Use cases for Maritime Surveillance DSS

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Types of Information Systems

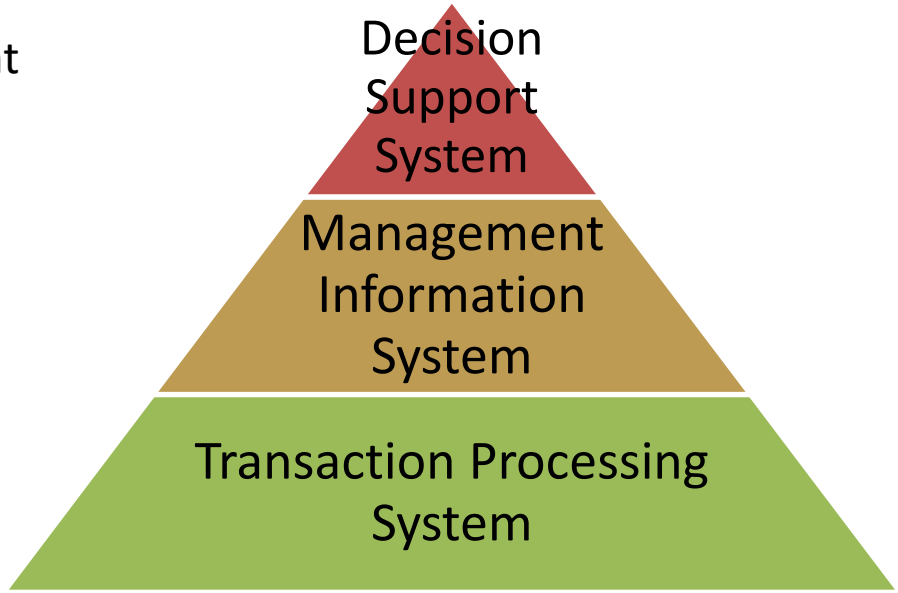
An information system is a formal ,sociotechnical , organisational system designed to

a. collect ,
b. process,
c. store and
d. distribute information.

Used by senior management for Decision making

Used by managers for operational efficiency

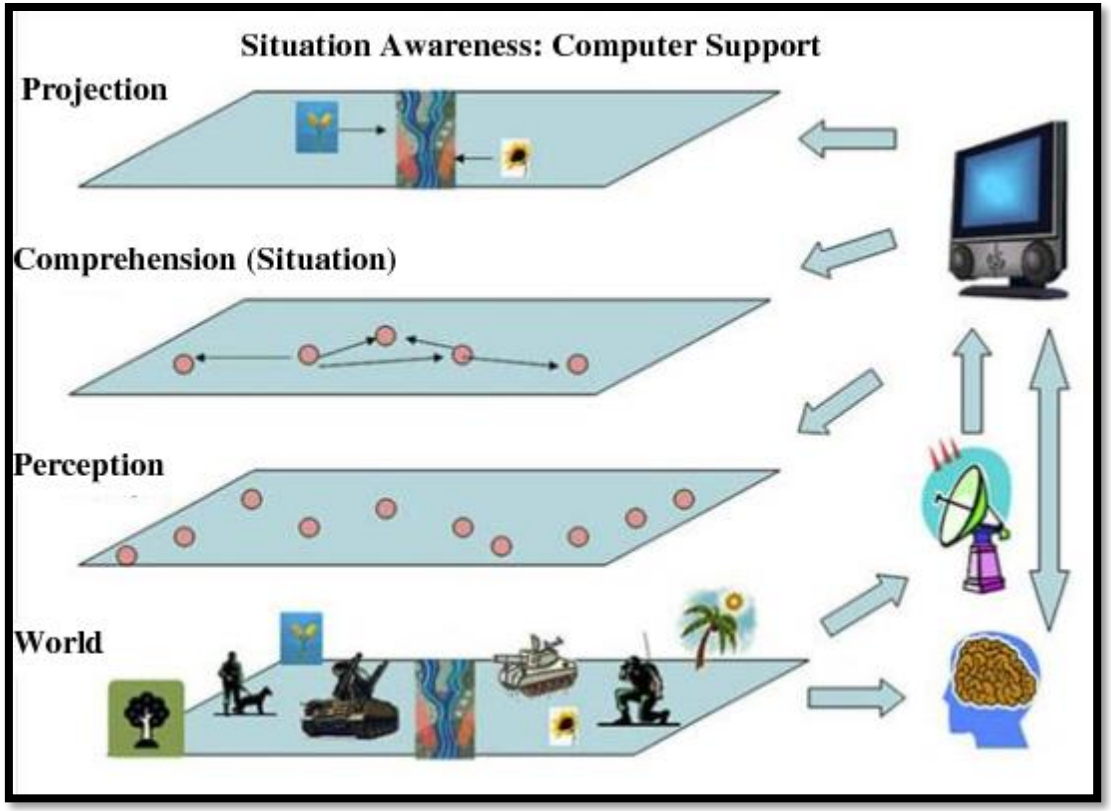
Used by workers for basic reporting



Maritime Situational Awareness System

Situation awareness can be described as

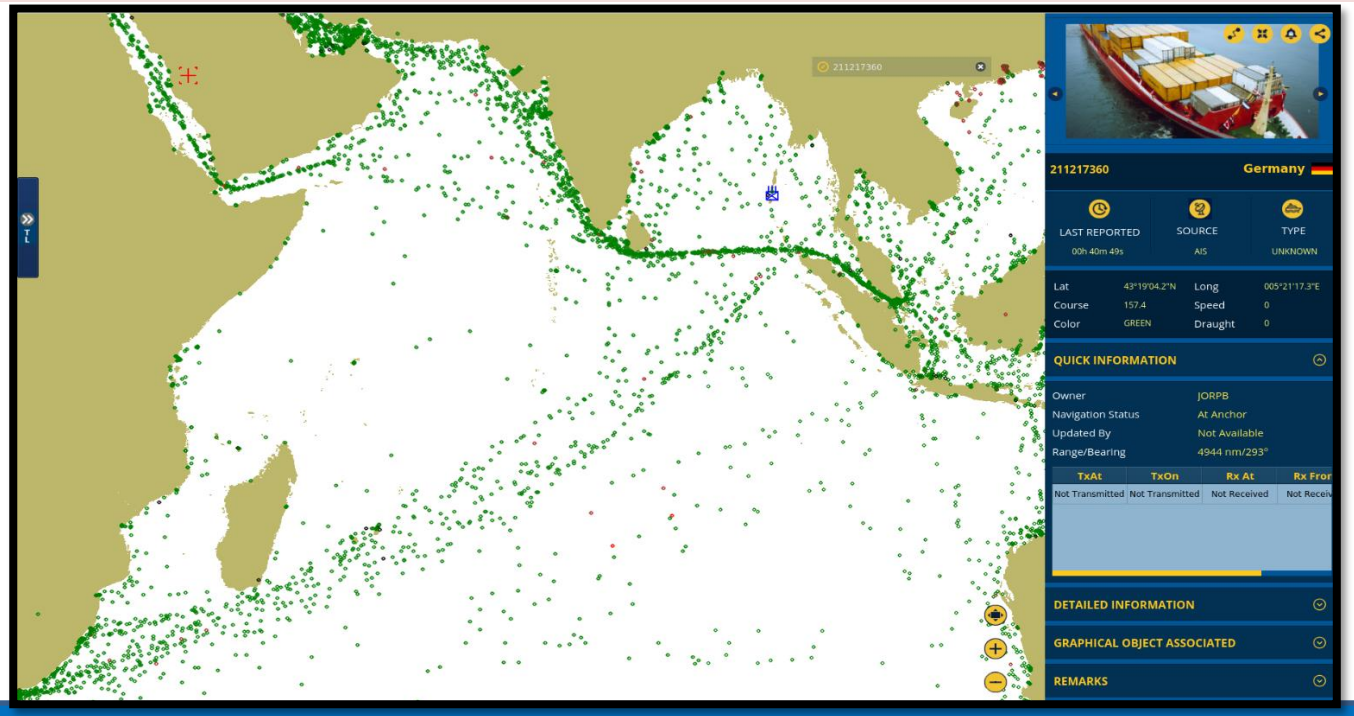
"the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future."



COP

A common operational picture is a single identical display of relevant information shared by more than one command. COP facilitates

1) Collaborative planning
2) Combined execution
3) Assists all echelons to achieve situational awareness

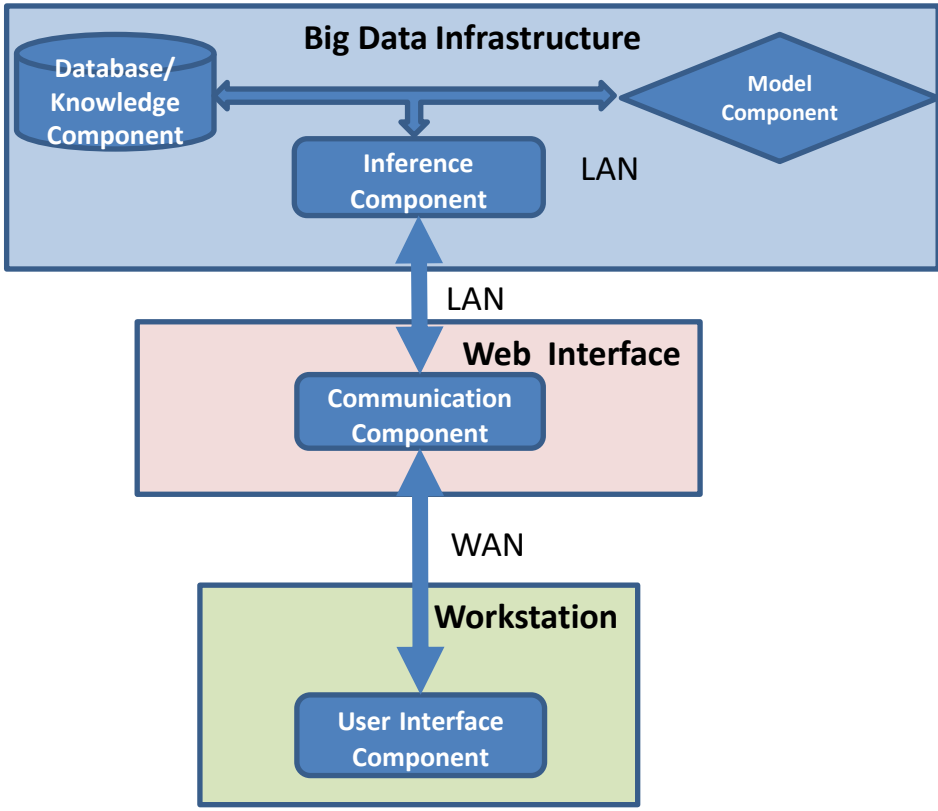


Maritime Surveillance Decision Support System

A Maritime Surveillance DSS is an information system that supports Maritime surveillance related decision-making activities.

Components of a DSS System:

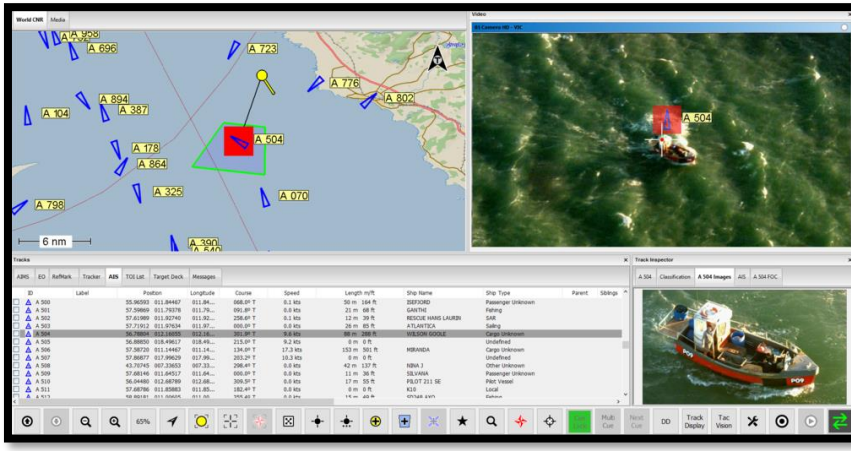
1) The Database (or Knowledge base)
2) The Model (ie , the decision context and user criteria)
3) The User interface



Maritime Surveillance DSS Operational Requirement

Naval Analyst shall use DSS sub system for enhanced situational awareness and Strategic Mission Planning by using following features:

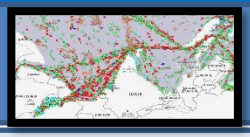
- **Leveraging various data sources, to extract insights for *detecting suspicious maritime behavior and situations*.**
- **Integrate heterogeneous data sources to create *correlated information about suspected maritime behavior and situations.***
- **Advanced features for *strategic/tactical mission planning.***



DSS for Maritime Surveillance

DSS Console

User Applications



Maritime Situational Awareness Console

Level1 Analytics Features:

1) Spatio-Temporal Analysis
2) Track Trajectory Extraction
3) Object Clustering
4) Maritime Route Extraction
5) Density Maps
6) Video/Image Analysis:
   1) Object Detection and Tracking

Level2 Analytics Features:

1) Track Information Fusion and Retrieval
2) Video/Image Geo Tagging and Track info tagging
3) Behaviour Analysis
4) Anomaly Detection & Classification
5) Business Intelligence
6) Multi Track Activity Detection

Level3 Analytics Features:

1) Track Path Prediction
2) Mission Planning

Data Analysis and Information Fusion Services

Access Control

Data Integration

Data Dissemination

Networking and Integration Services

Track Data

UAV Video/Image Data

Users Operational Systems

Satellite Imagery /Satellite Orbital Data

Internet Open Source Data/ Repositories

Weather Data

DSS Data and Information Sources

Track Behavior Modeling for Anomaly Detection

Develop data driven model of anomalous vessel behavior based on historical position reports

1) Vessels abnormal movement (Deviations from maritime routes)
2) Vessel Loitering
3) Vessel switching off transponder(Dark Ship)
4) Vessel in Drifting
5) Fishing Vessel Not Fishing
6) Fishing Vessel in Non Fishing Zone
7) Trans shipment at Sea
8) Abnormal port entry/exit pattern
9) Ghost Ship (Disguise origin and destination)
10) Change of heading higher than a threshold
11) Sudden change of speed

Track Behavior Modeling for Anomaly Detection

Develop data driven model of anomalous vessel behavior based on historical position reports

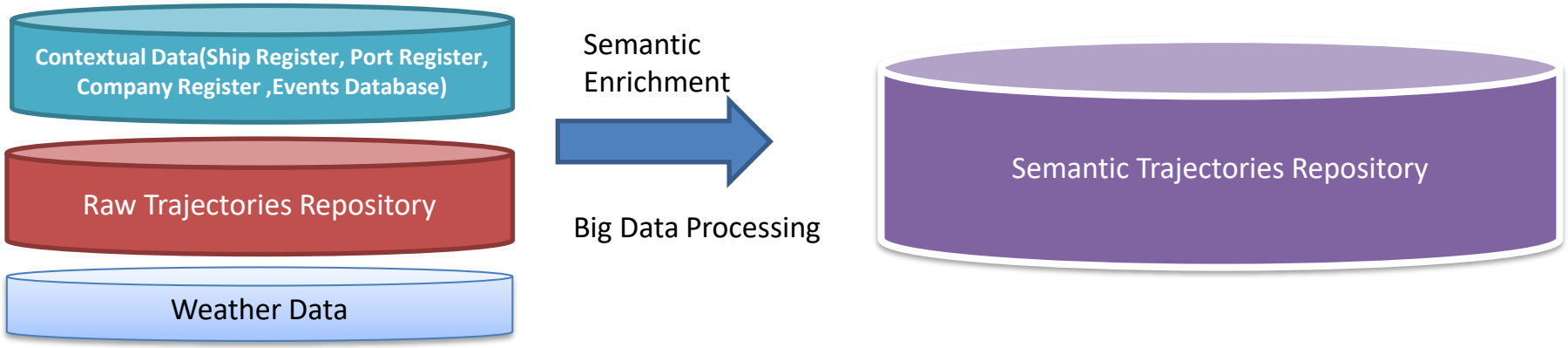
12) Frequency of vessel position report higher than expected

13) Passage of vessel close to shore

14) Passage of vessel close to AOI

15) Vessels approaching one another closer than an indicated distance with a speed below threshold

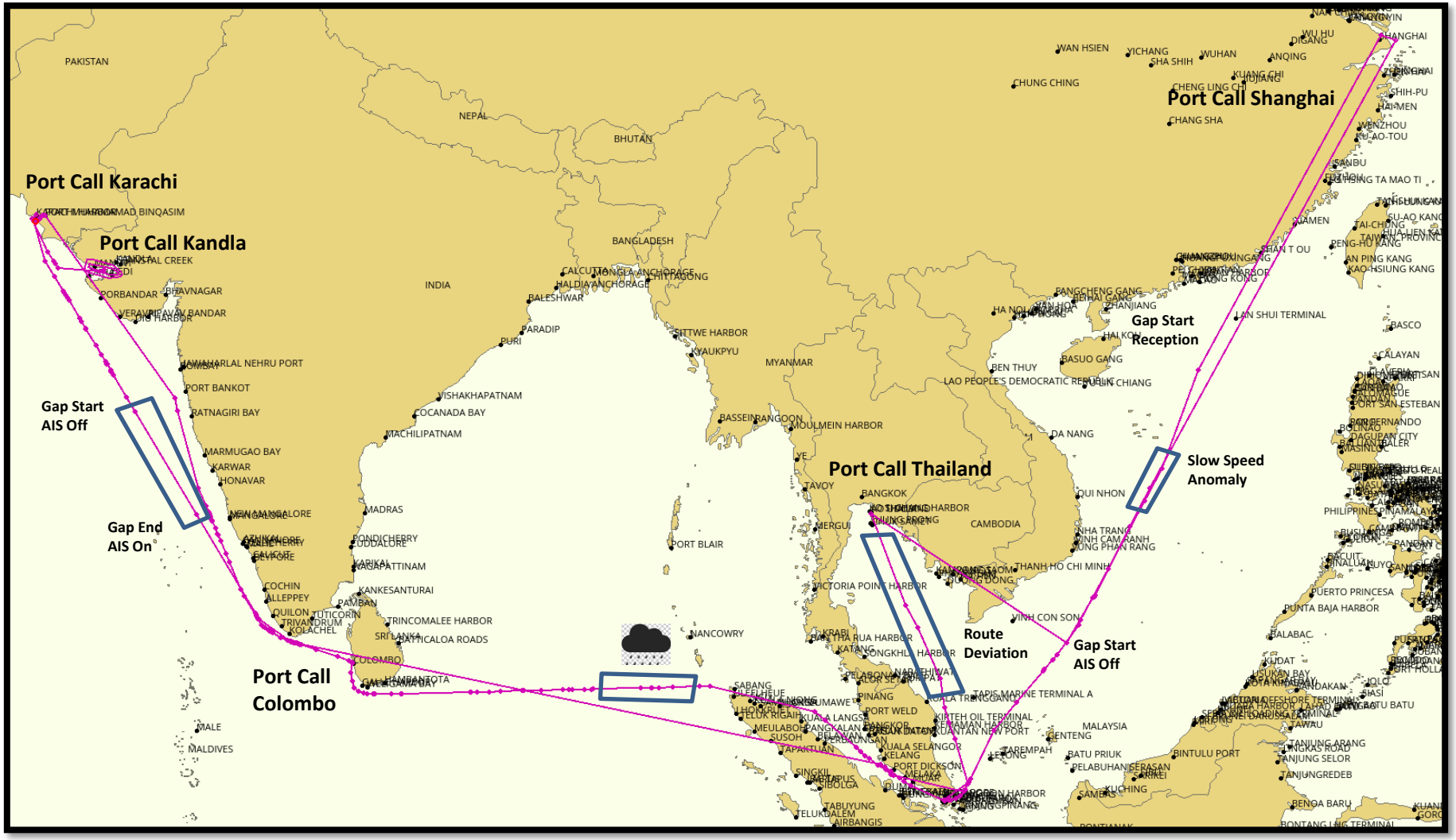
Semantic Trajectory Analytics



A semantic trajectory is a trajectory that has been enhanced with annotations and/or one or several complementary segmentations. It is defined as a tuple:

(trajectoryID, movingObjectID, trajectoryAnnotations, trace:
LISTOF position (instant, point, δ, positionAnnotations),
semanticGaps: LISTOF gap (t1, t2),
segmentations: SETOF segmentation (segmentationID,
episodes: LISTOF episode (t3, t4, definingAnnotation, episodeAnnotations)
))

Representative Semantic Trajectory



Predictive Analytics Usecases

Unknown Vessel Type Classification

I. Fishing/Non Fishing Classification
II. Merchant/Non Merchant Classification
III. Naval/Merchant Classification (Fleet Movement pattern)

Multi Vessel Interaction Classification

i. Merchant – Tug Interaction
ii. Merchant – Merchant Interaction
iii. Merchant – fishing boat Interaction

Vessel Prediction

I. Next Port of Call
II. Route Prediction

Visual Analytics(Imagery/Videos)

Being a self-reporting system AIS is prone to intentional/unintentional errors in data. For instance

- ❑ Error exists in the AIS information due to poor reception.
- ❑ Information may be input erroneously by operator.
- ❑ a ship may never update the AIS information.
- ❑ if the AIS equipment is switched off

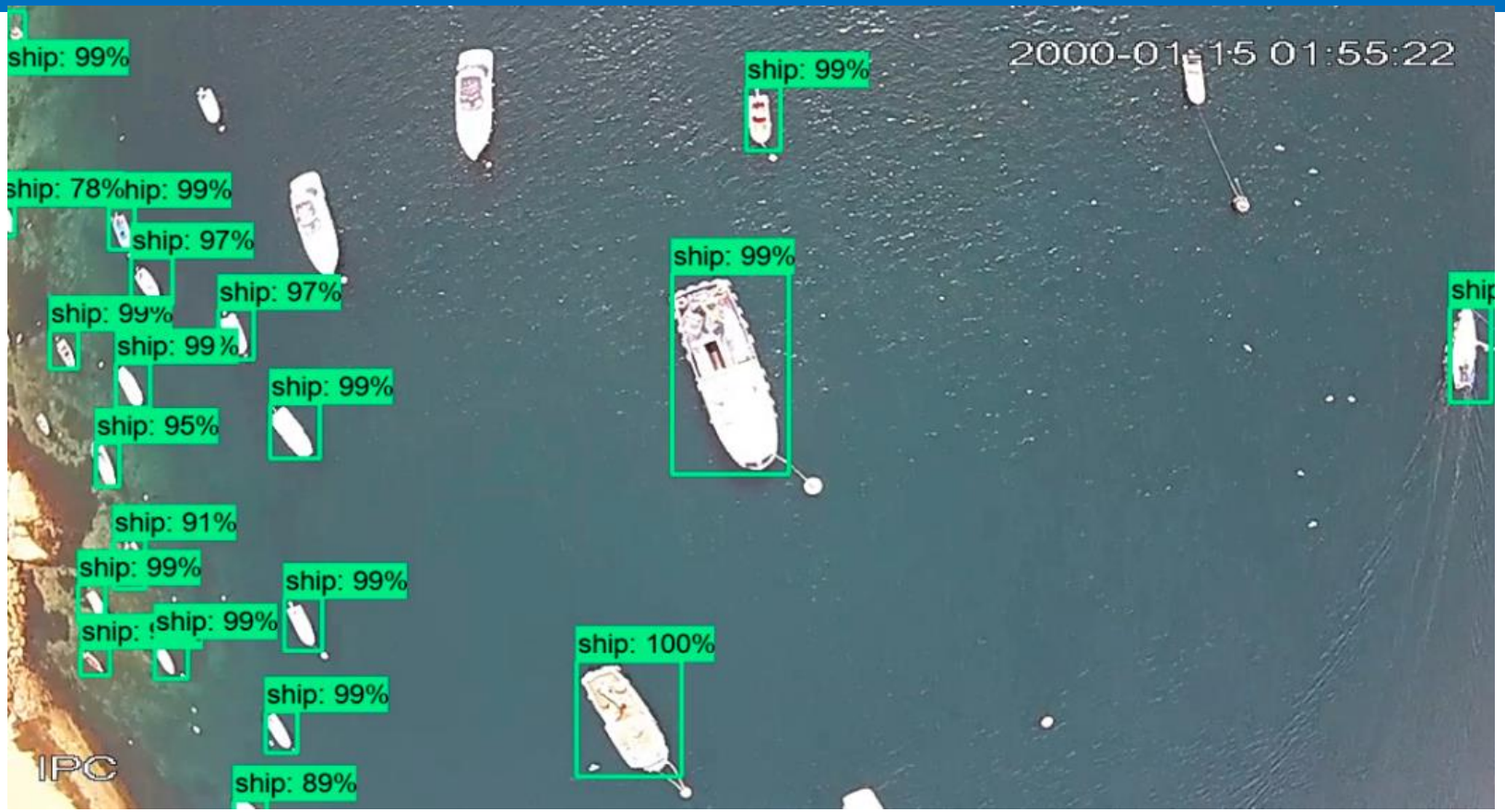
The Automatic Identification System (AIS) information

- ❑ **Dynamic – Position ,Speed ,Course**
- ❑ **Static – MMSI no ,IMO no ,Callsign ,Length ,Width ,Type**
- ❑ **Semi Static – Voyage and Cargo Related Information (ETA ,Cargo Type ,Source , Destination)**

- ❑ **Automatic Physical Verification of a vessel based on**
  1. **UAV video data**
  2. **SAR/Optical Imagery**

  By extracting Vessel features and associating with AIS information

Verification of AIS information with image/video data

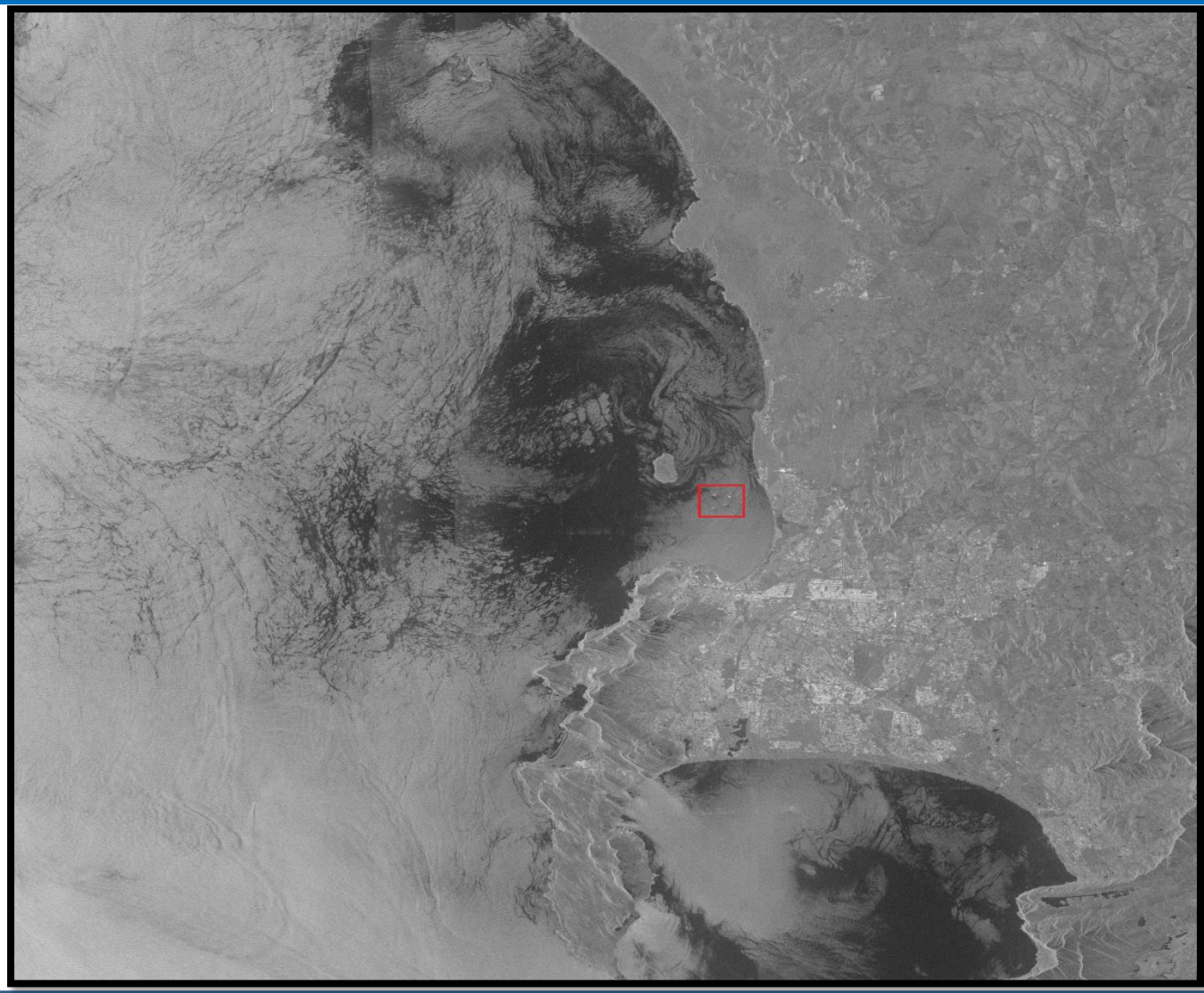


1) **Extract the ship features such as Position/Type from a UAV video steam .**
2) **Analyse the extracted ship position with the historical AIS data of the area.**
3) **Verify and highlight the ships that have given incorrect data.**

Satellite SAR/optical Imagery Analysis

Analysis Use cases

1. **Extraction of Ship position and Kinematics from SAR data**
2. **Track Association with AIS-Video(Extracted Ship) data**



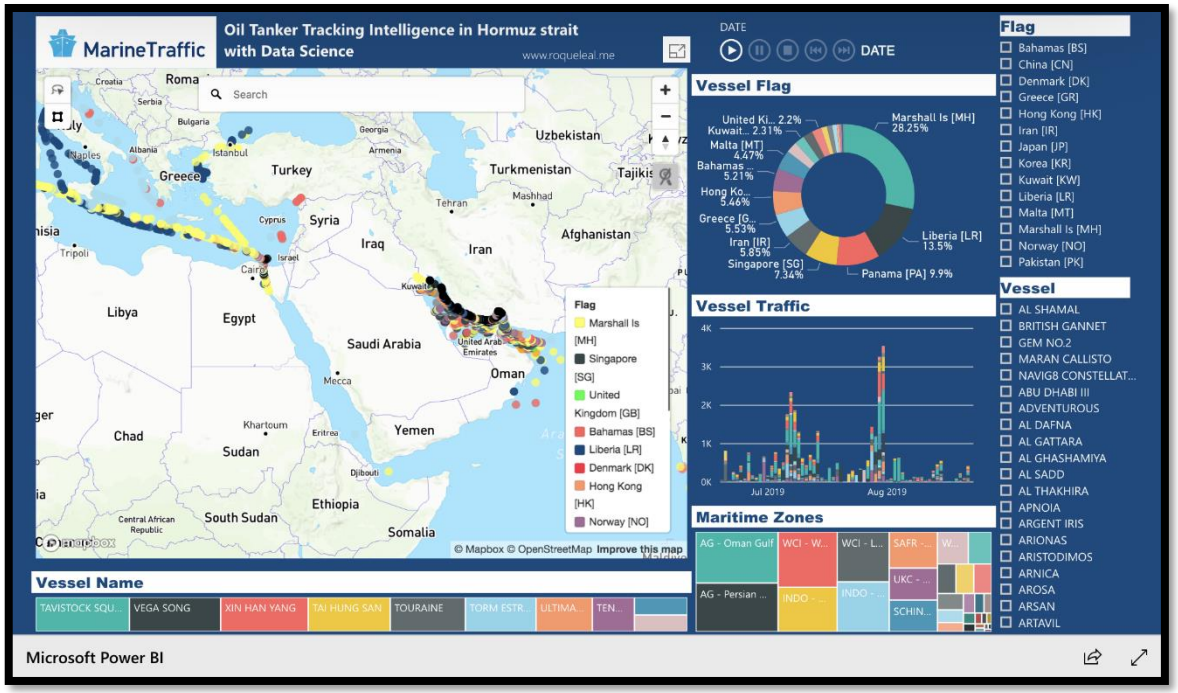
Video/Image Server

1. **Store Video/Image data received from various sources**
2. **Geotag the video/Image data**
3. **Tag the video/image data with Track information**
4. **Provide interface to search video/image data and deliver video streams simultaneously to many clients**
5. **Interface to share video data with external systems**

Advanced Visualization(DSS dashboard)

DSS dashboard with Charts and Graphs to visualize large amount of complex data to convey concepts and summarize

1) Line Charts
2) Area charts
3) Pie Charts
4) Bar Charts
5) Heat and Tree maps



Representative Image of a DSS Dashboard

Text Analytics

1. Deriving information about Tracks from text dataset generated by
    1. Remarks added by user,
    2. Web scrapping,
    3. Intelligence inputs etc.

2. To understand the contextual information of a text data using NLP and automatically take appropriate action such as
    1. generate alert (Track not sending AIS info)
    2. find anomalous behaviour of a Track (Find last port call, current position from web resources)
    3. Event Detection.(oil spill etc)

3. OSINT : Open-source intelligence is the collection and analysis of data generated from open sources (overt and publically available sources) to produce actionable intelligence.

Web Scrapping Resources

Cargo vessel MV Jag Anand to bring 23 Indian sailors stuck in China back home today

India

Times Now Digital
Updated Jan 14, 2021 | 06:39 IST

Cargo vessel MV Jag Anand was on anchorage near Jingtang port in China since June 13.


MV Jag Anand. | Pic courtesy: Fleetmon

New Delhi: The 23 Indian sailors onboard bulk cargo vessel MV Jag Anand, who were stuck in China since June 13, will likely be reaching the country on Thursday. Union Ports, Shipping and Waterways Minister Mansukh Mandaviya had earlier confirmed said that the Indian crew members would reach India on January 14.

"Our seafarers stuck in China are coming to India. Ship MV Jag Anand, having 23 Indian crew, stuck in China is set to SAIL toward China, Japan, to carry out crew change, will reach India on 14th January," Mandaviya had tweeted.

Cargo vessel MV Jag Anand was on anchorage near Jingtang port in China since June 13. Another vessel, MV Anastasia, which has 16 Indian nationals is on anchorage near the Caofeidian port in China since September 20.

Despite, several requests from the Indian government, China had cited COVID-19-related restrictions and didn't allow the ships to either dock or go for a crew change for months.

Notably, Beijing on December 25 had stated that there was no 'link' between the stranded Indian ship crew on its Chinese

istry of External Affairs Spokesperson Anurag Srivastava earlier this month had said the Indian Embassy in Beijing sly following up the issue with Chinese authorities.

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JAG ANAND

Bulk Carrier, IMO 9463308

VesselFinder » Vessels » Cargo vessels » JAG ANAND

Ship Electronic Record books
Comply with international laws and regulations, tamperproof, non-editable and automate.
MariApps Marine Solutions
Open

The current position of **JAG ANAND** is at Red Sea (coordinates 29.00513 N / 32.79056 E) reported 7 days ago by AIS. The vessel is en route to **TUNA PORT KANDLA**, sailing at a speed of 11.1 knots and expected to arrive there on **Feb 20, 06:30**.

The vessel **JAG ANAND** (IMO: 9463308, MMSI 419001180) is a Bulk Carrier built in 2011 (11 years old) and currently sailing under the flag of **India**.

POSITION & VOYAGE DATA

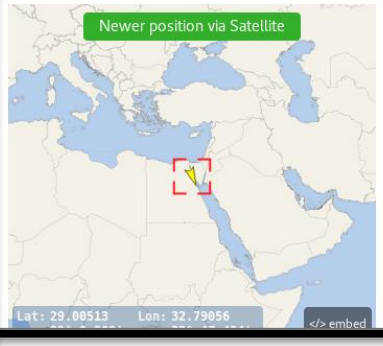
Track on Map | Add Photo | Add to fleet

TUNA PORT KANDLA
ETA: Feb 20, 06:30

Predicted ETA	-
Distance / Time	-
Course / Speed	159.0° / 11.1 kn
Current draught	14.5 m
Navigation Status	-
Position received	7 days ago
IMO / MMSI	9463308 / 419001180
Callsign	AWRM
Flag	India
Length / Beam	292 / 45 m

Port Said Anch., Egypt
ATD: Feb 8, 02:17 UTC

MAP POSITION & WEATHER



PORT CALLS

Port Said Anch., Egypt

Arrival (UTC)	Departure (UTC)	In Port
Feb 7, 14:37	Feb 8, 02:17	11h 40m

Gibraltar West Anch., Gibraltar

Arrival (UTC)	Departure (UTC)	In Port
Jan 30, 17:10	Jan 31, 07:52	14h 42m

Baltimore, USA, United States (USA)

Arrival (UTC)	Departure (UTC)	In Port
Jan 8, 19:25	Jan 12, 05:40	3d 10h

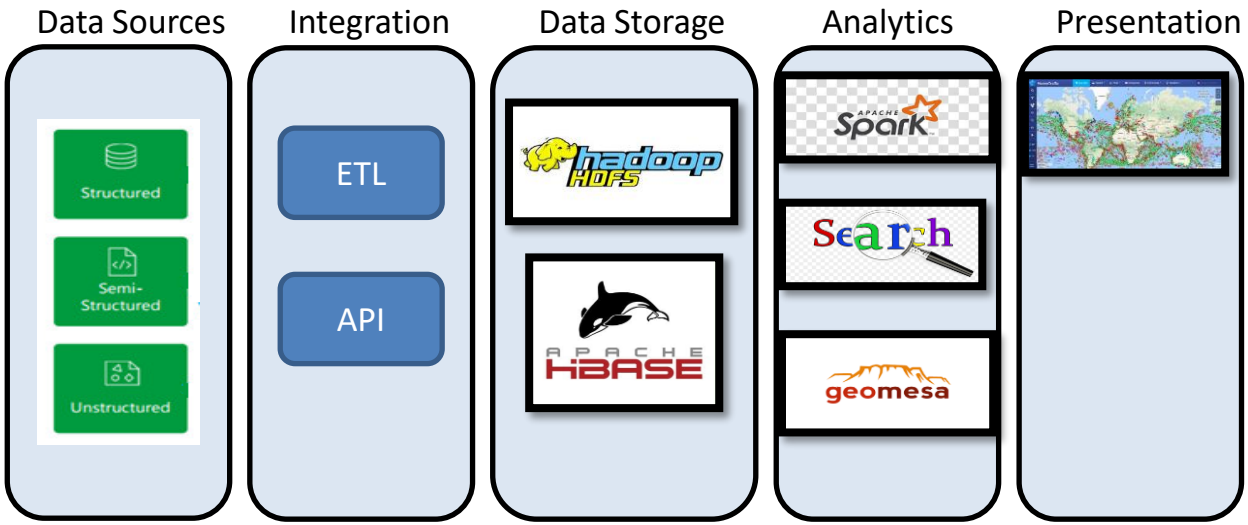
IJmuiden, Netherlands

Arrival (UTC)	Departure (UTC)	In Port
-	Dec 22, 08:08	-

Historical AIS Data

POC for DSS system

Maritime Traffic Analysis System



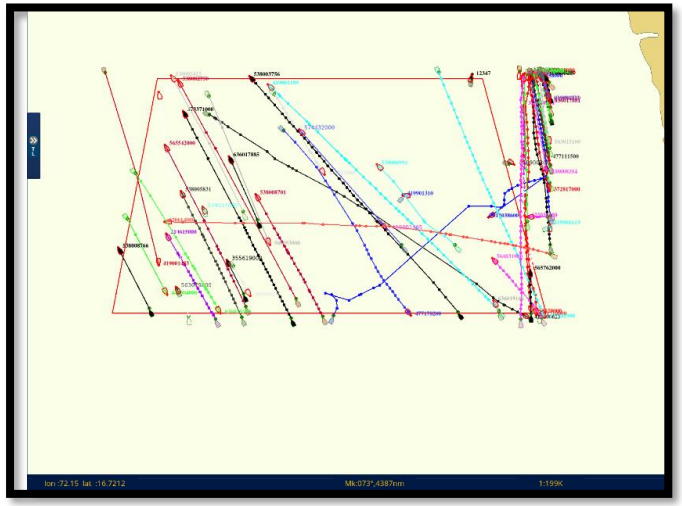
System Features

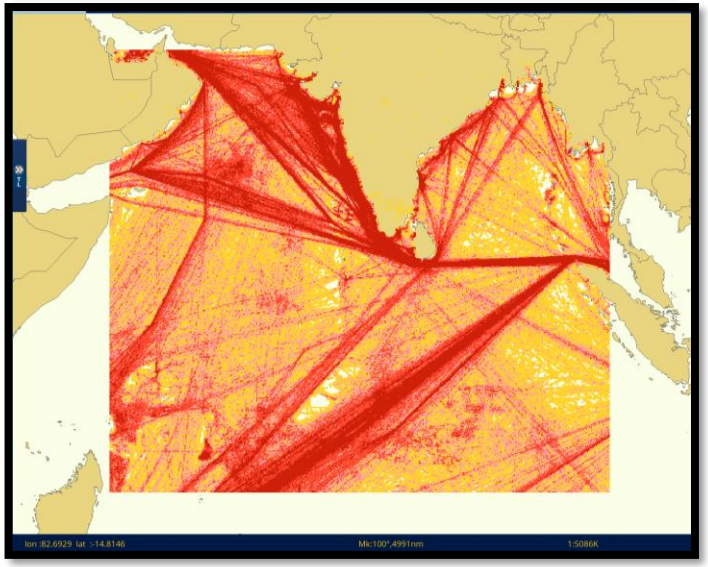
1. Implemented Using Big Data Technologies
2. High Availability and Horizontally Scalable
3. Data Repository for 10 Years
4. Features
   - I. High Performance Spatio Temporal Analysis on Large Dataset
   - II. Anomaly Detection and Classification
   - III. Record and replay
   - IV. Track Association

Analytics Use Cases

High Performance Spatio Temporal Query Analysis	**1. Track Trajectory Analysis** **2. Track Proximity Analysis** **3. Port Call Analysis** **4. Int Report Analysis** **5. Track Association** **6. Track Interaction Detection** **7. Density Map**
Unsupervised Learning	**1. Vessel Movement Pattern Extraction** **2. Abnormal Movement Detection** **3. Vessel Next Port of Call Prediction**
Supervised Learning	**1. Vessel Type Classification as Fishing/Non Fishing based on Kinematic Features**
Deep Learning for Computer Vision	**1. Ship feature detection from SAR/EO imagery**

Big Data Analytics on Large Spatiotemporal Dataset

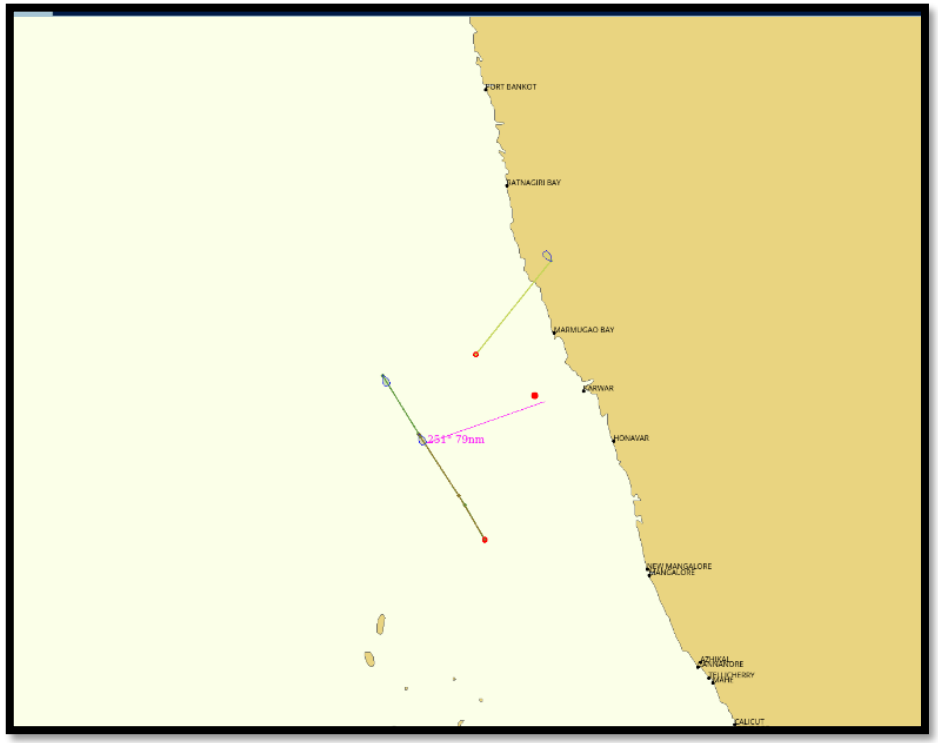




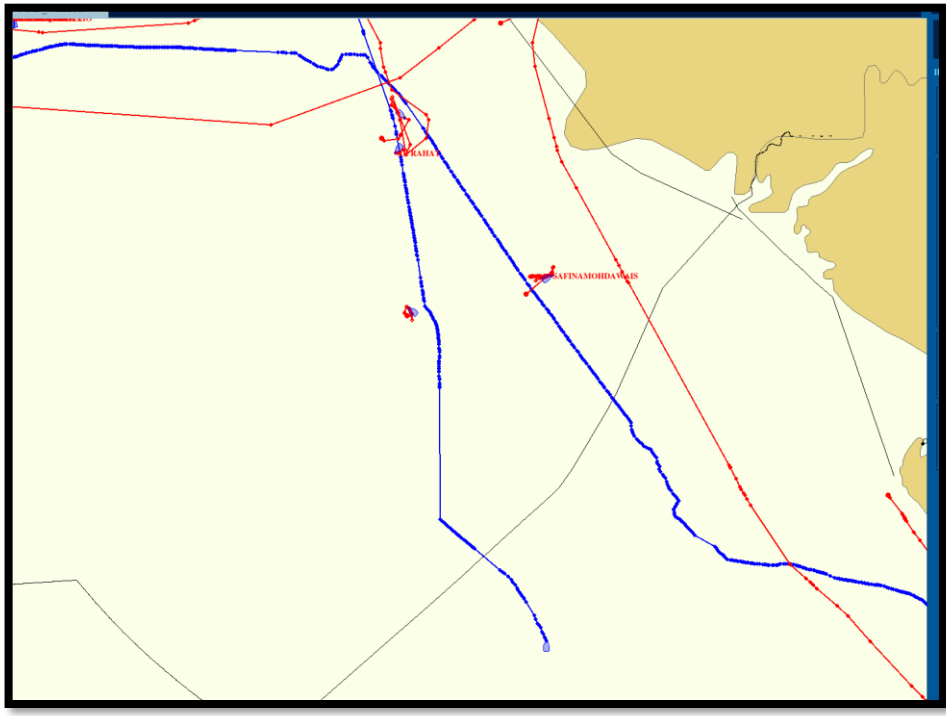
High Performance Spatiotemporal Analysis

a) Dataset size of hundreds of millions Records
b) Query Response in seconds

Spatio Temporal Analysis

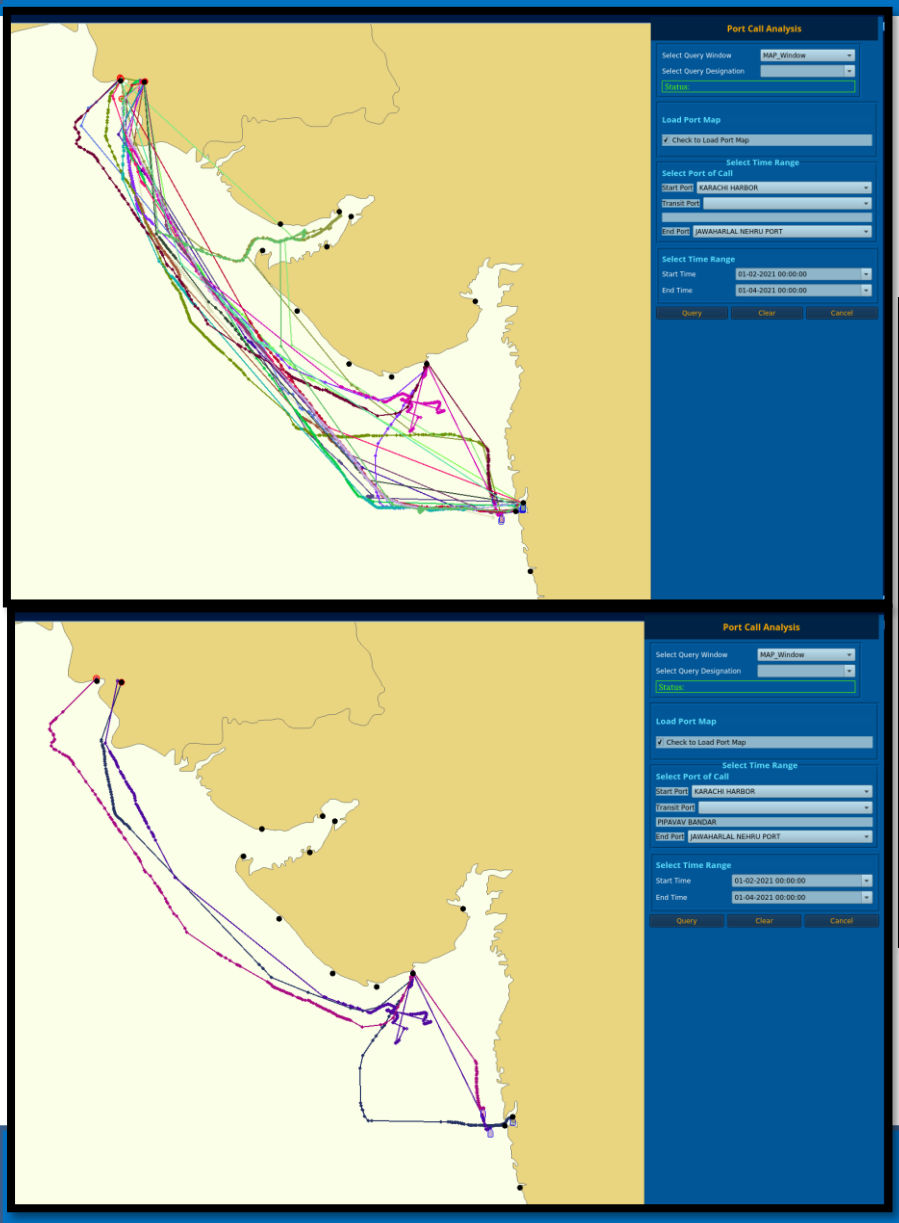


Track Movement Near Point of Interest

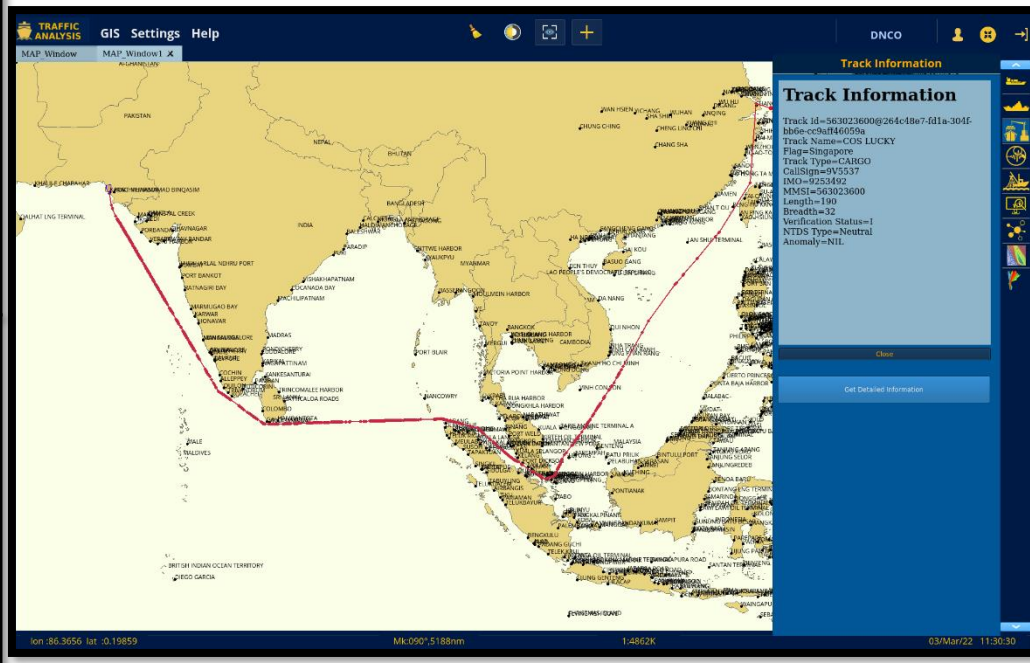


Track Movement Near Track of Interest

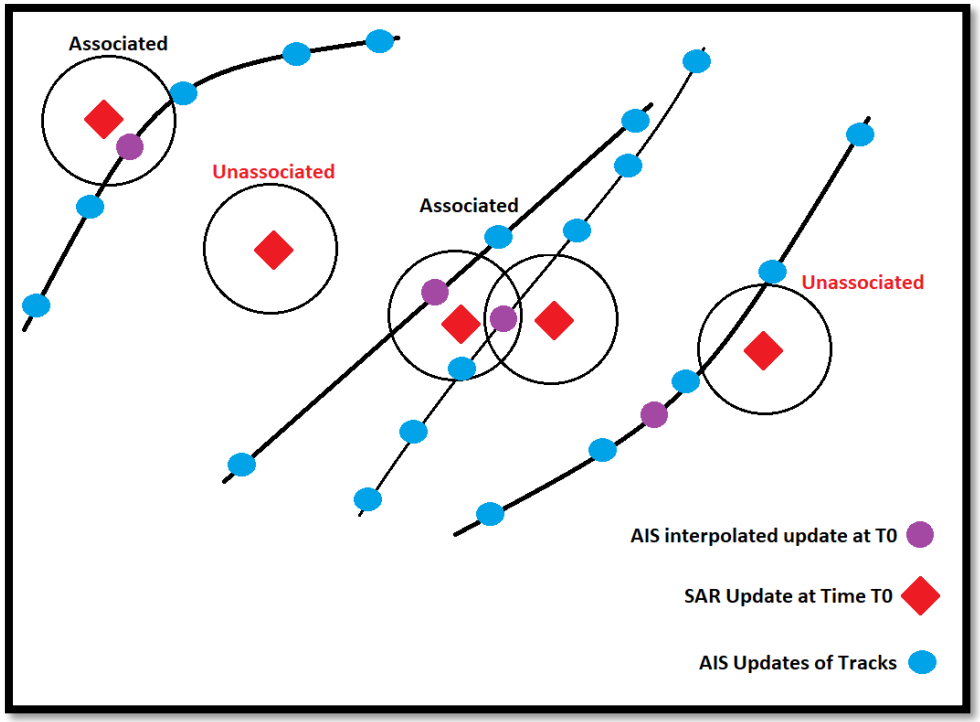
Port Call Analysis



Fetch Tracks Travelled between Given Ports:
Start Port
Transit Port
End Port



Track association



Aim : To associate the SAR Track positions with available AIS picture

Multi Target Tracking Problem:
Point To Track Association

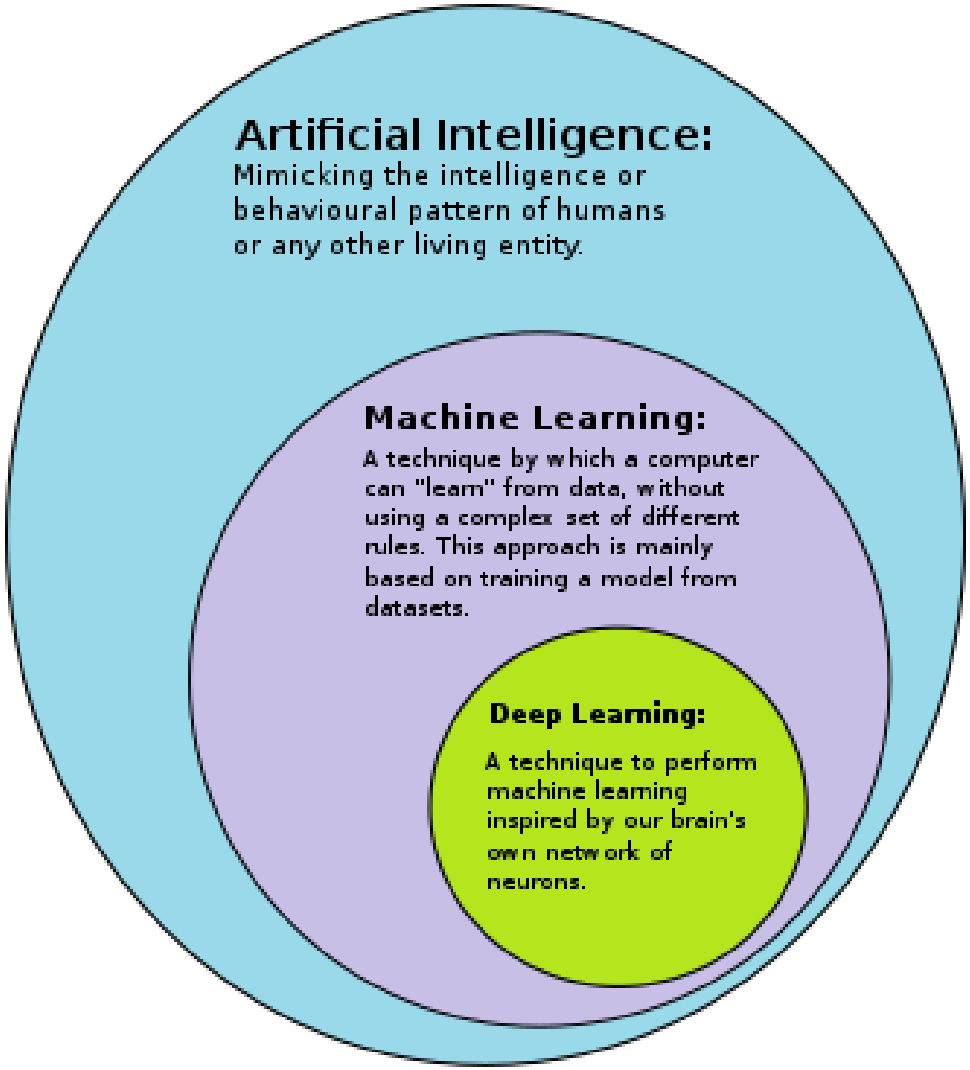
In case the Gate of a SAR updated has more than one AIS updates Hungarian Assignment Algorithm is used for optimal SAR-AIS assignment based on great circle distance cost matrix.

Query AIS Track Data in AOI → Interpolate AIS Data to SAR timestamp → Gating → Track Association → Show Unassociated SAR/AIS Tracks

Artificial Intelligence

Artificial intelligence (**AI**) is intelligence demonstrated by machines, as opposed to the **natural intelligence** displayed by animals including humans. Leading AI textbooks define the field as the study of

“intelligent agents": any system that perceives its environment and takes actions that maximize its chance of achieving its goals


Artificial Intelligence:
Mimicking the intelligence or behavioural pattern of humans or any other living entity.
Machine Learning:
A technique by which a computer can "learn" from data, without using a complex set of different rules. This approach is mainly based on training a model from datasets.
Deep Learning:
A technique to perform machine learning inspired by our brain's own network of neurons.

Machine Learning

Machine learning (ML) is the study of computer algorithms that can improve automatically through experience and by the use of data.

Machine learning algorithms build a model based on sample data, known as training data, in order to make predictions or decisions without being explicitly programmed to do so.

Broad Types of Learning

1. **Supervised learning**

   algorithms build a mathematical model of a set of data that contains both the inputs and the desired outputs. The data is known as training data, and consists of a set of training examples.

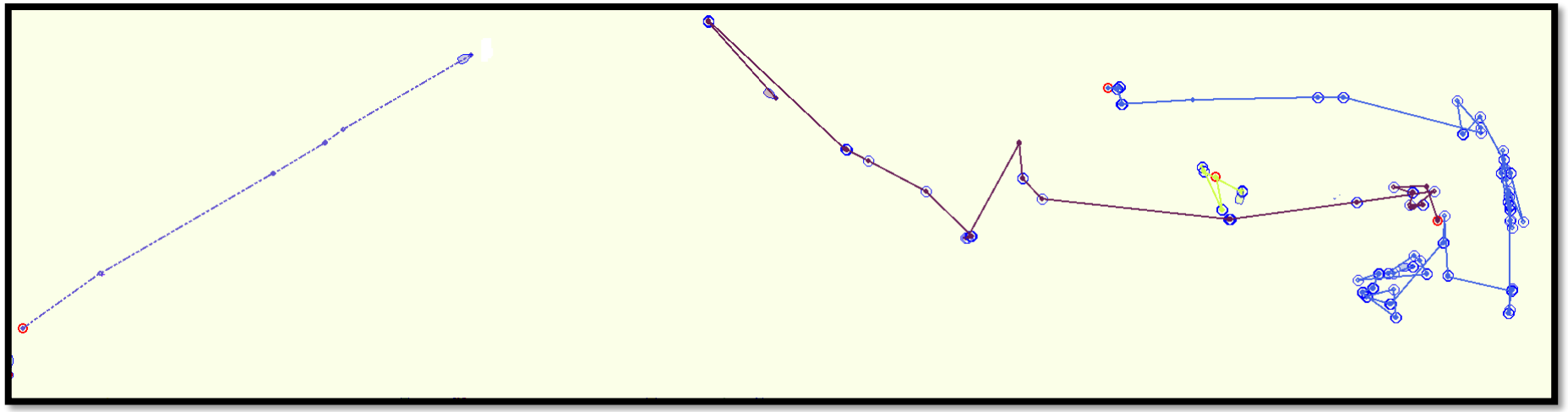
2. **Unsupervised learning**

   algorithms take a set of data that contains only inputs, and find structure in the data, like grouping or clustering of data points. The algorithms, therefore, learn from test data that has not been labeled, classified or categorized.

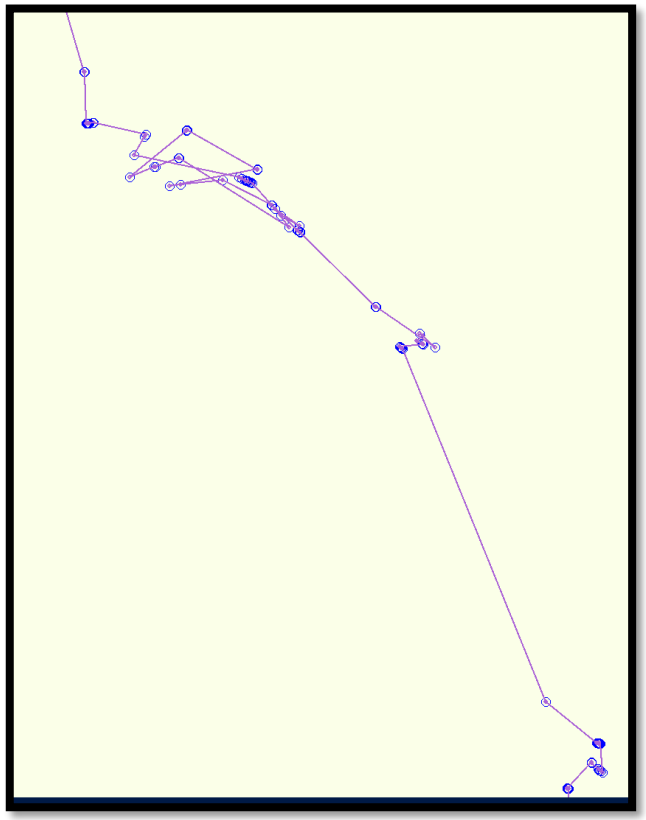
Fishing Anomaly Detection

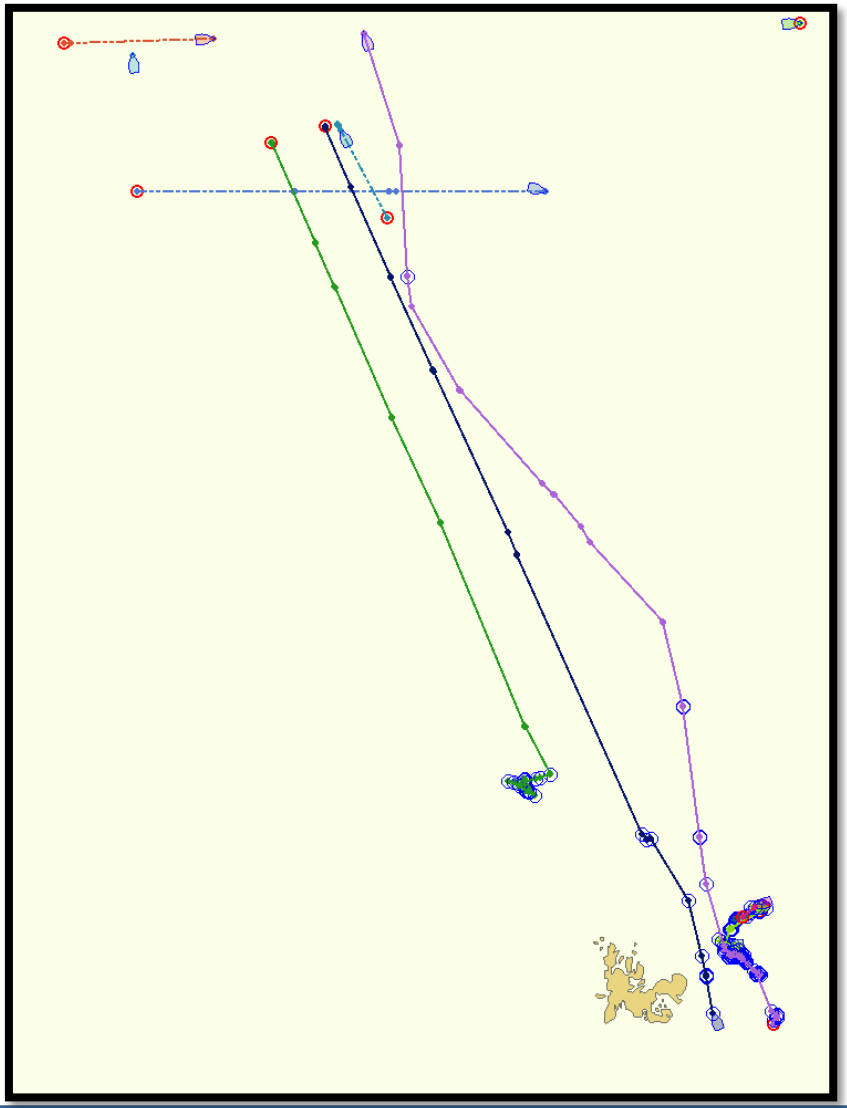
Aim: To detect Fishing Tracks that are not Fishing in AOI

1. Using Logistic Regression model from Global Fishing Watch of movement of fishing vessel while it is fishing.
2. The Model following vessel derived features for various time windows:
   a) Average speed
   b) Speed Standard deviation
   c) Course Standard deviation



Unknown Vessel Classification



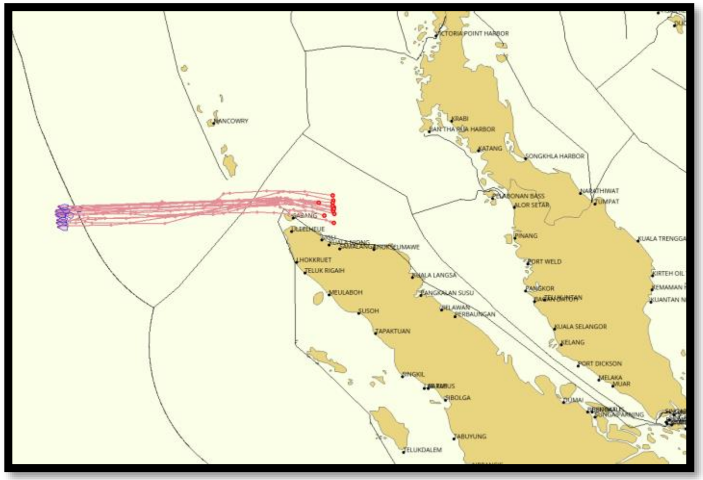


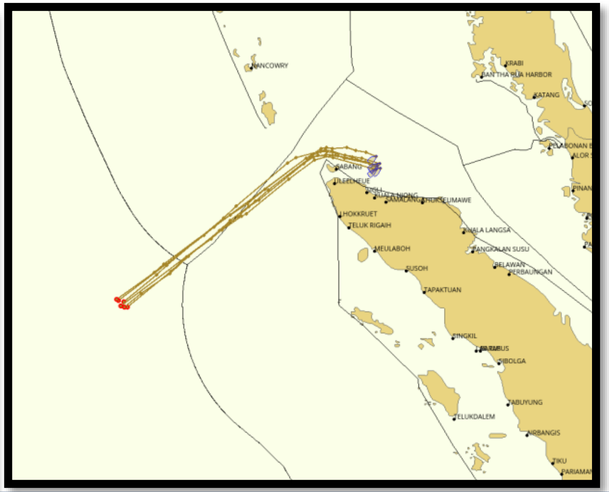
Track Movement Anomaly Detection

Aim: To detect Tracks not following Movement Pattern in AOI

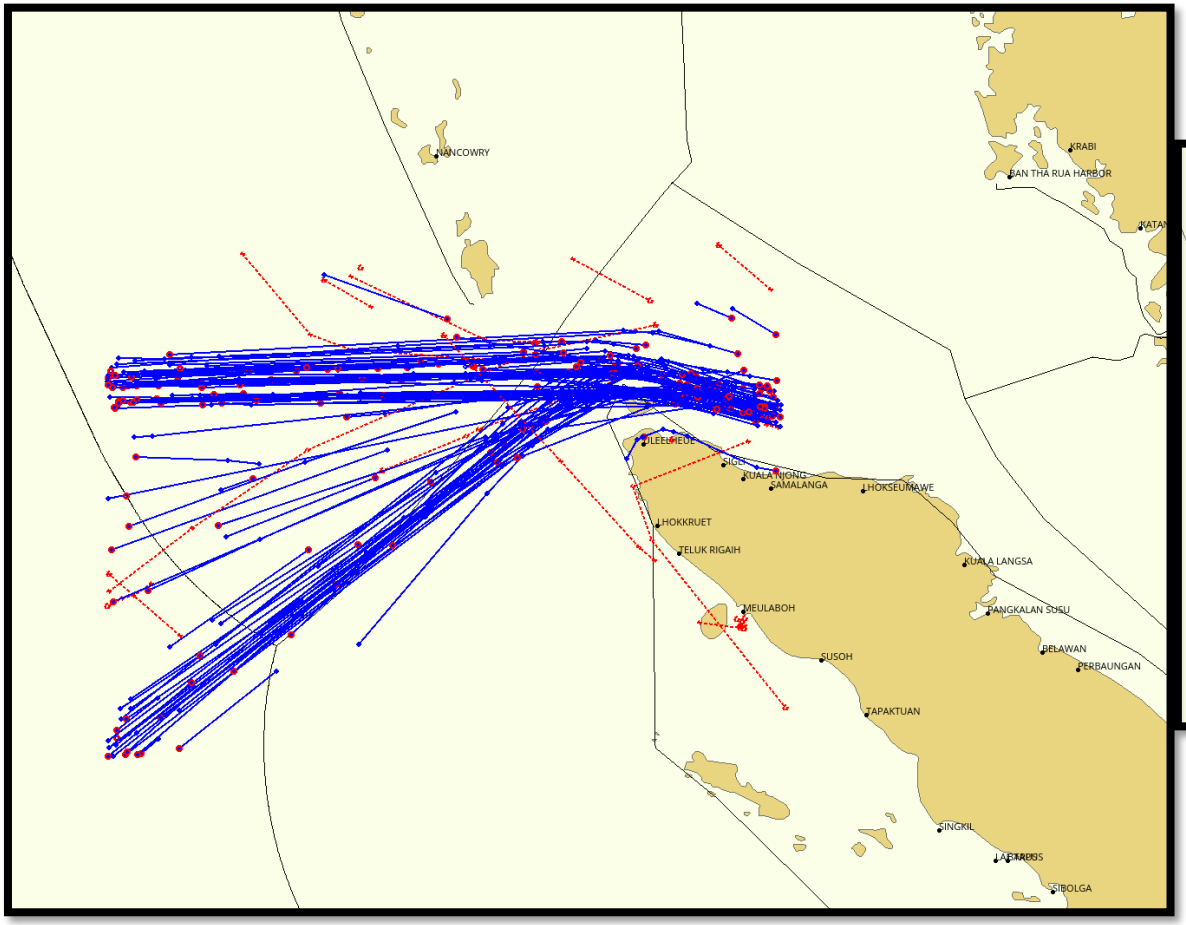
1. Find Normalcy model for track movement in AOI
   a) Find set of trajectory clusters in a AOI
2. Associate a track trajectory with all valid trajectory clusters
3. Show un-associated tracks as Anomalous Tracks

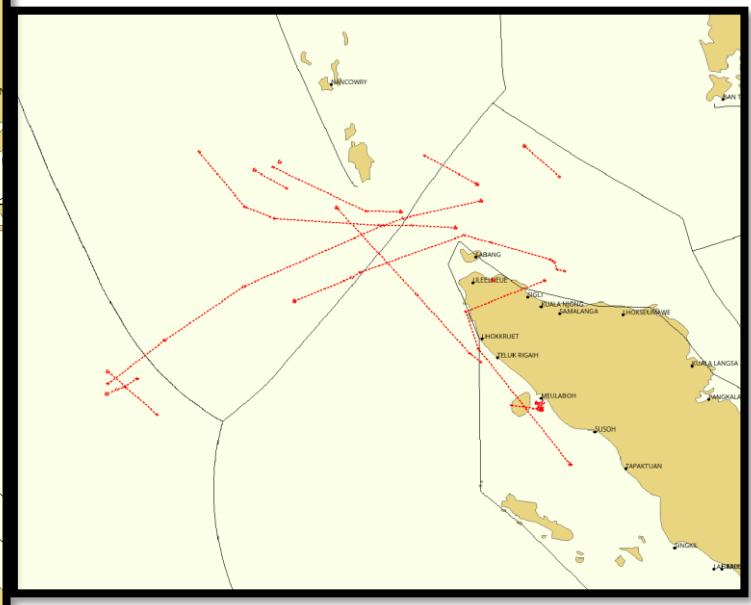
Movement Pattern Extraction near Malacca Strait



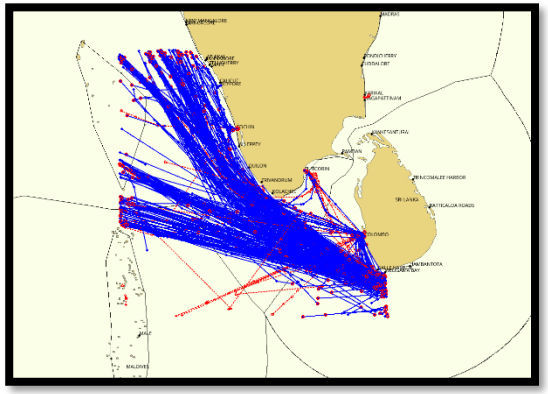
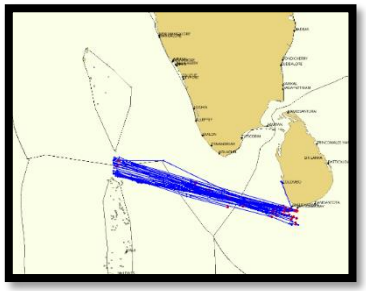
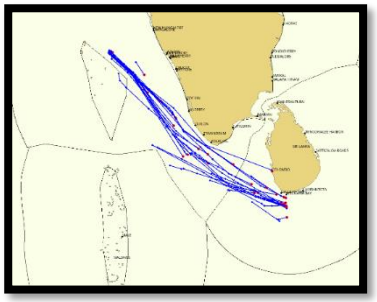
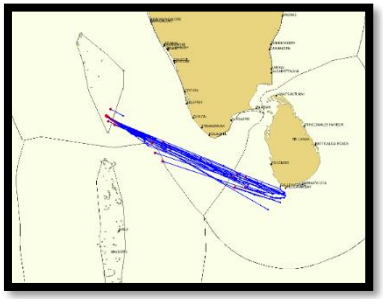
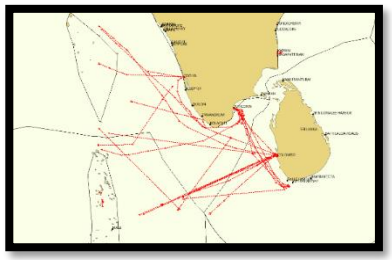
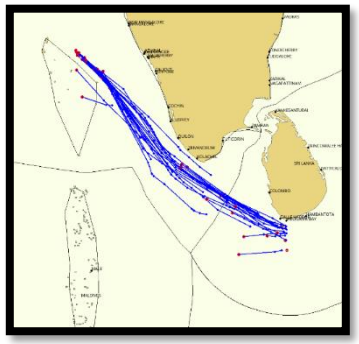
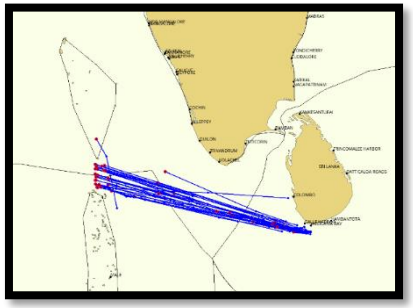
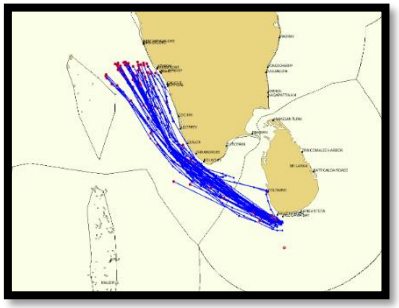


Abnormal Movement Detection





Movement Analysis : Prediction of Next Port Call

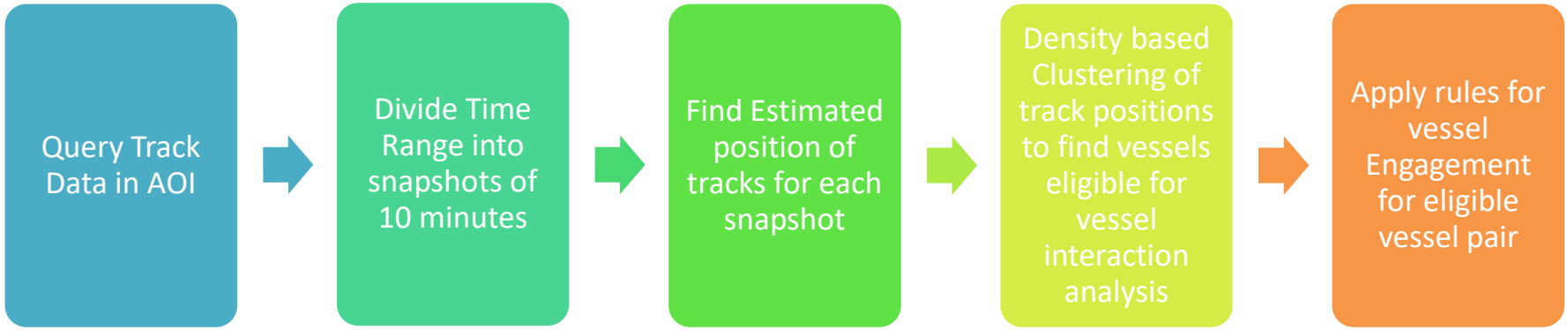









Associated Track To Route → Get The Port of Call Of Tracks Following the Route Historically → Select the Port of Call with Maximum instances

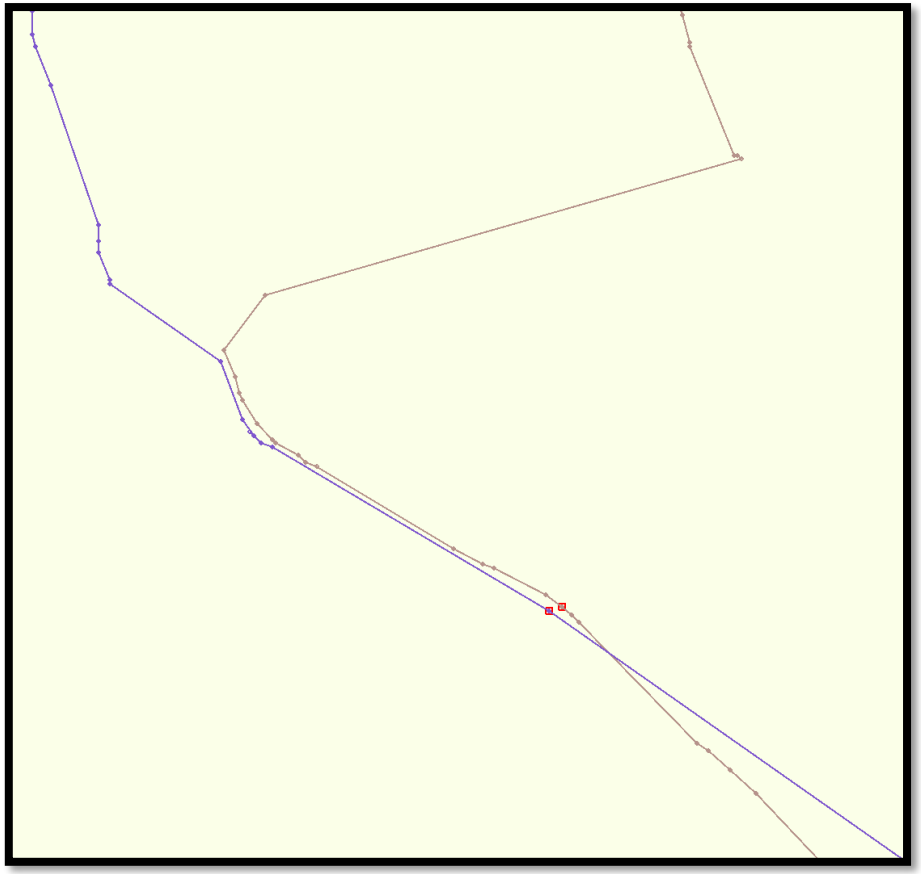
Vessel Engagement Analysis

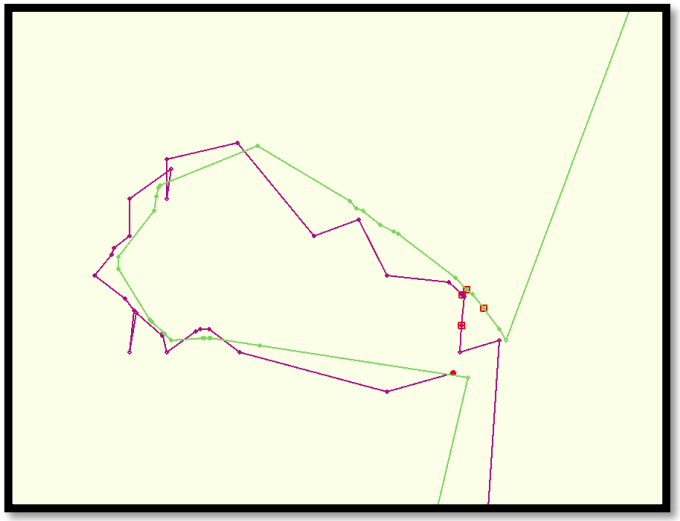
Aim: To detect Vessel Engagements in AOI

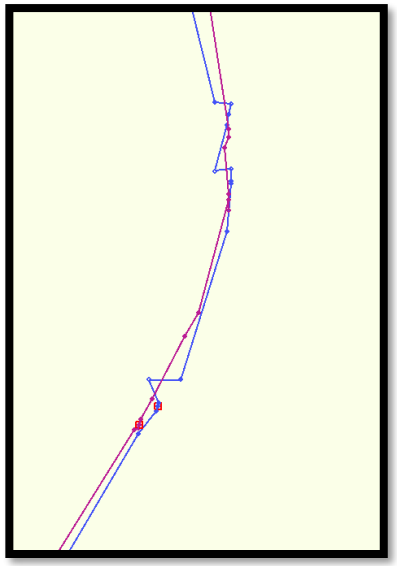
1. Rules for vessel engagement
   a) Distance between vessels < 250 meters
   b) Moving with slow speed < 5 Knots
   c) Course should be converging



Vessel Engagement Analysis



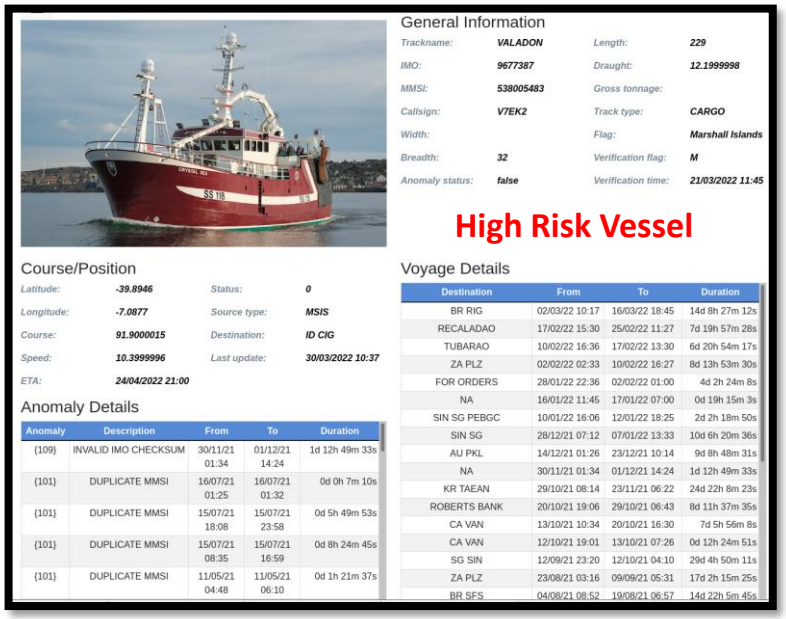




Ship Risk Profiling(SRP)

DSS system will calculate SRP Based on Customized algorithm

i. Ports Call History
ii. User defined scenarios/rules
iii. Anomalies detected by system
iv. Type of ship
v. Flag and change of flag
vi. Detentions



General Information

Trackname:	VALADON	Length:	229
IMO:	9677387	Draught:	12.1999998
MMSI:	538005483	Gross tonnage:	
Callsign:	V7EK2	Track type:	CARGO
Width:		Flag:	Marshall Islands
Breadth:	32	Verification flag:	M
Anomaly status:	false	Verification time:	21/03/2022 11:45

High Risk Vessel

Course/Position

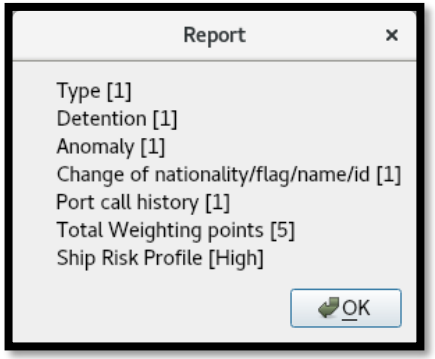
Latitude:	-39.8946	Status:	0
Longitude:	-7.0877	Source type:	MSIS
Course:	91.9000015	Destination:	ID CIG
Speed:	10.3999996	Last update:	30/03/2022 10:37
ETA:	24/04/2022 21:00		

Anomaly Details

Anomaly	Description	From	To	Duration
{109}	INVALID IMO CHECKSUM	30/11/21 01:34	01/12/21 14:24	1d 12h 49m 33s
{101}	DUPLICATE MMSI	16/07/21 01:25	16/07/21 01:32	0d 0h 7m 10s
{101}	DUPLICATE MMSI	15/07/21 18:08	15/07/21 23:58	0d 5h 49m 53s
{101}	DUPLICATE MMSI	15/07/21 08:35	15/07/21 16:59	0d 8h 24m 45s
{101}	DUPLICATE MMSI	11/05/21 04:48	11/05/21 06:10	0d 1h 21m 37s

Voyage Details

Destination	From	To	Duration
BR RIG	02/03/22 10:17	16/03/22 18:45	14d 8h 27m 12s
RECALADAO	17/02/22 15:30	25/02/22 11:27	7d 19h 57m 28s
TUBARAO	10/02/22 16:36	17/02/22 13:30	6d 20h 54m 17s
ZA PLZ	02/02/22 02:33	10/02/22 16:27	8d 13h 53m 30s
FOR ORDERS	28/01/22 22:36	02/02/22 01:00	4d 2h 24m 8s
NA	16/01/22 11:45	17/01/22 07:00	0d 19h 15m 3s
SIN SG PEBGC	10/01/22 16:06	12/01/22 18:25	2d 2h 18m 50s
SIN SG	28/12/21 07:12	07/01/22 13:33	10d 6h 20m 36s
AU PKL	14/12/21 01:26	23/12/21 10:14	9d 8h 48m 31s
NA	30/11/21 01:34	01/12/21 14:24	1d 12h 49m 33s
KR TAEAN	29/10/21 08:14	23/11/21 06:22	24d 22h 8m 23s
ROBERTS BANK	20/10/21 19:06	29/10/21 06:43	8d 11h 37m 35s
CA VAN	13/10/21 10:34	20/10/21 16:30	7d 5h 56m 8s
CA VAN	12/10/21 19:01	13/10/21 07:26	0d 12h 24m 51s
SG SIN	12/09/21 23:20	12/10/21 04:10	29d 4h 50m 11s
ZA PLZ	23/08/21 03:16	09/09/21 05:31	17d 2h 15m 25s
BR SFS	04/08/21 08:52	19/08/21 06:57	14d 22h 5m 45s



UAV Video Stream Ship Detection and Feature Extraction

THANK YOU