



# **Increasing Maritime Situational Awareness with Interoperating Distributed Information Sources**

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# + Outline



- Maritime Situational Awareness & RECONSURVE Project
- Data Sources
  - Sensor Systems
  - Automatic Identification System
  - UAV and Vessel Classification System
  - Port Management System
  - Web Sites
- Threat Analysis
- Alarm Generation & Dissemination
- Conclusion & Future Work

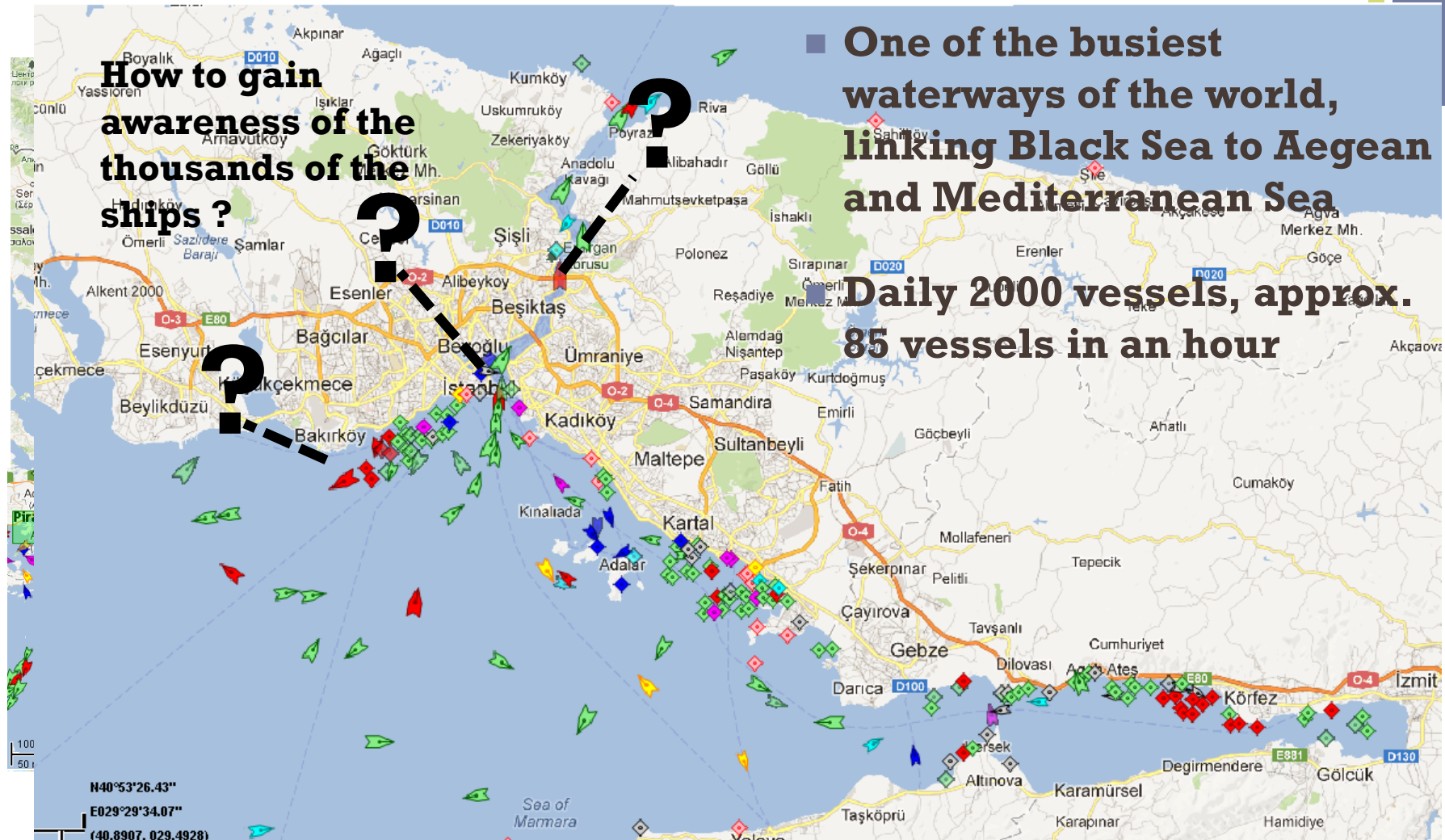


# Maritime Situational Awareness

**How to gain awareness of the thousands of the ships ?**

■ **One of the busiest waterways of the world, linking Black Sea to Aegean and Mediterranean Sea**

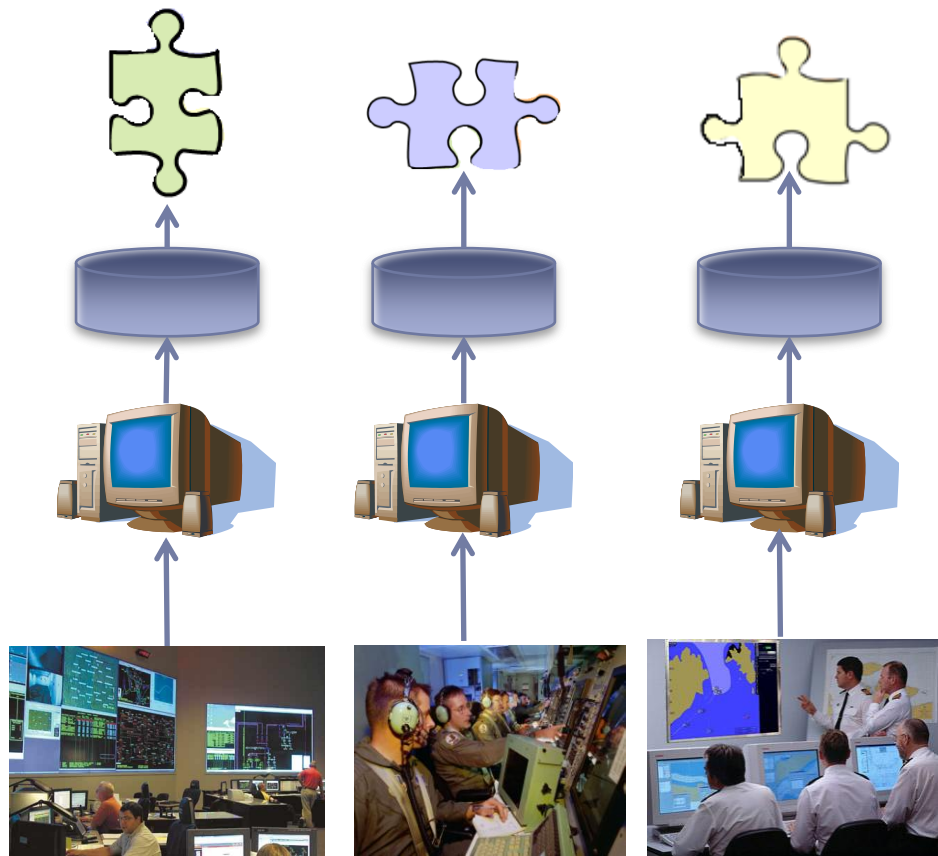
■ **Daily 2000 vessels, approx. 85 vessels in an hour**





- Aim is to provide cost effective  
wide-area sea border  
surveillance systems with  
intelligent decision support

# + Current Situation

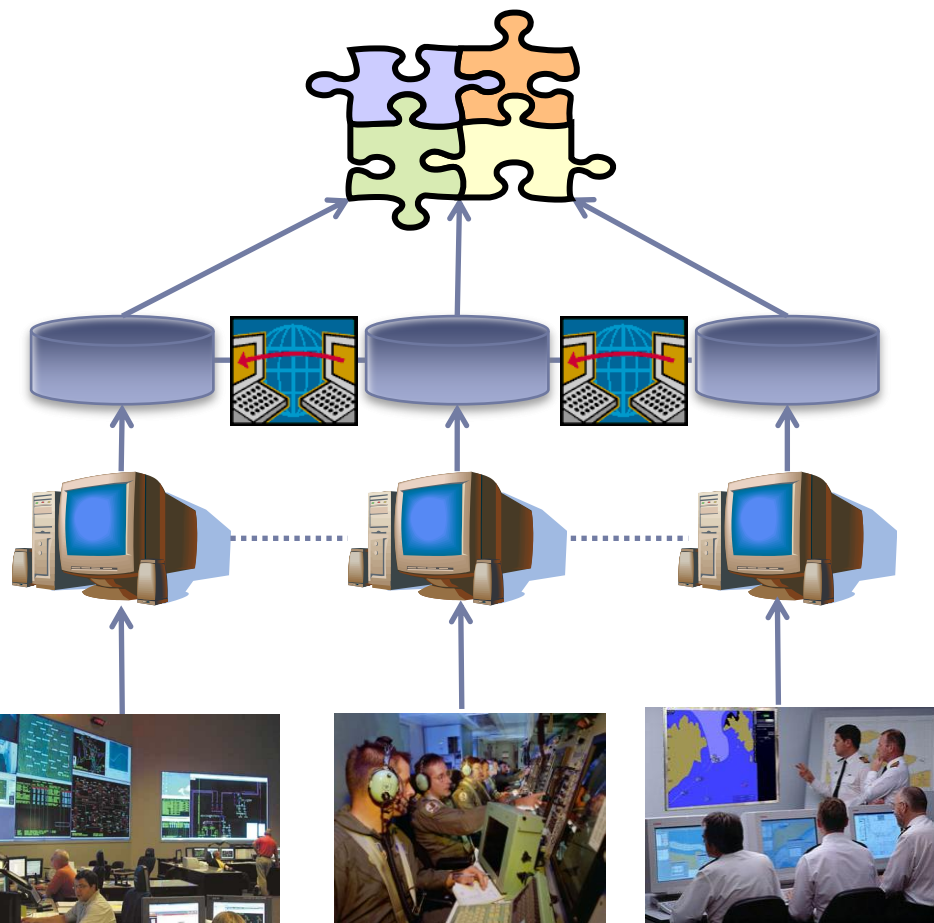


**Stovepipes System & Incomplete Pieces**

- A number of different maritime surveillance systems and authorities having different duties and responsibilities depending on their institutional role.
- Collection and analysis of data for their own purposes by means of dedicated monitoring and surveillance systems
- No information sharing technologies
- Results in:
  - obtaining incomplete operational picture,
  - collecting redundant data by different bodies,
  - spending too much time or effort to identify suspicious vessels,
  - overlooking suspicious events.



# + Our Aim



- **Awareness relies on the availability of information.**
  - Leverage available systems and data sources
- Increases the success rate of ship identification, leaving fewer unknown ships in the picture, thus reducing the amount of potential risks that need closer attention
- Creates a more complete common operational picture and better manageable maritime traffic

# + Data Sources

The Undersecretariat of Customs



Port Management System



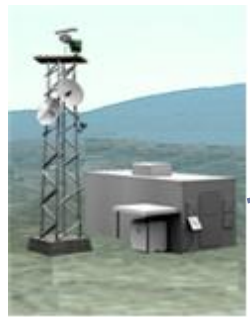
The Undersecretariat of Maritime Affairs



AIS



Online Web Sites



EO/IR Cameras



UAV



RADAR



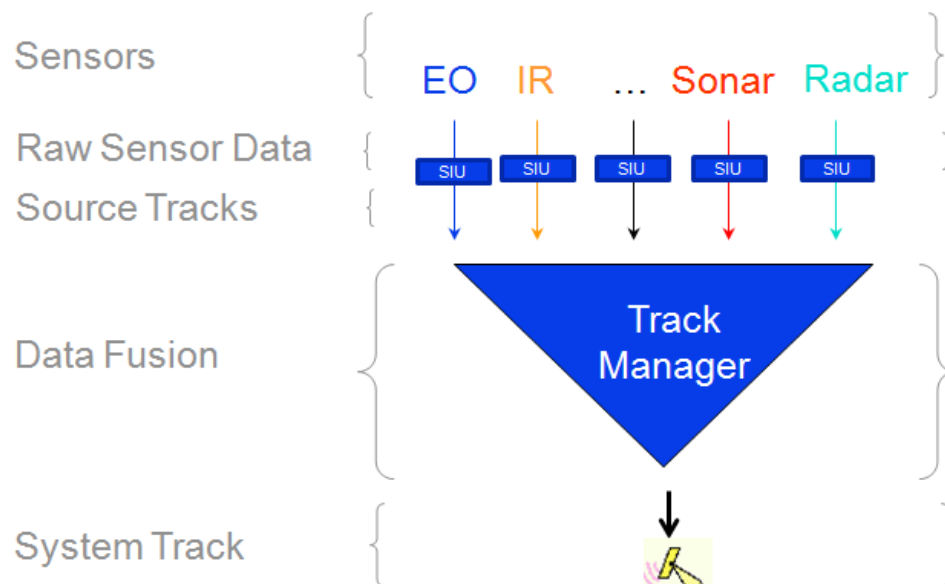
Sonars



TCGC

# + Sensor Systems

- Collection of data from EO/IR sensors, sonars and coastal surveillance radars deployed along the sea border
- Observation of data from multiple sensors provides complementary capabilities
- Track Managers correlates and associates data and creates a real-time, unified data
- Which tracks need to be fused is made by considering distance between tracks, and comparing course, speed, platform type, and, identification properties of the tracks







# Automatic Identification System



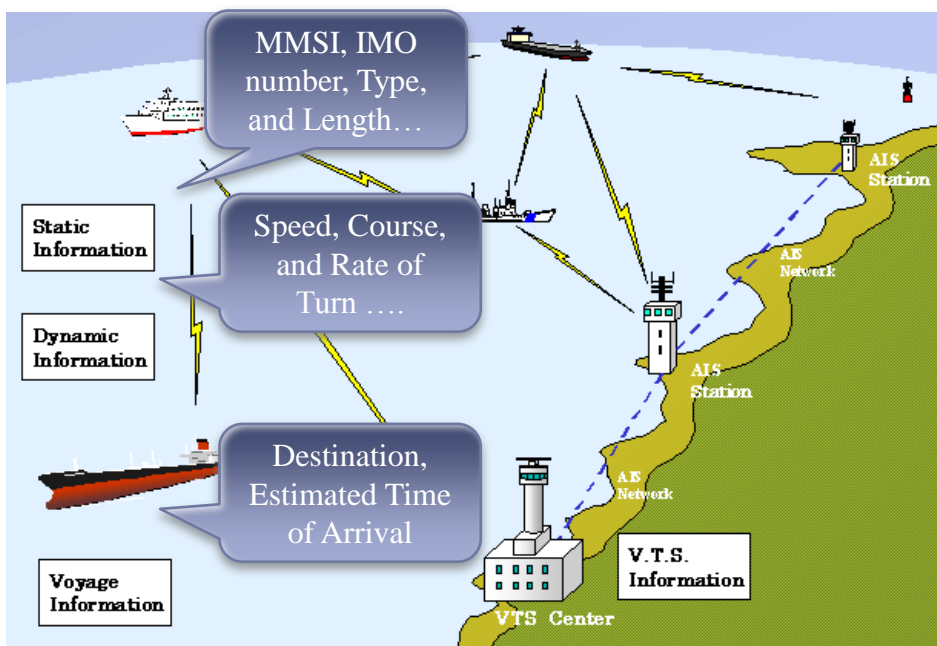
- **A ship-board self-reporting broadcast system used to identify and track ships**

- Mandatory for ships over 300 gross-tones, passenger ships, tankers and cargo ships over 500 gross-tones

- Carries valuable information but open to be spoofed.

- Utilized for two type of analysis:

- Data-Driven Anomaly Detection
  - Deviation or Conformance to patterns
  - Comparison of Detected and Reported Values
- Knowledge based expert systems



# + AIS Analyzer



- Patterns of accident and smuggling through ship's accidents and smuggling data
- Input data for analysis.
  - Position, Bearing, Specific Zone, Track, Speed, Course, Vessel Type, Ship Owner, Ship Size
- 5 analysis processors .
  - **Smuggling** - finding suspicious ship for smuggling
    - Black list for ship which has background in smuggling.
    - ships entering the region where smuggling happens frequently.
    - ships which breakaway and after returns to the designated route
  - **Area**– areas of environmental protection/danger/military/HRA
    - analysis for the ship entering and getting out of the particular area.
  - **Route** –specific route like passenger ship, oil tanker
    - behaviours break a basic rule of navigation
  - **Sailing Patten** – with abnormal operation like overtaking, zigzag, abrupt change etc.
  - **Collision prediction** – between 2 ships in specific danger distance

# + Unmanned Aerial Vehicle

- Much wider and possibly more accurate operational picture as opposed to shore-based, stationary systems
- Detection of all non-cooperative vessels such as small ships
- Down-linked images are used for vessel classification algorithms



Video,  
Telemetry data

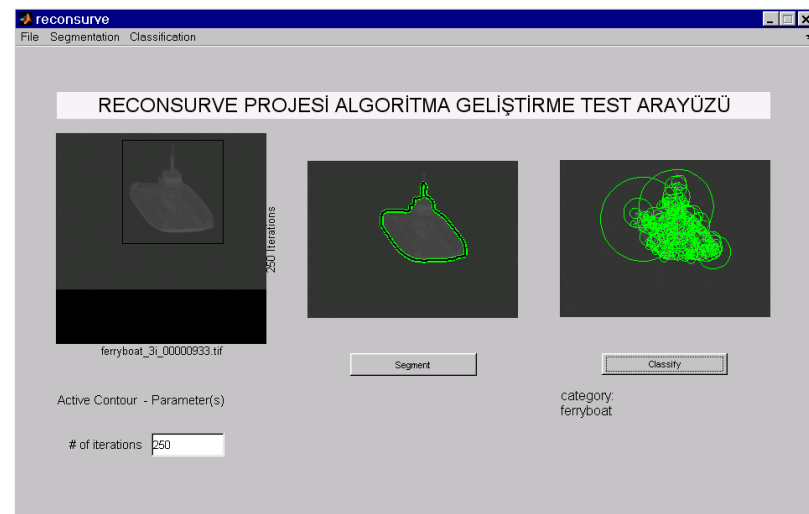
Image  
Preprocessin  
g

Target  
Detection

Segmentation

Silhouette-based  
Feature  
Extraction

Recognition





# Port Management Information System

- Online port departure and port arrival data of ships for all ports of Turkey
- Landing Report,
- Vessel Voyage History Report
- Port Departure Report.
- It presents the details of ships such as its current and previous cargo, destination, captain, crew, passengers and master data (e.g. IMO number, flag, agency, owner, width, length, etc)

The screenshot displays the 'Gemi Ara -- Web Sayfası İletişim Kutusu' (Ship Search -- Web Page Communication Box) interface. It features a search form for ship details and a table of search results.

**GEMİ BİLGİLERİ - TÜRK**

Gemi Adı :  →  
 IMO No : 8814213 →  
 Bağlama Kütüğü No :  →  
 Teknik Kütük Limanı : Seçiniz...  
 Teknik Kütük No :  →

Adı	Cins Kodu	IMO No	Sicil No	Teknik Kütük No
CEMAL -Ç	PETROL TANKERİ/ AKARYAKIT TANKERİ	8814213	TUGS 1349	25

**GEMİ BİLGİLERİ**

IMO No :   
 MMSI No :   
 Gemi Adı : MERTON 1

**Kalkış Bilgileri**

Gemi Kalkış Zamanı : 15:30  
 Kılavuz Kaptanın Gemiye Çıkış Tarihi / Saati : 08/02/2012 / 15:15  
 Kılavuz Kaptanın Gemiden İnış Tarihi / Saati : 08/02/2012 / 15:30  
 Kılavuz Kaptanın Adı Soyadı : K SUCU  
 LCB No : 2012-68-484  
 Baş - Kış iter var mı? : Yok  
 Baş - Kış Draftı : 4,50 - 5,00  
 Açıklama :

**Yanaşma Bilgileri**

Gemi Yanaşma Zamanı : 23:35  
 Kılavuz Kaptanın Gemiye Çıkış Tarihi / Saati : 07/02/2012 / 23:00  
 Kılavuz Kaptanın Gemiden İnış Tarihi / Saati : 07/02/2012 / 23:35  
 Kılavuz Kaptanın Adı Soyadı : K SUCU  
 Ordino No : 2012-68-789  
 Baş - Kış iter var mı? : Yok  
 Baş - Kış Draftı : 3,50 - 4,50  
 Açıklama :

**Çağrı İş.**

GEMİSİ ERMA5 Detay Seç

+ Web sites

**AIS Hub**  
data sharing center

Home AIS Statistics AIS Coverage Vessels Forum Live Ships Map Join us Link to us

**ATHARA**

MMSI: 247086200  
CALL SIGN: IBDI  
IMO: 9263655  
FLAG: Italy  
SIZE: 216 x 26  
DRAUGHT: 6.7  
TYPE: Passenger ship  
LAST UPDATE: 16-08-2012 09:16  
DESTINATION: OLBIA  
ETA: 557406  
LATITUDE: 40 9220 \*  
LONGITUDE: 9 52483 \*  
COG: 98.3  
SOG: 0 km.  
HEADING: 93  
SOURCES: AISHub TEST

AISHub  
Latest AIS Data

**Equasis.com:**  
Master information, management detail previous inspections its classification surveys, its previous names, flags and owners

www.equasis.org/EquasisWeb/restricted/ShipList7fs=ShipSearch

Ship info Association Inspection & manning History Data queried

Access protected by password

Add this ship to my favorites list

Following information is available:

- Key indicators
- Measurement detail
- Classification
- Safety management certificate
- PSI information

Name of key indicator	Value
(next) one of the IACS member societies	Yes
the black list of the Paris MoU	Yes
the white list of the Paris MoU	Yes
the black list of the Tokyo MoU	Yes
the white list of the Tokyo MoU	Yes
the targeted list of the USCG	No

Name of company	Address	Date of effect	Details
COMPAGNIA ITALIANA DI NAVIGAZIONE	Via del Rione Sngnano 2, 80121 Naples NA, Italy.	since 18-07-2012	
COMPAGNIA ITALIANA DI NAVIGAZIONE	Via del Rione Sngnano 2, 80121 Naples NA, Italy.	since 18-07-2012	
COMPAGNIA ITALIANA DI NAVIGAZIONE	Via del Rione Sngnano 2, 80121 Naples NA, Italy.	since 18-07-2012	

Inspection society	Date survey	Date next survey	Details
	17-06-2008	18-06-2013	
	18-06-2003	18-06-2013	

**VesselFinder.com**  
List of last visited ports

www.vesselfinder.com/vessel/ATHARA-IMO-9263655-MMSI-247086200

**Vessel details**

Flag: Italy  
Ais Type: Passenger ship  
GT: 35736 t  
Built: 2003  
DWT: 4700 t  
MMSI: 247086200  
Size: 216 x 26 m  
Callign: DRAUGHT  
BCD: 7.3 m  
Destination: OLBIA  
Last report: Aug 16, 2012 05:56 UTC  
ETA: Aug 16, 08:30  
Latitude: 40.92205 N  
Longitude: 9.52483 E  
Course: 125.7 °  
Speed: 0 kn.  
Last 5 port calls as detected by AIS  
Date / Time: Aug 15, 2012 19:04 UTC  
Port: GENOVA  
Country: Italy  
Aug 14, 2012 12:05 UTC  
Port: ARBATAX  
Country: Italy  
Aug 14, 2012 06:04 UTC  
Port: OLBIA  
Country: Italy  
Aug 13, 2012 19:04 UTC  
Port: GENOVA  
Country: Italy  
Aug 12, 2012 19:04 UTC  
Port: OLBIA  
Country: Italy

**Ship management**

Manager  
Owner  
Operator  
SM Manager  
PI Insurance  
Year scrapped  
Builder  
Hull  
Service status  
Service constraints  
Class

**Tonnage & dimensions**

Net Tonnage  
Length Overall  
Displacement  
Beam  
Height  
Depth

**Vessel's Communication contacts**

Sat Telnet  
Sat phone  
Sat Fax number

**Ship Capacity**

Holds/Tanks  
Hatches  
Bale  
Gear  
Cran  
Grain  
TTL

**Engines**

Number of Main Engine(s)  
Main Engine builder  
Main power  
Main fuel  
Main Model  
Main RPM  
Main Configuration

VesselFinder.com  
List of last visited ports

**MarineTraffic.com**  
Recent Port Calls

www.marinetraffic.com/ais/shipdetails.aspx?i=ATHARA

Live Map Vessels Ports Gallery  
World Map Cover your Search

**ATHARA**

Contribute to this page Add to My Fleet

**Vessel's Details**

Ship Type: Ro-ro/passenger ship  
Year Built: 2003  
Length x Breadth: 216 m x 26 m  
Gross Tonnage: 35736, DeadWeight: 4700 t  
Speed recorded (Max / Average): 25.7 / 22.3 knots  
Flag: Italy (IT)  
Call Sign: IBDI  
IMO: 9263655, MMSI: 247086200

**Last Position Received**

Area: Mediterranean  
Latitude / Longitude: 40.92205° / 9.524817° (Map)  
Currently in Port:  
Last Known Port: GENOVA  
Info Received: 0d 0h 1min ago  
Current Vessel's Track  
Itineraries History

**Voyage Related Info (Last Received)**

Draught: 6.7 m  
Destination: OLBIA  
ETA: 2012-08-16 05:30  
Info Received: 2012-08-16 05:12 (0d, 1h 4min ago)

**Recent Port Calls:**

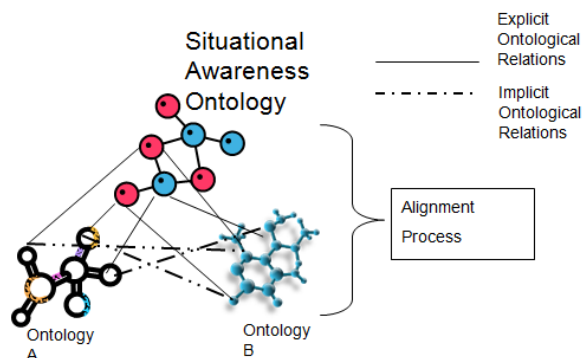
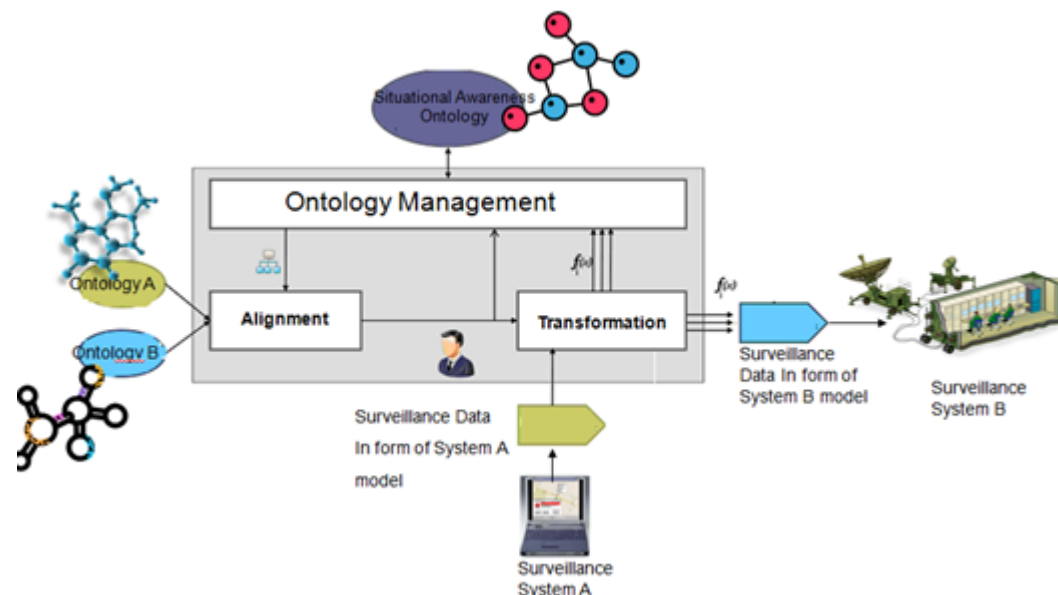
Port	Arrival (LT)	Departure (LT)
GENOVA	2012-08-15 07:31	
GENOVA		2012-08-13 22:01
GENOVA	2012-08-13 07:08	
OLBIA		2012-08-12 21:51
OLBIA	2012-08-12 18:09	

MarineTraffic  
Recent Port Calls



# + Other Surveillance Systems

- Inline with Semantic Interoperability Logical Framework recommended by NATO RTO IST-94 “Framework for Semantic Interoperability”.



- Situational Awareness Ontology is defined by the harmonization of the following standards:

- Joint Command, Control and Consultation Information Exchange Data Model (JC3IEDM)
- OASIS Common Alerting Protocol (CAP)
- Open Geospatial Consortium's Sensor Web Enablement (OGC-SWE)



# Threat Analysis



- More data cause more miss in important maritime domain threats
  - Interoperating different information sources does little more than “spam” the maritime “common operational picture”
- Need of intelligent decision support systems for highly skilled operators who constantly monitor and analyze the activity in an area of interest
  - Along with the expected activities and potential identified threats by utilizing processed set of information
- Early warning of possibly suspicious events by hybridized approach for threat recognition
  - Knowledge-based detection
  - Data-driven anomaly detection

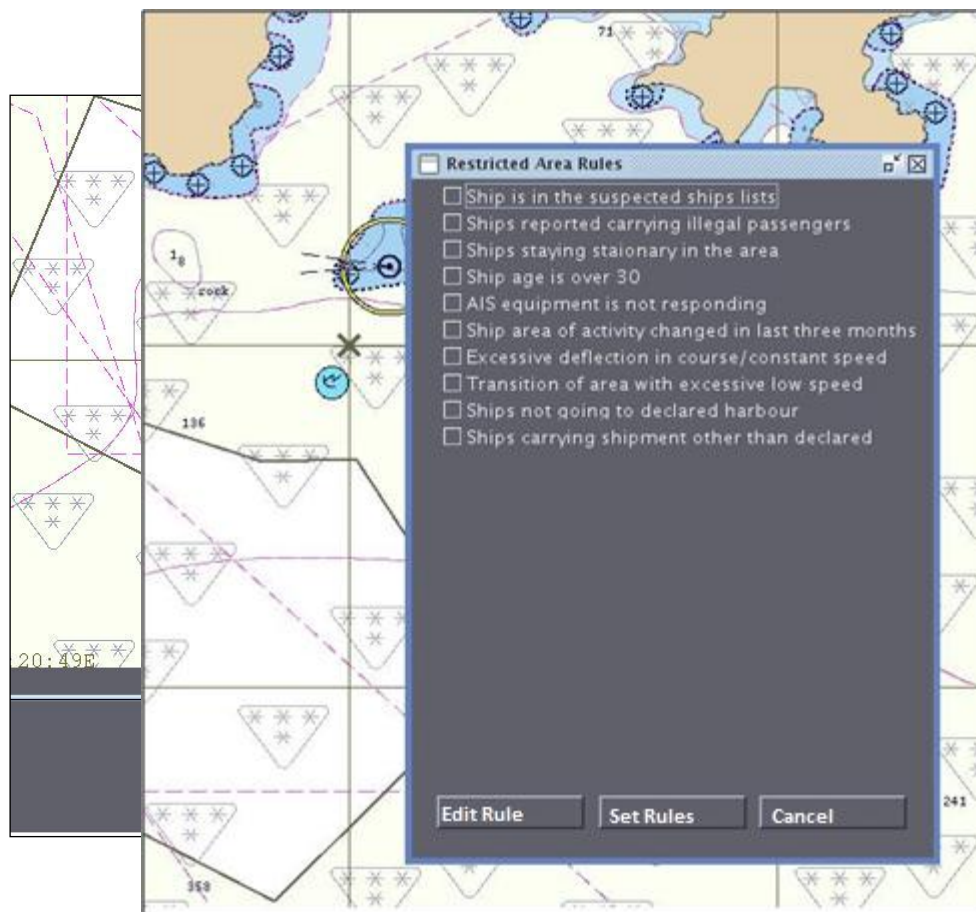


# Knowledge-based Detection



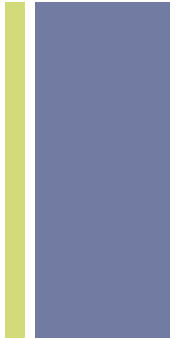
- A rule-based approach that encodes criteria to check suspiciousness of a vessel using Logic Programming rules.
- Collaboration with TCGC experts to understand how they normally analyze the data and decide on which vessel can cause a threat or perform an illegal activity
  - 55 situational awareness rules are encoded
  - System searches for anomalies
    - “small boats on open sea”
    - “a cargo vessel heading to a harbor other than the destination in the AIS message”
  - Some rules are spatial-temporal:
    - a ship entering a specified area
    - Boarding or sudden acceleration
    - a ship entering a specified area before a certain time

# + Rule Selection & Editing



- Focusing on relevant regions, events and candidate relations
- Thresholds may vary
- New conditions needs to be defined

# + Alarm



- Each rule is dynamically assigned a weighting (a kind of priority) to identify associated risk level and its confidence
  - a slight difference indicates lower risk values
- Three levels of alarm: Severe, Moderate and Minor
  - Coded with colors on UI
- Together with overridden rules and the level of uncertainty at the same time
- Data format: Common Alert Protocol (CAP) of OASIS  
Emergency Data Exchange Language (EDXL)





# Conclusion & Future Work



- The intention is to improve sea-border control, plugging the gaps in the maritime security with interoperability solutions and have wide-area situational awareness, thus particular reducing the number of illegal immigrants crossing sea borders in small boats, with a cost-effective approach
- These are interim results
  - Needs to be evaluated, tested and demonstrated
- Feedback functionality will be added to alarm to calculate false-positives and false-negatives
  - machine learning algorithms will be developed to adjust weight of rules according to feedbacks
- Hope to share future results with you.

# + Question & Answers

**Thank You**

ありがとう

*Obrigado!*

*Gracias*

*Vielen Dank*

*Teşekkürler*

謝謝

*Bedankt*

*Hvala*

شكراً

תודה

*Köszönettel*

*Merci*

*Díky*

*Ευχαριστώ*

ขอบคุณ