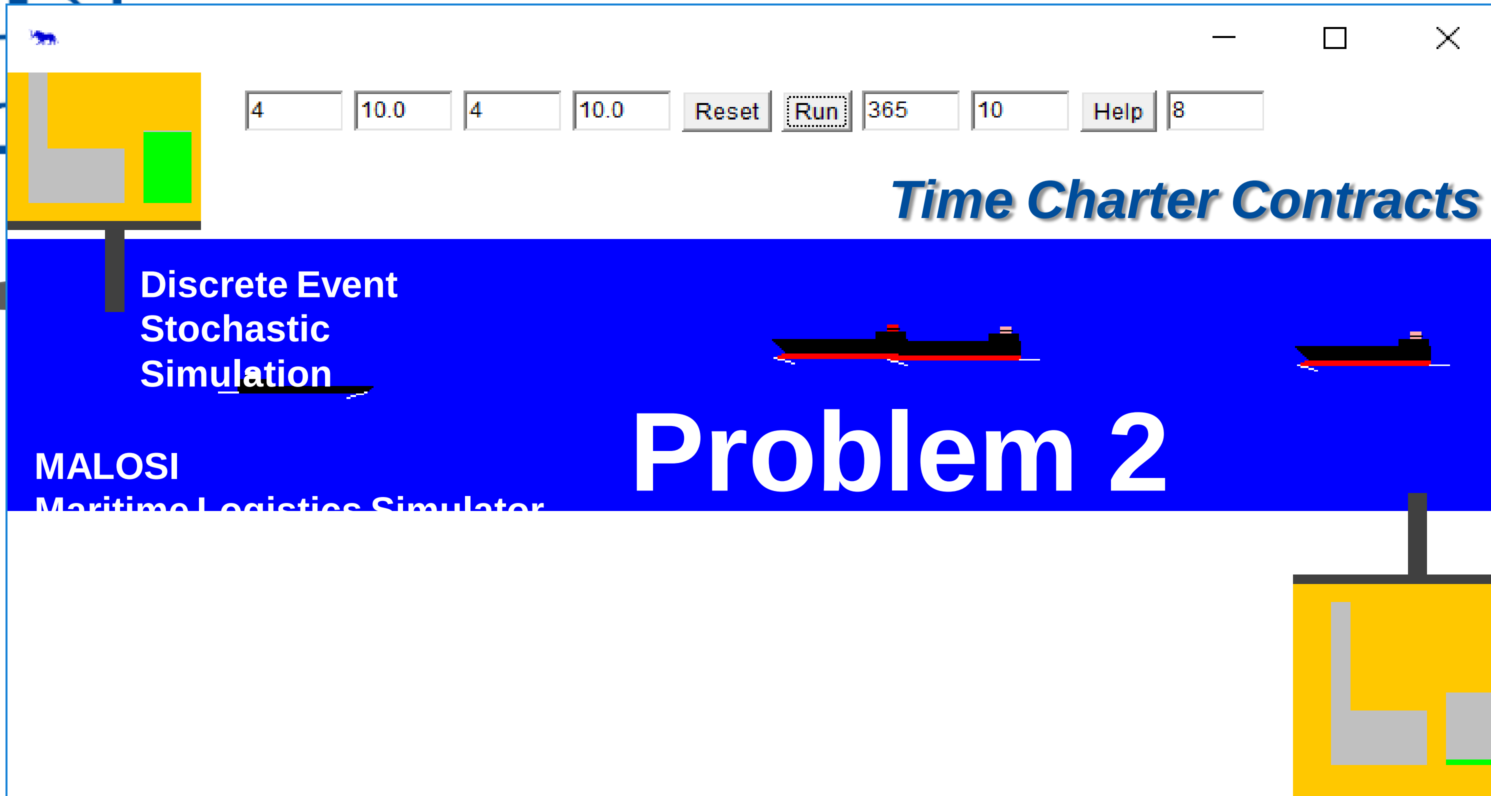
$A_{critical}$ = 11.2 days

Another Example: Problem 1

Problem 1 Solution



Another Example: Problem 2



ID Code: 2005.4863

A - Export Production Flow [kMT/day]: Mean = 13.37996 / STD 1.066194 - Stop Cost [k$/(kMT day)] 21.0
A - Export Max Storage Capability [kMT]: 53.147167

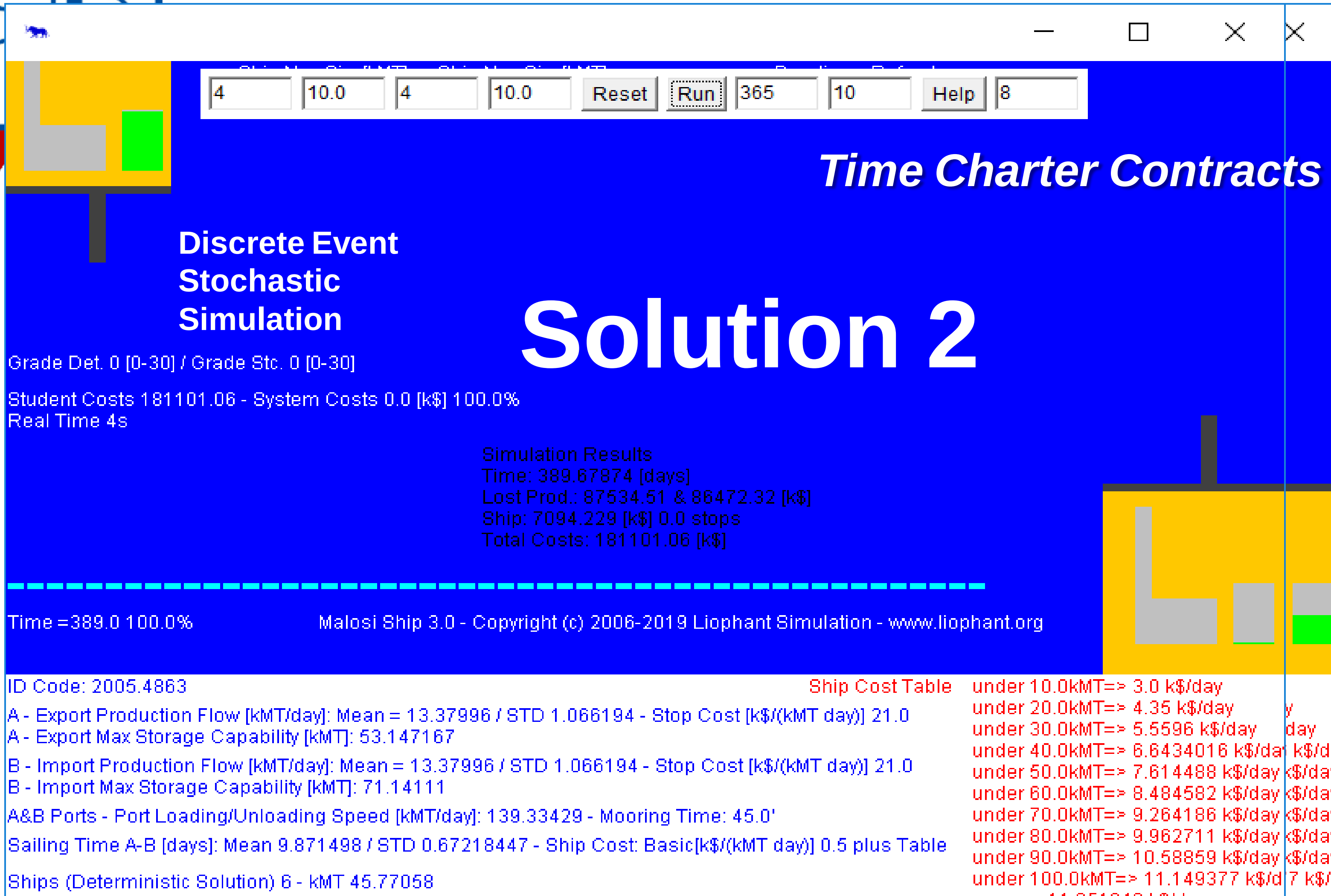
B - Import Production Flow [kMT/day]: Mean = 13.37996 / STD 1.066194 - Stop Cost [k$/(kMT day)] 21.0
B - Import Max Storage Capability [kMT]: 71.14111

A&B Ports - Port Loading/Unloading Speed [kMT/day]: 139.33429 - Mooring Time: 45.0'

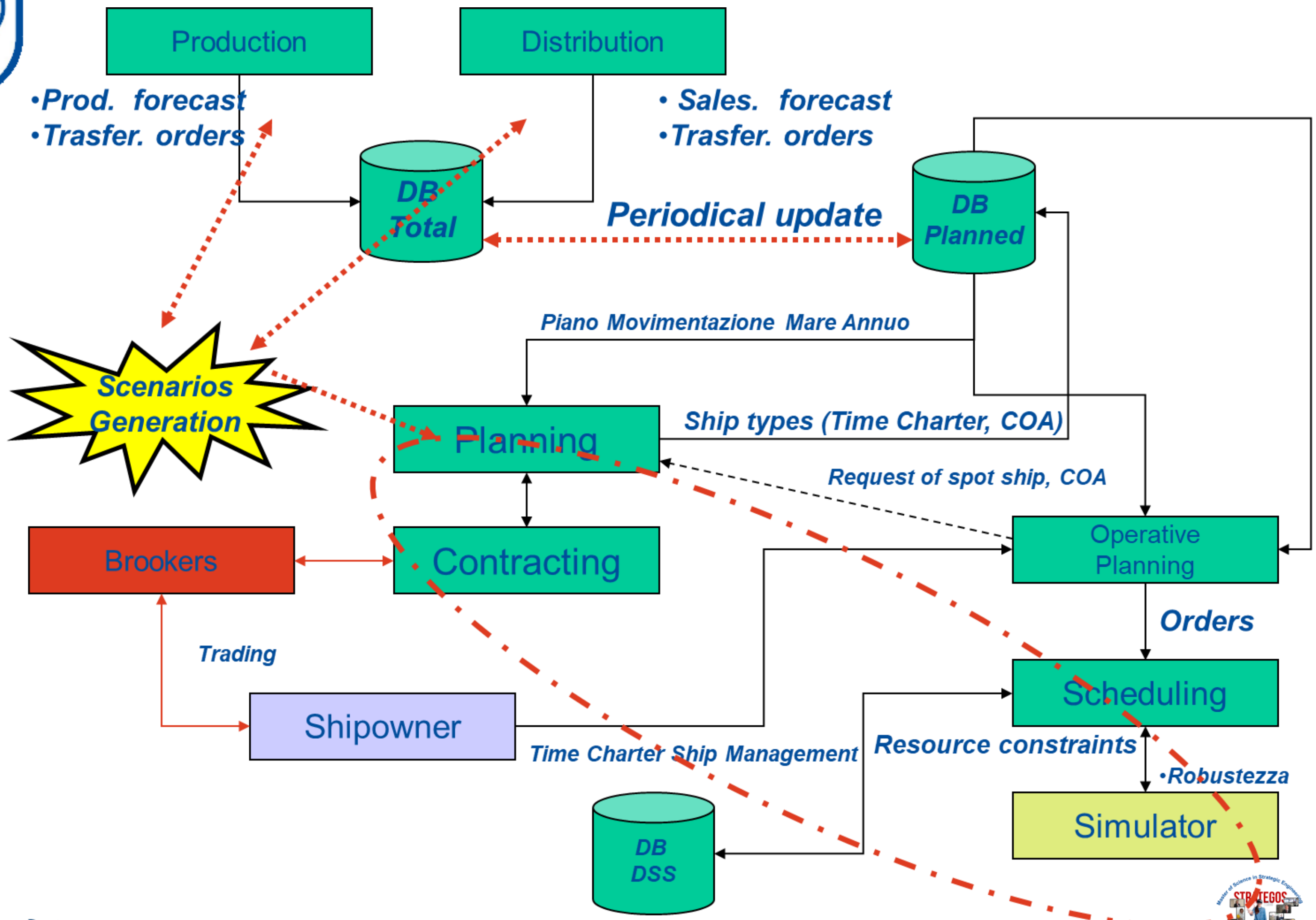
Sailing Time A-B [days]: Mean 9.871498 / STD 0.67218447 - Ship Cost: Basic[k$/(kMT day)] 0.5 plus Table

Ship Cost Table
under 10.0kMT=> 3.0 k$/day
under 20.0kMT=> 4.35 k$/day
under 30.0kMT=> 5.5596 k$/day
under 40.0kMT=> 6.6434016 k$/da
under 50.0kMT=> 7.614488 k$/day
under 60.0kMT=> 8.484582 k$/day

Problem 2 Solution



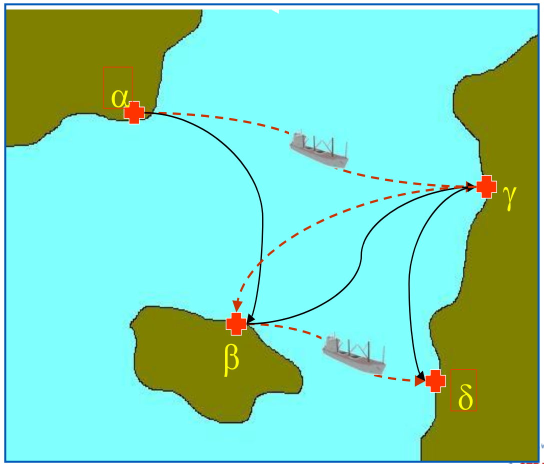
DSS General Architecture



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



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

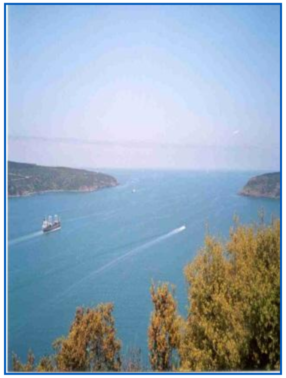
- Reduction of Maritime-Logistical costs of chemical products

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



Scientific References

1/2

- Bruzzone A.G., Longo F., Merkuryev Y., Mirabelli G., Piera M.A. (2008). Harbor, Maritime & Multimodal Logistics Modelling and Simulation. ISBN: 978-88-903724-1-4. GENOVA: DIPTEM Press (ITALY)
- Bruzzone A.G. (2018) “MS2G as Pillar for Developing Strategic Engineering as a New Discipline for Complex Problem Solving”, Keynote Speech at I3M, Budapest, September
- Bruzzone A.G., (2017) "Smart Simulation: Intelligent Agents, Simulation and Serious Games as enablers for Creating New Solutions in Engineering, Industry and Service of the Society. Keynote Speech at International Top-level Forum on Engineering Science and Technology Development Strategy- Artificial intelligence and simulation, Hangzhou, China
- Bruzzone A.G., David W., Agresta M., Iana F. Martinesi P., Richetti R. (2017) “Integrating Spatial Analysis, Disaster Modeling and Simulation for Risk Management and Community Relisience on Urbanized Coastal Areas”, Proc. of 5th Annual Interagency, Interaction in Crisis Managements and Disaster Response, CMDR, June 1-2
- Bruzzone A.G., Massei, M. (2017) “Simulation-Based Military Training”, in Guide to Simulation-Based Disciplines, Springer, pp. 315-361
- Bruzzone A.G., Di Matteo, R., Maglione, G. L., & Massei, M. (2017, July). Simulation models and artificial neural networks for vessels behavior analysis. In Proceedings of the Summer Simulation Multi-Conference (p. 17). Society for Computer Simulation International.
- Bruzzone, A. G., Massei, M., & Poggi, S. (2016). Infrastructures protection based on heterogeneous networks. International Journal of Simulation and Process Modelling, 11(1), 24-35.
- Bruzzone, A., Longo, F., Massei, M., Nicoletti, L., Agresta, M., Di Matteo, R., ... & Padovano, A. (2016, June). Disasters and emergency management in chemical and industrial plants: drones simulation for education and training. In International Workshop on Modelling and Simulation for Autonomous Systems (pp. 301-308). Springer, Cham.
- Bruzzone A.G., Merani D., Massei M., Tremori A., Bartolucci C., Ferrando A. (2013) “Modeling Cyber Warfare in Heterogeneous Networks for Protection of Infrastructures and Operations”, Proc.of I3M2013, Athens, Greece, September
- Bruzzone A.G., Massei M., Solis A., Poggi S., Bartolucci C., Capponi L. (2013) "Serious Games as enablers for Training and Education on Operations over Off-Shore Platforms and Ships", Proceedings of Summer Computer Simulation Conf., Toronto, Canada
- Bruzzone A.G., Tremori A., Longo F., (2012) “Interoperable Simulation for Protecting Port as Critical Infrastructures”, Proc. of HMS2012, Wien, September 19-21
- Bruzzone A.G., Tremori A., Merkuryev Y. (2011) “Asymmetric marine warfare: PANOPEA a piracy simulator for investigating new C2 solutions” Proceedings SCM MEMTS 2011, St.Petersburg June 29-30

Simulation Team

Scientific References

2/2

- Bruzzone A.G., Frydman C., Merkuriev Y., B.M. (2005) "Harbour, Maritime and Multimodal Logistics Modelling and Simulation", LSIS Press, ISBN 2-9520712-4-1 (pp 94)
- Bruzzone A.G., Williams E.,(2004) "Modeling and Simulation Methodologies for Logistics and Manufacturing Optimization", Vol 80, No.3 pg 119-174 ISSN 0037-5497
- Bruzzone A.G. (2004) "Introduction to Modeling and Simulation Methodologies for Logistics and Manufacturing Optimization", Vol 80, No.3 pg 119-120 ISSN 0037-5497
- Bruzzone A.G., Revetria, R., Simeoni, S., Rocca, A., Brandolini, M., & Studio, B. R. B. (2003). HLA Simulation for Operation and Analysis and Component Design of Naval Platforms. Proceedings of HMS2003, Riga Latvia, September, 18-20.
- Merkuryev Y., Bruzzone A.G., Merkuryeva G., Novitsky L., Williams E. (2003) "Harbour Maritime and Multimodal Logistics Modelling & Simulation 2003", DIPTEM Press, Riga, ISBN 9984-32-547-4 (400pp)
- Bruzzone A.G., Mosca R., Revetria R. (2002) "Cooperation in Maritime Training Process using Virtual Reality Based and HLA Compliant Simulation", Proceedings of XVIII International Port Conference, Alexandria Egypt, January 27-29
- Bruzzone A.G., A. Orsoni, S. Viazzo (2002) "Chaotic Inventory Management as Benchmarking for Maritime Supply Chain Performance Evaluation" Proceedings of the 2002 International Workshop on Harbour, Maritime and Multimodal Logistics Modelling and Simulation (HMS 2002), Bergeggi, Italy, October 3-5 pp.25-28
- Bruzzone A.G., R. Mosca, R. Revetria, A. Orsoni (2002) "System Architecture for Integrated Fleet Management: Advanced Decision Support in the Logistics of Diversified and Geographically Distributed Chemical Processing", Proceedings of AIS Simulation and Planning in High Autonomy Systems Conference, Lisbon, Portugal, April 7-10 pp. 309-314
- Bruzzone A.G., Mosca R., Revetria R. (2001). "Gestione Integrata di Sistemi Produttivi Interagenti: Metodi Quantitativi Avanzati per la Quick Response", DIPTEM Genova, Italy, ISBN: 88-900732-0-9
- Bruzzone A., Signorile R. (2001) "Container Terminal Planning by Using Simulation and Genetic Algorithms", Singapore Maritime & Port Journal, pp. 104-115 ISSN 0219-1555.
- Bruzzone A.G., Gambardella L.M., Giribone P., Merkuryev Y.A. (2000) "Harbour Maritime & Multmodal Logistics Modelling & Simulation 2000", SCS Europe, Genoa, ISBN 1-56555-207-5
- Bruzzone A.G., Merkuryev Y. et al. (1999) "Harbour Maritime & Industrial Logistics Modelling & Simulation", SCS Europe, ISBN 1-56555-175-3
- Bruzzone A.G., Mosca R. (1998) "Special Issue: Harbour and Maritime Simulation", Simulation, Vol.71, no.2, August
- Bruzzone A.G., Mosca R. (1998) "Introduction to the Harbour and Maritime Simulation Special Issue", Simulation, Vol.71, no.2, pp.72-73
- Merkuriev Y., Bruzzone A.G., Novitsky L (1998) "Modelling and Simulation within a Maritime Environment", SCS Europe, Ghent, Belgium, ISBN 1-56555-132-X

Simulation Team

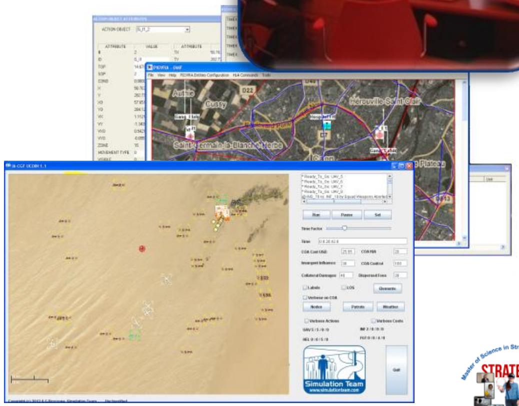
Prof. Agostino G. Bruzzone

Director of M&S Net (34 Centers WorldWide)
Director of the McLeod Institute Genoa Center
President Simulation Team (26 Partners)
President of Liophant
Council Chair of STRATEGOS
Director Int.Master MIPET

Full Professor in
DIME University of Genoa

via Opera Pia 15
16145 Genova, Italy

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



DIPTEM

SILENI

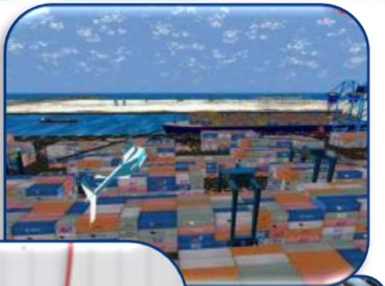
MITIM
Simulation Team
Genoa Center

M&SNet

Master of Science in Strategic Engineering
STRATEGOS
www.itim.unige.it/strategos

Simulation Team

References



DIME

Simulation Team MITIM
DIME Genoa University
via Opera Pia 15
16145 Genova, Italy
www.itim.unige.it
Agostino G. BRUZZONE
agostino@itim.unige.it