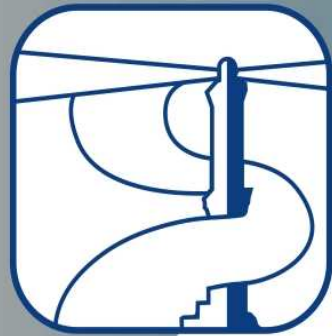
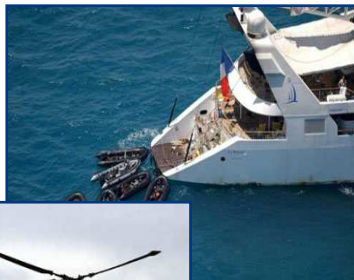


Simulation Team



Simulating Marine Asymmetric Scenarios for testing different C2 Maturity Levels



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Panopea
 Piracy Asymmetric Naval Operation
 Patterns modeling for Education & Analysis

www.simulationteam.com

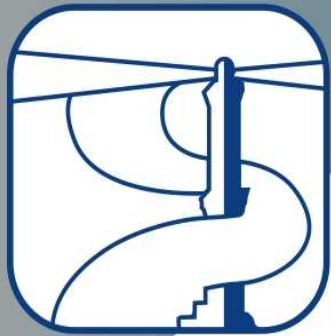
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DIPTM
 Università di Genova

MAST





The Existing Scenario...

- Today Maritime Security is a very critical aspect on Marine Framework introducing the concept of Asymmetric Marine Environment with new special attention to Threats such as:

- Piracy
- Conventional Terrorism
- CBRN

versus traditional Port and Ship Protection against Special Forces and Conventional Attacks





... as Evolving Scenario over Time

- *Some important aspects are expected to increase over Next Years their impact in General as well in Marine Framework increasing on Asymmetric Threats:*

Economic Issues

- Moving European Region Social Economic Center of Gravity to South increasing maritime traffic with North Africa
- Stabilization and Normalization Processes and Country Reconstruction Initiatives Overseas
- Overseas Developing Areas Growth, Production/Demand & Sustainability

Issues



Technologies

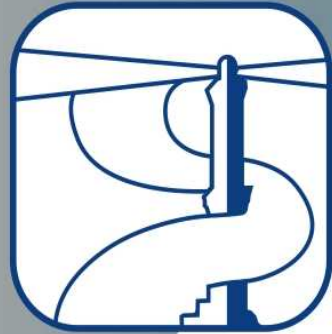
- Easier access to New Dimensions for preparing and creating critical threats (i.e. Cyberspace)
- Multiple opportunities to Access to Resources to develop WMD (i.e. smallpox, RDD)
- IT & Web empowering the potential of individuals and small groups (i.e. C2 capabilities)
- Increasing new reachable targets such as Oil Platform,

Environmental
Social Service



Political Issues

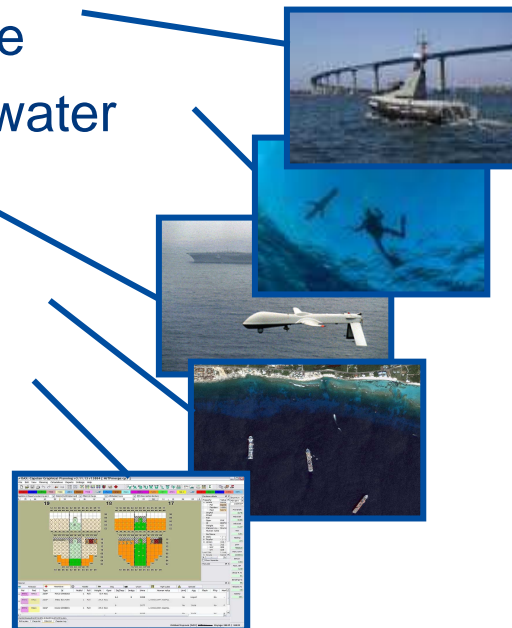
- Political Instability on Critical Regions (i.e. Africa)
- Evolution of Principle of Nations and Populations (i.e. Commercial States)
- Evolution of new critical issues requiring rational on joint Defense and Homeland Security Budgets (i.e. natural resource issues: water)



The Real World: Multi Dimension and Multi Layer Resolution

- A Real World on 5 Dimensions:

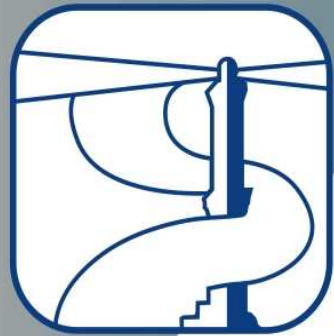
- Surface
- Underwater
- Air
- Space
- Cyber



- A Multi Layers & Resolutions Frame

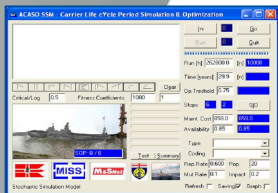
- Fleets and Parties
- Ships and Commercial Traffic
- Crew & People Accessing Ports/Vessels
- Services & Infrastructures

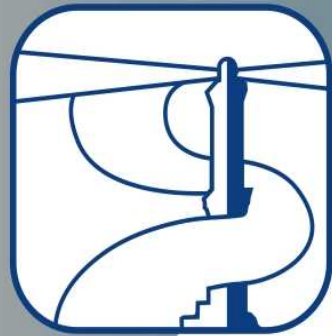




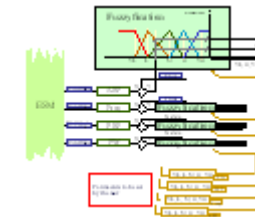
IA, CGF and HBM in Marine Frameworks

- New **IA** (*Intelligent Agents*), **CGF** (*Computer Generated Forces*) & **HBM** (*Human Behavior Modeling*) represent Strategic Issues in different Application Areas such as:
 - **Simulation Based Acquisition and Test & Analysis**
 - Capability to Proceed in Data Farming on Different Hypotheses on Vessel and System Design on Virtual Prototypes
 - **Training and Exercise**
 - Reduction of human personnel for Training & Exercising
 - New Scenarios involving Dynamic Simulated Complex System vs. the old pre-defined scripts
 - **Operational Planning**
 - Reducing Time for Planning Development due to the reduction of human experts employed in the different roles
 - Possibility to Experiments different Alternatives by replicated runs carried out in Automatic way
 - **Mission rehearsal and conduct operations**
 - Capability to keep the simulation on-line and to conduct statistical experimental analysis





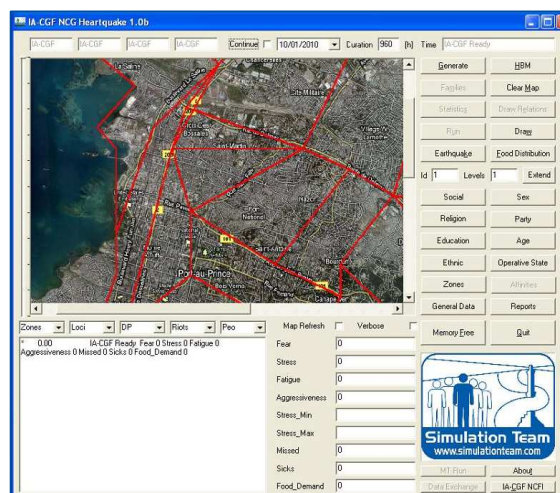
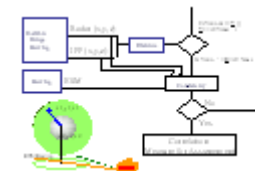
IA-CGF Elements



The new *IA-CGF* Modules devoted to create the CIMIC simulation include:

IA-CGF Units

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

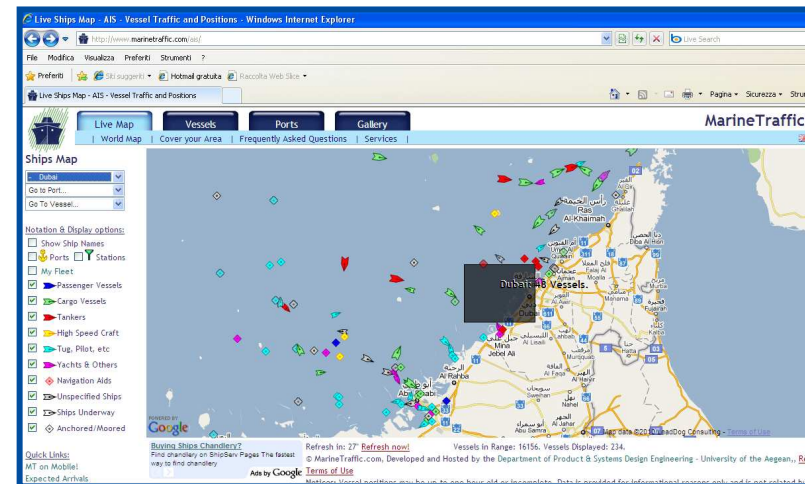




IA-CGF Units

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

- Police
- Gangs
- Pirates
- Local Population
- Cargo Traffic
- Yachting
- Local Authorities
- Warlords
- Criminal Organizations
- NGOs
- Cyber Services
- Air Traffic
- Domestic/National Situation:
 - Population
 - Media
 - Lobbies
- International Public Opinion
- International Diplomacy
- New Threats (i.e. 2nd Generation Terrorists)



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



IA-CGF Human Behaviors

Specific modules with *IA-CGF Human Behaviors*:

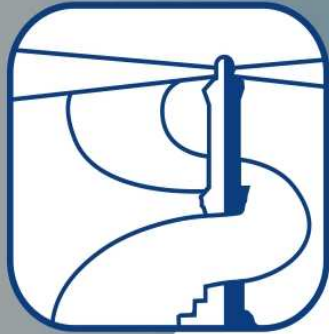
- Fear
- Stress
- Fatigue
- Training Level
- Aggressiveness
- Crew Harmony
- Combat Skills/Experience
- Other Factors (i.e. Ethnic, Religious, Social)



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

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





IA-CGF Non-Conventional Frameworks

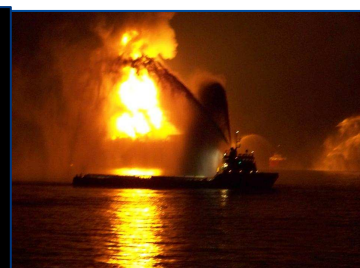
It is important to consider the integration in a scenario of the *IA-CGF-Non-Conventional Frameworks (IA-CGF-NCF)*, each simulating specific events:

- *IA-CGF FRAMEWORKS*
 - Food Distribution
 - Cargo Inspection and Area Protection
 - Logistics Support
- *IA-CGF Homeland Security and Civil Protection FRAMEWORKS*
 - Natural Disaster (i.e. Hurricanes, Earthquakes)
 - Man Made Disasters (i.e. Explosion, Hazardous Material Spills)
 - Evacuation
 - Oil Platform Accident
- *IA-CGF PSYOPS and INTELLIGENCE FRAMEWORKS*
 - Possible integration with *Sibilla*® Serious Game for Intelligence Officers training



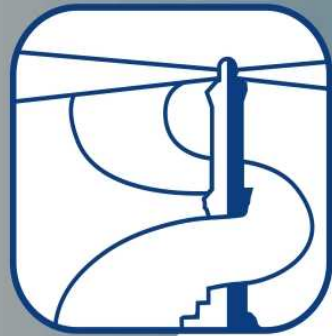
In non conventional scenarios for particular training purposes.

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



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Example of Scenario JFCOM Haiti Demo





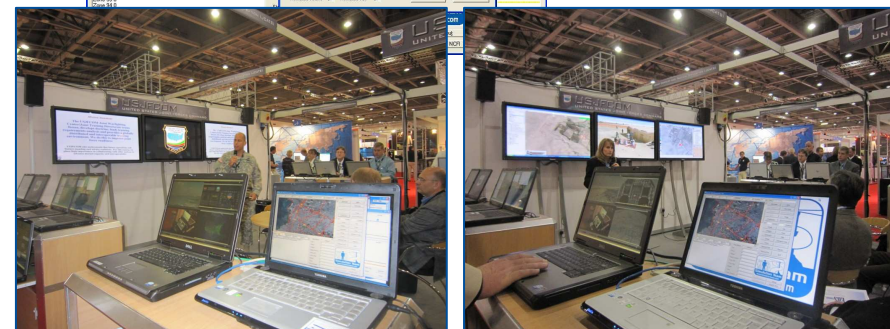
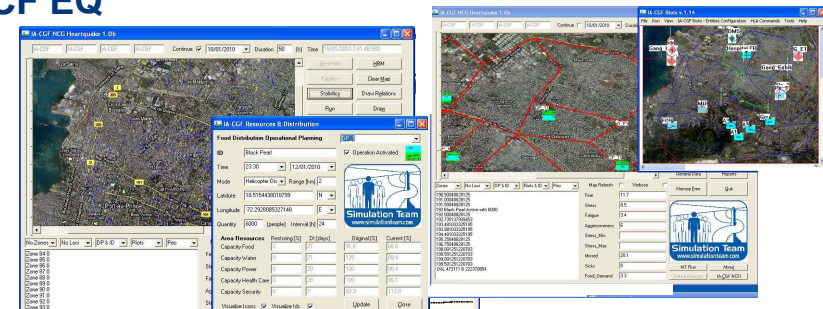
Haiti Case

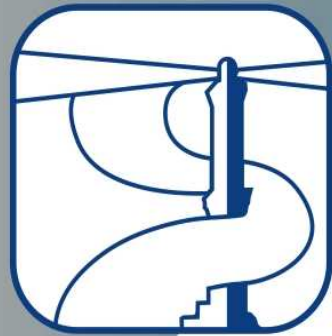
IA-CGF NCF Riots & IA-CGF NCF EQ

The Demonstration was based Haiti Earthquake 2010 and presented by USJFCOM at ITEC2010.

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.

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



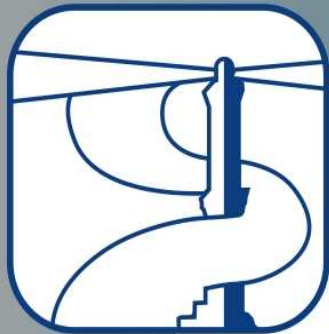


IA-CGF NCF Riots & IA-CGF NCF Humanitarian Support

The Simulation include impact of food distribution point and tactical operation on population human factors such as aggressiveness, fear, stress and fatigue

Area Resources	Restoring [%]	Dt (days)	Original [%]	Current [%]
Capacity Food	0	21	91.8	95.8
Capacity Water	0	21	125	95.4
Capacity Power	0	28	100	95.4
Capacity Health Care	0	28	100	95.1
Capacity Security	0	7	83.3	113.0





PANOPEA

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

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

PANOPEA - Piracy Asymmetric Naval Operation Patterns modelling

XY 11.8502028145 50.251773542285 Peac_390 702.624450883594
 * 704.024536132813 Time 29 [days] B 1 Crossings 188525 N_Figures 16 N_Fishermen
 FieldIntelligenceReports: 89 CargoFlow: 47.0779027475508 [Ship/Day] TerminateAtts
 MissedAttacks: 3 DiscussionsByVessels: 0 FailuresByVessels: 0 DiscussionsByHelicopt
 4
 Figures 16 Pirates 24 Intelligence 65
 DP -DM 294.412749702632 lat=Hel 2.7630942795127 Pirate -1
 XY 11.5743173595252 48.361007172992 Peac_39 705.504645996094
 DP -DM 109.6545247731 lat=Hel 1.1189754366736 Pirate -1
 XY 12.491982030964 43.921162402234 Peac_291 710.424836767813
 DP -DM 140.72789973834 lat=Hel 1.4252455833939 Pirate -1
 XY 14.8636512701416 51.5059332105469 Peac_292 713.425108862881
 DP -DM 97.7265397104032 lat=Hel 0.63636789592072 Pirate -1
 XY 12.479503227233 44.334636882024 Peac_212 713.825134277344
 * 714.025164949375 Time 29 [days] B 1 Crossings 202852 N_Figures 16 N_Fishermen
 FieldIntelligenceReports: 89 CargoFlow: 48.8218803406762 [Ship/Day] TerminateAtts
 MissedAttacks: 3 DiscussionsByVessels: 0 FailuresByVessels: 0 DiscussionsByHelicopt
 4
 Figures 16 Pirates 24 Intelligence 65
 DP -DM 215.820304849591 lat=Hel 3.09925494657280 Pirate -1
 XY 12.277338027954 50.3457321166392 Peac_443 719.825500498281

Ports	Ships	Demand	Flags

Total Attacks: 7 Pirates Successes: 4 Crossings: 202852 Flow: 46.8218803
 HelSuccesses: 0 Vessel Successes: 0 Hel Failures: 4 Ship Failures: 0

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Helicopter

Average Setup Time [h]: 0.1

Radar max [Nm]: 45 Eye Max [Nm]: 12

Speed [Knots]: 135

Max Distance to Try [Nm]: 240

Fisherman Boat/Pirates

Generate [boats]: 700

Pirates [%]: 3

Attack Threshold [Nm]: 8

Attack Probability [%]: 0.8

Fisher Speed [Knots]: 10

Pirate Speed [Knots]: 35

Cargo Ship Flow [ship/day]: _____ Randomize

Intelligence Detection Probability: 0.1

Close



Actors and Activities

- **Pirates**

Attack modalities: Outrunning, Maintaining Innocent Speed, Following a Ship, Hiding between Ships, Swarming

Characteristics: agile structure, knowledge of this sea area, support from local population and in some case from political structure.



- **Navy**

Strong coalition force patrolling the area but the command and control don't results "agile" like the pirates organization.

Patrol modality: mostly frigate, helicopters & special force squads



- **Intelligence Agencies**

Critical Support to the Navy to predict pirates attacks

Instruments: data analysis, special commandos, satellite and communication technologies

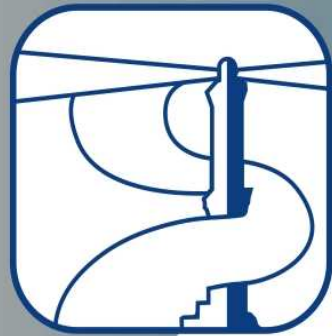


- **Local Authority**

Often Critical: i.e. "Failure Nations": no stable government, but strong presence of gangs, warlords etc...



Entities



~100 Cargo

~5-15 Vessels

~700 Boats

Cargo Ship

- Name
- Nationality
- Speed
- Radar Max
- Eye Max
- Communication Delays
- Number of Cargo Ship



Frigate

- Name
- Nationality
- Speed
- Radar Max
- Eye Max
- Communication Delay
- Number of Frigates

Helicopter

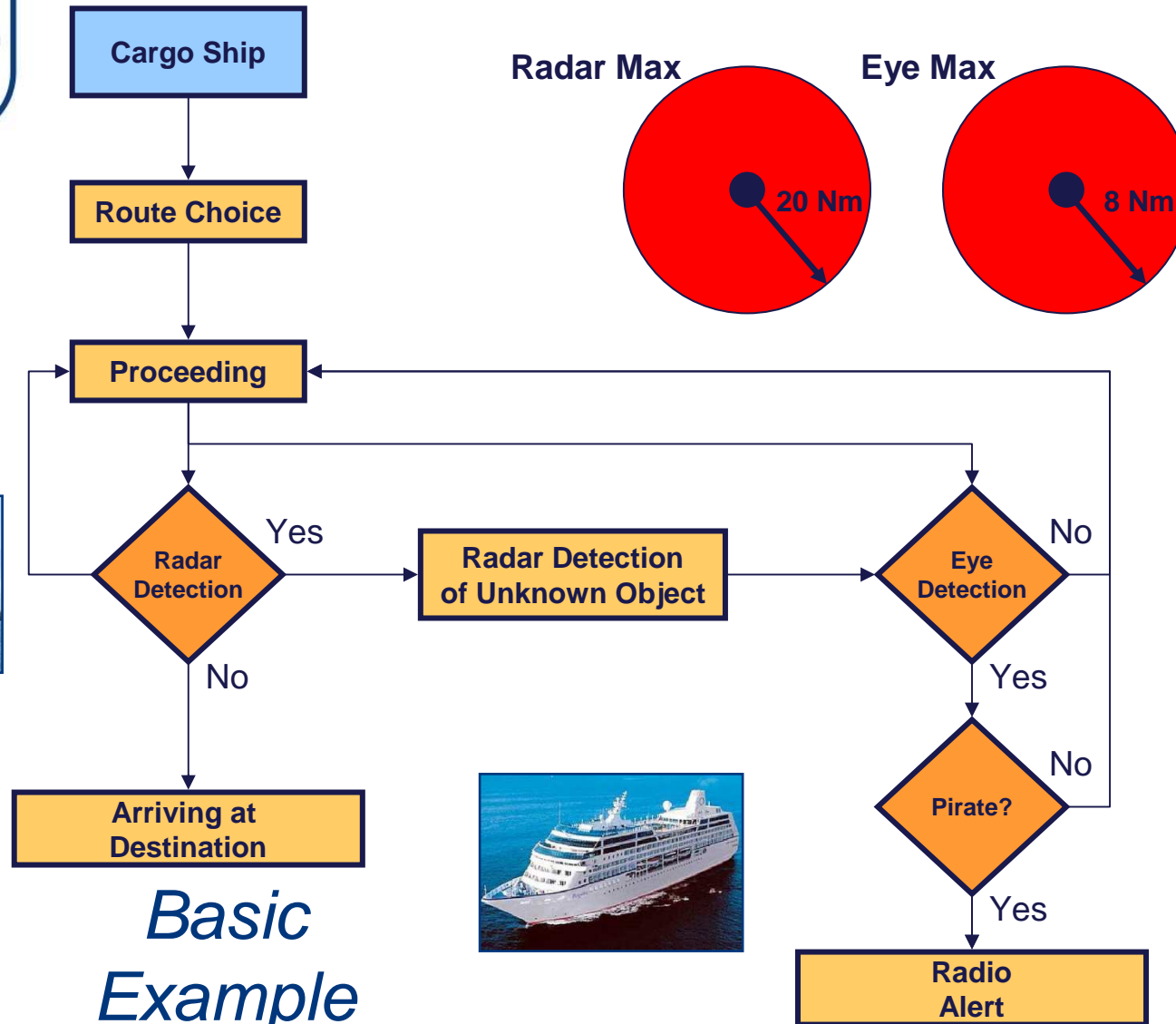
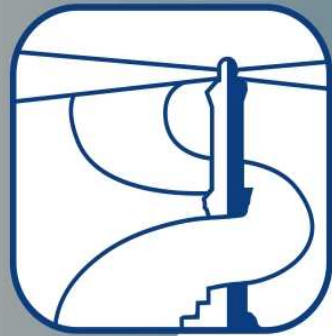
- Speed
- Radar Max
- Eye Max

Fisherman/Pirate Boat

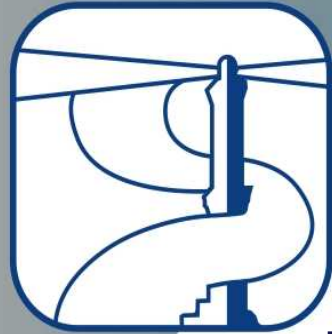
- Name
- Nationality
- Speed
- Pirates (%)
- Attack Distance
- Attack Probability
- Number of Fisherman boats



Cargo Ship Model



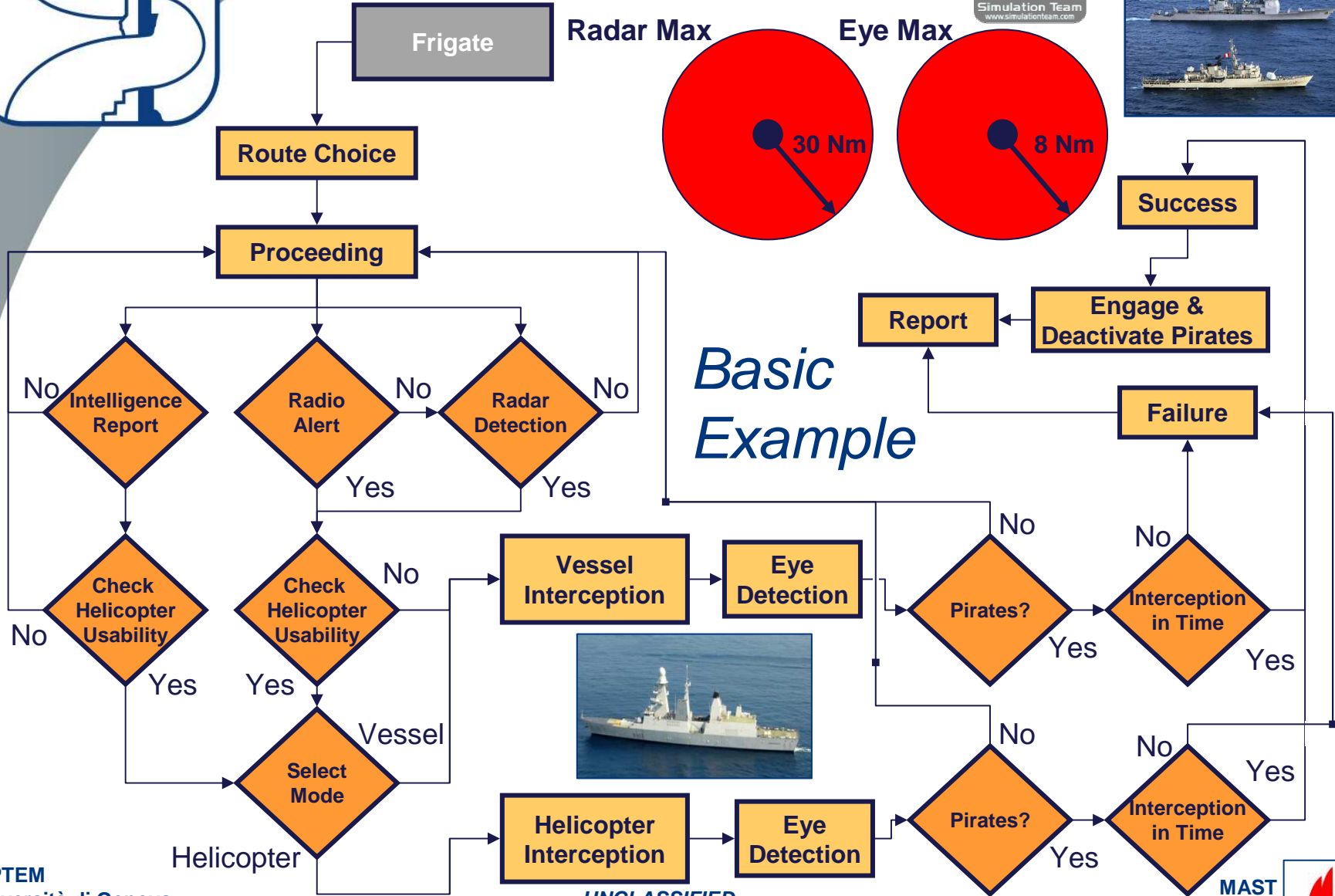
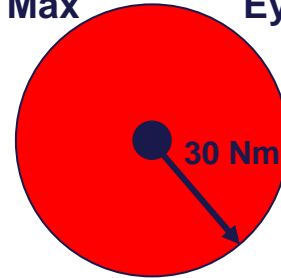
Frigate Model



Frigate

Radar Max

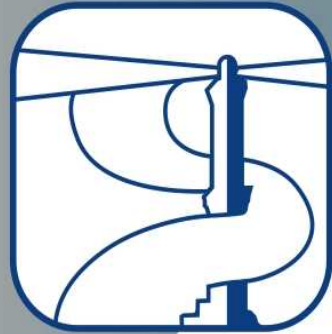
Eye Max



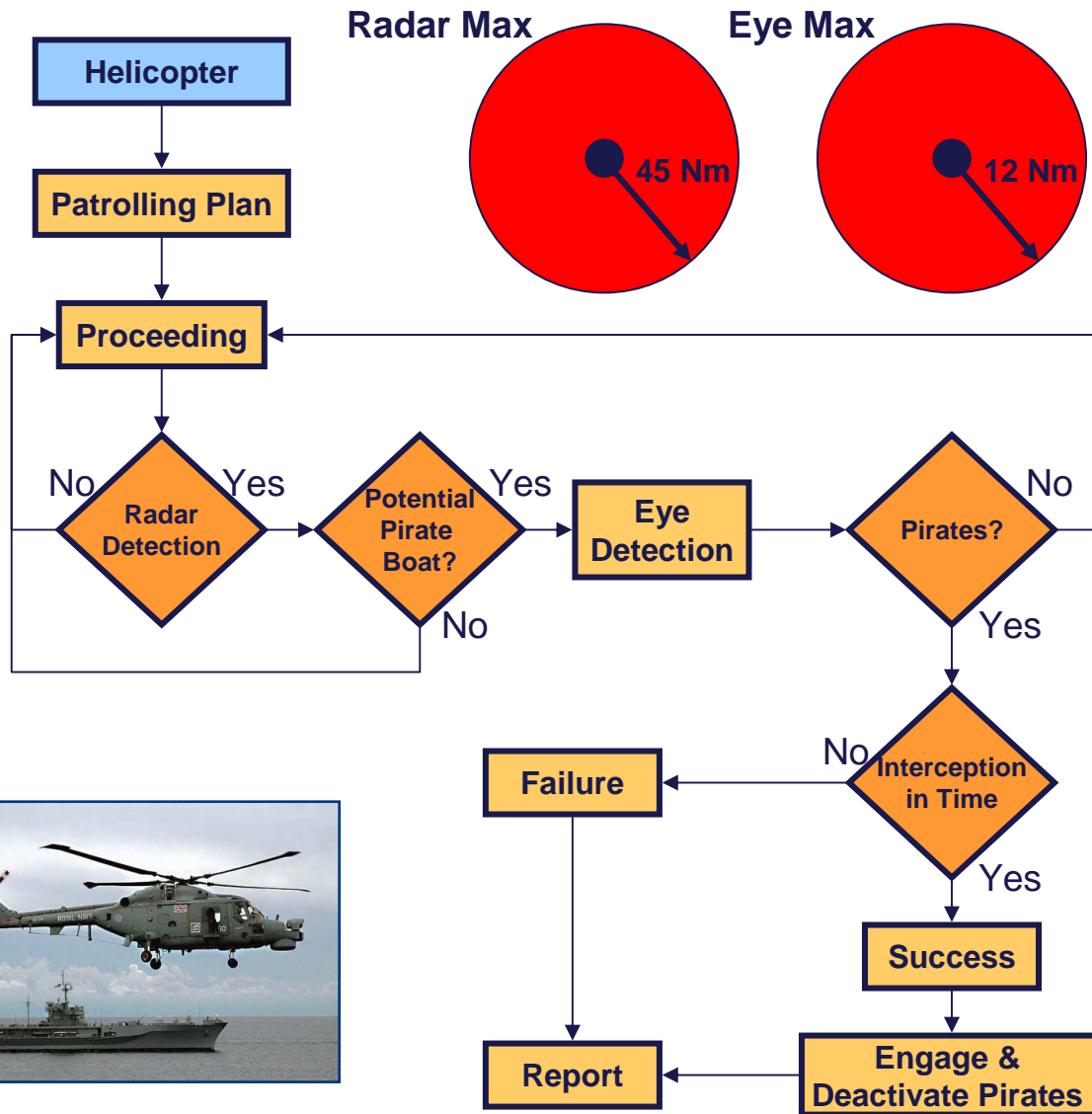
Basic Example



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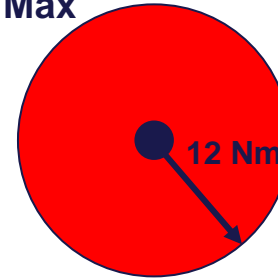
Helicopter Model



Radar Max

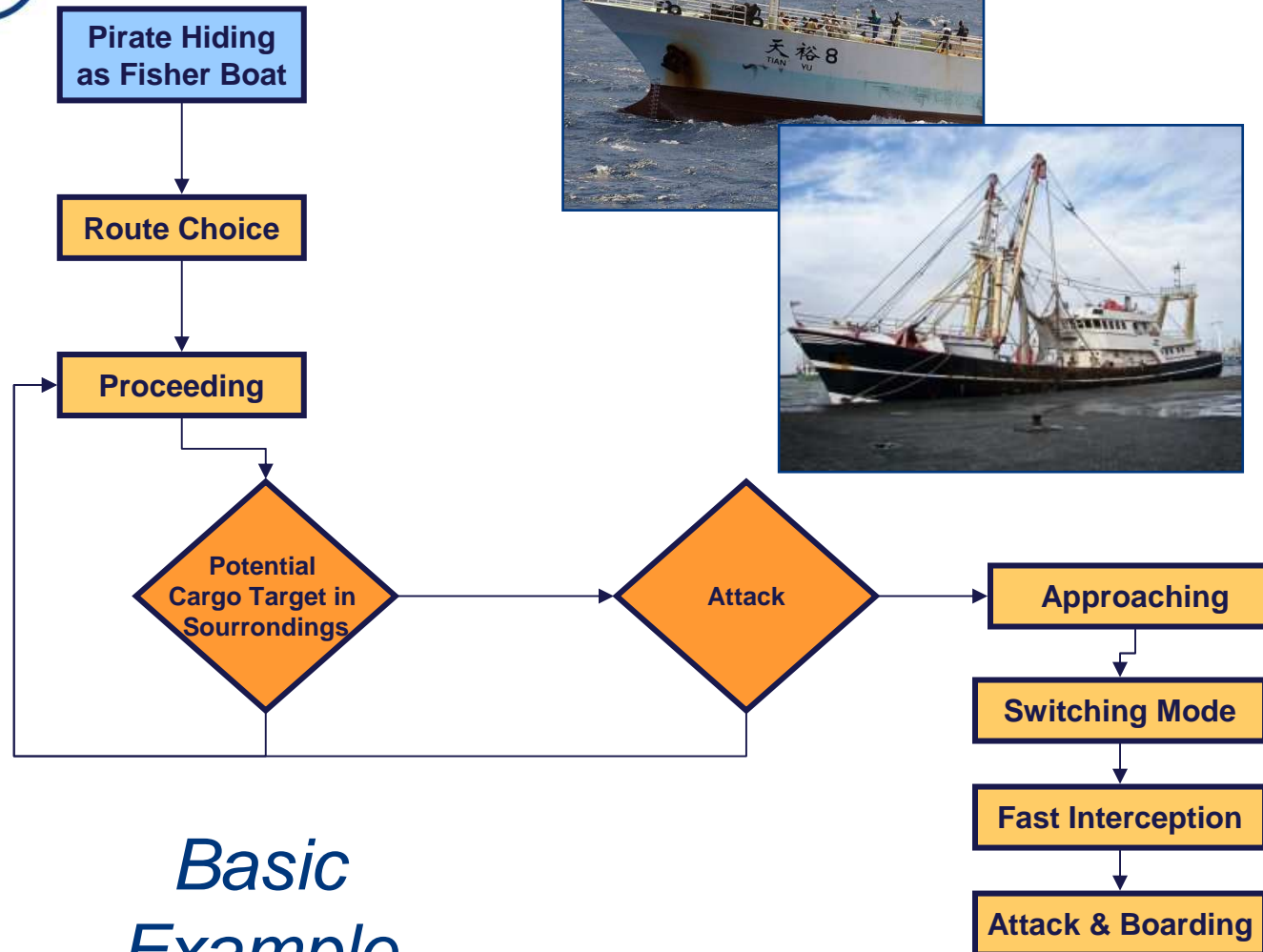
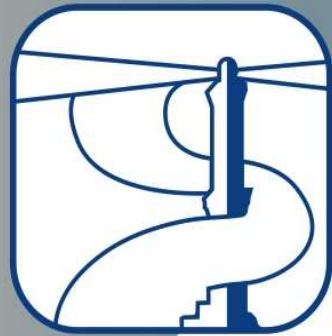


Eye Max

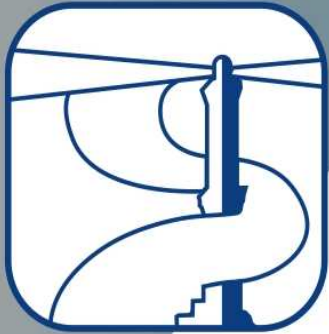


Basic Example on Patrolling

Simulation Team Fisher/pirate Boat Model



Basic Example



Scenario Overview

Number of Merchant Ships: 50 [ships/day]

Number of Frigate: 2-15

Number of Fisher Boat: 700

Attack Probability (%): ?

Communication Delay: 0.05 [hours]

Average Ship Speed: 20+/- 4 [Knots]

Frigate Cruise Speed: 20 [Knots]

Frigate Full Speed: 30 [Knots]

Fisher boat Speed: 10 [Knots]

Pirate boat Speed: 35 [Knots]

Helicopter Speed: 135 [Knots]

Attack Threshold: 8 [Nm]

Intelligence Detection (%): ?

PANOEPA - Piracy Asymmetric Naval Operation Patterns modelling for Education & Analysis

XY 11.950209236145 50.2517738342285 Pesc_390 702.624450683594
 *704.024535132913 Time: 29 [days] @ 1 Crossing: 139525 N_Frigate: 16 N_FisherBoats: 700 Pirates: 24
 FieldIntelligenceReports: 85 CargoFlow: 47.079037475586 [Ships/Day] TentativeAttacks: 7 PirateSuccesses: 4
 MissedAttacks: 3 DissuasionsbyVessels: 0 FailuresbyVessels: 0 DissuasionsbyHelicopter: 88 FailuresbyHelicopter:
 4
 Frigates: 16 Pirates: 24 Intelligence: 85
 DP - DM 294.412749702632 Int-Hel 2.7633042755127 Pirate - 1
 XY 11.6743173595243 49.961097712852 Pesc_ 95 705.824645996094
 DP - DM 109.69494347731 Int-Hel 1.11395754966736 Pirate - 1
 XY 12.4919652936843 43.5811482402344 Pesc_ 291 710.424926757813
 DP - DM 140.727895973634 Int-Hel 1.42526459693909 Pirate - 1
 XY 14.863612701416 51.905393105469 Pesc_ 292 713.425109863261
 DP - DM 57.7285307104032 Int-Hel 0.890363076933072 Pirate - 1
 XY 12.4785032272339 44.3346366882324 Pesc_ 212 713.825134277344
 *714.025146484375 Time: 29 [days] 18: 1 Crossing: 202852 N_Frigate: 16 N_FisherBoats: 700 Pirates: 24
 FieldIntelligenceReports: 89 CargoFlow: 46.8218903405762 [Ships/Day] TentativeAttacks: 7 PirateSuccesses: 4
 MissedAttacks: 3 DissuasionsbyVessels: 0 FailuresbyVessels: 0 DissuasionsbyHelicopter: 82 FailuresbyHelicopter:
 4
 Frigates: 16 Pirates: 24 Intelligence: 89
 DP - DM 315.963304949591 Int-Hel 0.09925494657209 Pirate - 1
 XY 12.277338027954 50.9457321166992 Pesc_ 449 719.825500488261

Panoeпа - Parameters

General
 Simulation Duration [days]: 30
 Statistical Time Advance [h]: 0.20

Cargo Ships
 Generate [ships/day]: 50
 Radar max [Nm]: 20
 Eye Max [Nm]: 8
 Average Speed [Knots]: 20
 Average Communication Delay [h]: 0.05
 Average Boarding Time [h]: 0.50

Frigate
 Generate [ships]: 16
 Radar max [Nm]: 30
 Eye Max [Nm]: 8
 Cruise Speed [Knots]: 20
 Full Speed [Knots]: 30
 Max Distance to Try [Nm]: 50
 Distance Ship vs Copter [Nm]: 5

Helicopter
 Average Setup Time [h]: 0.1
 Radar max [Nm]: 45
 Eye Max [Nm]: 12
 Speed [Knots]: 135
 Max Distance to Try [Nm]: 240

Fisherman Boat/Pirates
 Generate [boats]: 700
 Pirates (%): 3
 Attack Threshold [Nm]: 8
 Attack Probability (%): 0.8
 Fisher Speed [Knots]: 10
 Pirate Speed [Knots]: 35

Cargo Ship Flow [ship/day]: Randomize
 Intelligence Detection Probability: 0.1

Simulation Features

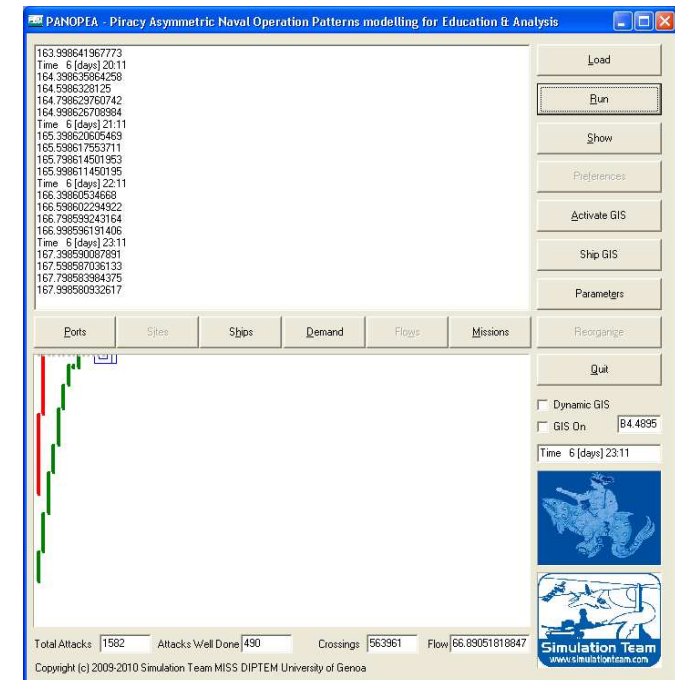


Simulation Characteristics

- Simulation Duration
- Stochastic Influence
- Replications

Outputs

- Total Reports from Cargo Ship
- Number of Frigate Successful Operations
- Number of Successful Operations due to Intelligence Reports
- Number of Pirate Successful Attacks
- Number of Inspections by Frigate





Active Objects

•Cargo ship

Speed: 16 – 20 knots.

Tecnology VHF radio, gps, radar system

No guns on board, but in some case shipowner engage contractors.



•Frigate

Speed: 18– 30 knots

Tecnology : Communication Systems , Sensors (Radars, IR, EO, ESM), gps

Armament: cannons, helicopters, ...



•Helicopter

Speed : 150 - 200km/h



Tecnology: military communication systems, gps, Sensors (IR, EO, Radars)

Armament: special forces on board, machine gun...

•Generic boat

Speed: 12 – 20 knots



A generic boat could represents both pirates (these are able to ramp up to 35 knots and armed with assault rifles, machine guns, grenades and rockets) or a civil traffic (i.e.fish boats)

•Ground Radar systems

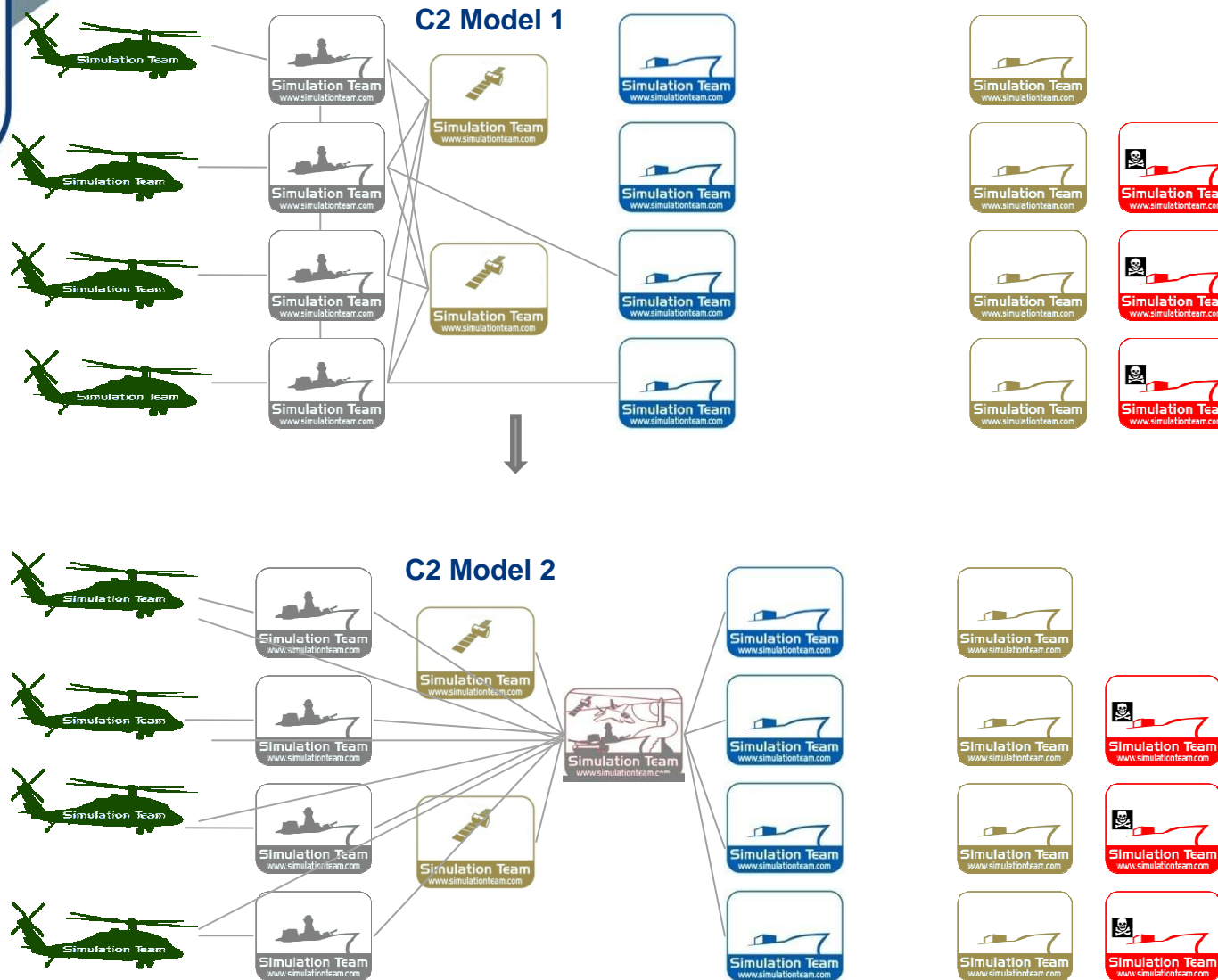
Range of action: 20- 45 Nm

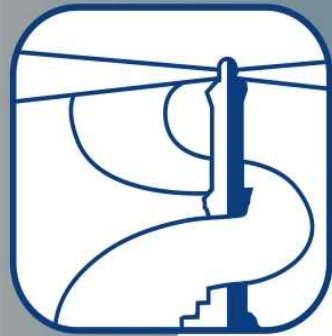
•Satellite system

Technologies: optical system, height tech cameras ,...



C2 Configuration





Objects in Experiments



Local Coast Guard



**Intelligence
Coalition HQs
National HQs**

Local Traffic: Fisher Boats

Pirates

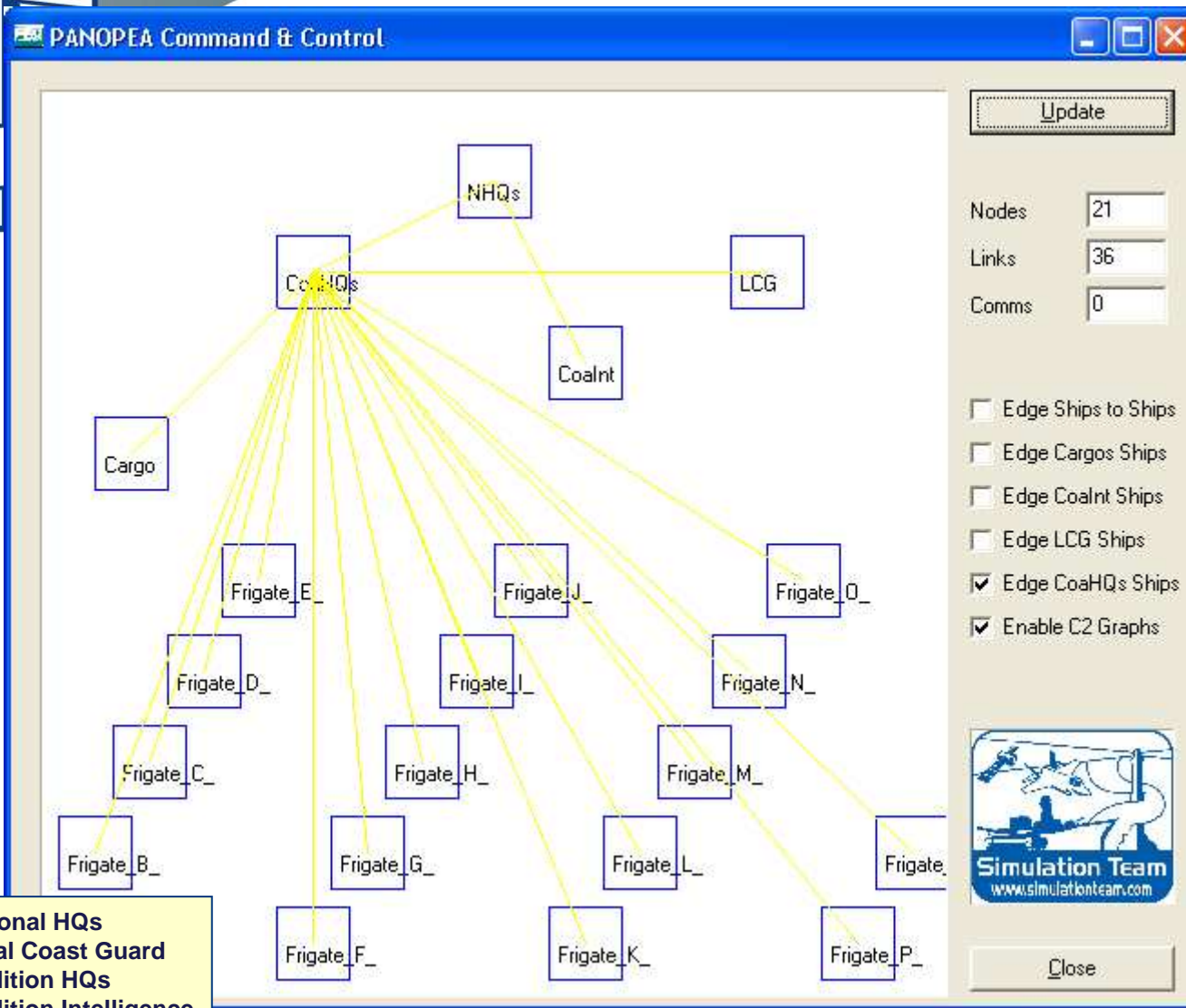


**Frigates
Helicopters
Special Force Teams**

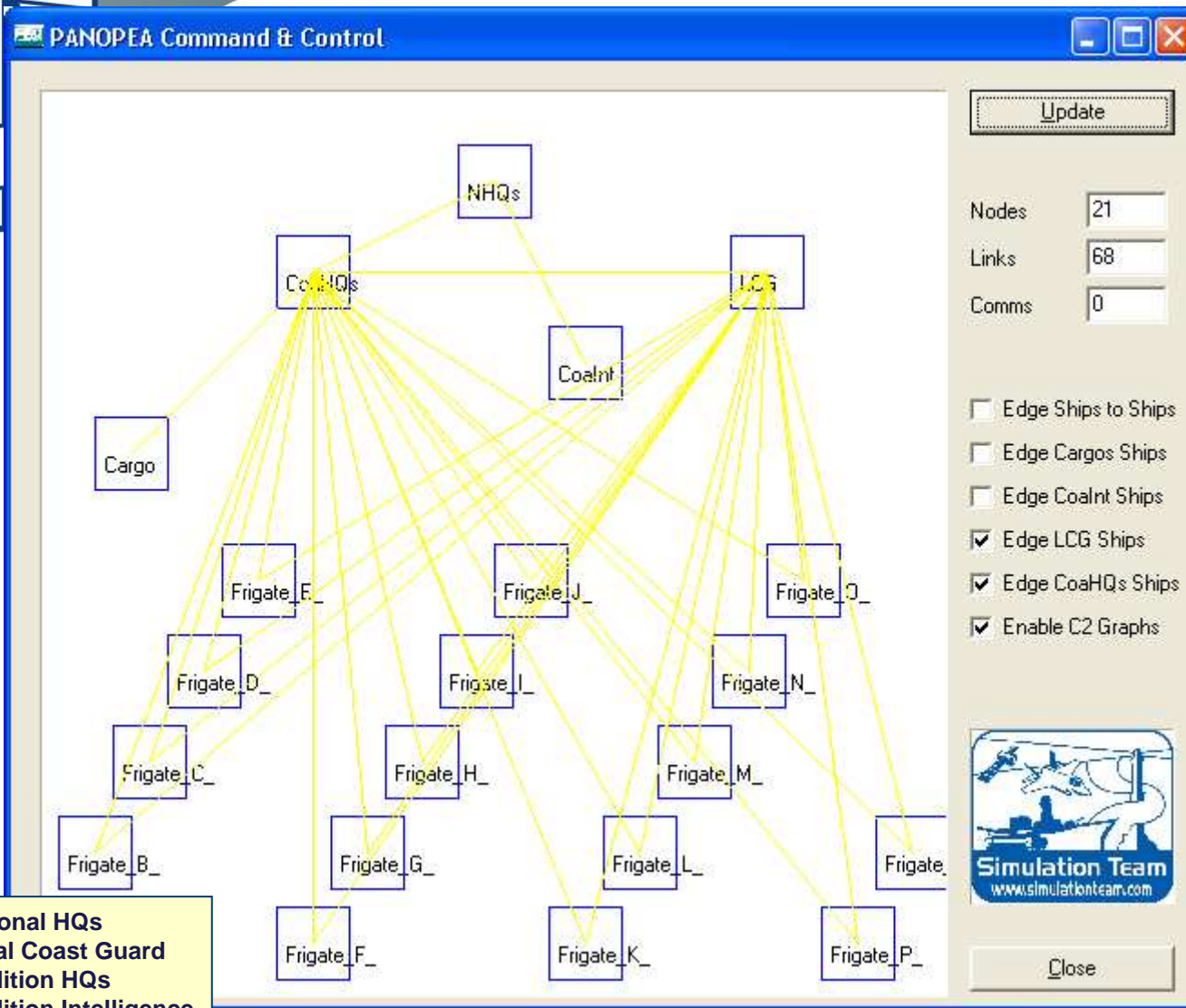


**Cargo Ships
Crew on Board
On Board Contractors**

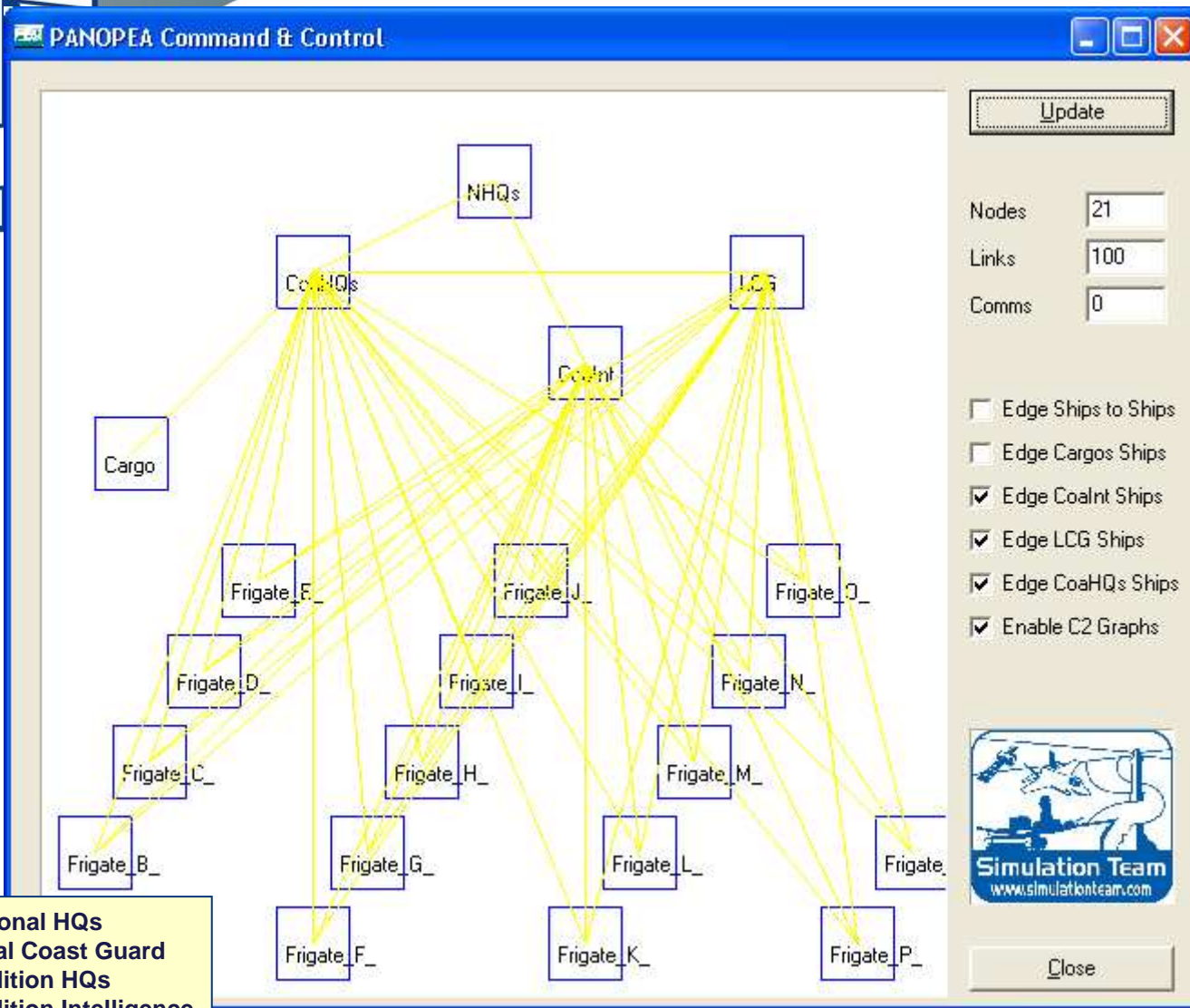




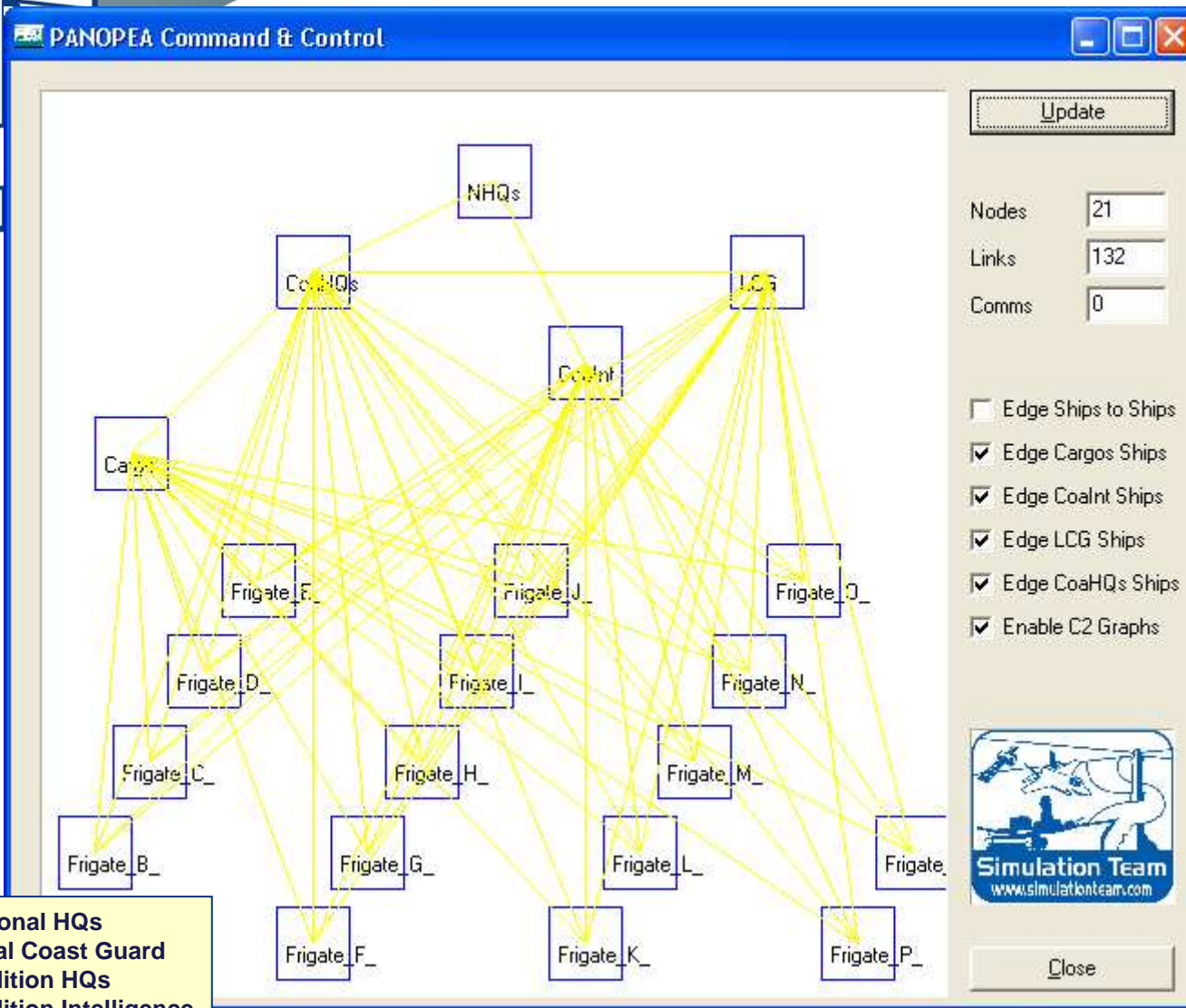
NHQs	National HQs
LCG	Local Coast Guard
CoaHQs	Coalition HQs
Coalnt	Coalition Intelligence
Cargo	Cargos
Frigate_X	Frigate i



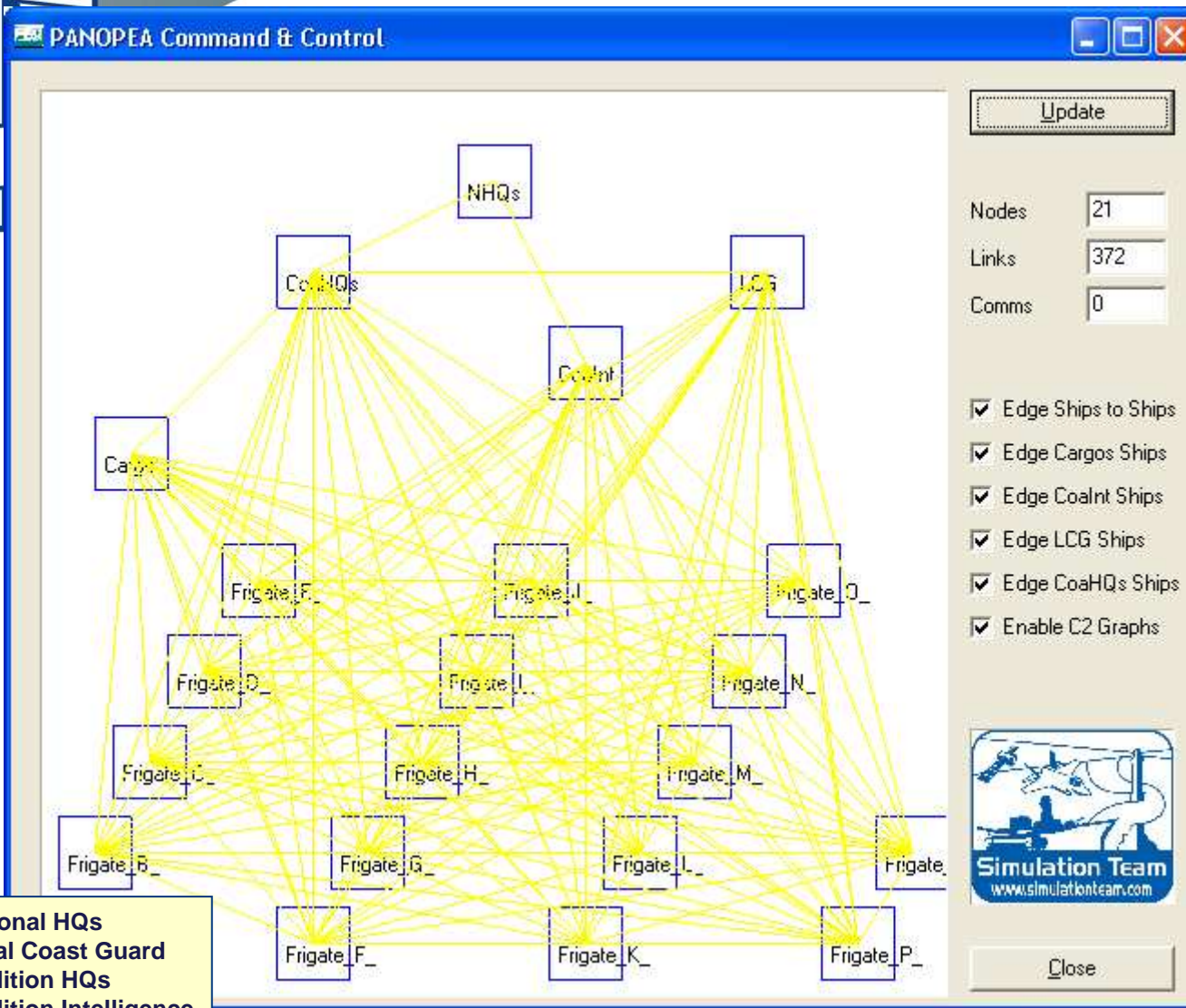
NHQs	National HQs
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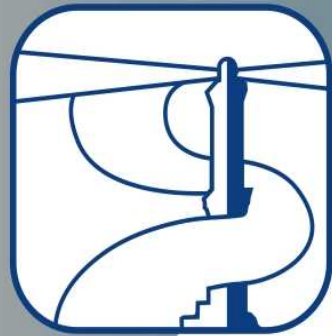
NHQs	National HQs
LCG	Local Coast Guard
CoaHQs	Coalition HQs
Coalnt	Coalition Intelligence
Cargo	Cargos
Frigate_X	Frigate i



NHQs	National HQs
LCG	Local Coast Guard
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NHQs	National HQs
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Coalnt	Coalition Intelligence
Cargo	Cargos
Frigate_X	Frigate i



Interface

PANOPEA - Piracy Asymmetric Naval Operation Patterns modelling for Education & Analysis

15 33
16 34
17 35
0 0
1 1
2 2
3 3
4 4
5 5
6 6
7 7
8 8
9 27
10 28
11 29
12 30
13 31
14 32
15 33
16 34
17 35

Ports Sites Ships Demand Flows Missions BGI C2GI

Load
Run
Show
Preferences
Activate GIS
GIS Layers
Ship GIS
Parameters
Reorganize
Quit

Dynamic GIS
 GIS On 82.8169

Time 9 [days] 23:54 20 20

Graph Data Trust

Total Attacks 16 Attacks Well Done 13 Cross Fact. 10197 Flow 59.42093276
 HellWellDone 15 ShipWellDone 29 HellMissed 12 ShipMissed 17
 Escorts 30 Inspections 194 Hely Insp. 7 Ship Insp. 3

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Panopea - Parameters

General
 Simulation Duration [days] 30
 Statistical Time Advance [h] 0.20

Cargo Ships
 Generate [ships/day] 50
 Radar max [Nm] 20
 Eye Max [Nm] 8
 Average Speed [Knots] 20
 Average Communication Delay [h] 0.05
 Average Boarding Time [h] 0.50

Frigate
 Generate [ships] 16
 Radar max [Nm] 30 Eye Max [Nm] 8
 Cruise Speed [Knots] 20 Full Speed [Knots] 30
 Max Distance to Try [Nm] 50
 Distance Ship vs Copter [Nm] 5

Helicopter
 Average Setup Time [h] 0.1
 Radar max [Nm] 45 Eye Max [Nm] 12
 Speed [Knots] 135
 Max Distance to Try [Nm] 240

Fisherman Boat/Pyrates
 Generate [boats] 700
 Pirates (%) 3
 Attack Threshold [Nm] 8
 Attack Probability (%) 0.8
 Fisher Speed [Knots] 10
 Pyrate Speed [Knots] 35

Cargo Ship Flow [ship/day] Randomize
 Intelligence Detection Probability 0.1

Close

Input



PANOPEA - GIS Layers

Frigate
 Cargos

Helicopters
 Fisher Boats

PANOPEA - Piracy Asymmetric Naval Operation Pa

XY 11.850209236145 50.2517738342285 Pesc_390 702.6244506

Panopea - Parameters

General	Simulation Duration [days]	<input type="text" value="10"/>	Intelligence	Local Intelligence Detection Prob. [%]	<input type="text" value=".05"/>
	Statistical Time Advance [h]	<input type="text" value="0.1"/>		Coalition Intelligence Detection Prob. [%]	<input type="text" value=".15"/>
	Configuration File Path	<input type="text" value="C:\zz\zz2010\tes\pano"/>			
Cargo Ships	Generate [ships/day]	<input type="text" value="50"/>	Helicopter	Radar max [Nm]	<input type="text" value="45"/>
	Radar max [Nm]	<input type="text" value="20"/>		Eye Max [Nm]	<input type="text" value="12"/>
	Eye Max [Nm]	<input type="text" value="8"/>		Speed [Knots]	<input type="text" value="135"/>
	Average Speed [Knots]	<input type="text" value="20"/>		Average Setup Time [h]	<input type="text" value="0.2"/>
	Average Commutation Delay [h]	<input type="text" value="0.1"/>			
	Average Boarding Time [h]	<input type="text" value="0.20"/>			
Frigate	Generate [ships]	<input type="text" value="16"/>	Fisherman Boat/Pyrates	Generate [boats]	<input type="text" value="700"/>
	Radar max [Nm]	<input type="text" value="30"/>		Pirates [%]	<input type="text" value="3"/>
	Eye Max [Nm]	<input type="text" value="8"/>		Attack Treshold [Nm]	<input type="text" value="8"/>
	Cruise Speed [Knots]	<input type="text" value="20"/>		Attack Probability [%]	<input type="text" value="0.8"/>
	Full Speed [Knots]	<input type="text" value="30"/>		Fisher Speed [Knots]	<input type="text" value="10"/>
	Inps. Sampling [%]	<input type="text" value="25"/>		Pyrate Speed [Knots]	<input type="text" value="35"/>
	Escorting <input checked="" type="checkbox"/>			Cargo Ship Flow [ship/day]	<input type="text" value="-----"/>
	Inspecting <input checked="" type="checkbox"/>			Frigate Number	<input type="text" value="-----"/>
				<input checked="" type="checkbox"/> Randomize	
				<input type="button" value="Close"/>	

Cargo Ship Missions



Panopea - Missions

Mission_1
Mission_2
Mission_3
Mission_4
Mission_5
Mission_6
Mission_7
Mission_8
Mission_9
Mission_10
Mission_11
Mission_12
Mission_13
Mission_14
Mission_15
Mission_16
Mission_17
Mission_18
Mission_19
Mission_20
Mission_21
Mission_22
Mission_23
Mission_24
Mission_25
Mission_26

Mission Flows
flow6 Propilene Q 1159.86535644531 BOSASO JEDDAH
flow5 Butadiene Q 1335.82690429688 ASSAB DJIBOUTI

Site Sequence
P7
P6

Port Sequence
NISHTUN
JEDDAH
NISHTUN

Mission Ships
FF_1
FF_9
Pesc_229
Pesc_235
Pesc_247

Unassigned Flows
flow13
flow18
flow19
flow20
flow21
flow22
flow23
flow24
flow25
flow26
flow27
flow28
flow29

Unassigned Ships

Ok Close

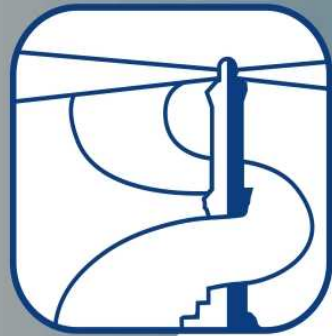
Cargo Ship Missions



Panopea - Missions

Mission_1	Mission Flows	flow6 Propilene Q 1159.86535644531 BOSASO JEDDAH	->	Unassigned Flows
Mission_2	none NA Q 0			flow13
Mission_3	flow1 C4 Q 2795.34619140625 JEDDAH NISHTUN		<-	flow18
Mission_4	Site Sequence	P7		flow19
Mission_5	P1			flow20
Mission_6	P2			flow21
Mission_7	Port Sequence	NISHTUN		flow22
Mission_8	CRATER			flow23
Mission_9	LITTLE_ADEN			flow24
Mission_10	NISHTUN			flow25
Mission_11	Mission Ships	FF_4	->	flow26
Mission_12	FF_12			<-
Mission_13				flow28
Mission_14				flow29
Mission_15				
Mission_16				
Mission_17				
Mission_18				
Mission_19				
Mission_20				
Mission_21				
Mission_22				
Mission_23				
Mission_24				
Mission_25				
Mission_26				

Ok Close



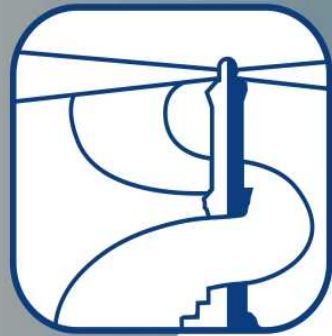
Ships Details

Panopea - Ships

Ship	Lat	Long	Port	Flag	DWT	Bay	Bay	Carb.Costs	Ship Costs	Port Costs	Ex. Costs	Total Costs	SOP
					[tons]	Type	[tons]	[kEuro]	[kEuro]	[kEuro]	[kEuro]	[kEuro]	
Telpur_Zek	24:40:0 N	35:31:0 E	S1	Brazil	59169	0	0	32169.55468	111726.9453	40	0	143936.5	1
D_Fast	24:59:0 N	35:18:0 E	S1	Bulgaria	60373	0	0	22841.96875	100469.9765	40	0	123351.9453	500
Lucio_Rich	14:51:0 N	41:54:0 E	E1	Sao_Tome_	36719	0	0	21108.38867	83731.28125	30	0	104869.6695	1
Trismedlax	21:24:0 N	37:38:0 E	S1	Iran	45947	Propilene	2000	19497.00390	81359.19531	40	10000	110896.1992	1
ontodex	19:11:0 N	39:50:0 E	E1	Dominican_F	65765	Propilene	2000	15470.49605	85589.38281	30	10000	111089.8785	1
Waytel_Elvar_Elvar	21:22:0 N	38:41:0 E	E2	Guatemala	39899	0	0	33127.91796	115052.6326	30	0	148210.5507	1
Icy_Rebel_Crystal	22:51:0 N	37:54:0 E	E3	Tonga	43390	0	0	23018.05273	101252.2890	30	0	124300.3417	1

Dynamic Update During Simulation

Ok Close

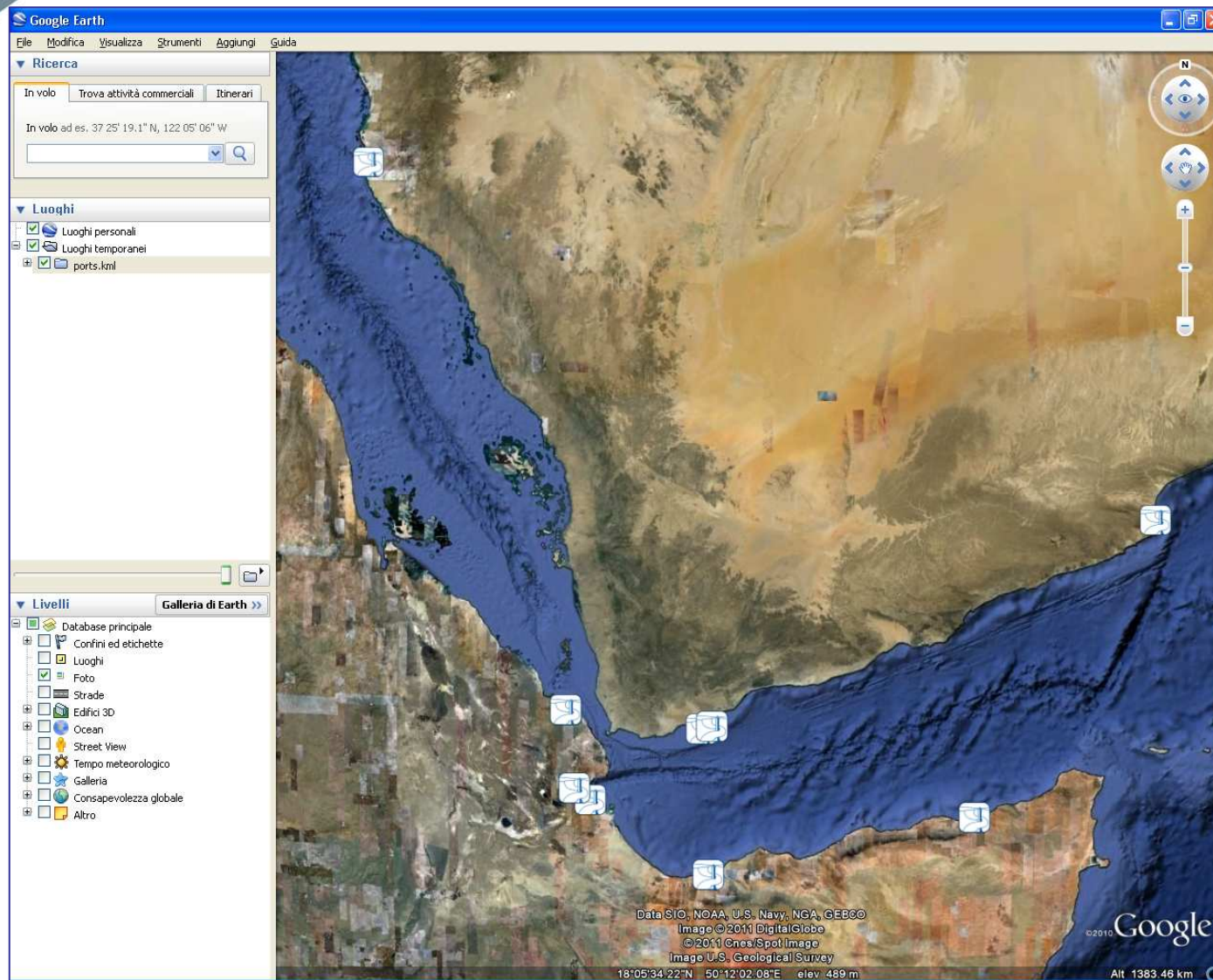


Port Details

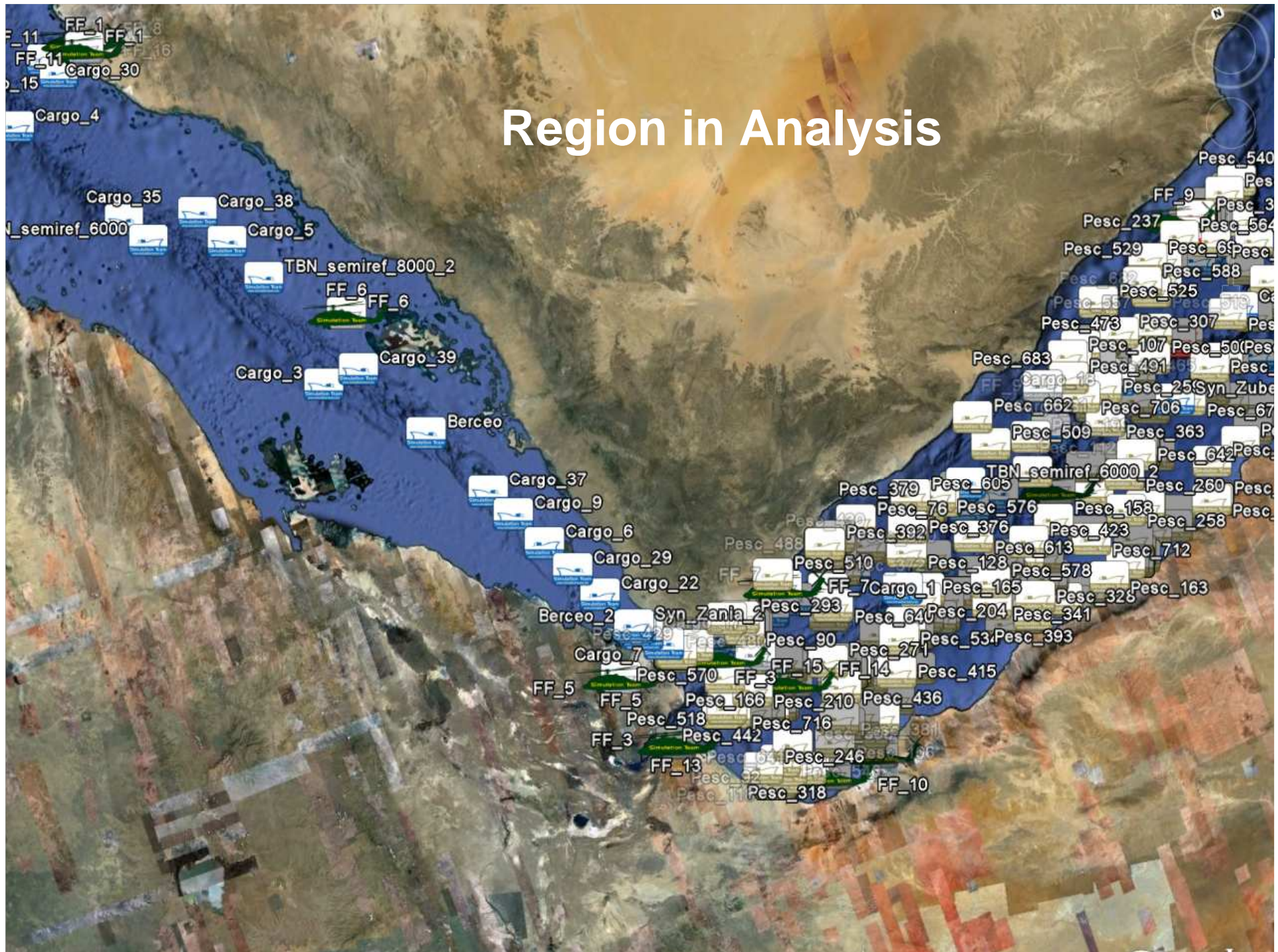
The screenshot shows a dialog box titled "Panopea - Ports" with a table of port details. The table has three columns: "Port", "Dock 1", and "Dock 2". All ports listed are marked as "Available" in both dock columns. Below the table, there is a "Dynamic Update" checkbox which is checked, and "Ok" and "Close" buttons.

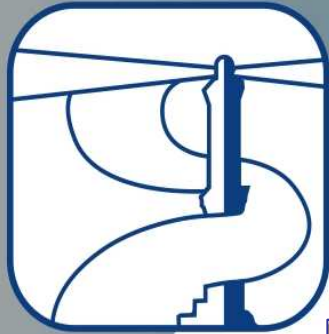
Port	Dock 1	Dock 2
CRATER	Available	Available
LITTLE_ADEN	Available	Available
DJIBOUTI	Available	Available
TADJOURA	Available	Available
ASSAB	Available	Available
JEDDAH	Available	Available
NISHTUN	Available	Available
BERBERA	Available	Available
BOSASO	Available	Available
E1	Available	Available
E2	Available	Available
E3	Available	Available
E4	Available	Available

GIS Integration



Region in Analysis

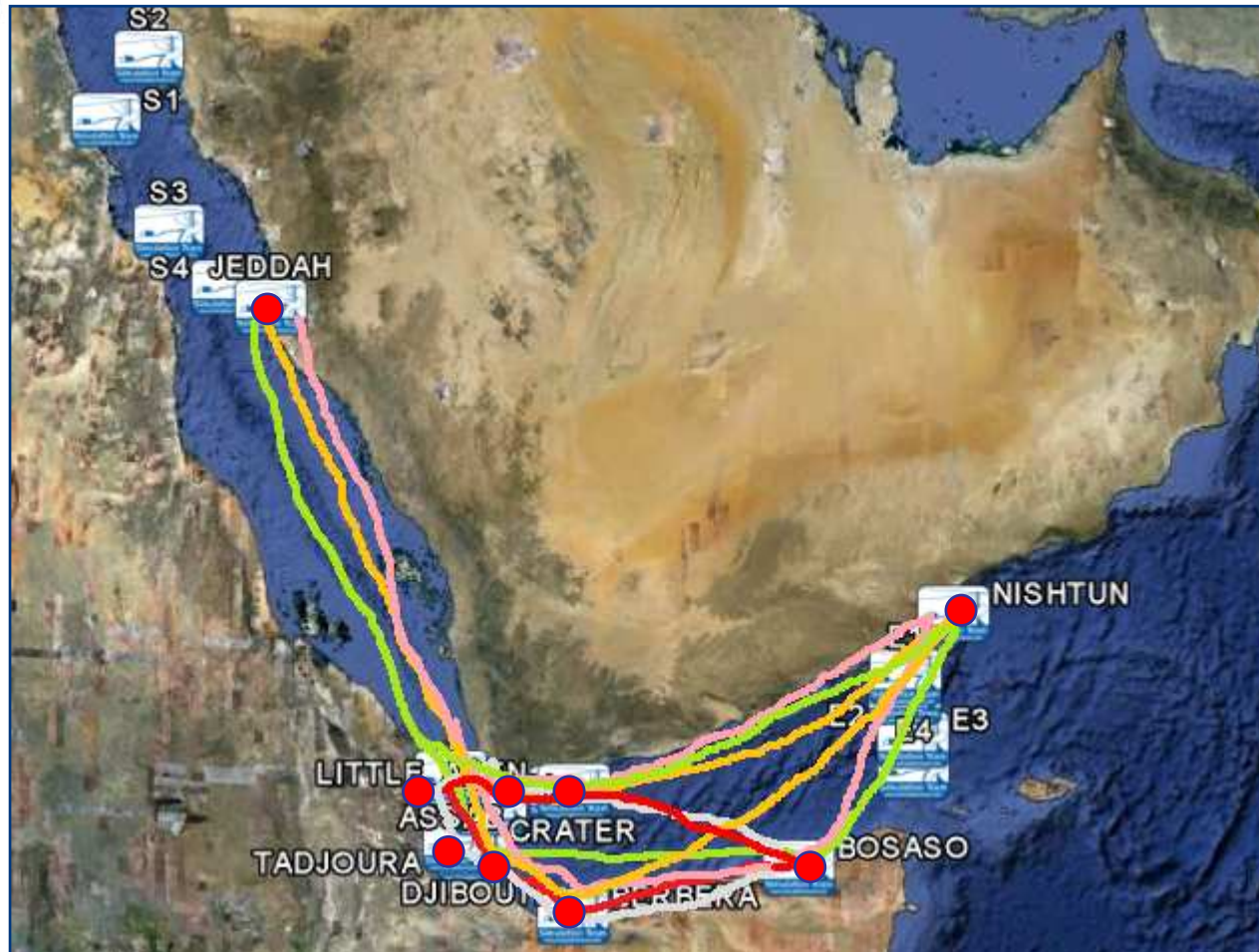


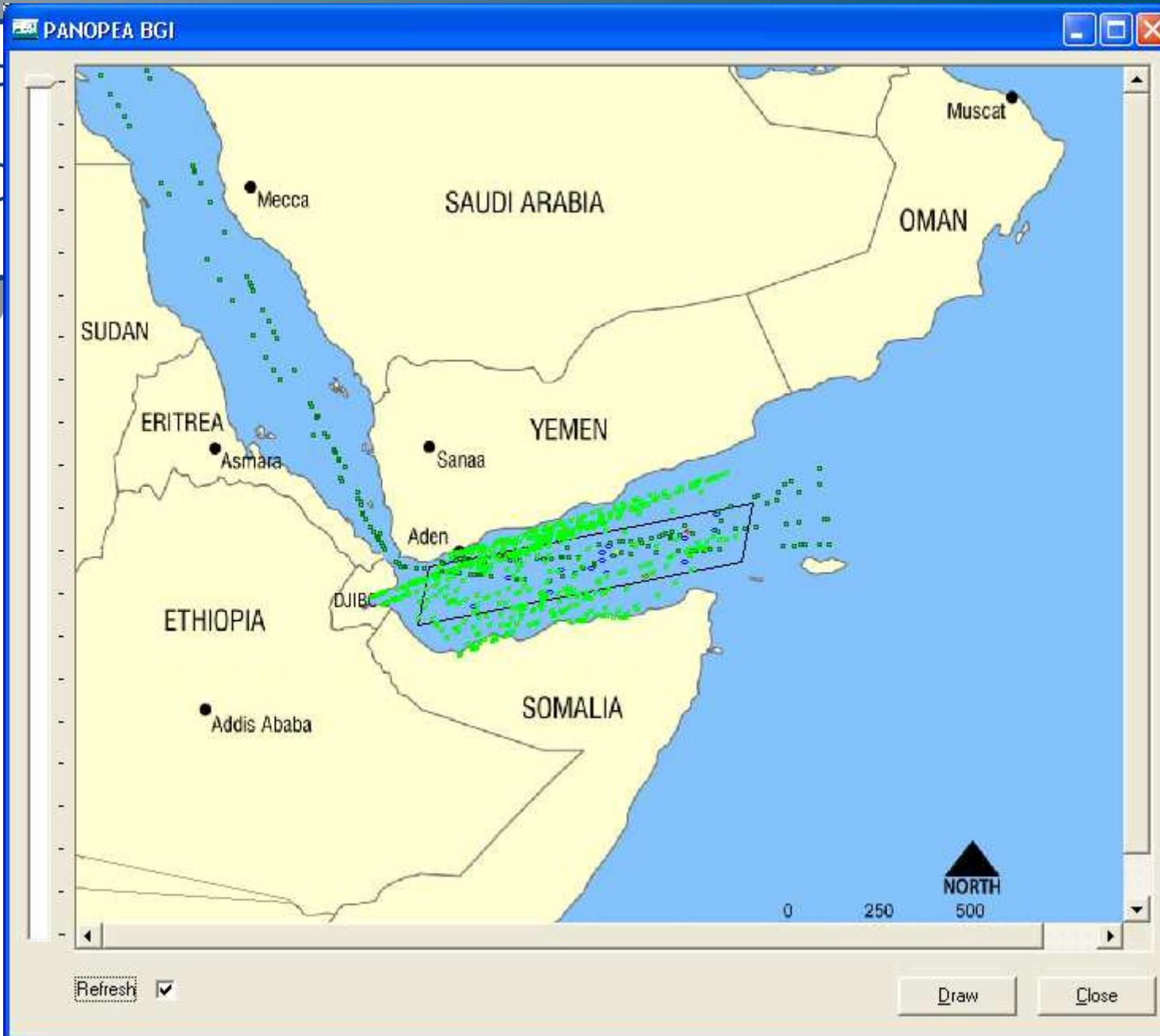


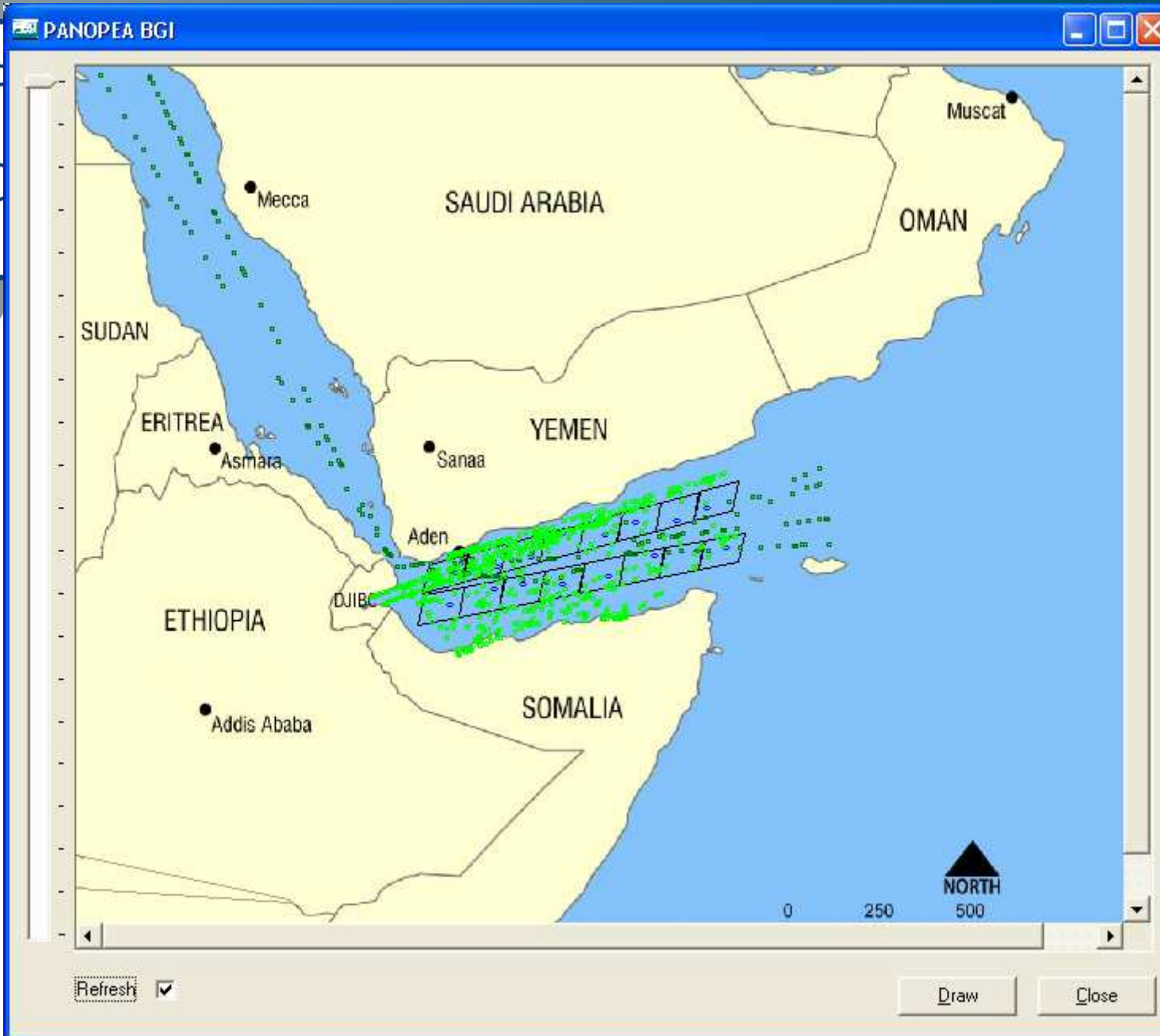
Cargo Ships

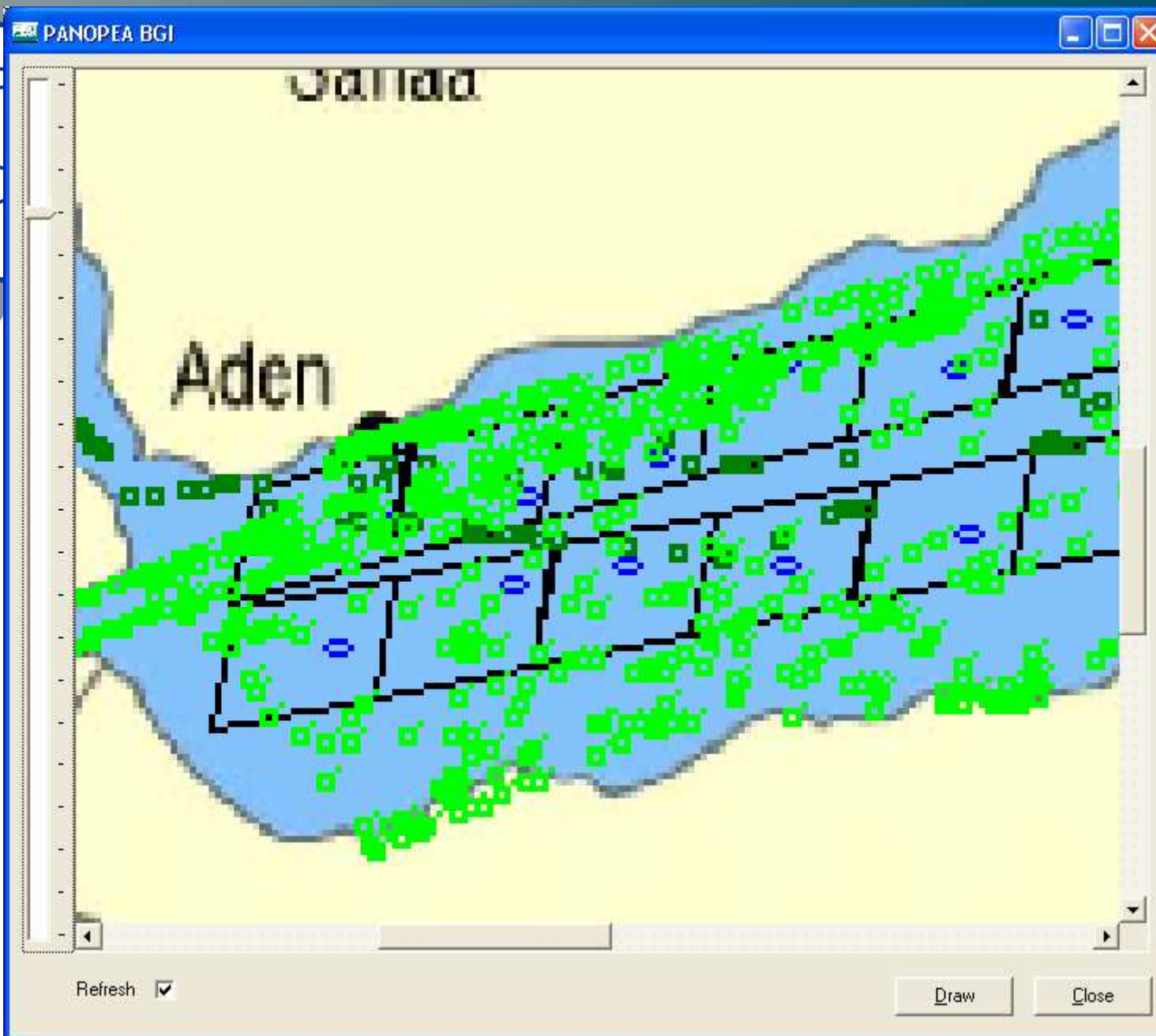


Frigate Patrolling







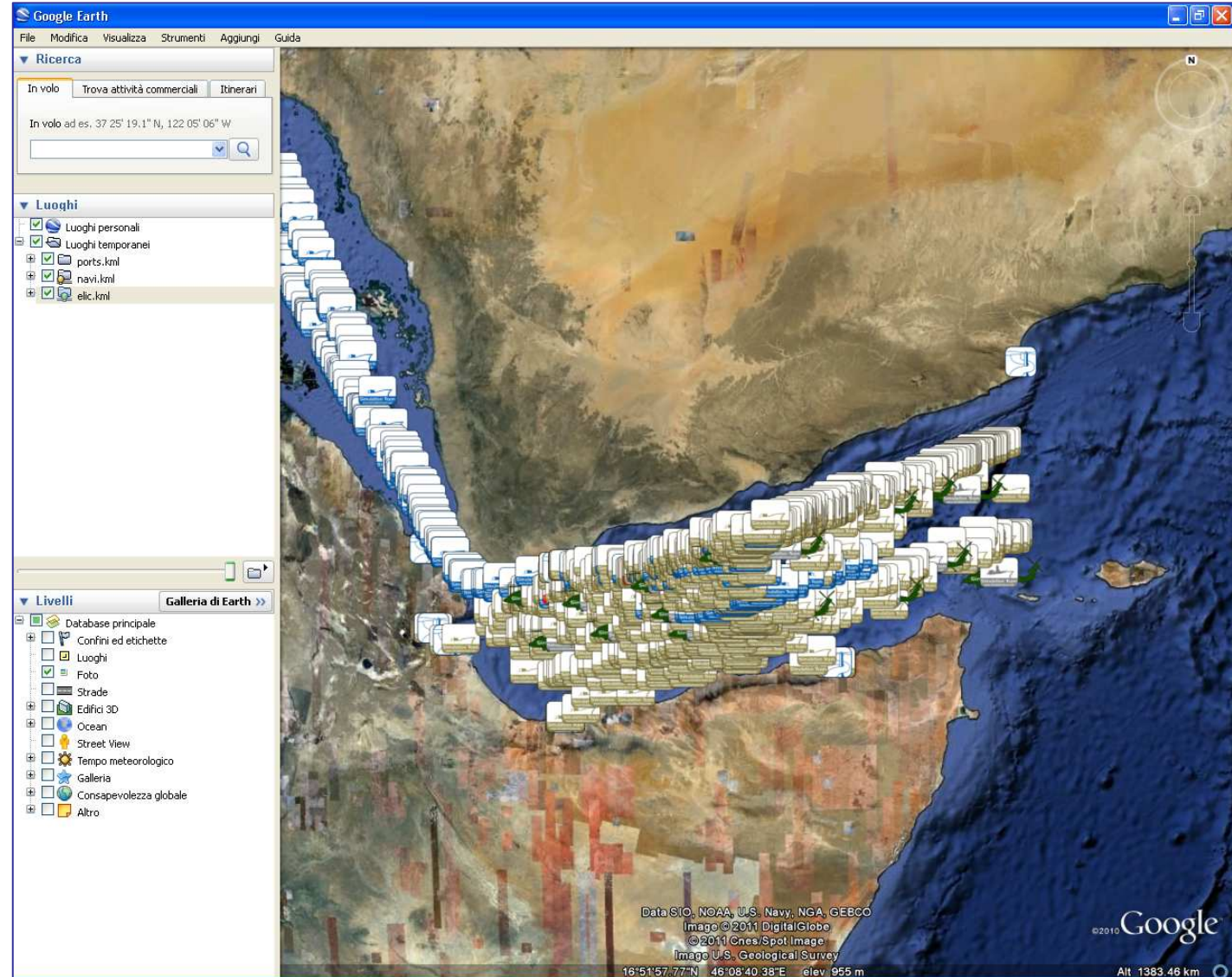




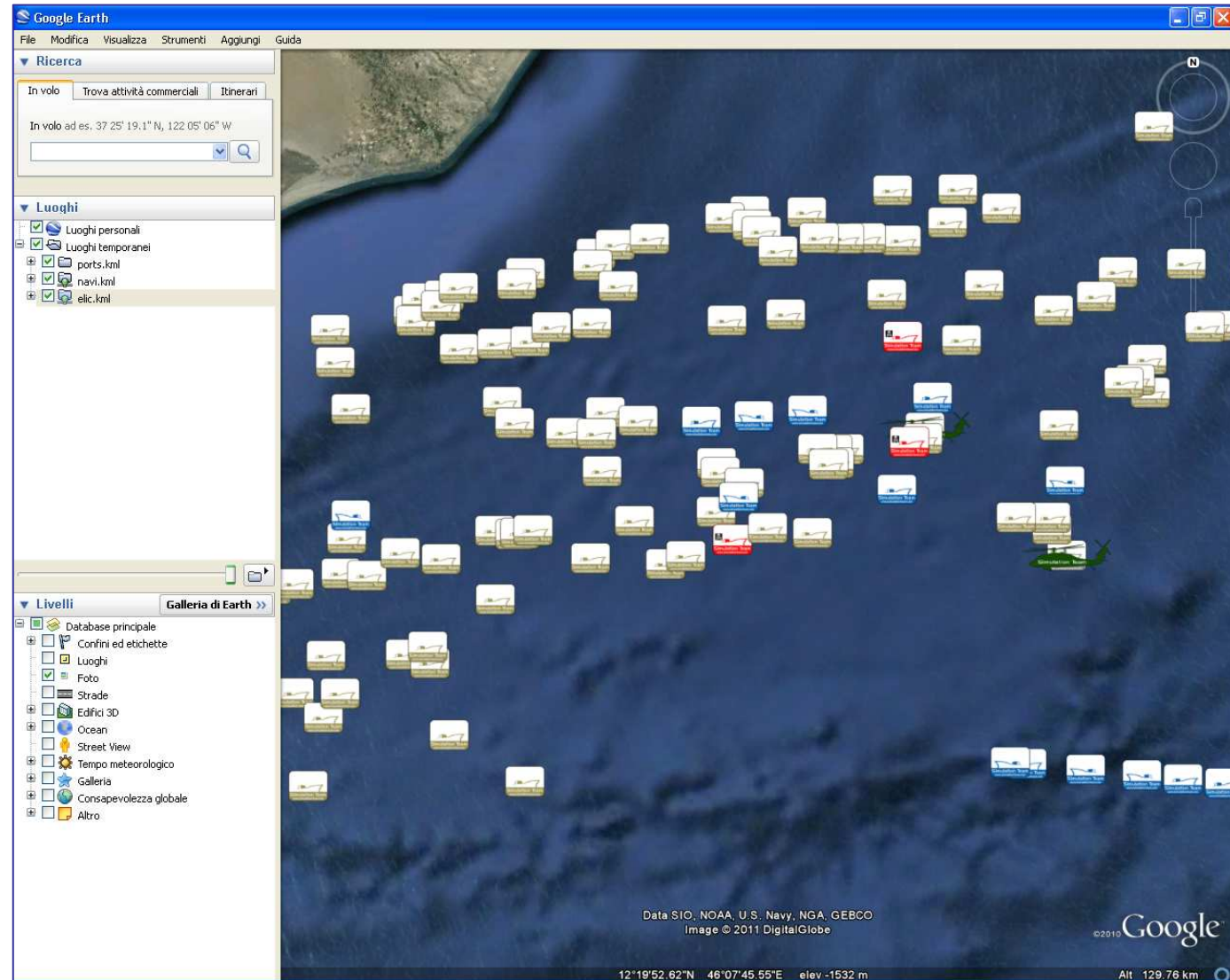
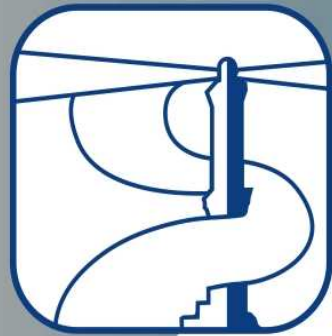
Fisher Boats



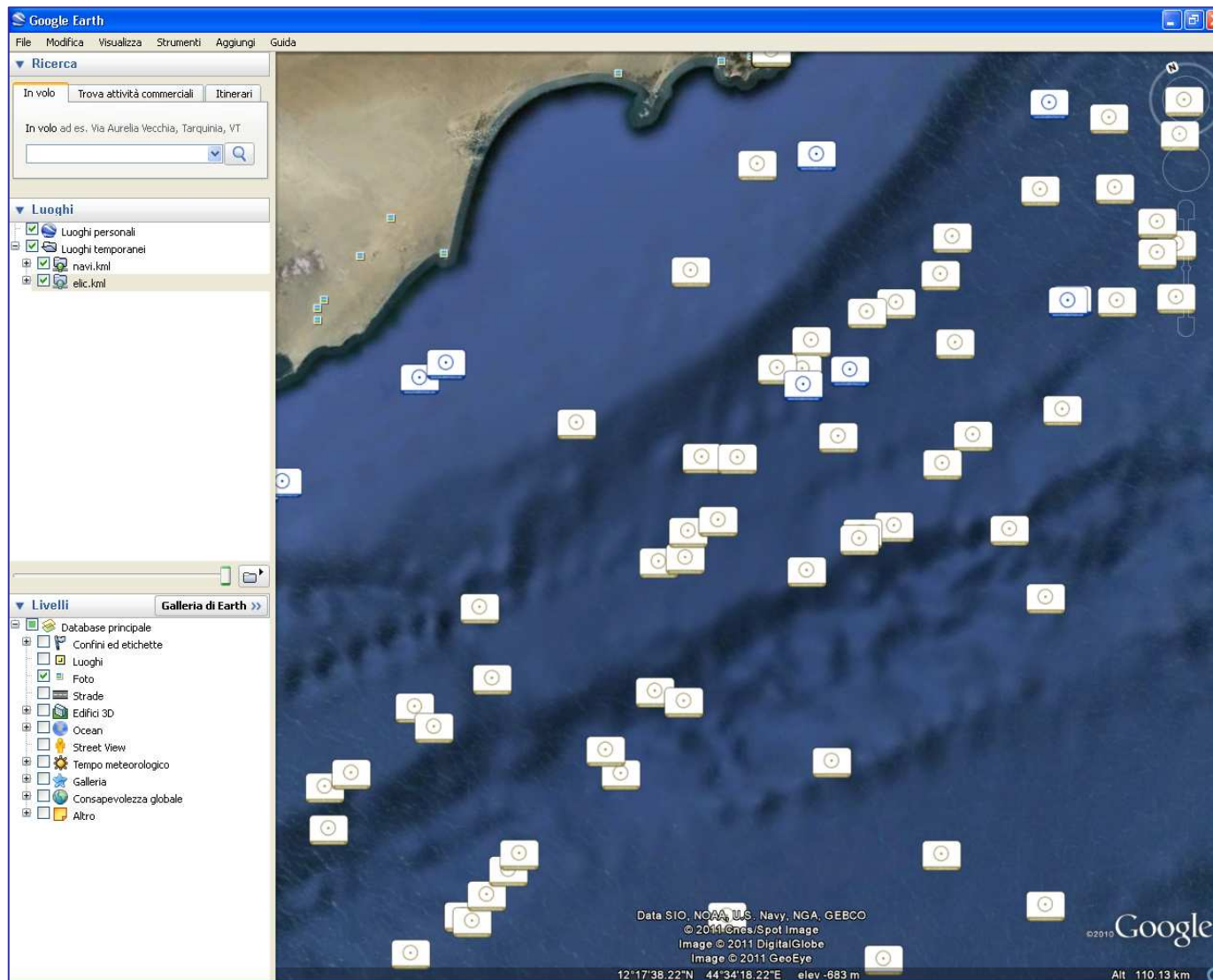
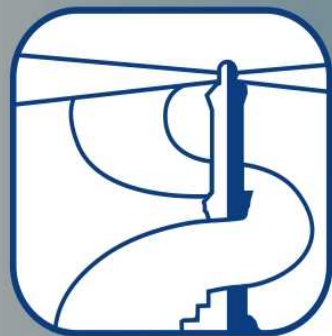
High Traffic Density



Simulation Team Inspections & Engagements



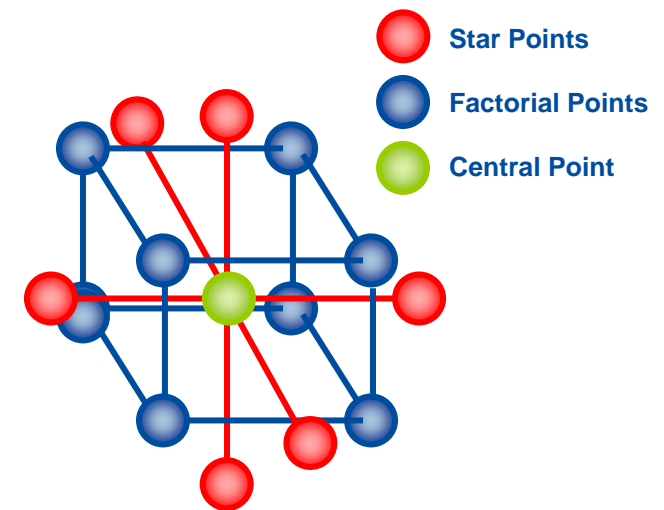
Simulation Team Details on the Ship Behaviors



Design of Experiments



	<i>Input Variable</i>	<i>Min</i>	<i>Average</i>	<i>Max</i>
A	Detections Probability by Local Intelligence	5%	10%	15%
B	Detections Probability by Coalition Intelligence	10%	18%	25%
C	Pirates Ships	3%	5%	7%
D	Cargo Flow [ships/day]	52	60	68
E	Military Vessels	6	11	16



The authors defined a Central Composite Design (CCD) experimental project composed by a 2^k factorial part (in which each factor has two levels corresponding to the maximum and minimum range) and central replications.

Considering:

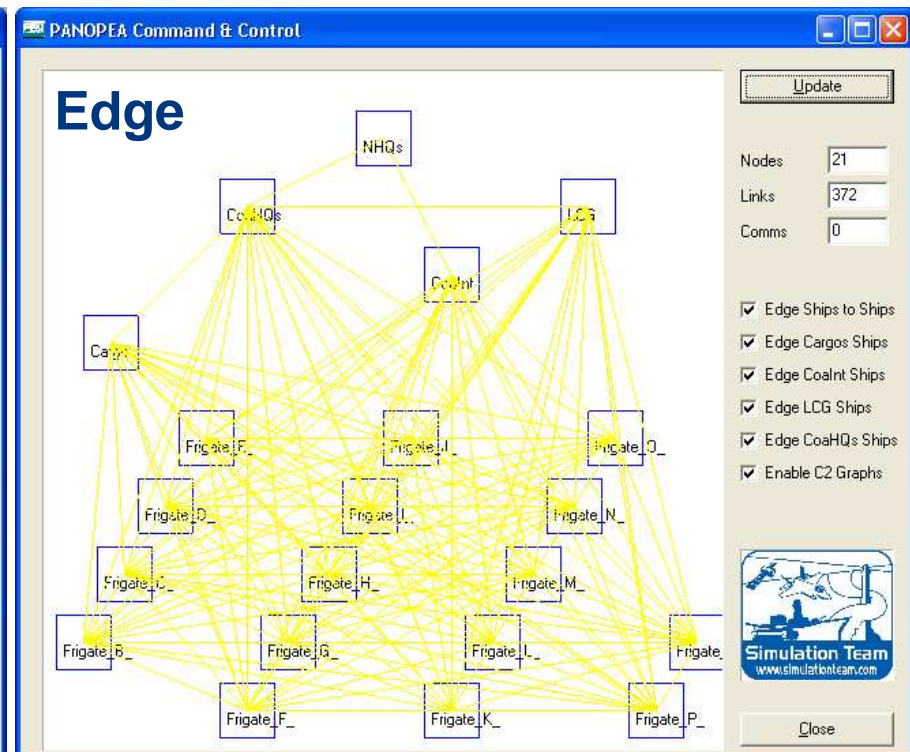
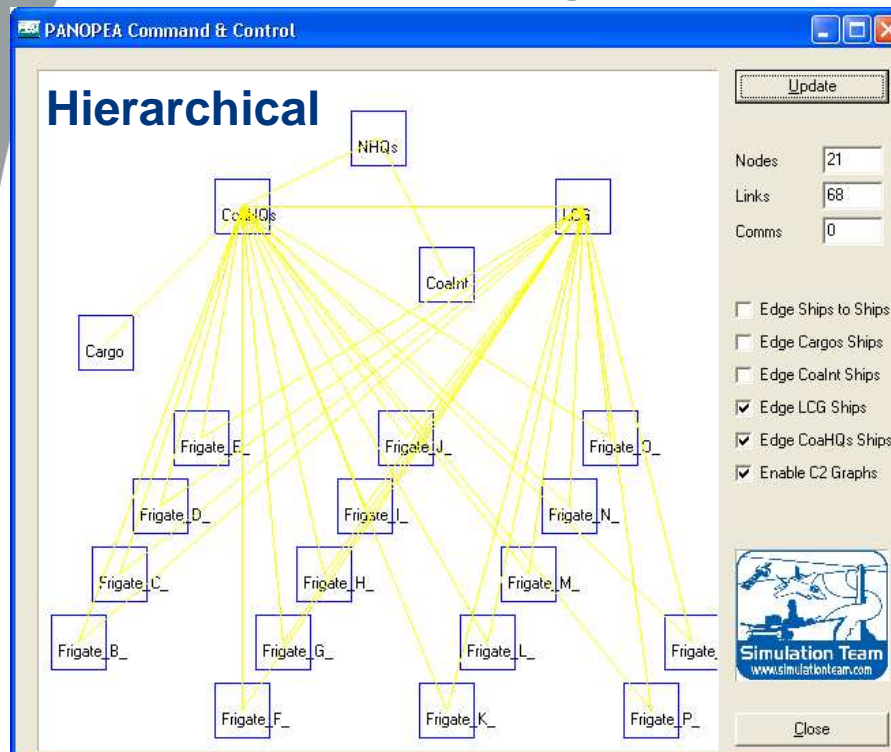
- n_0 central replications on the reference values by changing the seed of pseudo-random numbers
- 2^k factorial replications to evaluate the effect of variables and their combinations
- $2k$ star points for extending the knowledge in the experimental area

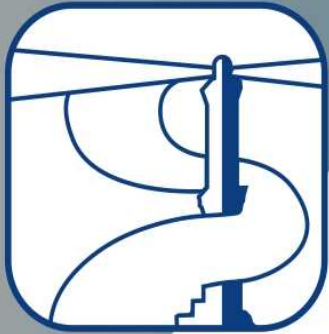


C2 Tested Scenarios

Two Factorial Designs: $2^k + n_0$

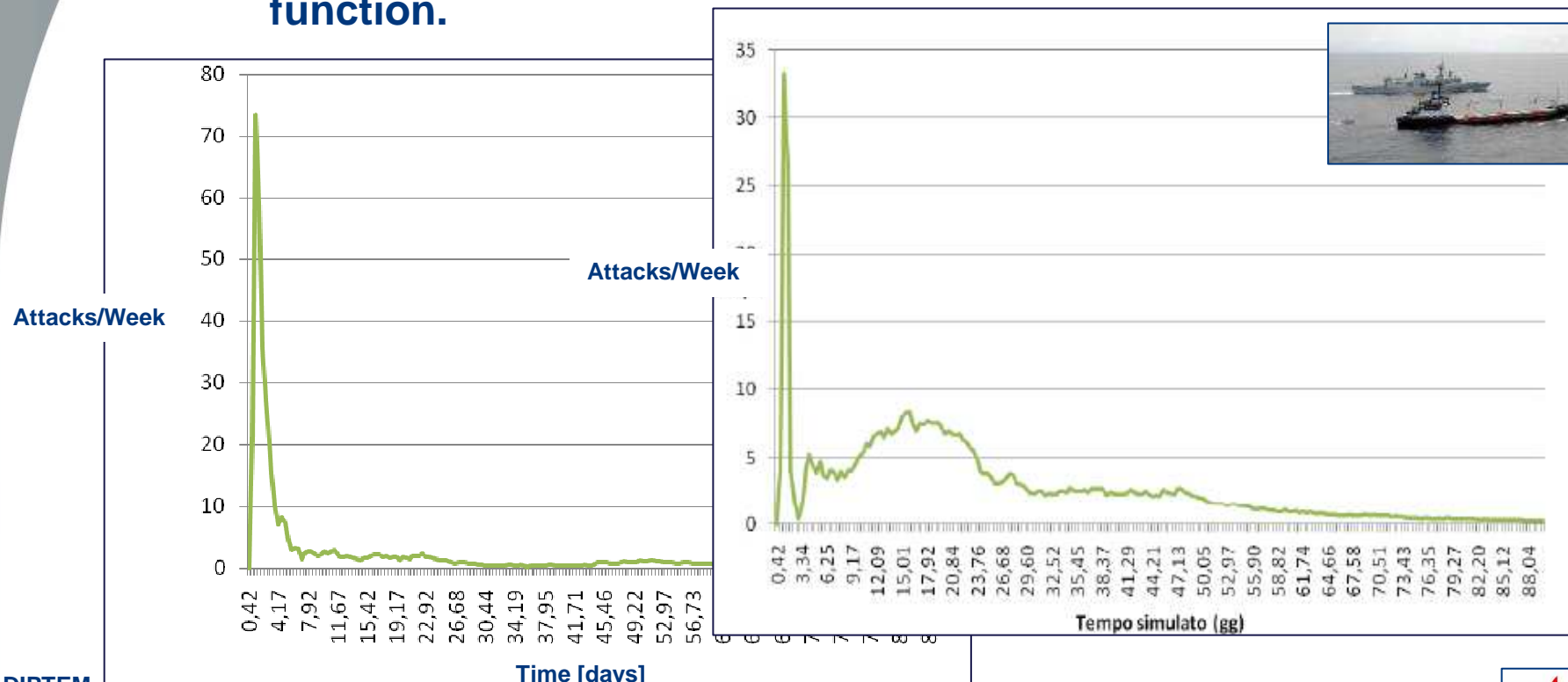
- C2 Centralized
- C2 Edge



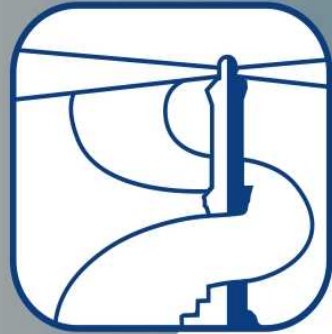


Experimental Error

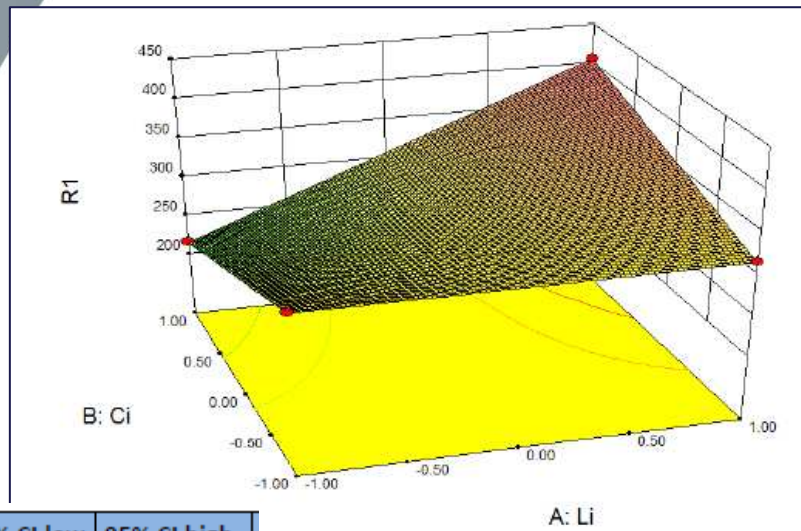
Mean Square pure Error technique is used to evaluate simulation length (number of days) to achieve system stability. Total Prevented Attacks is the parameter choose as target function.



Sensitivity Analysis & RSM



C2 Traditional Scenario



95% CI low	95% CI high
333,44	480,56

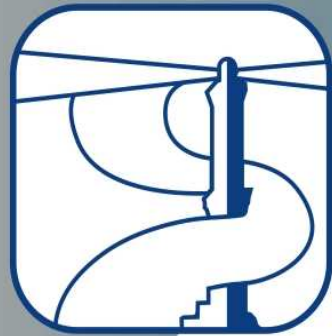
A
B
C
D
E

Input Variable	Min	Average	Max
Detections Probability by Local Intelligence	5%	10%	15%
Detections Probability by Coalition Intelligence	10%	18%	25%
Pirates Ships	3%	5%	7%
Cargo Flow [ships/day]	52	60	68
Military Vessels	6	11	16

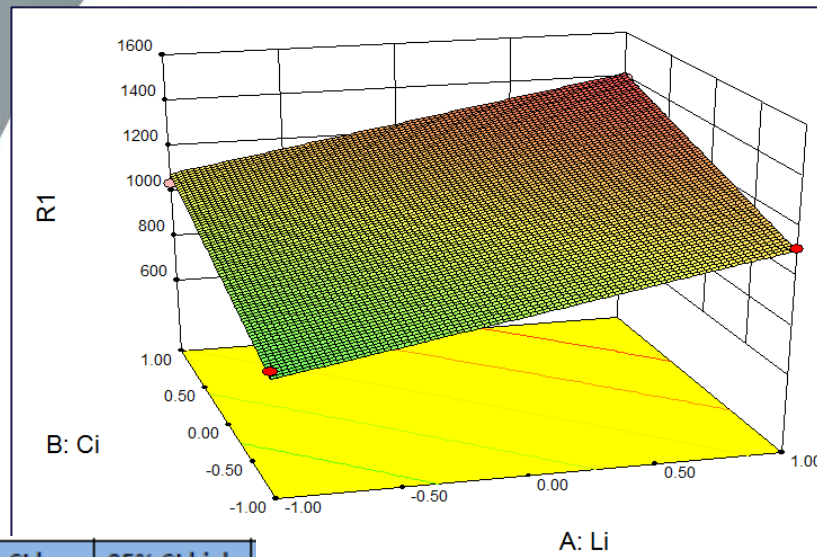
Source	Sum of Squares	df	Mean Square	F Value	p-value Prob > F	
Model	551.3778	31	17.78638	19.46467	0.0018	significant
A-Li	26.76681	1	26.76681	29.29247	0.0029	
B-Ci	0.268889	1	0.268889	0.294261	0.6108	
C-Pirates	63.28125	1	63.28125	69.25234	0.0004	
D-cargo f	0.21125	1	0.21125	0.231183	0.6509	
E-frigate	351.125	1	351.125	384.2564	< 0.0001	
AB	2.10125	1	2.10125	2.29952	0.1899	
AC	0.027222	1	0.027222	0.029791	0.8697	
AD	1.742222	1	1.742222	1.906615	0.2259	
AE	13.78125	1	13.78125	15.08162	0.0116	
BC	0.586806	1	0.586806	0.642175	0.4593	
BD	0.000139	1	0.000139	0.000152	0.9906	
BE	1.075556	1	1.075556	1.177043	0.3275	
CD	0.245	1	0.245	0.268118	0.6267	
CE	49.50125	1	49.50125	54.17209	0.0007	
DE	0.116806	1	0.116806	0.127827	0.7353	
ABC	0.067222	1	0.067222	0.073565	0.7971	
ABD	8.405	1	8.405	9.198079	0.0290	
ABE	0.586806	1	0.586806	0.642175	0.4593	
ACD	0.116806	1	0.116806	0.127827	0.7353	
ACE	2.067222	1	2.067222	2.262281	0.1929	
ADE	1.868889	1	1.868889	2.045233	0.2121	
BCD	0.035556	1	0.035556	0.038911	0.8514	
BCE	1.650139	1	1.650139	1.805843	0.2368	
BDE	0.390139	1	0.390139	0.426952	0.5423	
CDE	0.18	1	0.18	0.196984	0.6757	
ABCD	9.03125	1	9.03125	9.88342	0.0256	
ABCE	0.18	1	0.18	0.196984	0.6757	
ABDE	7.475556	1	7.475556	8.180934	0.0354	
ACDE	0.390139	1	0.390139	0.426952	0.5423	
BCDE	0.035556	1	0.035556	0.038911	0.8514	
ABCDE	8.066806	1	8.066806	8.827973	0.0311	
Residual	4.568889	5	0.913778			
Lack of Fit	0.263111	1	0.263111	0.244426	0.6469	not significant
Pure Error	4.305778	4	1.076444			
Cor Total	555.9467	36				



Sensitivity Analysis & RSM



C2 Edge Scenario

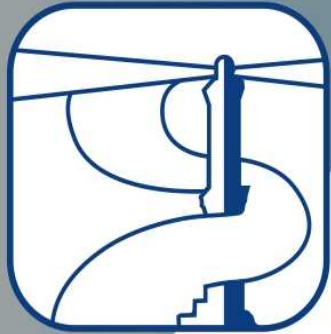


95% CI low	95% CI high
1239,89	1593,31

Input Variable	Min	Average	Max
A Detections Probability by Local Intelligence	5%	10%	15%
B Detections Probability by Coalition Intelligence	10%	18%	25%
C Pirates Ships	3%	5%	7%
D Cargo Flow [ships/day]	52	60	68
E Military Vessels	6	11	16

Source	Sum of Squares	df	Mean Square	F Value	p-value Prob > F	
Model	1594.051	31	51.42099	51.16562	0.0002	significant
A-Li	0.564453	1	0.564453	0.56165	0.4873	
B-Ci	22.08355	1	22.08355	21.97387	0.0054	
C-Pirates	118.3876	1	118.3876	117.7996	0.0001	
D-cargo f	0.316675	1	0.316675	0.315103	0.5988	
E-frigate	1246.461	1	1246.461	1240.27	< 0.0001	
AB	0.495842	1	0.495842	0.493379	0.5138	
AC	0.609592	1	0.609592	0.606565	0.4713	
AD	7.588759	1	7.588759	7.55107	0.0404	
AE	2.751467	1	2.751467	2.737802	0.1589	
BC	7.883759	1	7.883759	7.844604	0.0380	
BD	1.925703	1	1.925703	1.916139	0.2249	
BE	15.65668	1	15.65668	15.57892	0.0109	
CD	0.66605	1	0.66605	0.662742	0.4526	
CE	110.8188	1	110.8188	110.2685	0.0001	
DE	0.099384	1	0.099384	0.09889	0.7659	
ABC	0.002509	1	0.002509	0.002496	0.9621	
ABD	3.093828	1	3.093828	3.078463	0.1397	
ABE	0.675703	1	0.675703	0.672347	0.4495	
ACD	6.615703	1	6.615703	6.582847	0.0503	
ACE	2.77105	1	2.77105	2.757288	0.1577	
ADE	11.66043	1	11.66043	11.60251	0.0191	
BCD	5.267717	1	5.267717	5.241555	0.0707	
BCE	8.62855	1	8.62855	8.585697	0.0326	
BDE	2.058759	1	2.058759	2.048534	0.2118	
CDE	0.408759	1	0.408759	0.406729	0.5517	
ABCD	1.0573	1	1.0573	1.052049	0.3521	
ABCE	0.009453	1	0.009453	0.009406	0.9265	
ABDE	2.144175	1	2.144175	2.133526	0.2039	
ACDE	6.737509	1	6.737509	6.704047	0.0489	
BCDE	5.376467	1	5.376467	5.349765	0.0687	
ABCDE	1.233759	1	1.233759	1.227631	0.3183	
Residual	5.024956	5	1.004991			
Lack of Fit	3.030845	1	3.030845	6.079591	0.0693	not significant
Pure Error	1.994111	4	0.498528			
Cor Total	1599.076	36				

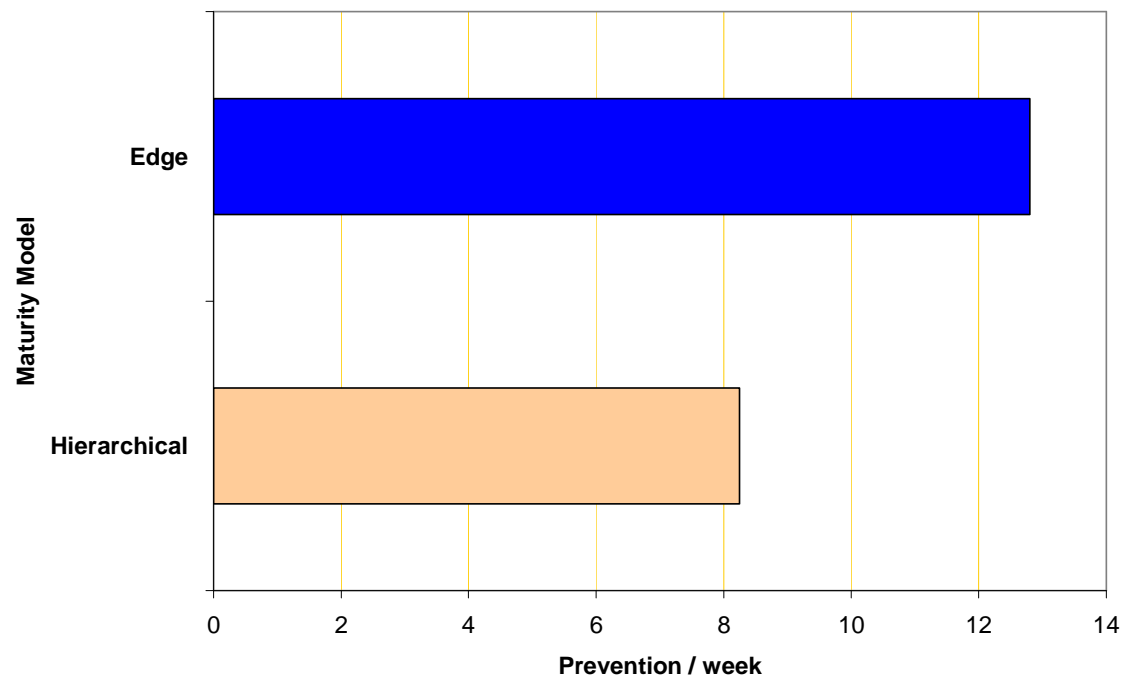




Centralized C2 vs. Edge C2

Edge solution results more effective, even if it requires good capabilities in information distribution and elaboration as well as operations management

C2 Comparison





Summarizing

Panopea allows to simulate complex scenario and to estimate the the efficiency and effectiveness of C2 solutions

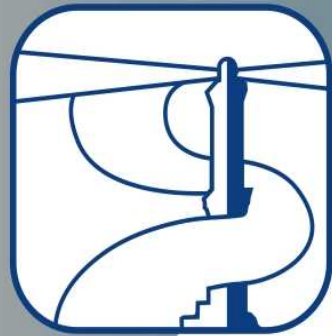
The main goal of this research is to test different Net C2 M2 models in order to evaluate them by the simulator.

By using the simulator and experimental analysis it was possible to consider the influence of independent variables and their interactions respect target functions.

It is proposed an experimental results related to a case study similar to situation of piracy within Aden Gulf able to demonstrate the potential of using M&S in supporting analysis of different C2 maturity models.

PANOPEA simulator resulted an useful tool for the evaluation of piracy scenarios, and to investigate alternative C2 strategies and the analysis of different scenarios.





What is the Simulation Team?

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



DIPTM
Università
di Genova



Genoa



CentraLabs
Cagliari



Centre for Research
In Complex Systems

CSU
Australia



CIREM
Università di Cagliari



MSC-LES



etea SICUREZZA



Blizzard Srl
Software
Evolution



Ant@ptima
we speed up your business



DLM Solutions
Simulating Real Processes for Better Decisions



Mik
Riga TU



DIPMEC
Università Calabria



MISS Universitat
Autònoma de Barcelona



MISS
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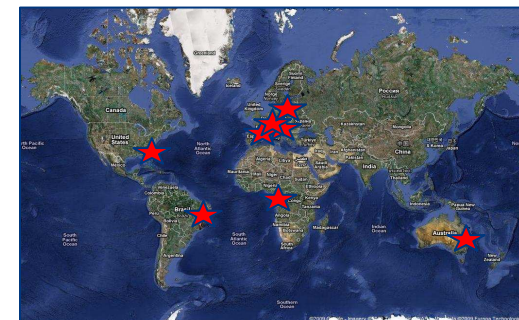
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References



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