Maritime Insights: Space-based data and analytics

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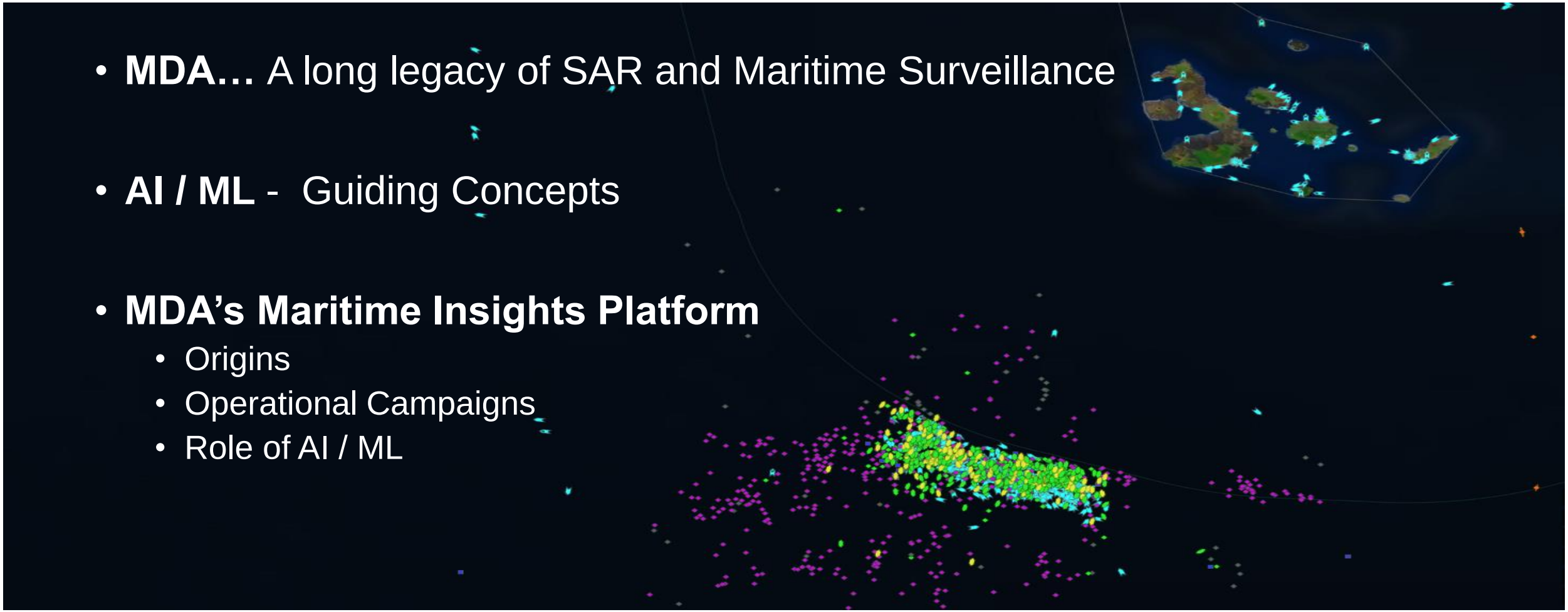
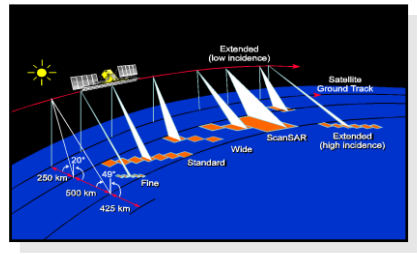
Outline

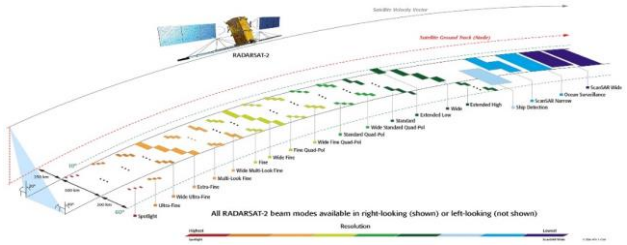


- **MDA…** A long legacy of SAR and Maritime Surveillance
- **AI / ML** - Guiding Concepts
- **MDA's Maritime Insights Platform**
  - Origins
  - Operational Campaigns
  - Role of AI / ML

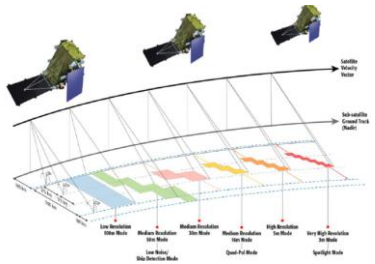
MDA's SAR Satellite Missions



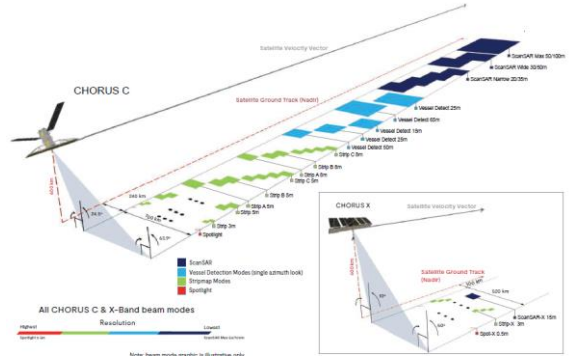
- **RADARSAT-1 (1995)**
  - Flawless performance over 17+ years
  - Set the standard for operational space-based radar
  - Resolution 10 – 100m, up to 500 km swath
  - **Key Applications**: Monitoring of Ice and Oceans



- **RADARSAT-2 (2007)**
  - Highly robust and operational SAR (1 Millionth image – Sept '22!)
  - Multi-polarization, Ship Detection modes
  - Resolution 1 – 100m, up to 525 km swath
  - **Key Applications**: Maritime monitoring (Ice, ships, oil)

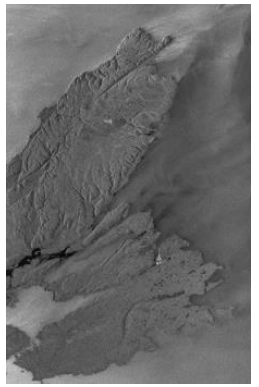


- **RADARSAT Constellation Mission – RCM (2019)**
  - Continuation of the radar program in Canada
  - Ship Detection Mode plus AIS onboard
  - Three satellite constellation
  - **Key Applications**: Maritime surveillance



- **4th Generation: CHORUS-C + -X**
  - Broad area coverage (700km) and high resolution
  - Inclined orbit for high repeat frequency (non-polar)
  - **Key Applications**: Maritime surveillance and GeoInt

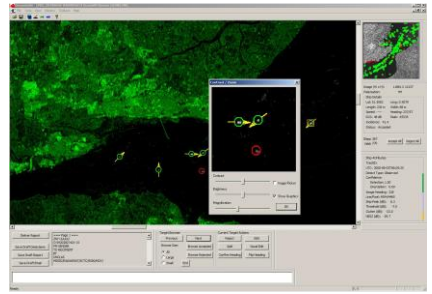
MDA's Maritime Legacy



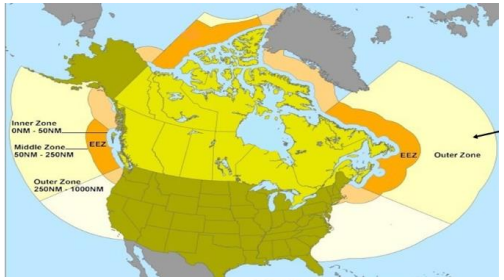
RADARSAT-1, first image

RADARSAT-2, 1 Millionth image

RADARSAT Program – 25+ Years Of Investment In The RADARSAT Missions And Developing Maritime Analytics



OceanSuite Development – Multi-source SAR-based vessel detection component developed for the Government of Canada



Polar Epsilon Program (1 / 2) – Government of Canada, Gold standard for space-base maritime surveillance, with <10 minute latency

NATO Triton – An integrated, robust, and flexible Maritime Command and Control (C2) System currently being rolled out to NATO Nations

The Role of AI and ML in EO (AI4EO)

Sharing the cognitive load

- Scaling the automation of repetitive and menial cognitive tasks

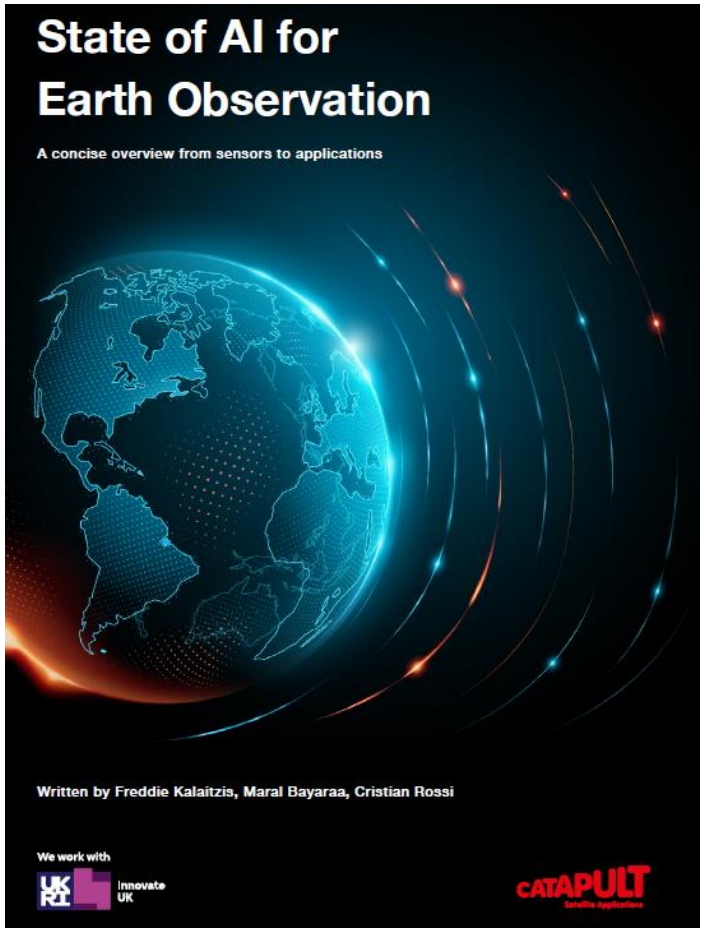
Defying complexity

- To overcome data complexities that defy human intuition

Complementing human intuition

- One cannot simply automate the production of actionable intelligence. A tenacity to discern cause from effect coupled with domain expertise, allows humans to ‘connect the dots’ in ways that are not yet reproducible by computers

<u>Keep these three themes in mind as we explore our Maritime Insights offering…</u>



https://sa.catapult.org.uk/wp-content/uploads/2022/09/State-of-AI-for-Earth-Observation.pdf

Background – Dark Vessel Detection (DVD) Program

- **Government of Canada** (multi-agency) lead, $15+ Million program with **MDA** as **Prime Contractor**, to detect vessels engaging in Illegal, Unreported, Unregulated (IUU) fishing, also known as “dark vessels”

- System integrates commercial **space-based** data layers and analytics to provide a comprehensive maritime picture to operational stakeholders

- MDA’s investment to commercialize the offering is **Maritime Insights**


To fight illegal fishing in the Galapagos, Ecuador turns to Canadian satellite and sensing technology

1 in 5 fish caught globally believed to be stolen

Chris Arsenault, Philippe Le Billon · CBC News · Posted: Jun 04, 2022 4:00 AM ET | Last Updated: June 4

Ecuadorian naval Capt. Ivan Bolanos Nava is on the front lines of protecting the Galapagos marine reserve, home to some of the world's greatest biodiversity. From illegal fishing, Ecuador's security forces are working with Canadian technology firms to fight back against environmental crimes. (Philippe Le Billon/CBC News)

DARKVESSEL DETECTION

MDA MARITIME INSIGHTS

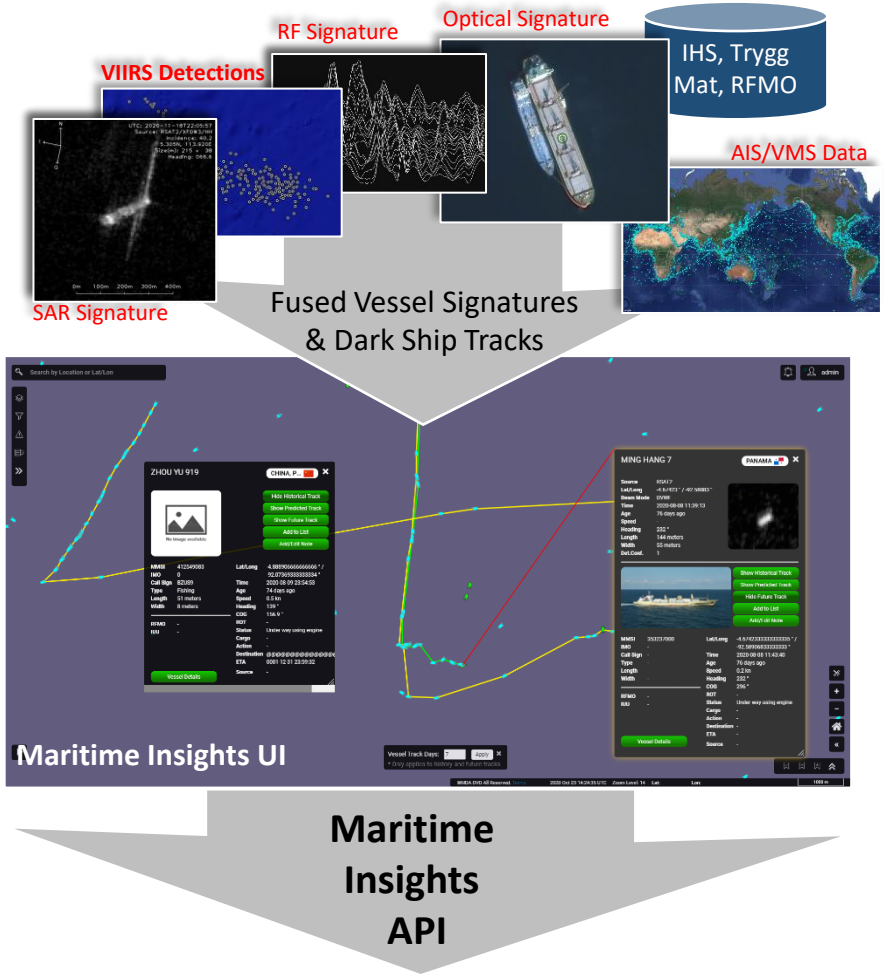
MDA Maritime Insights Platform Offering

What Is It: Cloud-Based Platform Accessible via UI/API For Combatting IUU Fishing, Narco-Trafficking, Smuggling, Crime and Supporting Defense Missions.

Target Audience: Intelligence, Navy, Coast Guard, Police, Border Security, Customs and Transport agencies.

The Value of MDA's Maritime Insights:

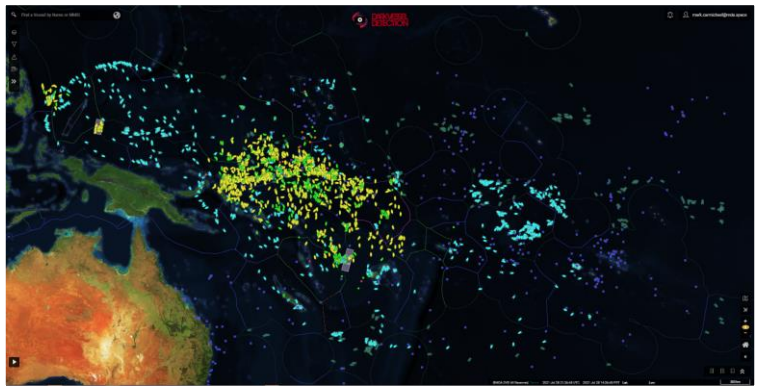
- **Detect, Classify, Identify and Track Vessels Using Multi-Source Data**
- **Automated Vessel Behaviors Alerting (e.g. Fishing, Spoofing, Rendezvous, etc)**
- **Create/Exploit Pattern of Life To Understand Past Behaviors and Detect Anomalies**
- **Capture and Compare Detected Vessels Against A Global Vessel Knowledge Base**



Current Operational Campaigns

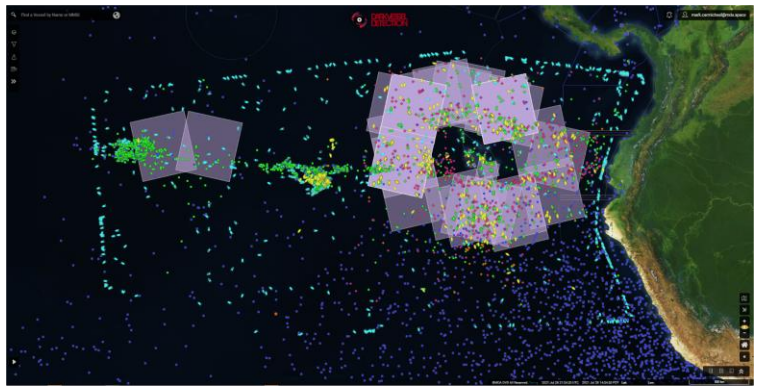
- The Government of Canada DVD Project Is Using MDA's Technology To Lead Operational Campaigns Fighting Illegal Fishing and Other Forms Of Maritime Crime

Pacific Islands FFA



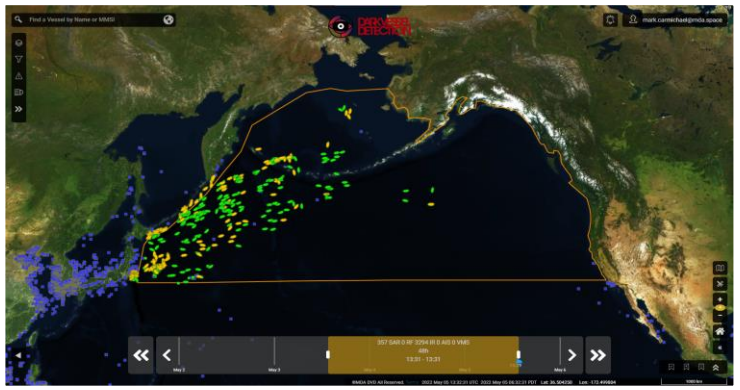
Missions
- **Counter IUU Fishing**
- **Counter Narcotics**
- **Coordinating Air & Sea Assets**

Ecuador Navy/Coast Guard



Missions
- **Counter IUU Fishing**
- **Counter Narcotics**
- **Monitoring Distant Water Fleet**

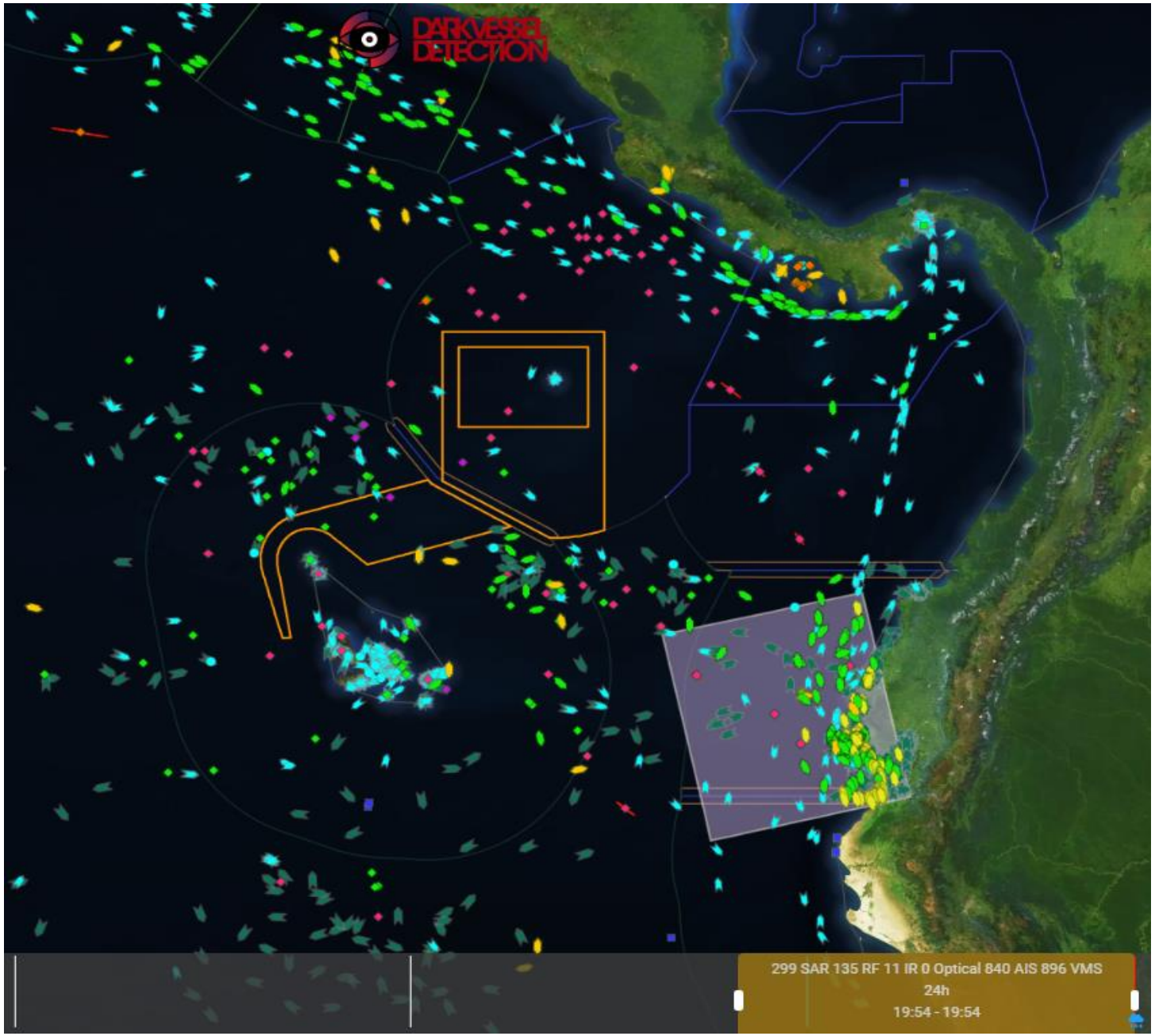
North Pacific Guard: MSOC



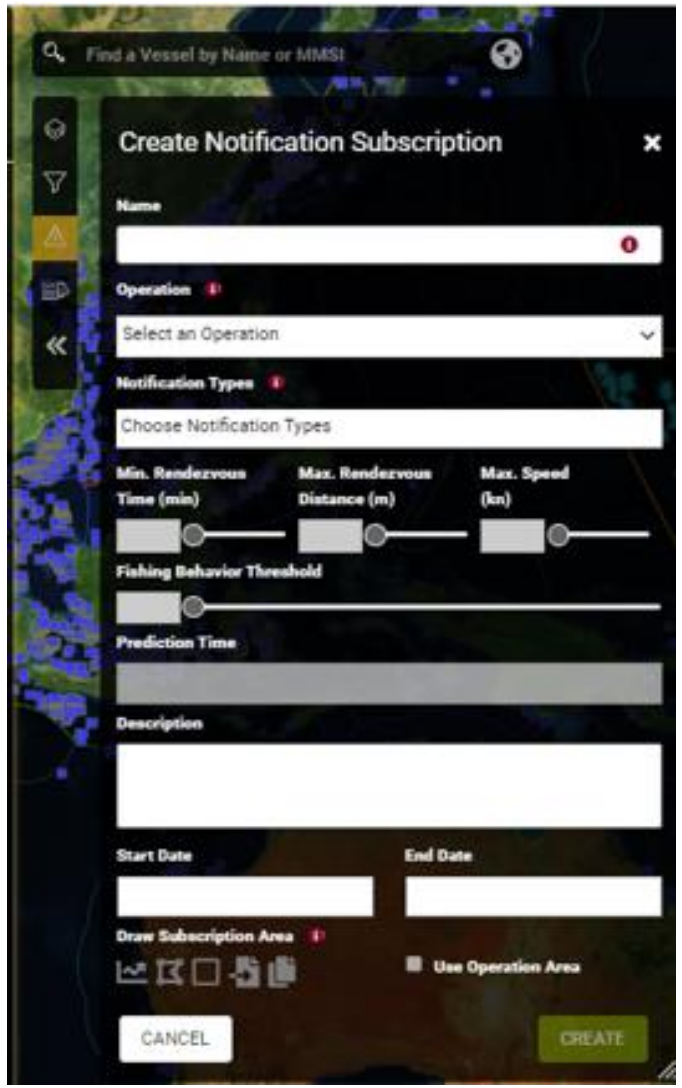
Missions
- **Tuna Fisheries Enforcement**
- **Counter Narcotics**
- **Sovereignty Monitoring**

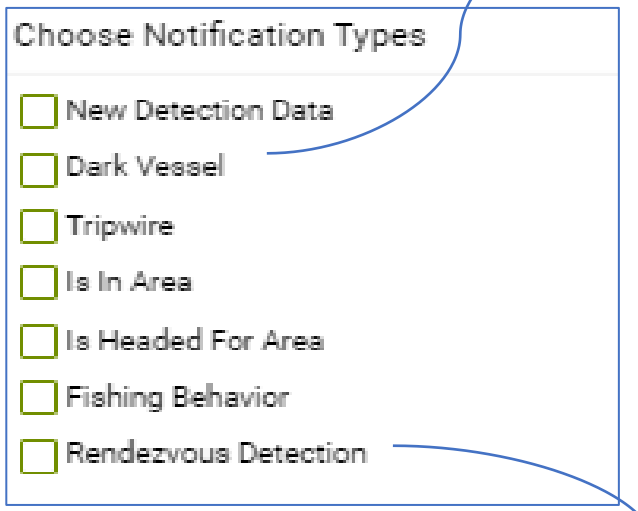
Sharing the Cognitive Load…

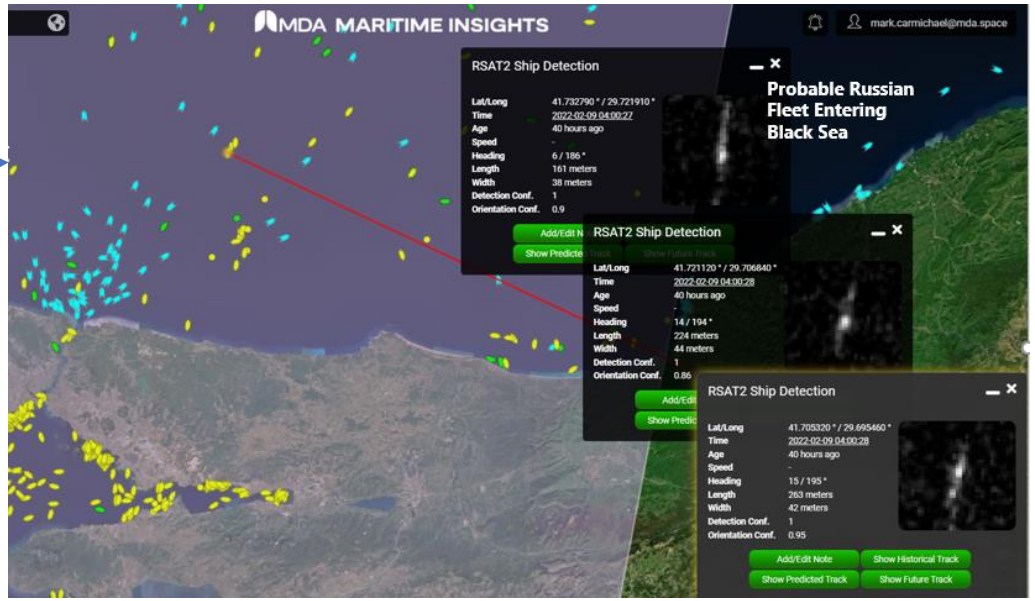
- The 24 hour picture for Ecuadorian EEZ and surrounding maritime area
- Data from ~100+ different satellites, thousands of different data points

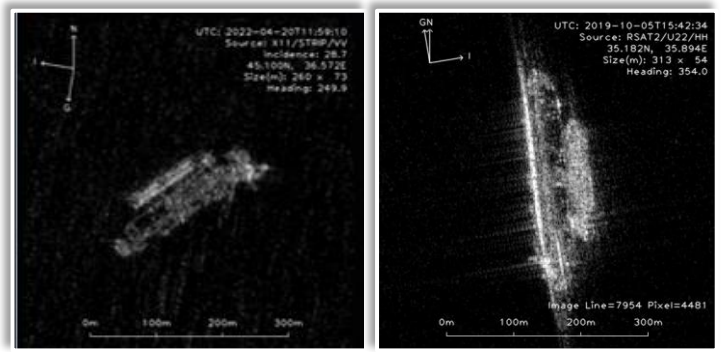


Cognitive Load – Shared!



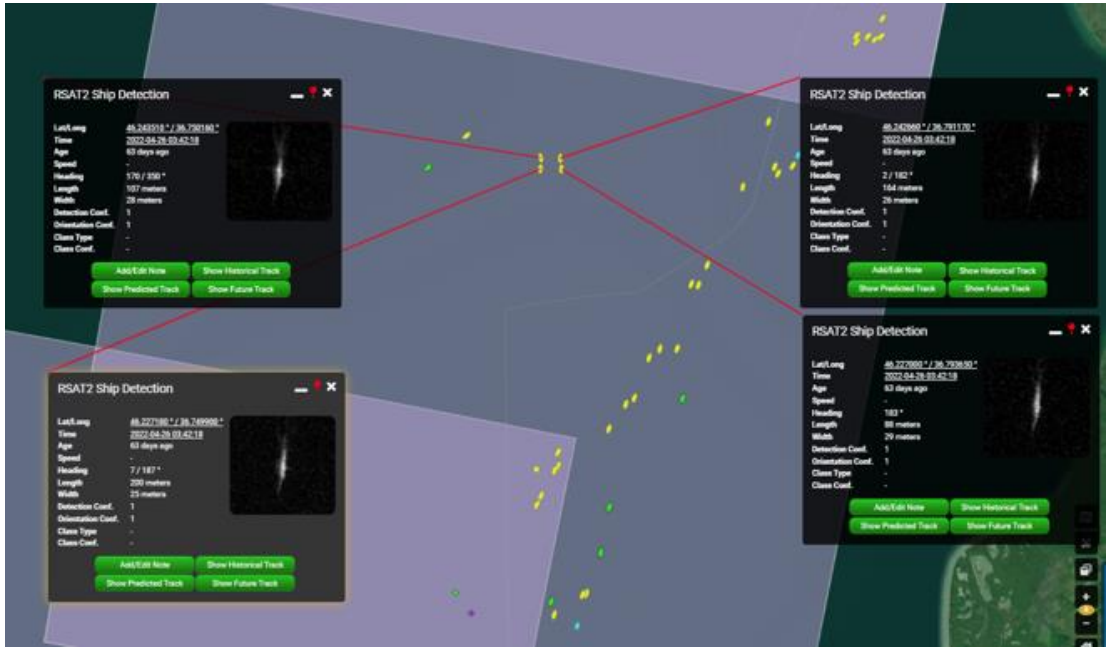






Defying Complexity – Advanced SAR Techniques

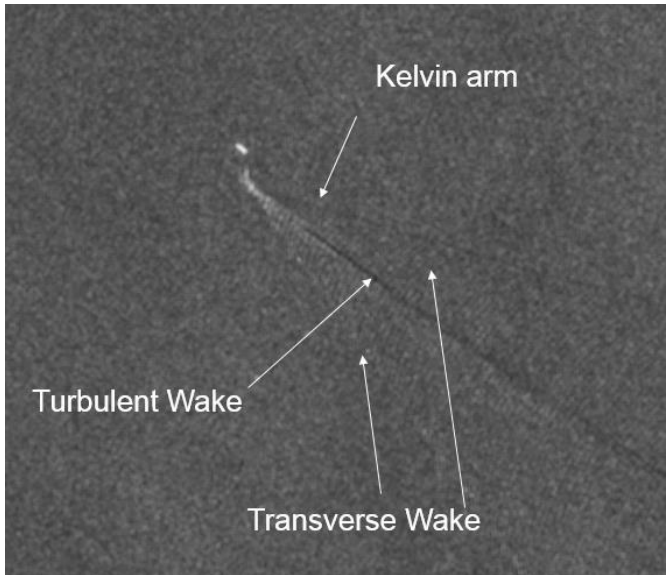
- Maritime Insights is leveraging key advancements in SAR data handling to augment the information provided operationally
- Two of these features are particularly important as they can provide significant inputs with respect to ‘dark’ targets from **SAR** Imagery:
  - **Vessel Velocity Estimation**
  - **Vessel Classification**

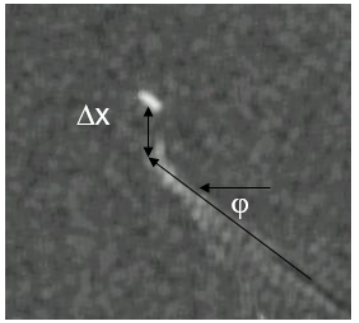


Many maritime areas / situations have large number of unidentified vessels
Sea of Azov, April 2022

Vessel Velocity Estimation – Traditional

- It is possible to estimate the speed of a vessel when the wake is clearly visible in a SAR image
- This is an effective and relative accurate approach**, <u>however</u>** wake visibility is highly variable:
  - Ship Characteristics (e.g., hull, propulsion, speed)
  - Environmental Conditions (wind speed/waves)
  - Sensor Parameters (polarization, incidence angle)





V_S ~ 7 km/s (exact value from data header)
Δx = 454 m (measure from image)
R = 880 km (function of incidence angle)
φ = 36° (measure from image)

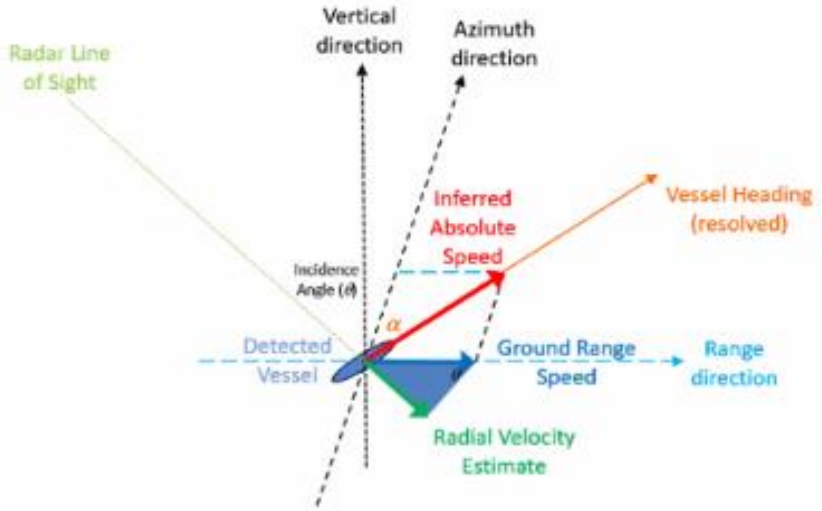
Vessel speed can be calculated by measuring the vessel displacement from the wake using the relationship,

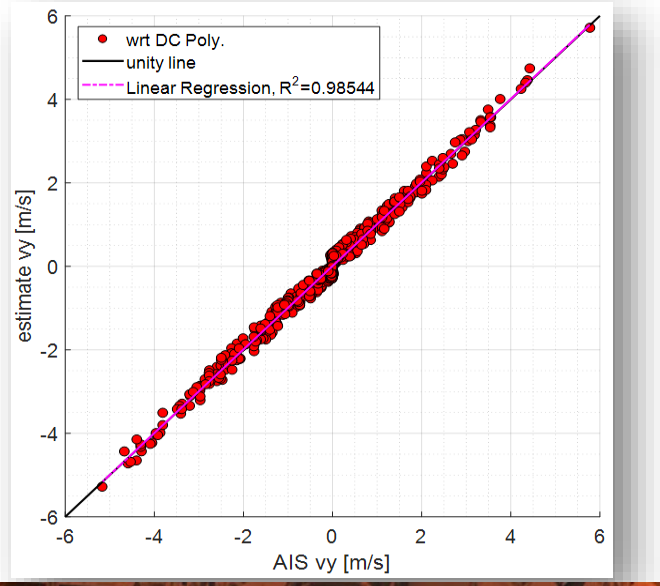
$$V_{ship} = V_S \Delta x / (R \cos(\varphi))$$

where V_{ship} is the ship velocity, V_S is the satellite orbit speed, Δx is ship displacement from its wake, R is the slant range, and φ is the angle between the ship velocity vector and the SAR look-direction.

Vessel Velocity Estimation – Advanced

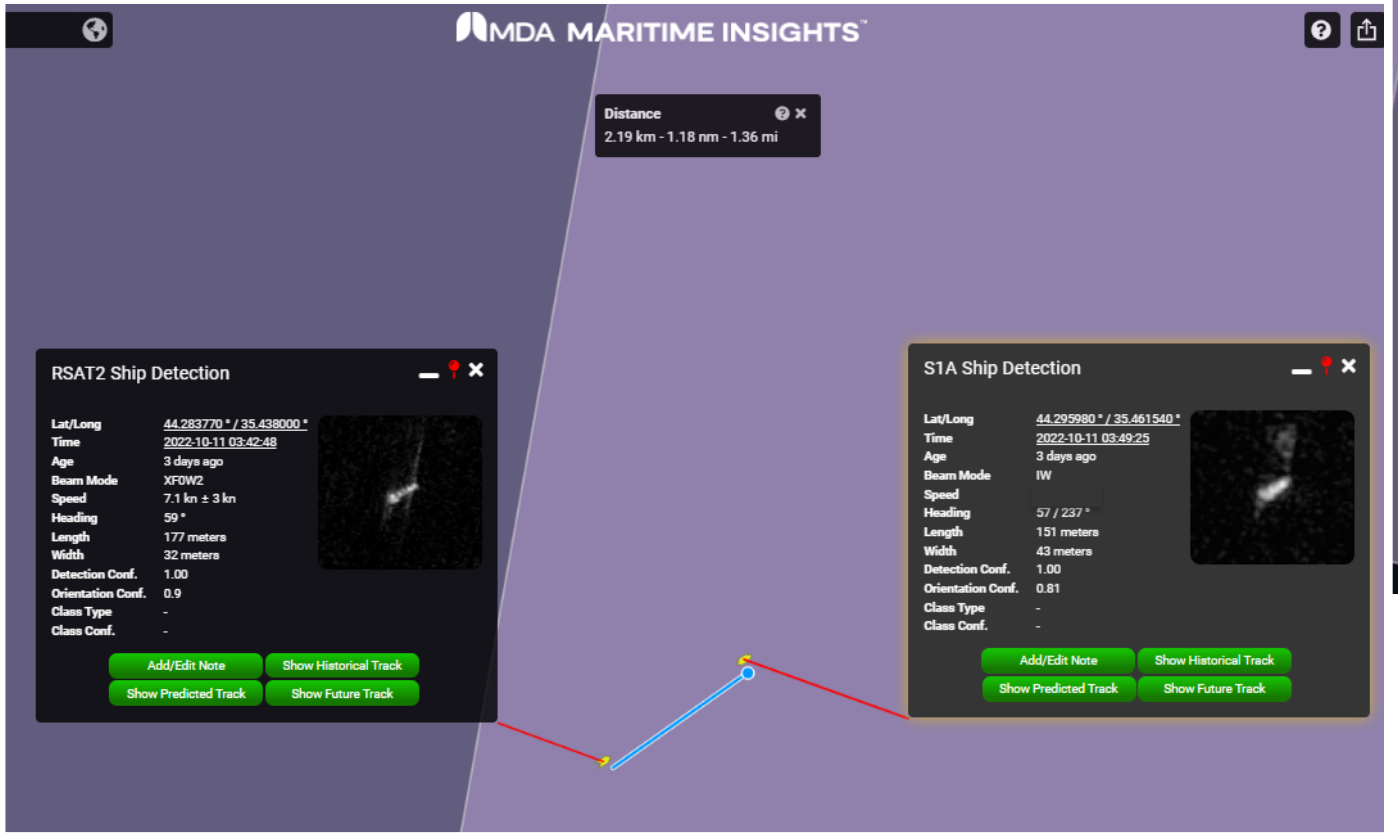
- Uses Doppler shift estimation of moving targets in single-channel Single Look Complex (SLC) RADARSAT-2 imagery
  - Allows for an accurate radial (line-of-sight) velocity estimation and accurate heading of vessels
  - Cannot estimate velocity for targets travelling in near azimuthal direction
- Very successful in RADARSAT-2 ExtraFine (XF) mode
  - Suitable for all single beam stripmap modes, including those on the RCM (not ScanSAR modes)
  - CHORUS-C will have VVE implanted on **all** modes, including ScanSAR

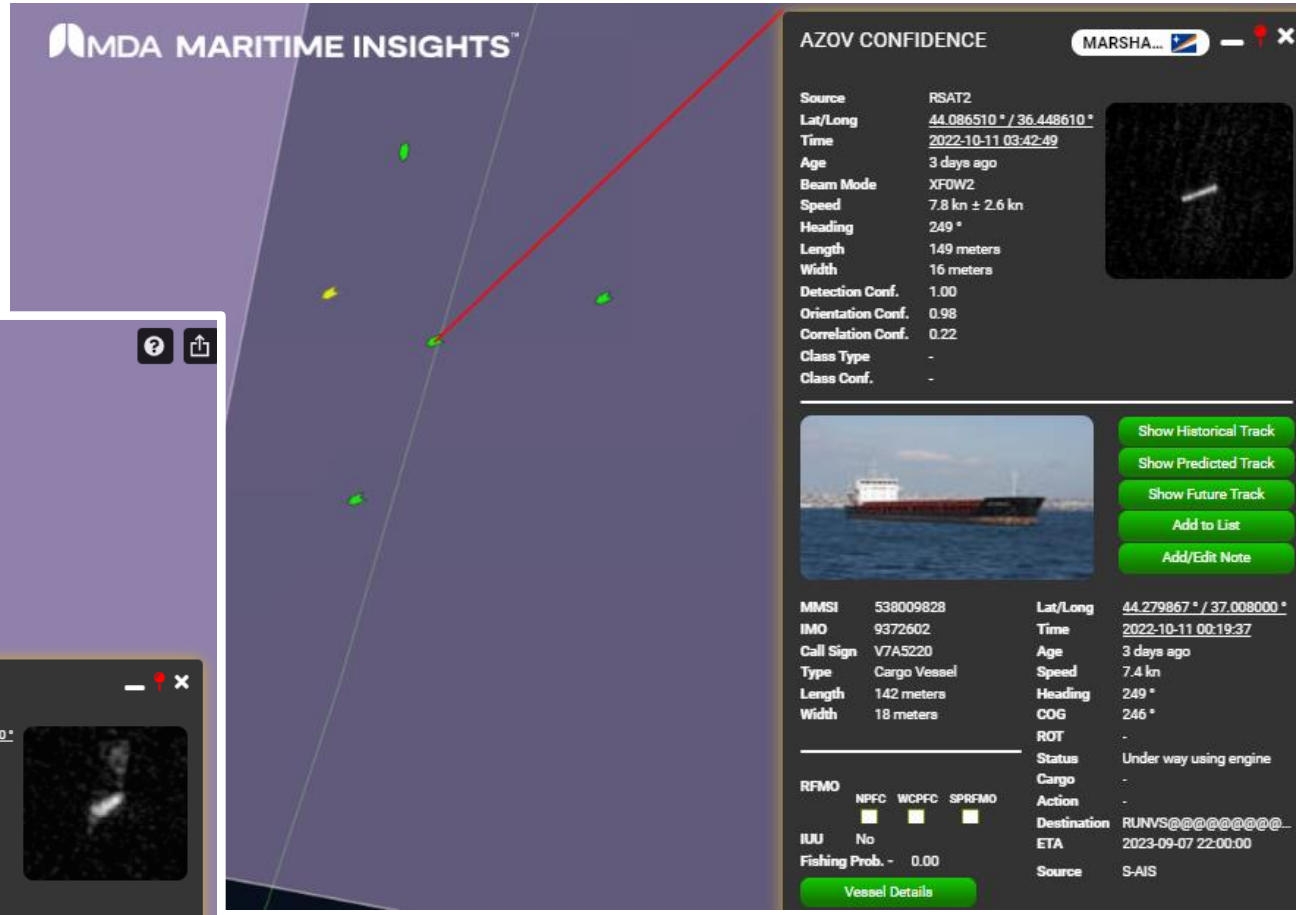




Operational Examples - VVE

- RSAT-2 / S-1A collects ~6 minutes apart, Vessel detections ~1.2 NM separation = 10.5 kn est. speed (manual method)
- VVE Results for RSAT-2 only = 7.1 kn +/- 3 kn
- ***(Below)***

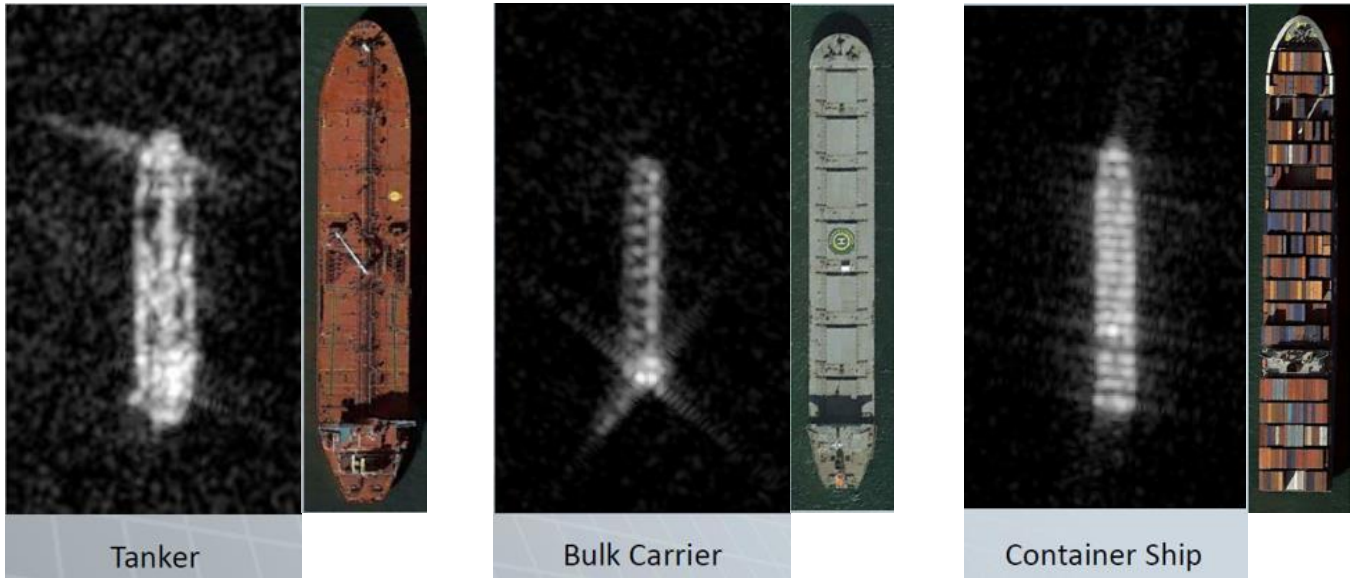




- RSAT-2 detection with correlated AIS reported speed = 7.4 kn
- VVE Results for RSAT-2 only = 7.8 kn +/- 2.6 kn
- ***(above)***

Automated Vessel Classification

- RADARSAT-2 has several modes well suited for Vessel Detection, as well as general **Classification**
  - Most viable mode for maritime monitoring and classification is ExtraFine (XF), with a **5 metre** resolution and a **125 km** wide swath
  - Ship Detection Mode (DVWF), with a 450 km swath used extensively for broad area surveillance and vessels 25+ m in length
- Machine learning efforts have focused on automating and improving the results
  - Thousands of vessel image chips from XF and DVWF used to advance algorithms

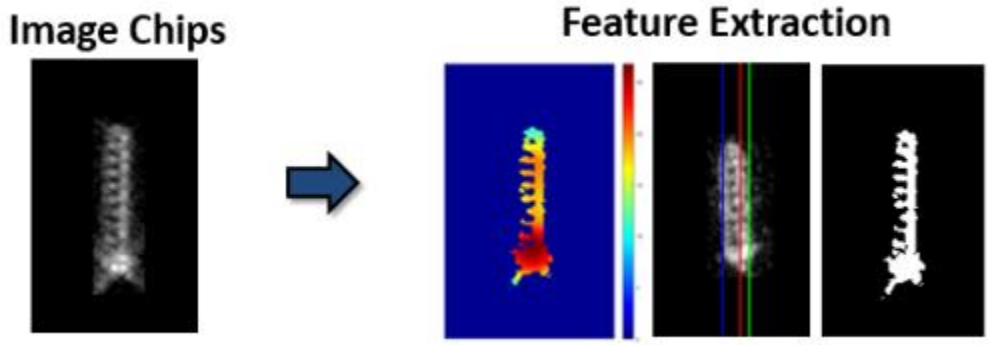


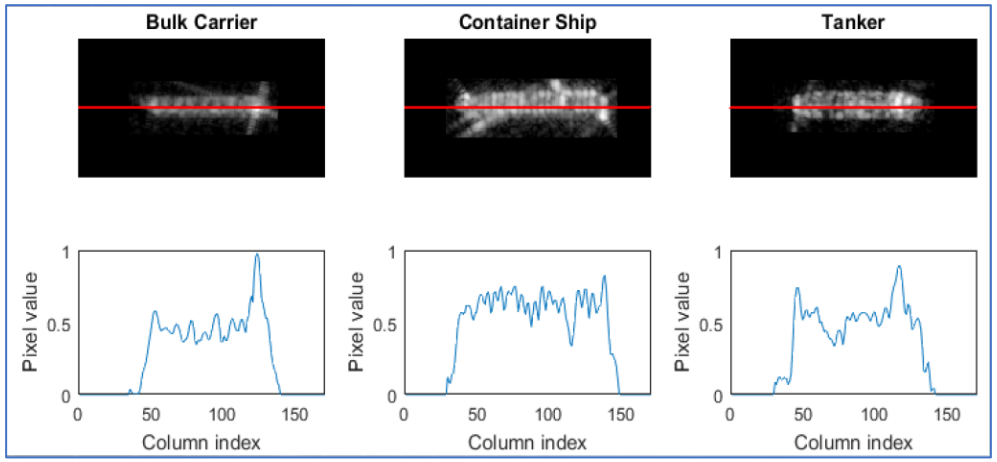
Results - AVC

- **Human** (analyst) Classification:
  - XF data: average accuracy: **~ 50%**
  - DVWF data**:** average accuracy: **~25%**
- **Neural Network** Classification:
  - XF data: average accuracy: **~75%**
  - DVWF data: average accuracy: **~50%**
- **Latest: Feature Vectors and Support Vector Machines (SVM):**
  - Designing feature vectors for each beam mode and using an SVM classifier (machine learning, supervised learning models) produced the best classification results for the XF and DVWF datasets

XF data: average accuracy: ~80%

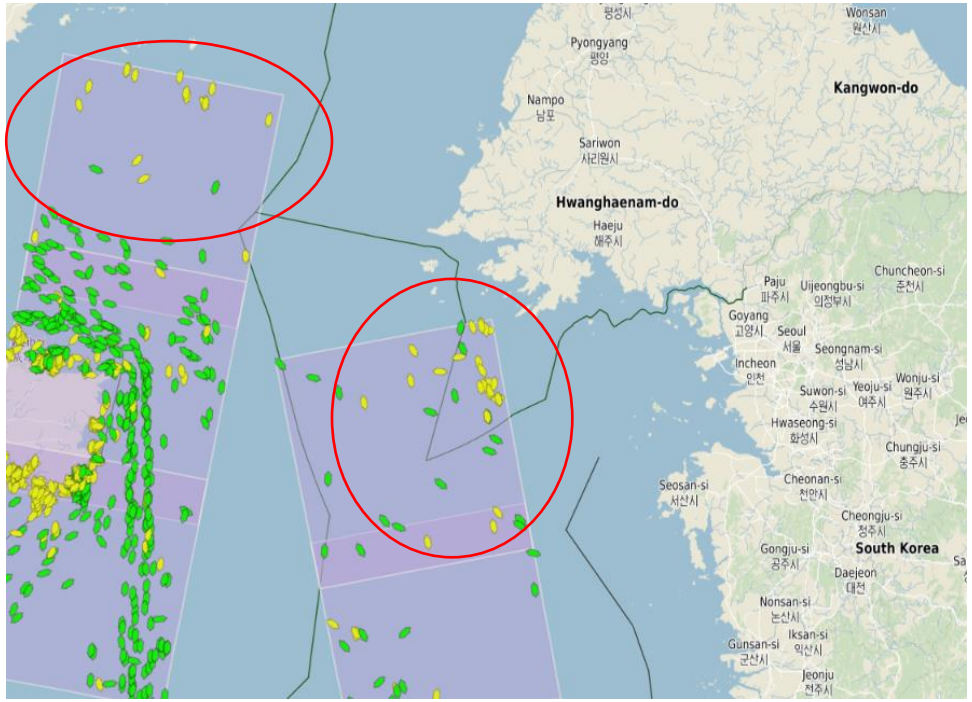
DVWF data: average accuracy: ~60%

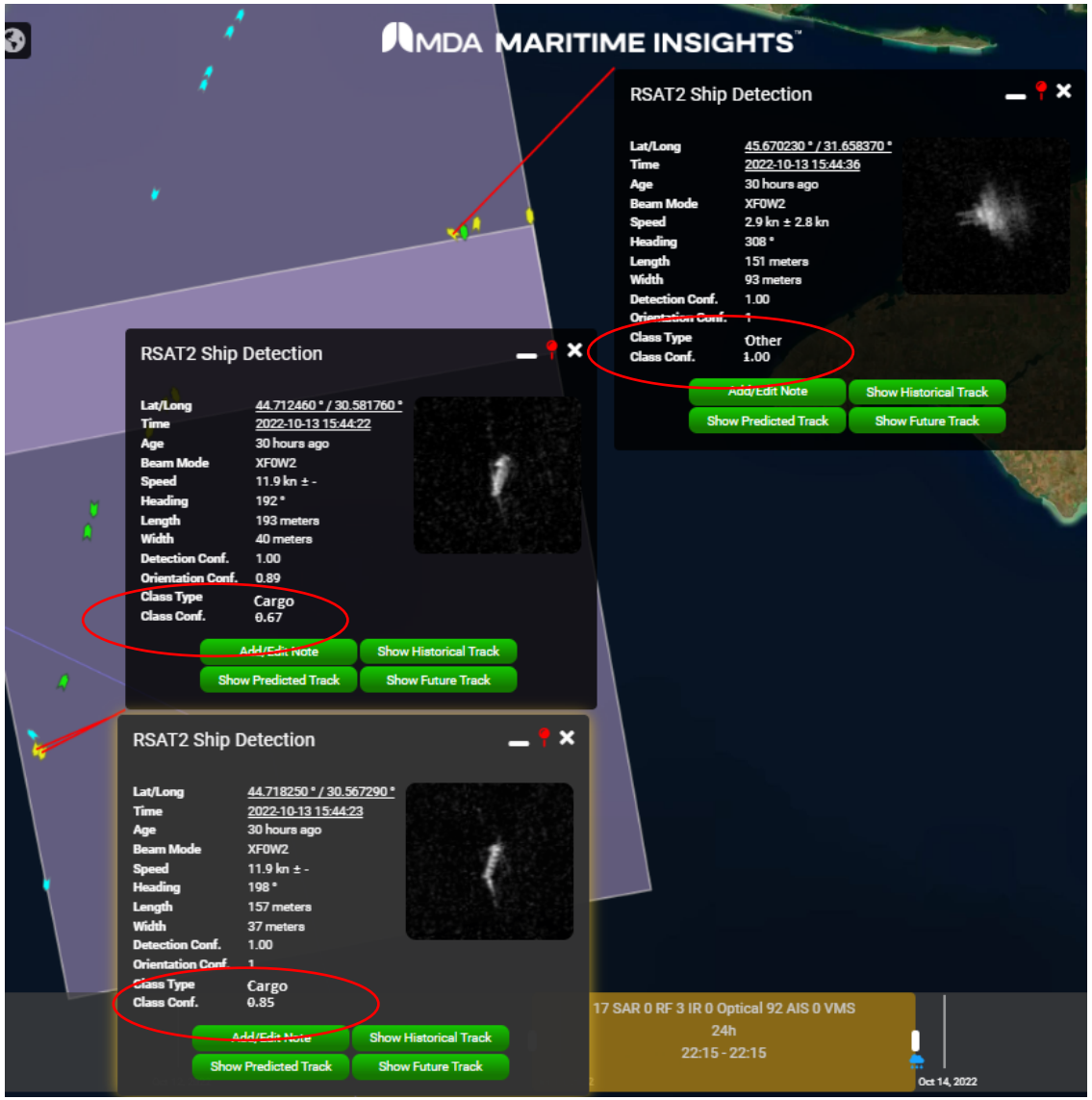




Operational Examples - AVC

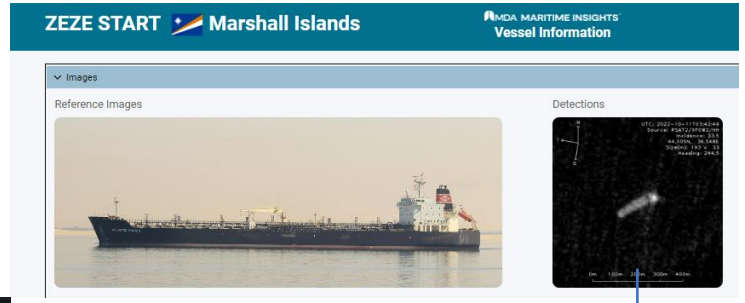
- Automated classification of ‘dark’ vessels can rapidly aid the identification of possible Vessels of Interest (further expedited via filtering) (**Right:** Black Sea, automated classification of vessels, RSAT-2 XF)
- As mentioned previously, specific AOIs and situations can have large numbers of unidentified vessels (**Below:** Korean Peninsula, yellow=“dark’)

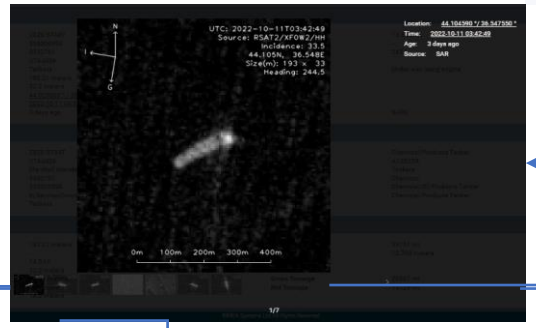


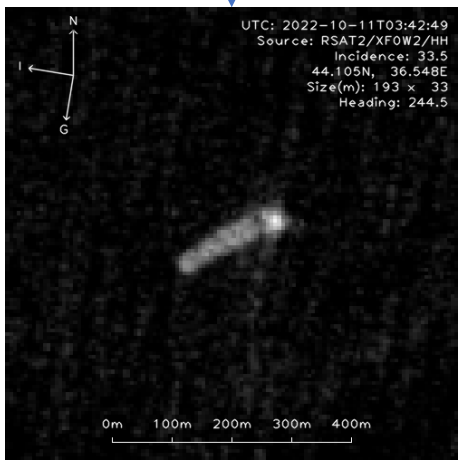


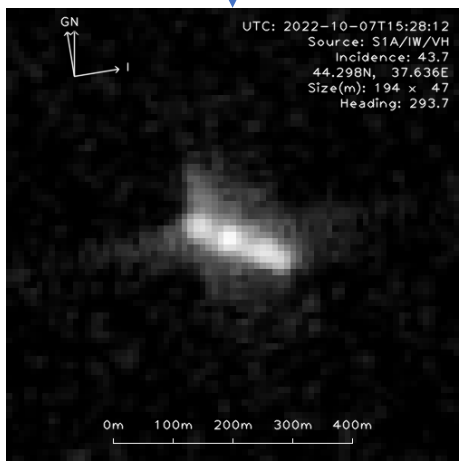
Next Step: Automated Vessel Identification

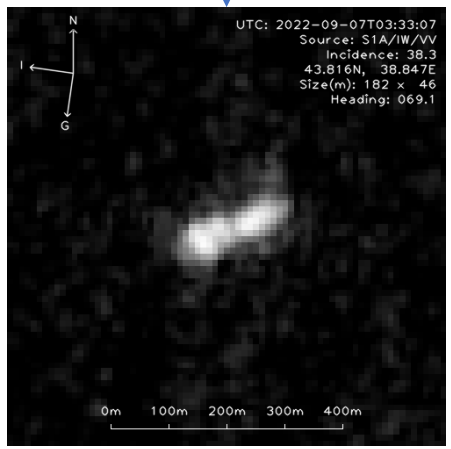
- Currently building database of ‘all-source’ detections for correlated targets within Maritime Insights
- Near term efforts to utilize this database to assign possible ‘ID’ to a vessel that has a sufficient number of detections in the database, should that vessel “go dark”

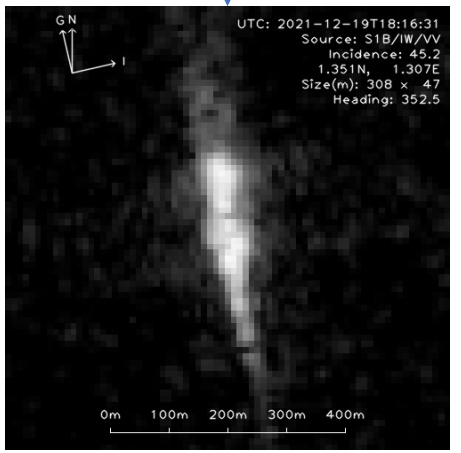






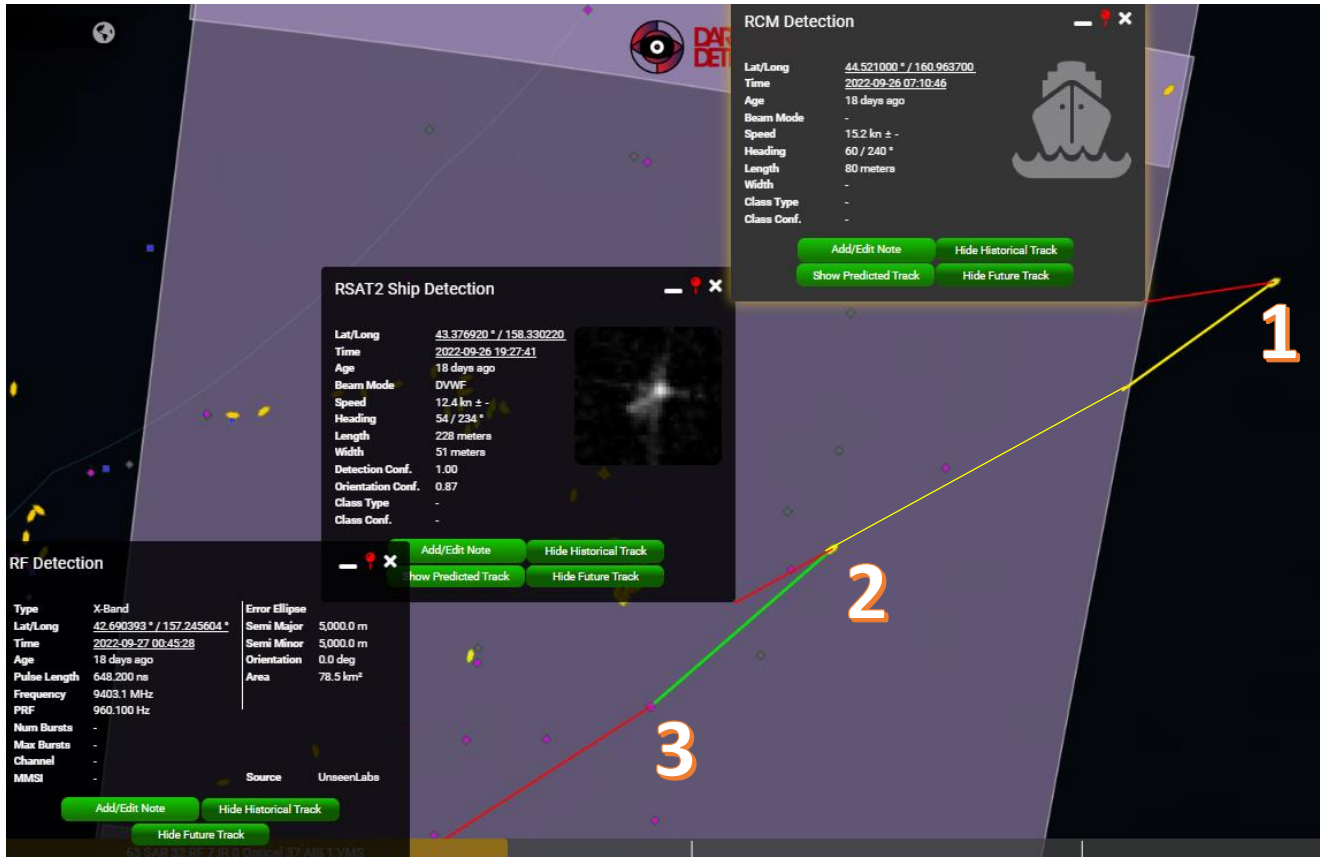






Near Term: Complementing human intuition

- All-Source ‘Dark’ Target Tracking
  - Link multiple source detects to one track / ‘dark’ vessel
- SAR Small Vessel Detection
  - Improve capabilities to discern small vessels from SAR imagery
- SAR Vessel Characterization
  - Further improvements to refine vessel characteristics such vessel type, length, width, heading
- Advanced Track Prediction
  - Predict probable location a few hours into future using historical AIS, vessel historical database
- Vessel Behaviour Detection (AIS Analytics)
  - Detects vessel behaviour based on its track. This includes transiting, fishing, rendezvous, dark operations
  - Detects unusual vessel track behaviours which do not correspond to previously recognized behaviours



1. RCM 26-Sep @ 07:10 UTC
2. RSAT-2 26-Sep @ 19:27 UTC
3. RF X-Band 27-Sep @ 00:45 UTC

Thank you

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