Increasing Maritime Situational Awareness with Interoperating Distributed Information Sources

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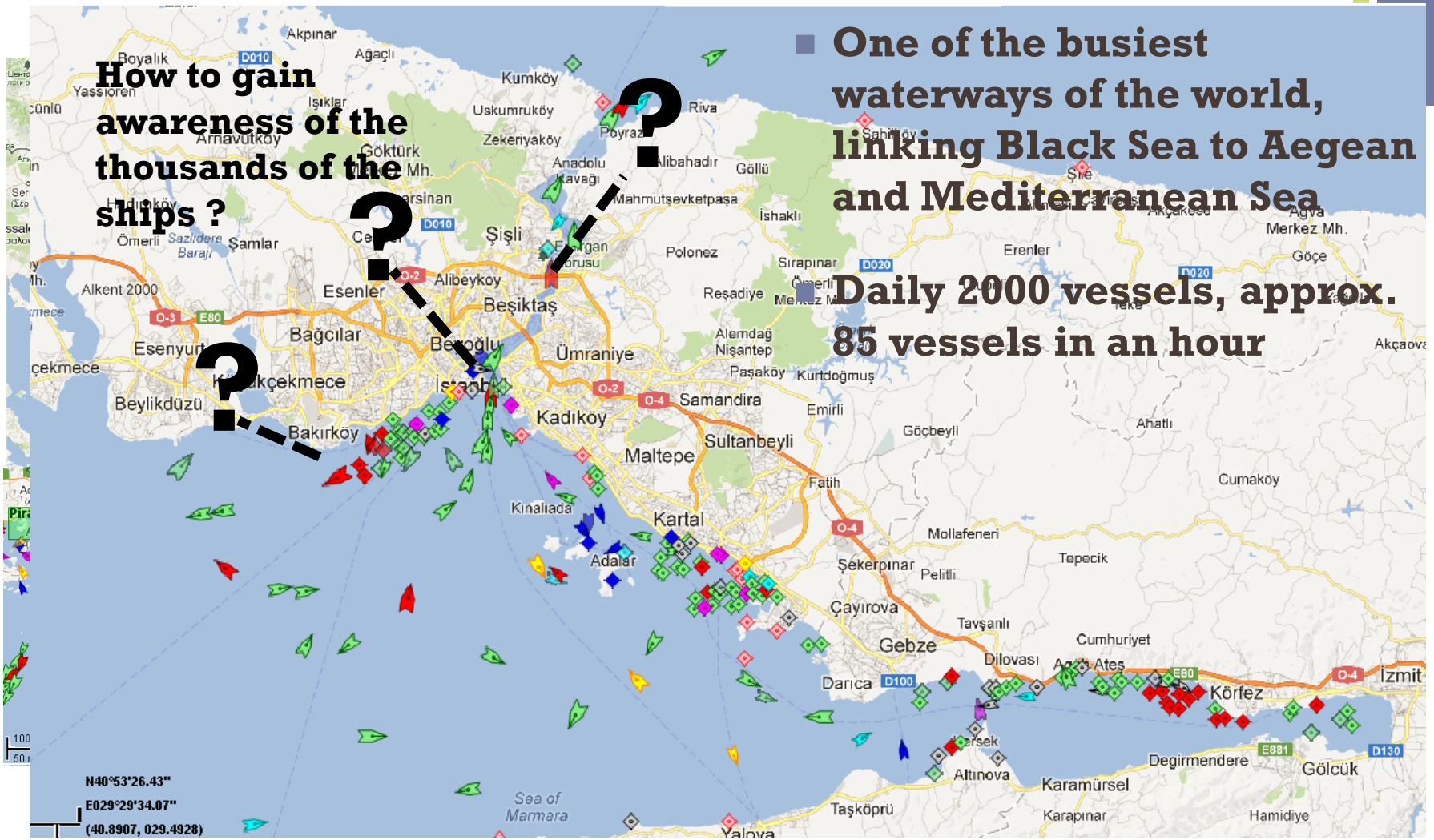
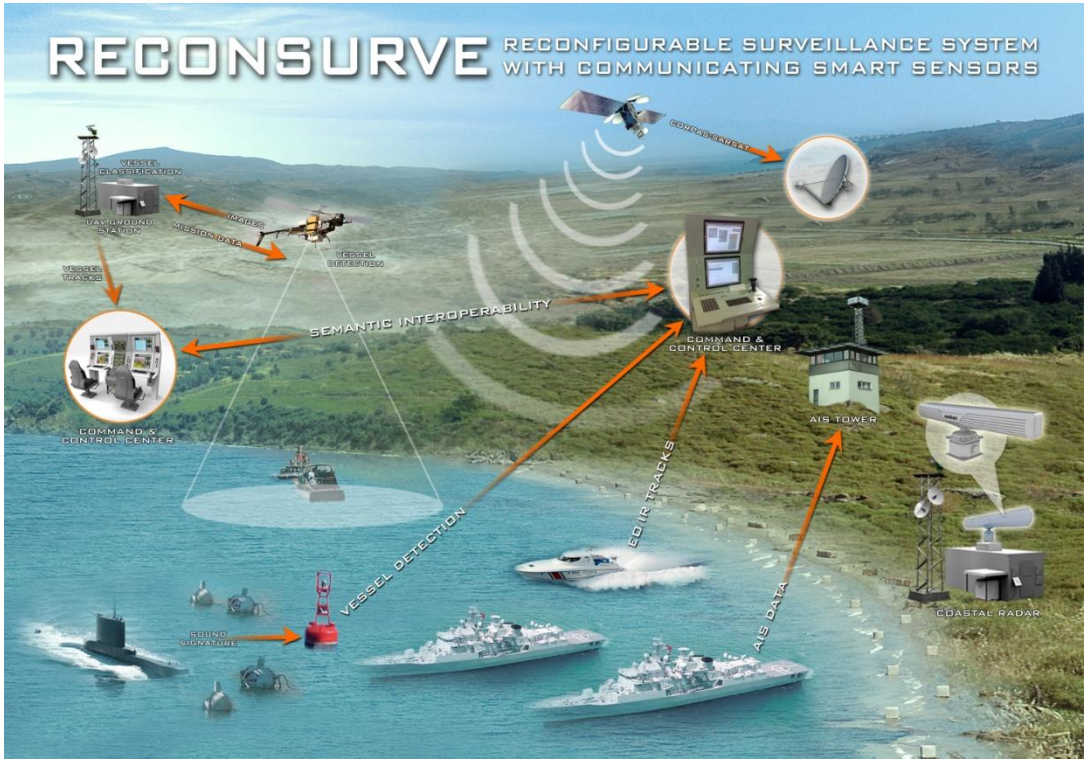
Outline

- 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



RECONSURVE Project



Reconfigurable Surveillance System with Communicating Smart Sensors

- Eureka, ITEA2 Cluster Projects
- Start Date: January, 2011
- Duration: 48 month-long

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

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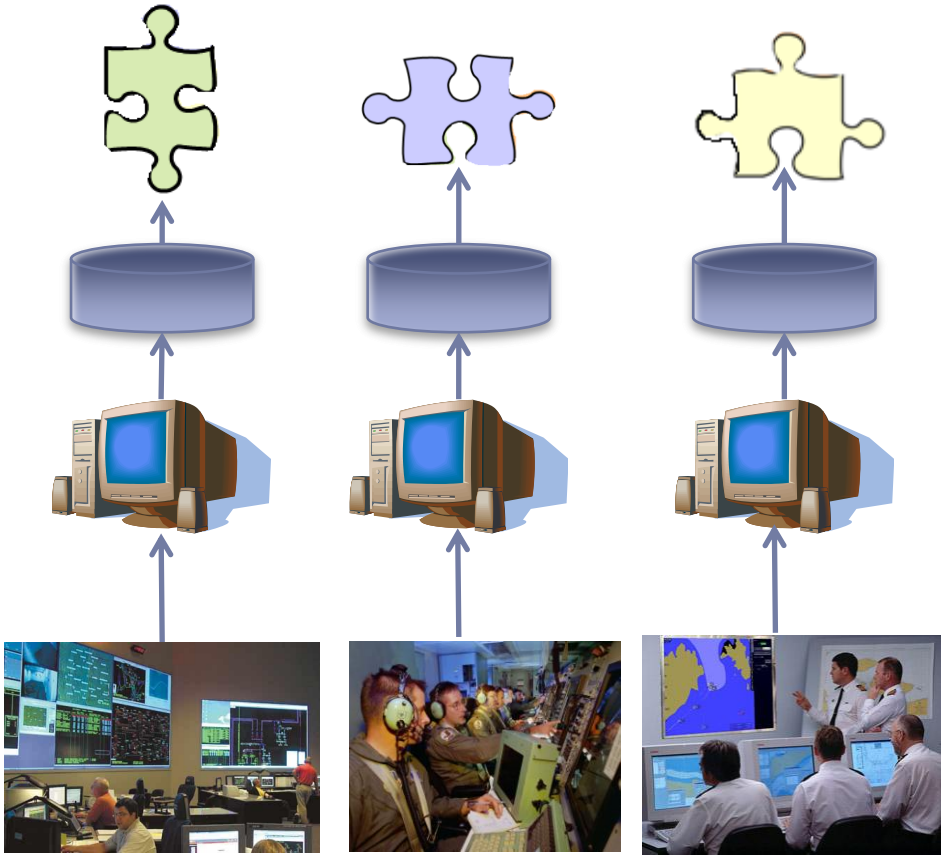
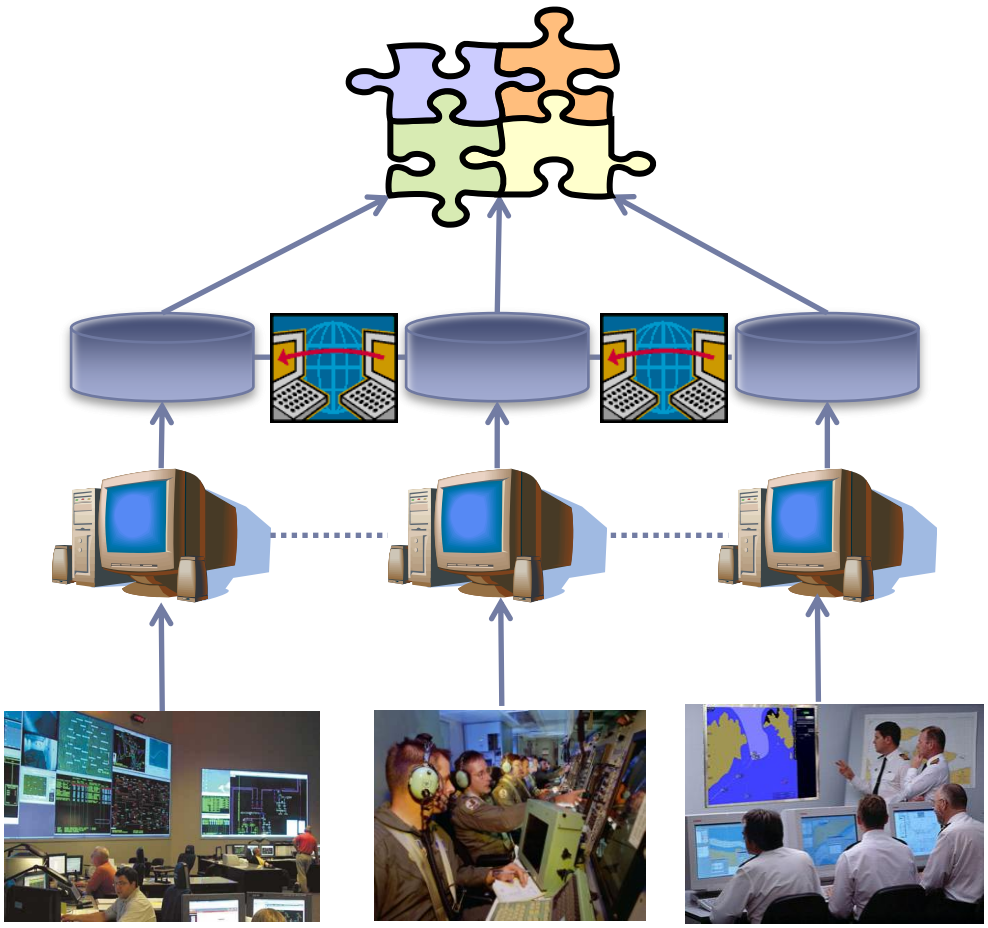
Current Situation



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

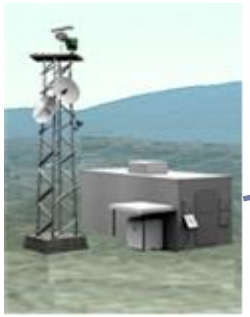
The Undersecretariat of Customs

The Undersecretariat of Maritime Affairs

AIS

Online Web Sites

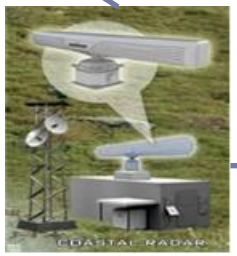
Port Management System



EO/IR Cameras

Sonars

UAV



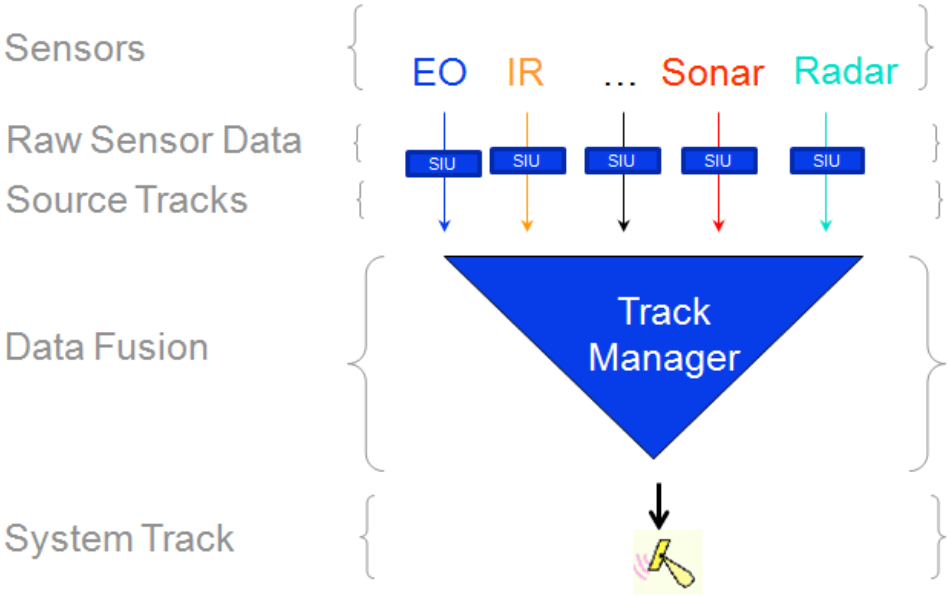
RADAR

TCGC

aselsan

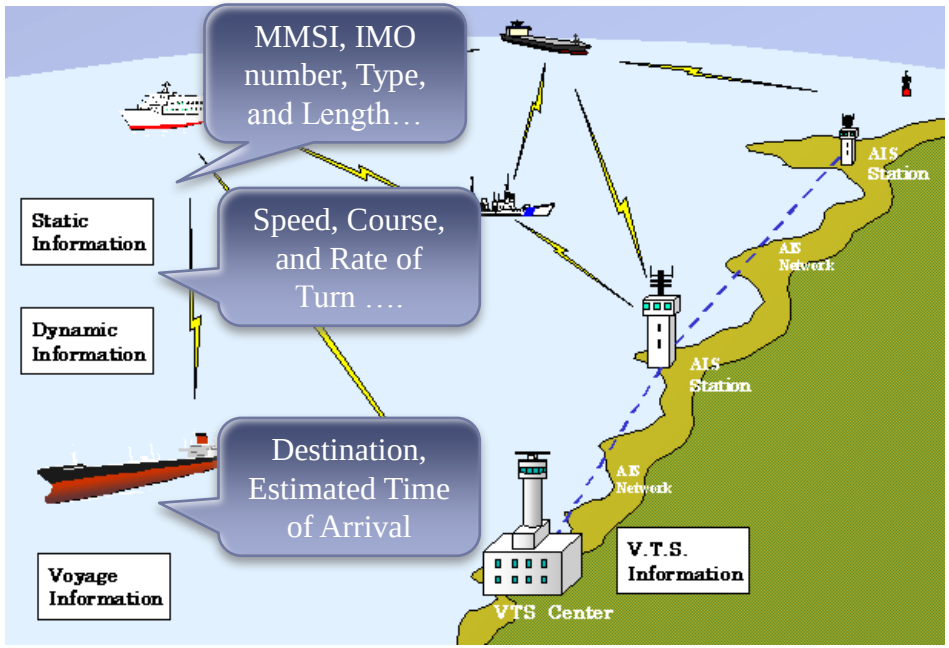
Sensor Systems

- 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

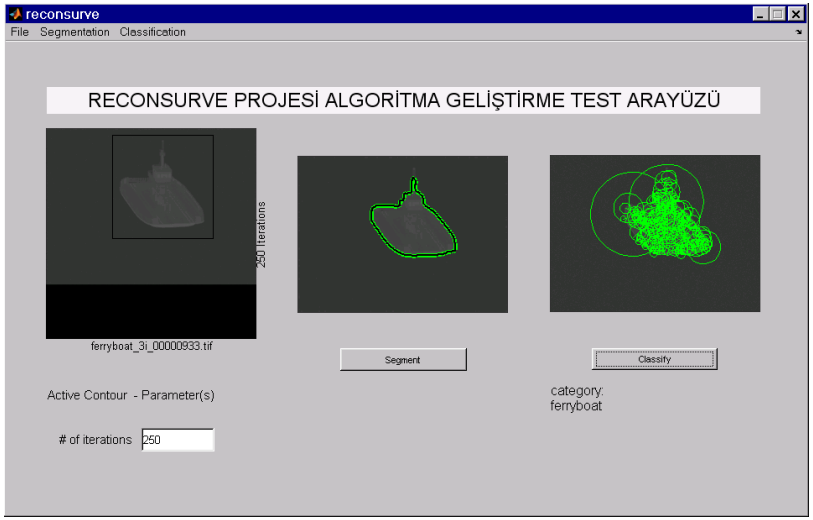


AIS Analyzer

- 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

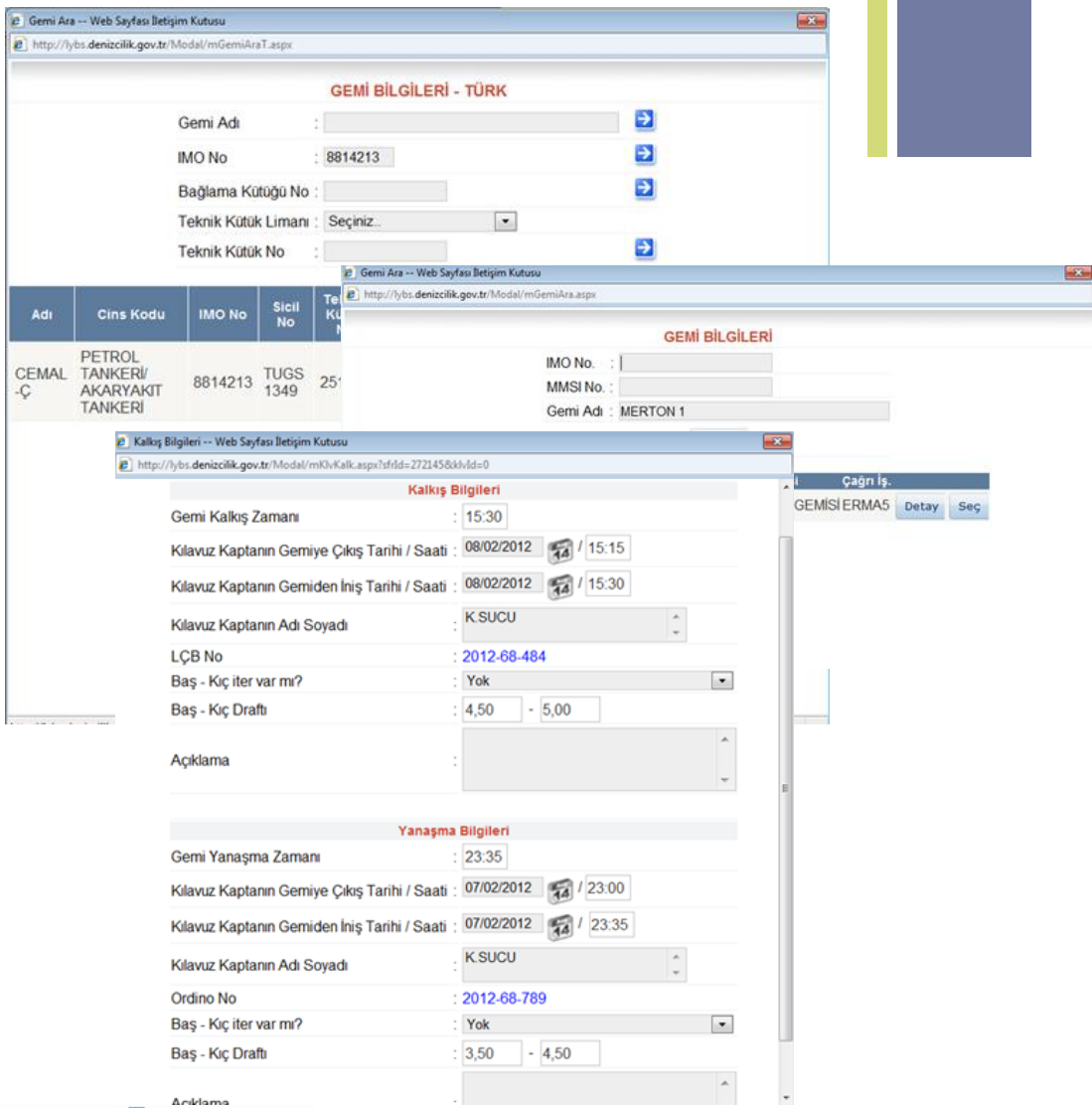


Video,
Telemetry data

Image Preprocessing → 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)



Web sites

AISHub
Latest AIS Data

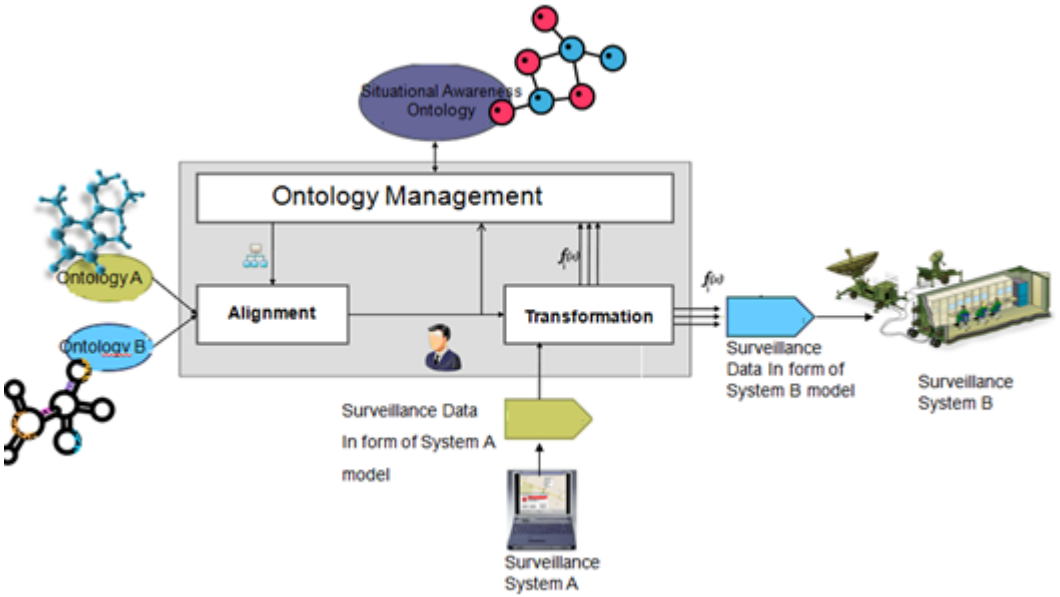
VesselFinder.com
List of last visited ports

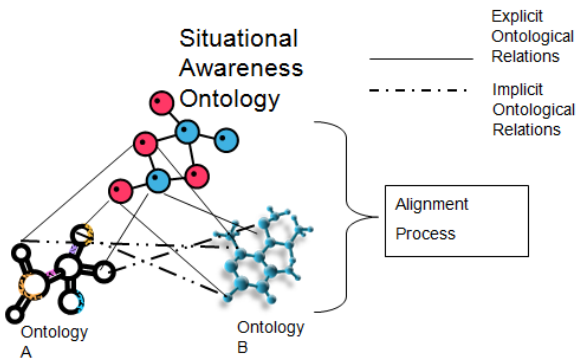
Equasis.com:
Master information, management detail previous inspections its classification surveys,
its previous names, flags and owners

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)
  - Automatic Identification System (AIS)

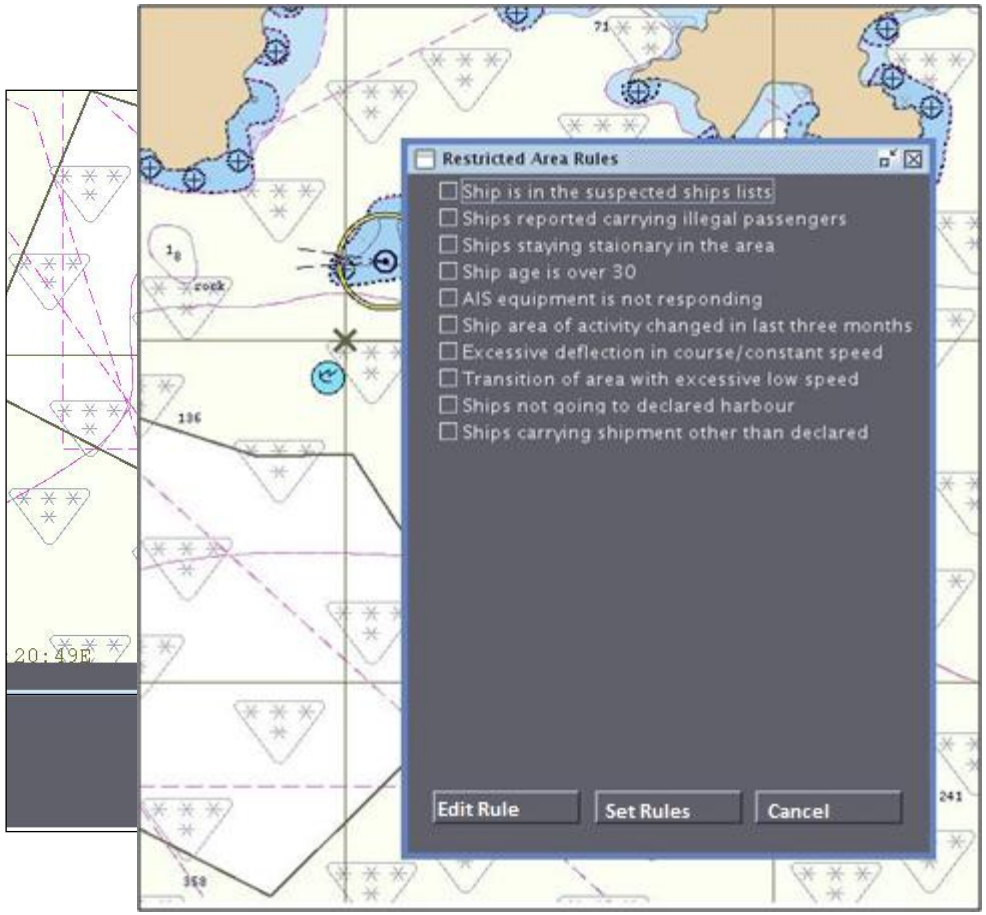
Threat Analysis

- 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 then 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