Grand Challenge Information Sheet

PS-09- AI tools for Maritime Domain Awareness

Problem Statement-An automated solution to undertake the following: -

1. Vessel detection on medium resolution of satellite imagery in open sea
2. Correct estimation of Length, Width and Heading of the detected ships
3. Classification of these detections into commercial vessels, vessels of interest based and other classes based on a training dataset developed in consultation with user.
4. Correlation of these detections with the following data sets: -
    (a) Automatic Identification System (AIS) data
    (b) RF Geolocation data
    (c) Other time-series data sets provided in the form of ‘csv’ or ‘postgres’ data base
5. Vessel path interpolation/prediction in open sea based on past data and current geography

Outcomes

1. **Stage-1**
    A complete end to end dockerized solution which includes implementation of the following: -

    (a) Data pipeline
    (b) Reading data-files in formats defined in datasets section.
    (c) Pre-processing as required.
    (d) ML/DL inferencing model for ship detection in EO and SAR images
    (e) Algorithms for correlation between ship detections and AIS data
    (f) Algorithms for path interpolation- For sparse AIS points interpolating the intermediate points.
    (g) Output in formats defined in evaluation section.

2. **Stage-2-** Exact details will be updated prior to beginning of this stage. The solution would broadly have to focus on the following (including Planetscope data): -
    (a) Ship Detection
    (b) Classification of vessels as per pre-defined classes
    (c) Correlation with AIS
    (d) Path interpolation
    (e) Path prediction

3. **Stage-3-**Exact details will be updated prior to beginning of this stage. The solution would broadly have to focus on the following on internal datasets : -
    (a) Ship Detection
    (b) Classification of vessels as per pre-defined classes
    (c) Correlation with AIS and other spatio-temporal datasets
    (d) Path interpolation
    (e) Path prediction within 2 knots of speed and 5 deg of course
    (f) Use historical data for providing more insights

Datasets

1. **Training Dataset**. Datasets in table below can be referred for training purpose.

Sl. No.	**Stage**	**Type of Dataset**	**Dataset**	**Formats**	**Data and annotation Links**	**Remarks**
1.	Stage-1	OpenSource	Sentinel EO	Zip having all the bands in JP2	browser.dataspace.copernicus.eu zenodo.org/records/10046342 github.com/allenai/vessel-detection-sentinels	Sample AIS data pasted in Appendix-A
2.			Sentinel SAR	Zip having all the bands in tiff	browser.dataspace.copernicus.eu	

					http://iuu.xview.us	
3.			MarineCadastre AIS	csv	hub.marinecadastre.gov/pages/vesseltraffic	
4.	Stage-2	OpenSource	Sentinel EO	Zip having all the bands in JP2	browser.dataspace.copernicus.eu zenodo.org/records/10046342 github.com/allenai/vessel-detection-sentinels	These might get updated later.
5.			Sentinel SAR	Zip having all the bands in tiff	browser.dataspace.copernicus.eu	
6.			MarineCadestre AIS	csv	hub.marinecadastre.gov/pages/vesseltraffic	
7.			Planet		zenodo.org/records/14926693	
8.	Stage-3	Internal	Internal datasets	Formats similar to open source datasets in Stage-I and Stage-II However the datasets could be of different size and resolution and environmental conditions.		

**Disclaimer-While using the open-source datasets in Stage-I and Stage-II, the teams must follow the terms and conditions mentioned in the respective websites for usage of datasets.

Procedures and Guidelines

1. **Modeling guidelines-** These are suggestions which can be followed but not necessary: -

(a) Pre-processing with environmental and sensor aspects along with cloud masking will help greatly in achieving desired accuracy in the ML/DL models.
(b) Multiple models can be developed for better working with highly varying datasets (based on sensors, environment conditions etc). However, in case of Multiple models, end product must be generated incorporating all the models in automated way on any test data.
(c) The final solution should have no dependency on the internet i.e. we are looking for offline solution.

2. Mock Test Datasets

(a) Mock Test Datasets (3 mocks) similar to the Evaluation Datasets indicated at Para 3 below will be shared with the participants at 10:00 AM IST on following dates: -

Sl. No.	Type	Dates (2025)
1.	Mock test data	Sept. 18, Oct 9, Oct 16

(b) The Mock Test is for self-evaluation by the participants and procedure for submission by the participants and evaluation by the organizers would be same as indicated in the online evaluation procedure indicated at Para 4 below.
(c) Results submitted by the participants will be tested against reference annotations held with the organizers and feedback indicating team's performance in terms of percentile of overall submissions will be shared.
(d) Reports/feedbacks will be shared within a week of corresponding submission.

3. Shortlisting and Holdout Datasets in Stage -1 – Evaluation datasets (.zip file with satellite imagery (all bands in tiff/jp2 format) & AIS) for online evaluation (shortlisting datasets) and offline evaluation (holdout dataset) will have the data-points with following characteristics: -

(a) Similar to the training datasets referred in the table above .
(b) Imagery including Sentinel EO and SAR
(c) Locations would include open sea, near shore etc.
(d) Environmental conditions including cloudy, hazy, clean and clear sunny etc would be included
(e) Land-masking will be used as "detections in open-sea" is the primary objective. Detections towards land from land-mask boundary will not be considered. (land-mask boundary can be accessed via link pasted in Appendix-A)

(f) AIS data will include 2D point cloud and sparse paths with complex movements of ship near shore and in open-sea.
(g) The datasets will have following:-,

i. Sentinel EO Images for ship detection-10
ii. Sentinel SAR Images for ship detection-10
iii. EO/SAR Images (from within the above 20) and AIS for correlation - 5
iv. 10 Sparse paths based on AIS for interpolation, which will include complex ship path, near shore and in open-sea

4. Online Evaluation Procedure for Stage-I (on shortlisting datasets)

(a) Reference to the imageries along with reference to AIS for online evaluation (shortlisting datasets) will be shared with the participants at 10:00 AM IST on following dates: -

Sl. No.	Type	Dates (2025)
1.	Shortlisting dataset	Oct 30, Nov 04

(b) For AIS data interpolation, data will be shared during the same period as indicated above.
(c) Solutions are expected to be submitted within 24 hours of data being available.
(d) Participants need to run their detection code/models, correlation algorithms &interpolation algorithms and need to submit the results in the specified format which are indicated in Appendix 'B'.
(e) Each submission should be named and dated properly (YYYY_MM_DD_<STARTUP_NAME>_<FILE_NAME>)
(f) Submission with overlapping bounding boxes (detections) in an image will not be considered for evaluation.
(g) Scores will be computed based on the Model evaluation metrics indicated below,

Sl. No.	**Stage**	**Data**	**Objectives**	**Evaluation Metrics**	**% Weight**	**Remarks**
1.	Stage-1	Imagery	Vessel Detection	AP	50	Sample implementations are pasted in appendix-C
2.		Imagery+AIS	AIS correlation	F-1 Score	30	
3.		AIS	Path Interpolation	RMSE	20	

(a) Results submitted by the participants will be tested against reference annotations held with the organizers and feedback indicating team's performance in terms of percentile of overall submissions will be shared.
(h) Average score of both submissions against the shortlisting datasets will be used for final ranking and shortlisting.
(i) Based on performance top 15 to 20 participants will be called for offline evaluation. The number may vary based on the overall performance at the discretion of the Jury for this Problem Statement.

5. Offline solution evaluation after Stage-1 deadline (on holdout datasets)

(a) Selected participants will be asked to demonstrate their codes and overall capability offline at IIT Delhi.
(b) Participants have to get a dockerised solution for the offline evaluation.
(c) Participants will be allotted the slots in which they need to run their codes/models on holdout dataset provided by the organizers on organizer's resources with following specifications: -

1. OS – Ubuntu 24.04 LTS
2. CPU – 64 core
3. RAM – 512 GB
4. GPU - A-100, 80 GB
5. Solution Demo Duration: 02 Hours for each selected team

(d) Selected participants will also be asked to make a presentation on their methodology and capability for developing a comprehensive MDA solution.
(e) Based on the results from models demonstration and presentation final scores will be computed based on Evaluation Metrics indicated below: -

Sl. No.	Category	Criteria	Description	% Weight
1.	Model Evaluation	Activity-wise metrics (As mentioned in table with 2.(a).vii under "procedures and guidelines")	Score based on official metric on hidden hold-out data of organizer	75
2.	Code Quality	Quality of solution	Quality of proposed solution (Latency, reproducibility,	10

			readability, documentation, resource optimization)	
3.	Presentation Evaluation	Approach to solving the Problem Statement, capability and plan for future stages	Startup to provide a presentation covering the following aspects: - (a) Prior work, if any, and current approach (b) Existing tools/packages used or novel codes developed and reason for their selection. (c) Available capabilities and plan to develop overall solution for maritime domain awareness.	15

(f) At most top 6 teams will be selected based on final score for Stage-2

6. **Evaluation** Criteria for Stage-II and Stage-III would be similar as above. These would be released before the start of the respective stages.

7. **Sessions with Mentors\Experts**

(a) For Stage-1, the organisers plan to meet participants via online meet or email to resolve their doubts, if any. This provision will be made active from 15th Aug 2025 and details regarding interaction will be shared on this website. Kindly keep viewing this website regularly for updates on this.

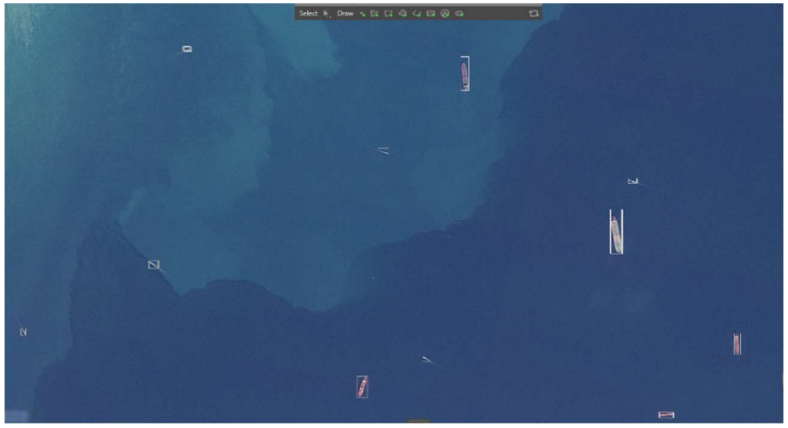
(b) There will be sessions with Mentors\Experts in Stage-2 and Stage-3 for the willing selected participants to help them in achieving the best solutions.

Appendix-A

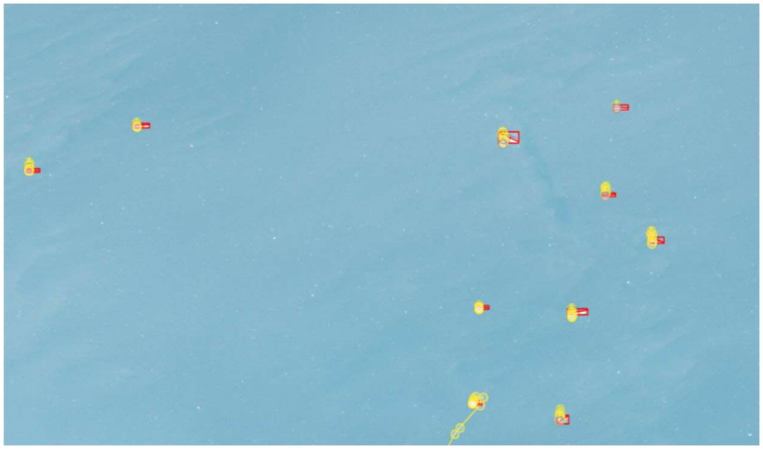
Dataset Samples

Sentinel EO

Vessel Detection in Sentinel EO



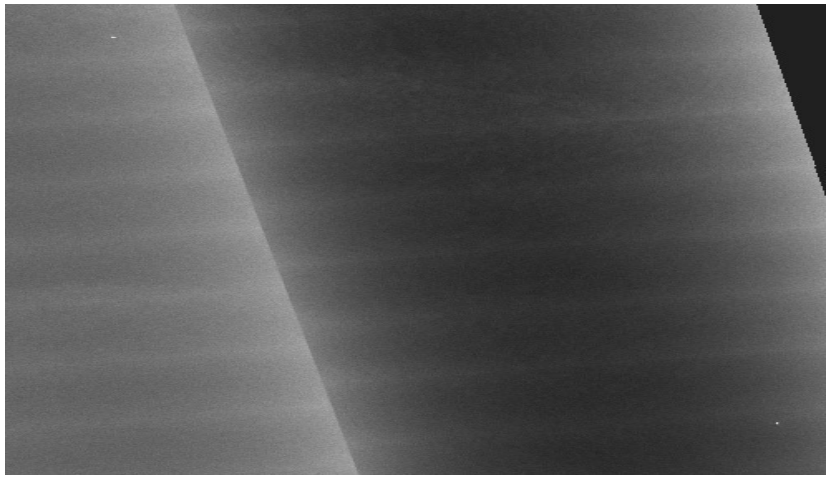
AIS points(yellow) plotted on Sentinel EO imagery



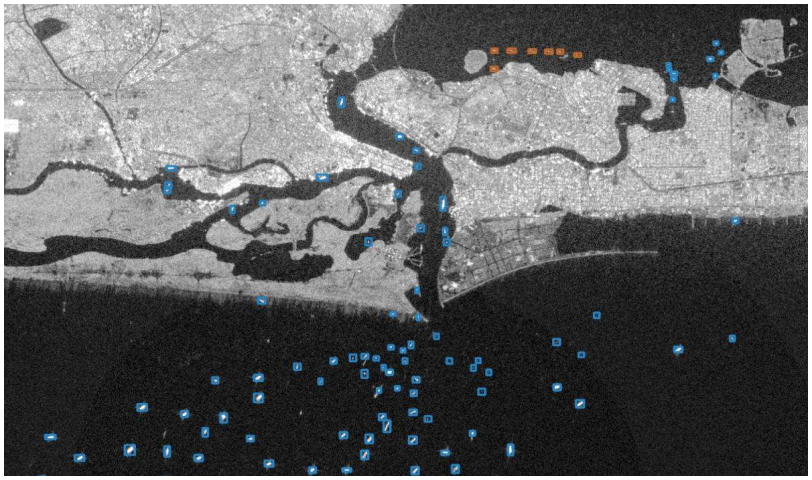
Correlation (Ship - Detected in image and AIS)

Sentinel SAR

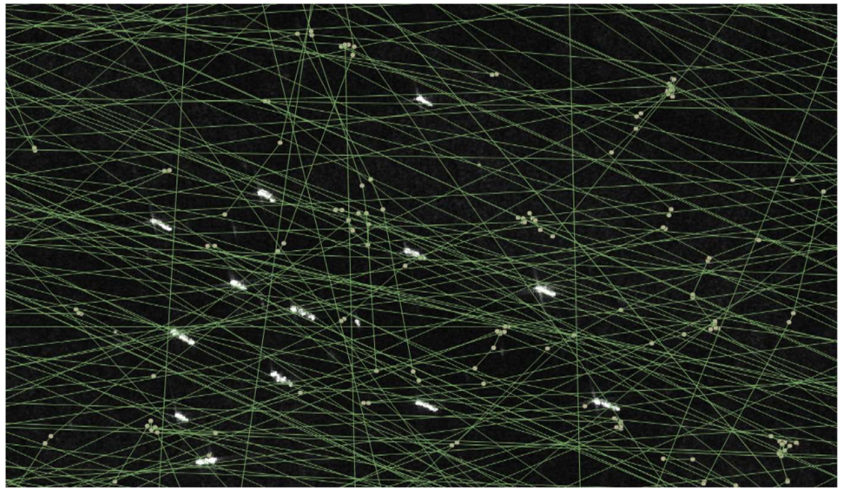
Vessel Detection on Sentinel SAR

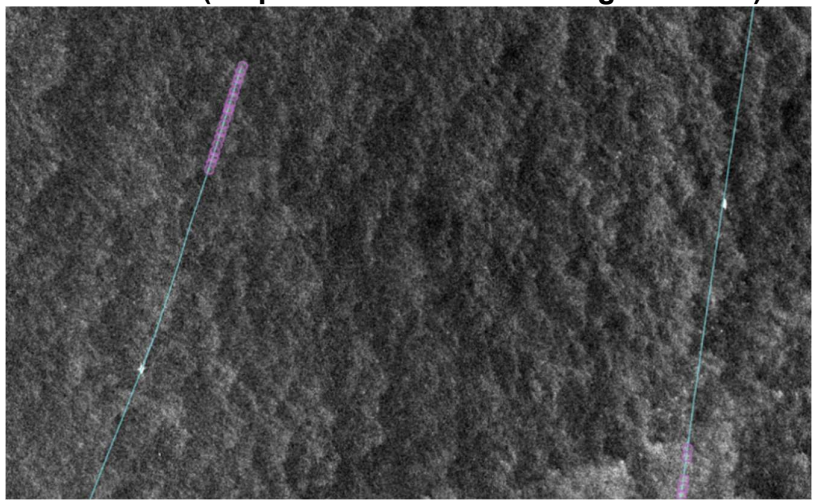


AIS Paths and Sentinel SAR image for correlation



Correlation (Ship - Detected in SAR image and AIS)





Land-masking boundaries

https://www.naturalearthdata.com/downloads/10m-physical-vectors/10m-coastline

Sample AIS data (Decoded data as available in Marine Cadastre website)

MMSI	BaseDateTime	LAT	LON	SOG	COG	Heading	VesselName	IMO	CallSign	VesselType	Status	Length	Width	Draft	Cargo	TransceiverClass
538004033	2024-12-03T15:57:07	28.90308	-94.24104	13.1	281.2	282	SEAWAYS SABINE	IMO9594755	V7UU6	80	0	274	48	9.3	89	A
642122013	2024-12-03T15:57:18	28.60945	-94.68967	10.4	58.9	62	MAETIGA	IMO9386861	5AWX	80	0	183	32	8.5	80	A
319017600	2024-12-03T15:57:07	28.6409	-94.98252	12	317.3	324	STOLT FLAMENCO	IMO9391995	ZGAH7	80	0	124	20	5.4	80	A
563074600	2024-12-03T15:57:41	28.92193	-94.59416	1.4	248.4	23	EAGLE BRASILIA	IMO9795062	9V5383	80	0	250	44	13.7	80	A
538004033	2024-12-03T15:58:15	28.90393	-94.24569	13.2	281.5	282	SEAWAYS SABINE	IMO9594755	V7UU6	80	0	274	48	9.3	89	A
403534000	2024-12-03T15:58:10	28.58915	-94.22925	0.1	178	92	RIMTHAN	IMO9779836	HZDV	80	1	333	60	21	80	A
241770000	2024-12-03T15:58:17	28.685	-94.65651	0.6	173.9	90	ATLANTIC	IMO9912139	SVDL8	30	1	274	48	9.2	80	A
538006343	2024-12-03T15:58:58	28.80017	-94.48704	0.4	21.3	67	STI SPIGA	IMO9708148	V7MB8	80	1	256	43	8.8	80	A
538006199	2024-12-03T15:57:09	28.69629	-94.74073	2.2	304.4	7	AMAX ANTHEM	IMO9472634	V7KZ4	80	0	249	44	13.3	80	A
538006199	2024-12-03T15:59:38	28.69717	-94.74226	2.4	301.4	5	AMAX ANTHEM	IMO9472634	V7KZ4	80	0	249	44	13.3	80	A
565949000	2024-12-03T15:59:04	28.54615	-94.25357	3.7	162	130	EAGLE KUANTAN	IMO9417012	9V8376	88	0	244	42	8.9	80	A
538002845	2024-12-03T15:58:59	28.71687	-93.94318	11.4	101	101	YASA GOLDEN DARDANEL	IMO9339985	V7ME9	80	0	246	42	13.6	80	A
538002845	2024-12-03T15:57:51	28.71763	-93.94725	11.4	101	101	YASA GOLDEN DARDANEL	IMO9339985	V7ME9	80	0	246	42	13.6	80	A
565949000	2024-12-03T16:00:04	28.54525	-94.25325	3.3	161.8	124	EAGLE KUANTAN	IMO9417012	9V8376	88	0	244	42	8.9	80	A
563074600	2024-12-03T15:58:51	28.92179	-94.59453	1.4	245.1	18	EAGLE BRASILIA	IMO9795062	9V5383	80	0	250	44	13.7	80	A
538004033	2024-12-03T15:59:17	28.90471	-94.25	13	281.5	282	SEAWAYS SABINE	IMO9594755	V7UU6	80	0	274	48	9.3	89	A
319017600	2024-12-03T15:59:28	28.6467	-94.98859	12	316.2	324	STOLT FLAMENCO	IMO9391995	ZGAH7	80	0	124	20	5.4	80	A
538002845	2024-12-03T15:59:59	28.71623	-93.93963	11.4	101	101	YASA GOLDEN DARDANEL	IMO9339985	V7ME9	80	0	246	42	13.6	80	A
642122013	2024-12-03T15:59:37	28.613	-94.68302	10.5	57.9	62	MAETIGA	IMO9386861	5AWX	80	0	183	32	8.5	80	A

Appendix-B

Submission formats

Detection

1. Submission should be in geoJSON.
2. This is an indicative example
3. Reference to “images” and corresponding “id” will be provided with test data update
4. There should be no overlapping bounding box (detections) for an image.
5. Qgis compatible Shapefile (.shp) for detections (one shapefile for each image) need to be submitted along with submission.

```
{
  "info": {
    "description": "Grand challenge MDA",
    "version": "1.0",
    "year": 2025,
    "predicted_by": <participant_name>
  },
  "licenses": [],
  "images": [
    {
      "id": 1,
      "file_name": "S2A_MSIL1C_20241203T165701_N0511_R026_T15RUM_20241203T185555.SAFE",
```

```
    "width": 10980,
    "height": 10980,
    "date_captured": "2024-12-03 18:55:55"
  }
],
"categories": [
  { "id": 1, "name": "ship"},
],
"annotations": [
  {
    "image_id": 1,
    "category_id": 1,
    "bbox": <POLYGON-1>,
    "score": 0.90,
    "id": 1},
  {
    "image_id": 1,
    "category_id": 1,
    "bbox": <POLYGON-2>,
    "score": 0.85,
```

"id": 2}]}

Where “PLOYGON-i” is a simple (Not oriented) rectangular bbox in terms of latitude and longitude.

Correlation – in csv

Sl. No.	image_name	timestamp	vessel_latitude*	vessel_longitude*	mmsi
1.					
2.					

*Latitude and Logitude is for the centroid of the bounding box

Interpolation – in csv

Sl. No.	timestamp	path_id	point_id	point_latitude	Point_longitude	Speed on Ground	Course on Ground
1.							
2.							

Appendix-C

Metrics

AP

General AP computation can be read on the following link:-

https://cocodataset.org/#detection-eval

F-1 Score

https://scikit-learn.org/stable/modules/generated/sklearn.metrics.f1_score.html

```
>>> import numpy as np
>>> from sklearn.metrics import f1_score
>>> y_true = [0, 1, 2, 0, 1, 2]
>>> y_pred = [0, 2, 1, 0, 0, 1]
>>> f1_score(y_true, y_pred, average='macro')
0.267
>>> f1_score(y_true, y_pred, average='micro')
0.33
>>> f1_score(y_true, y_pred, average='weighted')
0.267
>>> f1_score(y_true, y_pred, average=None)
array([0.8, 0. , 0. ])
```

```
>>> # binary classification
>>> y_true_empty = [0, 0, 0, 0, 0, 0]
>>> y_pred_empty = [0, 0, 0, 0, 0, 0]
>>> f1_score(y_true_empty, y_pred_empty)
0.0...
>>> f1_score(y_true_empty, y_pred_empty, zero_division=1.0)
1.0...
>>> f1_score(y_true_empty, y_pred_empty, zero_division=np.nan)
nan...
```

```
>>> # multilabel classification
>>> y_true = [[0, 0, 0], [1, 1, 1], [0, 1, 1]]
>>> y_pred = [[0, 0, 0], [1, 1, 1], [1, 1, 0]]
>>> f1_score(y_true, y_pred, average=None)
array([0.66666667, 1.        , 0.66666667])
```

RMSE

https://scikit-learn.org/stable/modules/generated/sklearn.metrics.root_mean_squared_error.html

```
>>> from sklearn.metrics import root_mean_squared_error
>>> y_true = [3, -0.5, 2, 7]
>>> y_pred = [2.5, 0.0, 2, 8]
>>> root_mean_squared_error(y_true, y_pred)
0.612...
>>> y_true = [[0.5, 1],[-1, 1],[7, -6]]
>>> y_pred = [[0, 2],[-1, 2],[8, -5]]
>>> root_mean_squared_error(y_true, y_pred)
0.822...
```