Trajectory based analytics: A Maritime Situational Awareness Perspective

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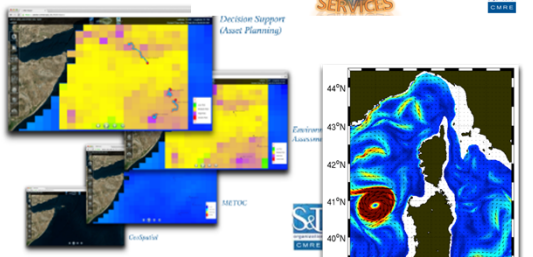
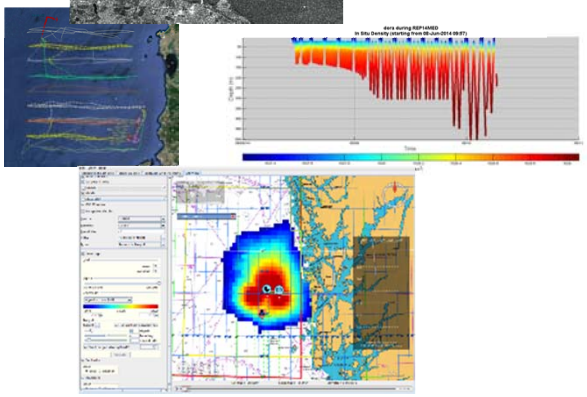
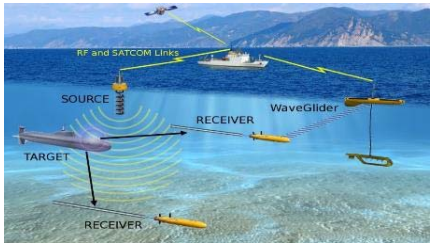
Centre for Maritime Research and Experimentation

STO CMRE conducts scientific research and technology development and delivers field-tested S&T solutions to address the defense and security needs of the Alliance in the **maritime domain**







The Data Knowledge and Operational Effectiveness (**DKOE**) project deals with Maritime Security and Maritime Situational Awareness

Similarities in Situational Awareness

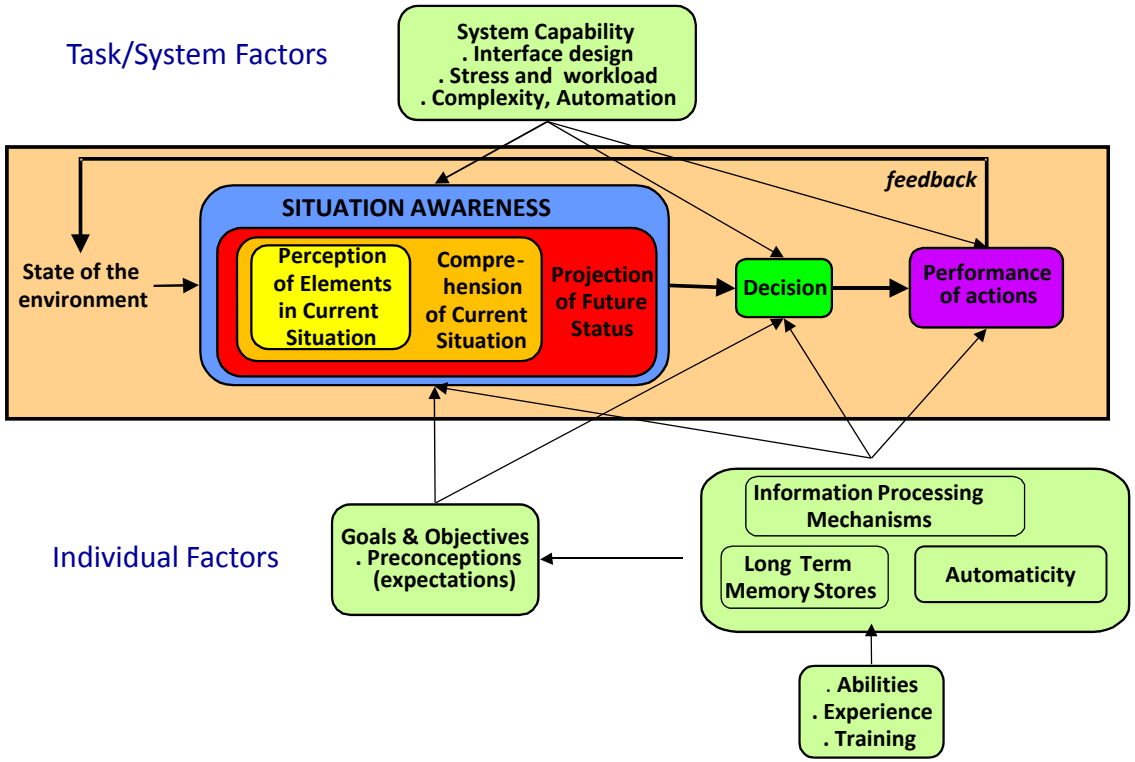
Aviation Situational Awareness

https://en.wikipedia.org/wiki/Air_traffic_control

Maritime Situational Awareness

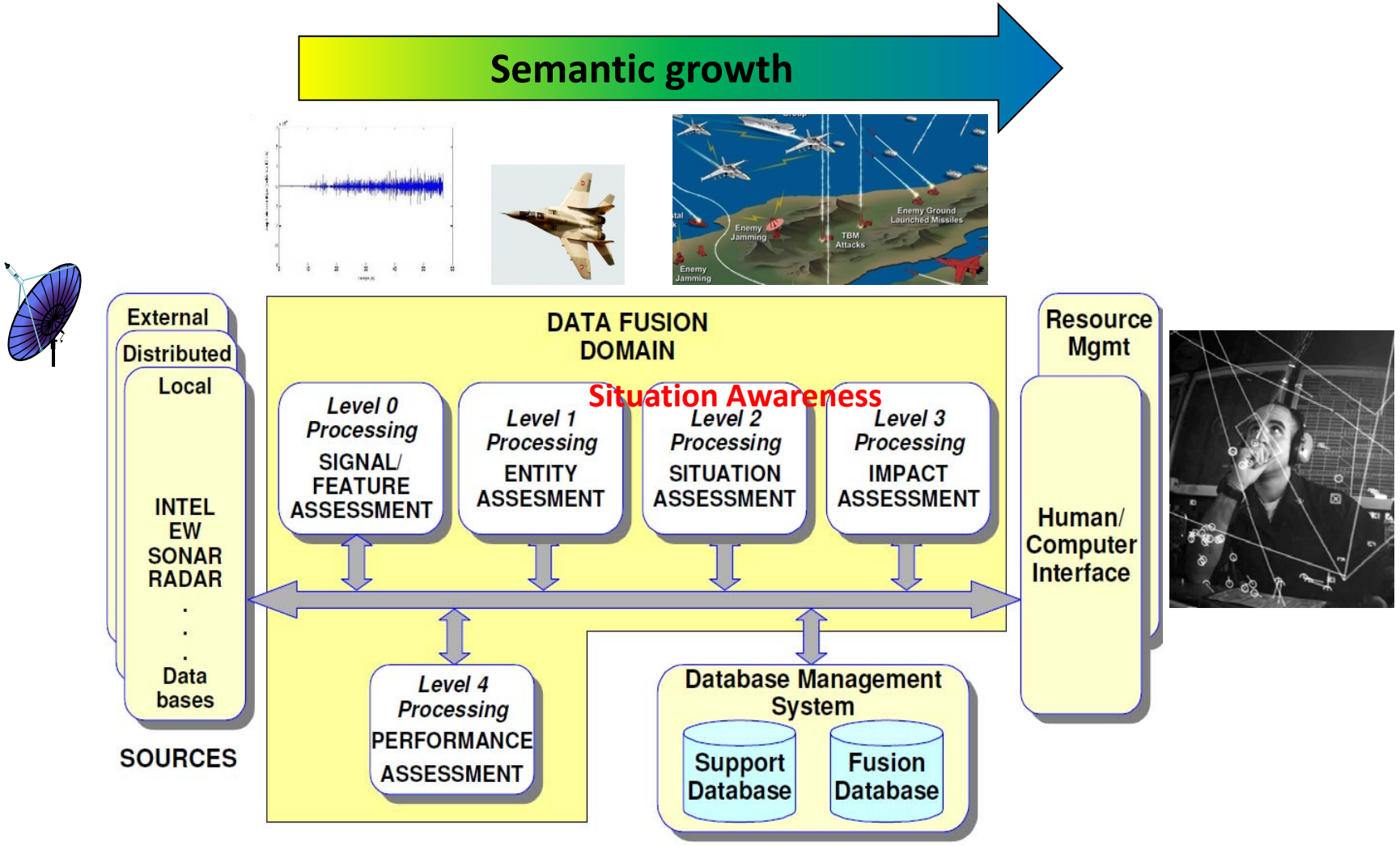
https://pla.co.uk/Safety/Vessel-Traffic-Services-VTS-/About-London-VTS

Situational Awareness



Functional model from:
Endsley, M.R. (2000). Theoretical underpinnings of situation awareness: A critical review. In M.R. Endsley & D.J. Garland (Eds.), Situation awareness analysis and measurement. Mahwah, NJ: LEA.
Endsley, M.R. (1995a). "Measurement of situation awareness in dynamic systems". Human Factors. ***37*** *(1): 65–84.*

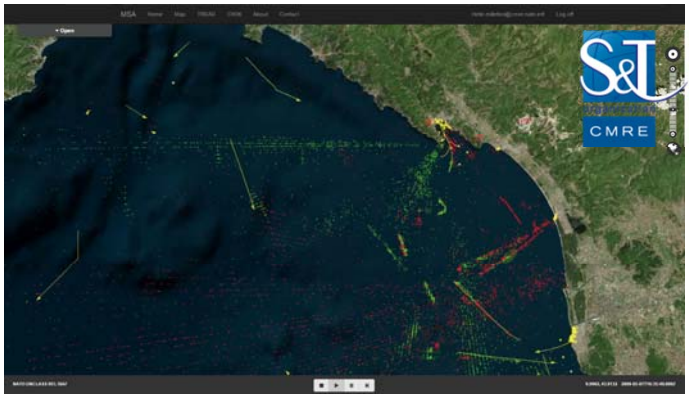
The JDL (Joint Director Laboratory) fusion model

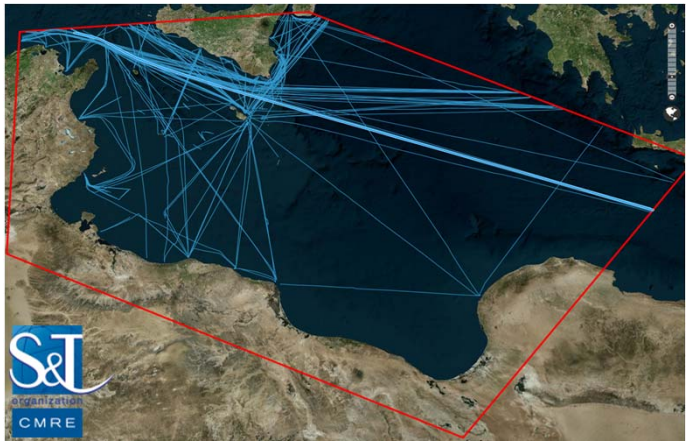


Fusion model from: Steinberg, Alan & L Bowman, Christopher. (2004). Rethinking the JDL data fusion levels.

Data

- Terrestrial and Satellite Automatic Identification System (T-AIS and S-AIS)
- Long Range Identification and Tracking System (LRIT)
- VTS costal Radar, HF radar, Shipborne and Airborne radar
- Synthetic Aperture Radar (SAR) and Inverse Synthetic Aperture Radar (ISAR) Imagery
- Vessel Management System (VMS) for fishing vessels
- Global Maritime Distress and Safety System (GMDSS)
- EO and Remote sensing Imagery
- Visible light and infrared cameras
- Meteorological and oceanographic models and Observations (e.g., Gliders sensors, CTDs, Waveriders, Wavegliders, XBTs, Meteo Buoys)
- Acoustic data (e.g., PAS/CAS Sonar, Hydrophones)
- Optic data (e.g., LIDAR imagery)
- Contextual information (maritime regulations and charts, traffic separation schemes, protected or closed areas, anchoring areas, activity reports, registry data - vessels and ports, black lists)



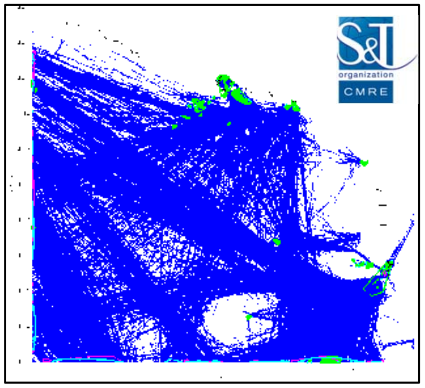


Benefits and limitations of approaches

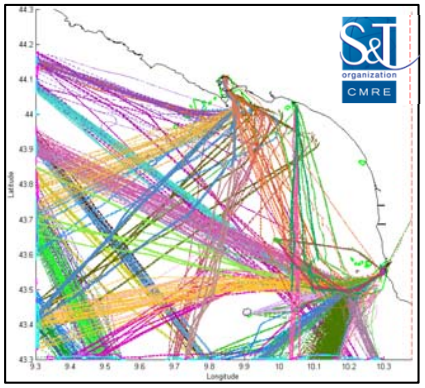
- A->B
- Inductive (A B, ->)
  - Implies data compression, thus
    - Compression can imply information loss
    - Requires the knowledge of the purpose of use
- Deduction (A->, B)
  - Good for event detection.
  - But if a conclusion is compelling (e.g. collision), it is too late to avoid it
- Abduction (->B, A)
  - Different possible interpretations which might not be comprehensive, thus combine approaches:
    - Probabilistic
    - Possibilistic

Inductive route extraction

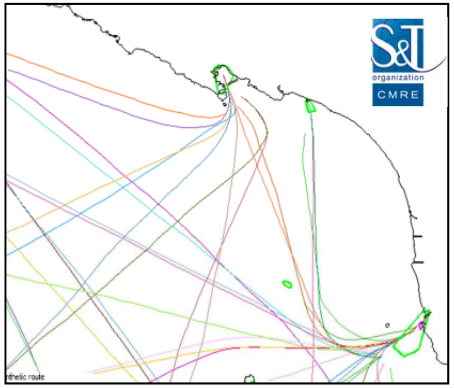
AIS raw data



Clustered trajectories



Synthetic routes

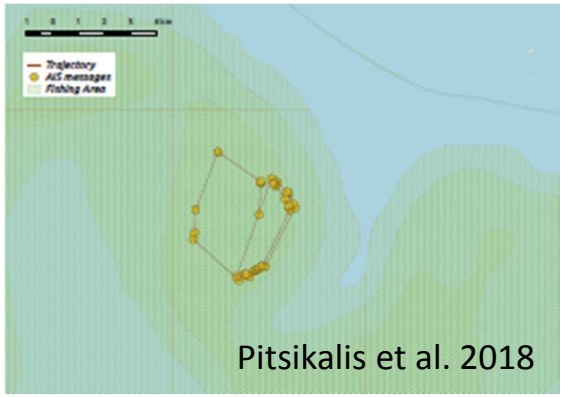


Providing interpretation context for enriching machine learning algorithms with meaning

Pictures from: Pallotta G., Vespe M., Bryan K. (2013) "Vessel Pattern Knowledge Discovery from AIS Data: a Framework for Anomaly Detection and Route Prediction". *Entropy, Big Data Issue* 15(6), pp. 2218-2245. ISSN 1099-4300

Deductive pattern detection

Trawling pattern detection

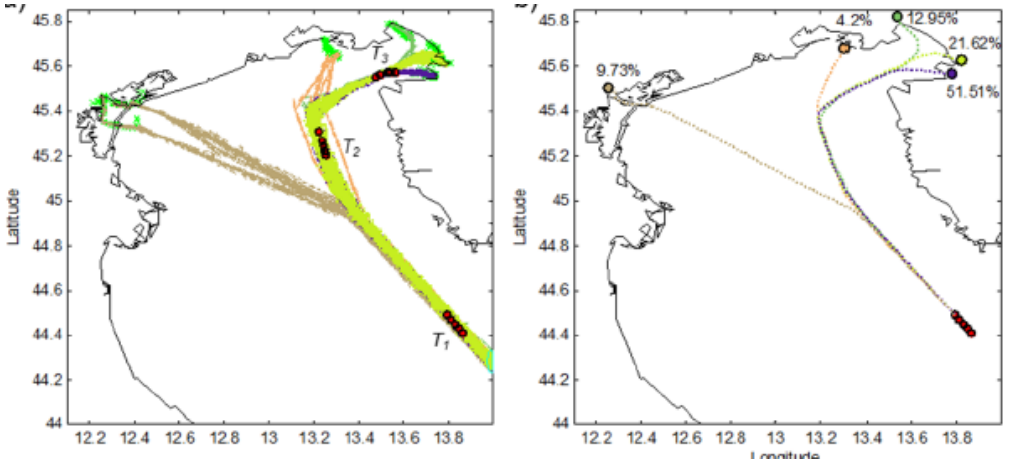


holdsFor(trawling(Vessel) = true, I) ←
vesselType(Vessel, fishing),
holdsFor(trawlSpeed(Vessel) = true, It),
holdsFor(withinArea(Vessel) = fishing, Iw),
intersect_all([It, Iw], Ii),
intDurGreater (Ii, Ttr , I).

Enabling the combination of observed data with prior knowledge.

Picture and Rule from: Manolis Pitsikalis, Ioannis Kontopoulos, Alexander Artikis, Elias Alevizos, Paul Delaunay, Jules-Edouard Pouessel, Richard Dreo, Cyril Ray, Elena Camossi, Anne-Laure Jousselme, Melita Hadzagic, Composite Event Patterns for Maritime Monitoring, 10th Hellenic Conference on Artificial Intelligence (SETN 2018), July 2018

Abductive destination prediction



- Combining inductively generated information for proposing possible interpretations of the observations and predictions.

Pictures from: Pallotta G., Vespe M., Bryan K. (2013) "Vessel Pattern Knowledge Discovery from AIS Data: a Framework for Anomaly Detection and Route Prediction". *Entropy, Big Data Issue* 15(6), pp. 2218-2245. ISSN 1099-4300

Thank you for your attention