REMOTE SENSING FOR MARITIME SITUATIONAL AWARENESS

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Earth Observation Center EOC

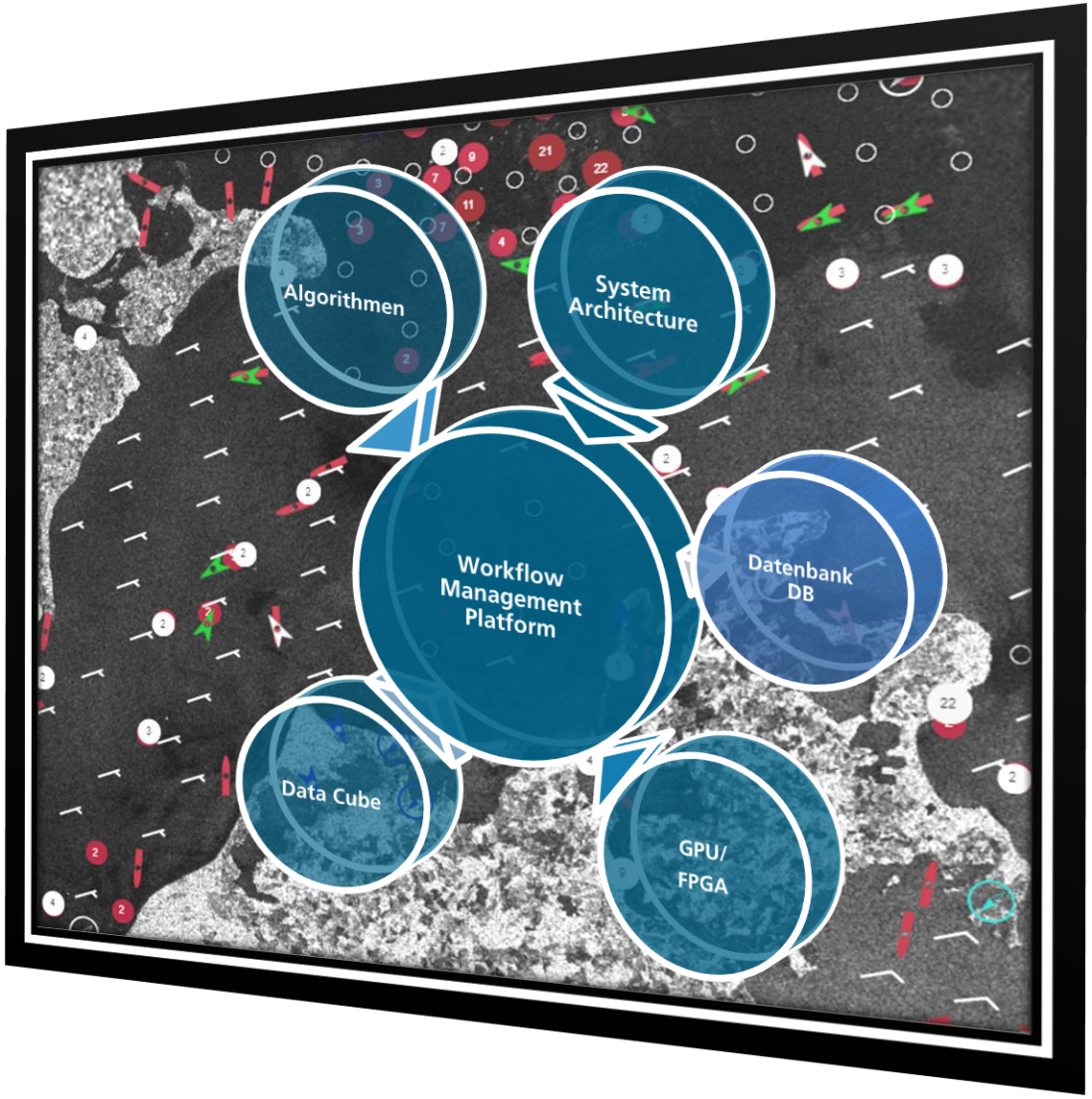
DLR

INTRODUCTION

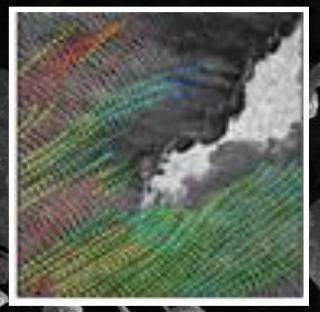
DLR Maritime Safety and Security Labs Bremen and Neustrelitz

Objective and Motivation

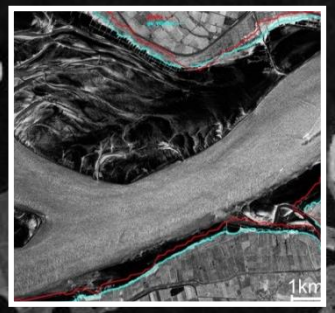
- Fundamental science, development of new methods and algorithms
- Development of operational software processors to generate value added maritime data and information products
- Linking thematic research and application development
- System developments directly close the gap between methodological research and operational applicability
- Development focus on near-real-time (NRT) application



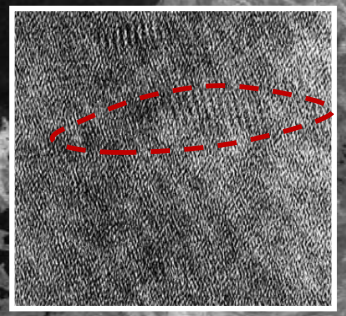
Subject of Research and Application Development for Maritime Domain Awareness



Bathymetry

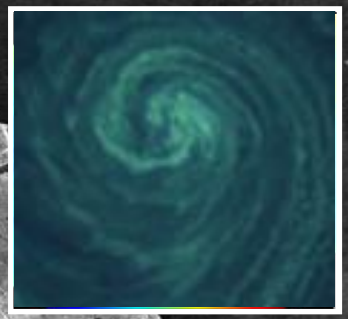


Land-Water Line

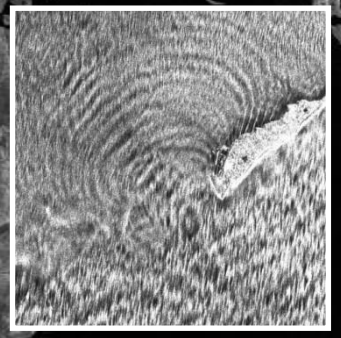


Wave groups & Forecast

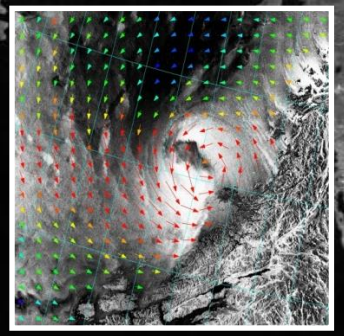
Wave breaking



hazardous substances



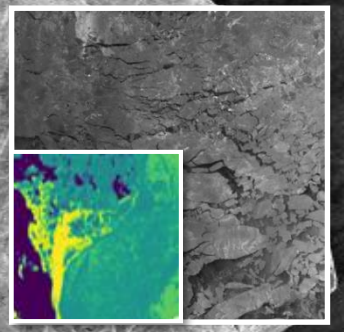
Sea State



Wind

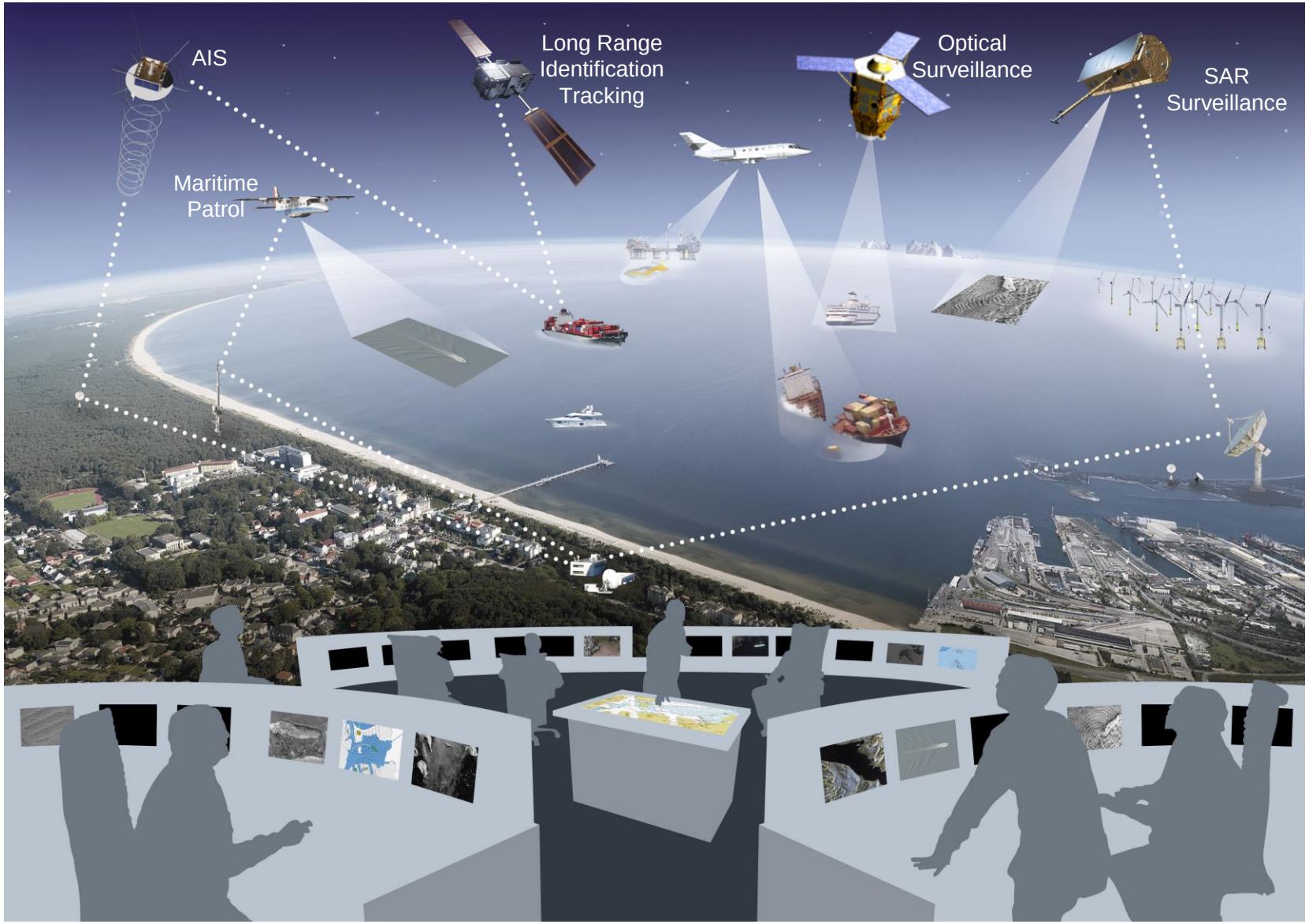
Object- detection

Oil Spills



Iceberg-detection, Ice classification

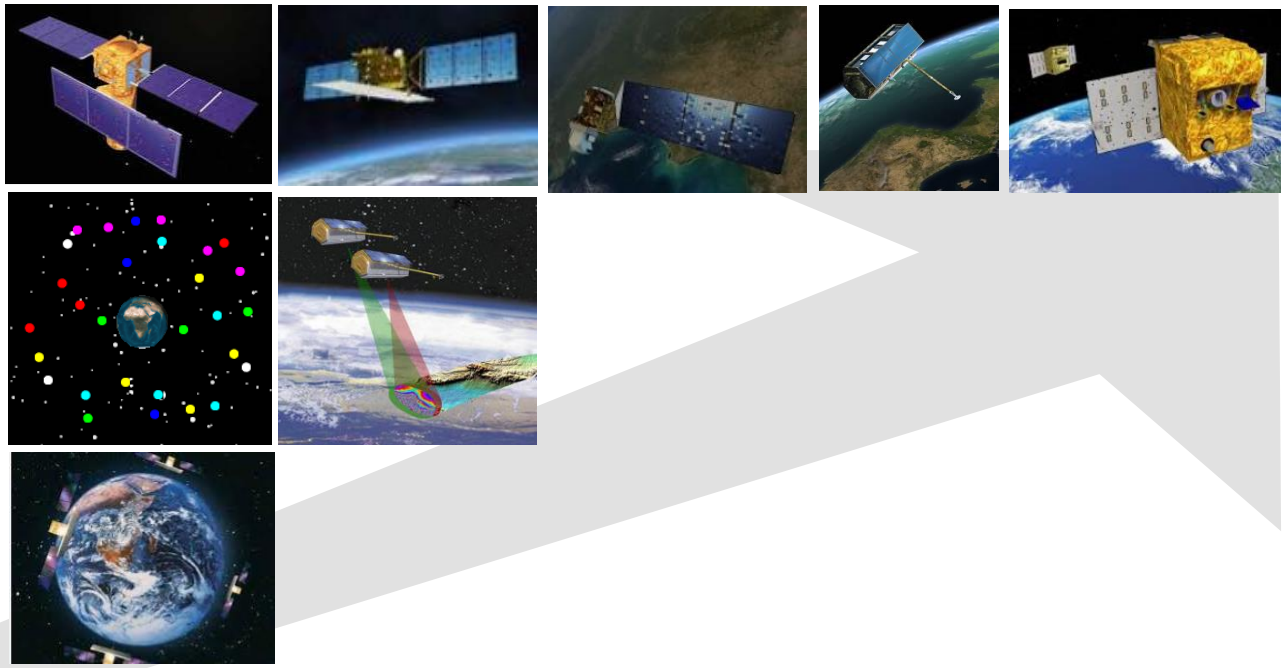
Components of Maritime Surveillance Systems



- Earth Observation
  - SAR Satellites
  - Optical Satellites
  - Radio Frequency
- Aircraft
- Remotely Piloted Aircraft
- Automatic Identification System AIS
- Long Range Identification & Tracking LRIT (EMSA)

Global Space Capabilities

- Number of Satellites and Satellite Constellations increase
- Higher Number of small satellites, with lower costs of manufacture, launch, and operations
  - e.g., ICEYE, Capella, planet, Satellogic
- Increased revisit time and flexibility
- Higher Coverage update and higher image resolution
- Higher service reliability
  - More data
  - New Products
  - Shorter response time



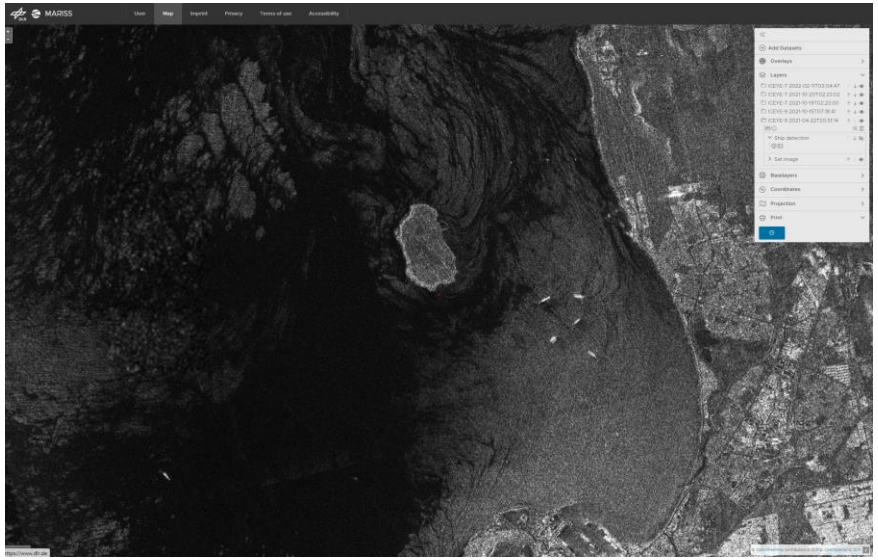
Operational Satellites Application	2018	2019	2020	2021	2022
Communications	742	777	898	1832	3135
Earth Observation	**596**	**710**	**884**	**906**	**1030**
Technology Demonstration	193	223	312	350	385
Navigation and Global Position	108	137	148	150	154
Space Science	67	85	92	104	108

http://www.pixalytics.com

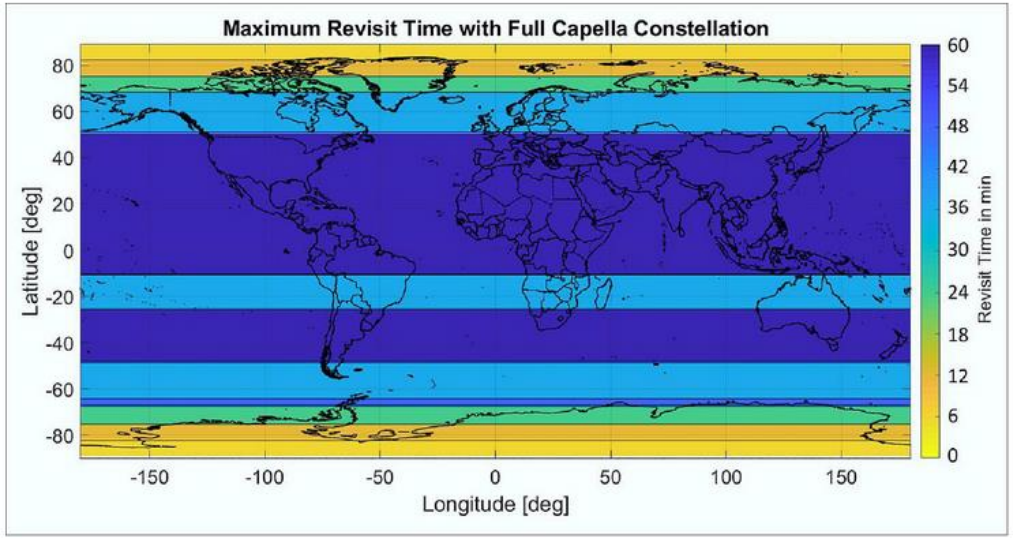
Space Capabilities, SAR Constellation Example SAR

- ICEYE, Synthetic Aperture Radar (SAR)
  - constellation of **27 microsatellites < 100 kg** equipped with SAR instrument, (beginning 2022)
  - Resolution:
    - Spot Fine 5*5 km, 50x25 cm,
    - Stripmap 30*50 km 2,5x3 m,
    - ScanSAR 100*100 km 15x15 m

- Capella Space, Synthetic Aperture Radar (SAR)
    - constellation of **36 sub-50 kg satellites** deployed in 2021
    - Resolution:
      - Spotlight 50x30 cm,
      - Stripmap SLC 1,2x0,75 m
- Umbra
  - constellation of currently **8 microsatellites ~ 70kg,** planned in total 24 satellites
  - Resolution:
    - Very High Resolution 4*4 km, 25 cm up to 1 m
    - Medium Resolution 4*4 km, 1x1 m



Example: ICEYE Campaign 2022(@DLR)



https://www.eoportal.org/satellite-missions/capella-x-sar

Space Capabilities, Constellation Example (optic)

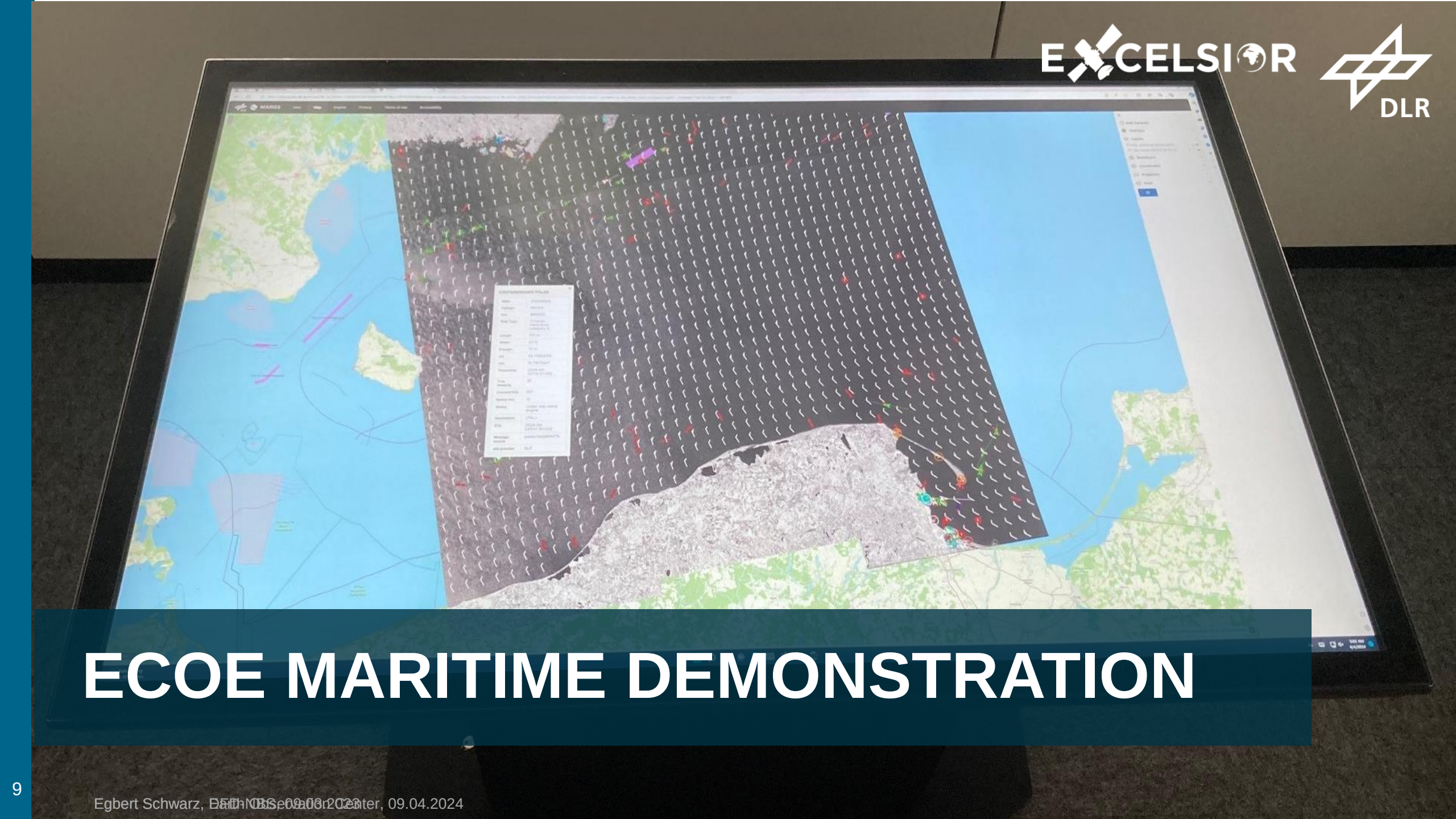
- **Pléiades Neo**, Very High Resolution Multispectral
  - **2 satellites**, **30 cm**, 5 bands + NIR

- **MAXAR Legion**, Very High Resolution Multispectral
  - **6 WorldView Legion satellites, 29 cm**, 8 bands will fly in both polar and mid-inclination orbits (2022 onwards)

- **PLANET**, High Resolution Multispectral
  - operates more than **188 Dove CubeSats** (PLANETSCOPE 3.7 meter resolution)

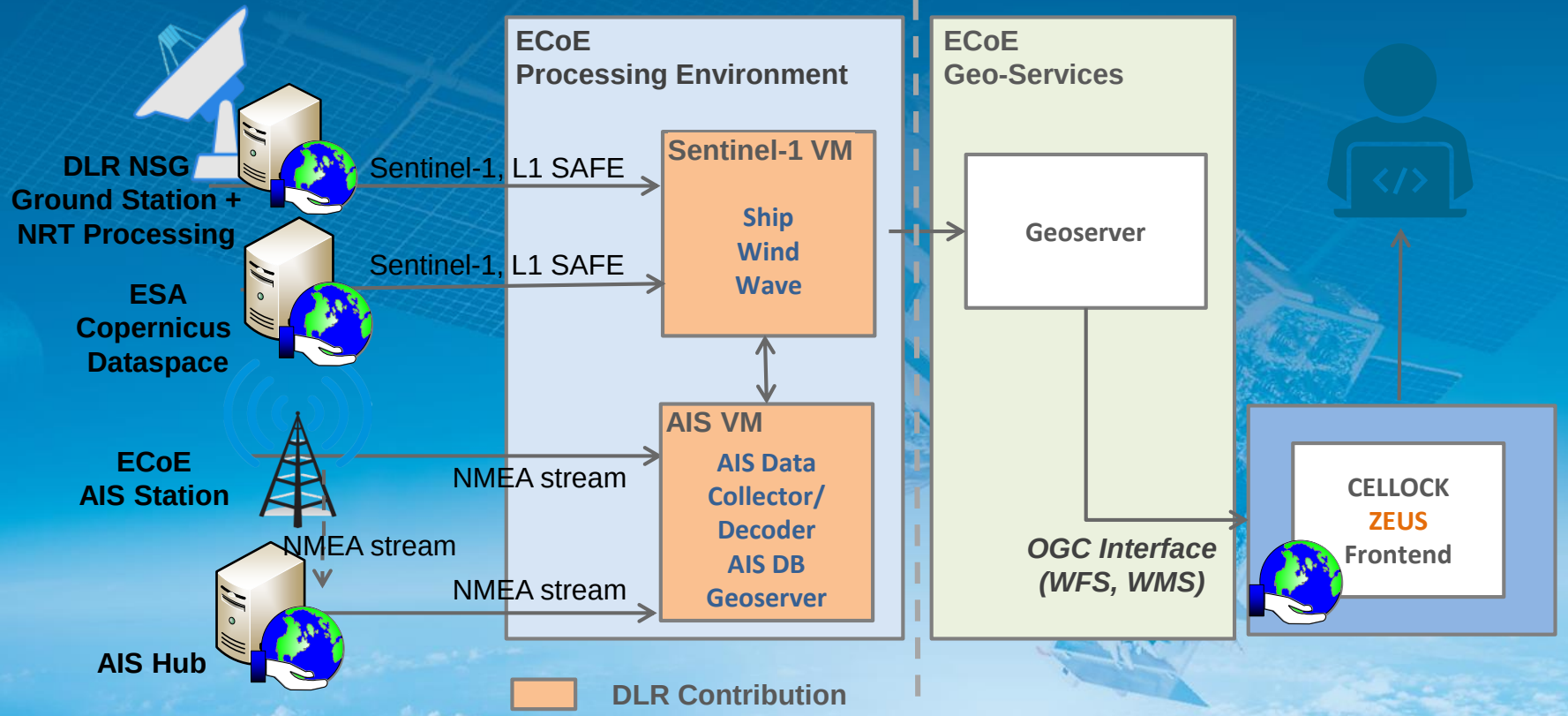
© WorldView Legion | European Space Imaging (euspaceimaging.com)

- **Satellogic**, Very High Resolution Multispectral + hyperspectral
  - constellation currently consists of **26 operational microsatellites (60 planned by 2023)**, **30 – 99 cm** resolution multispectral camera 16 bands + SWIR and a 29-band hyperspectral camera



ECOE MARITIME DEMONSTRATION

ECoE Maritime Demonstration

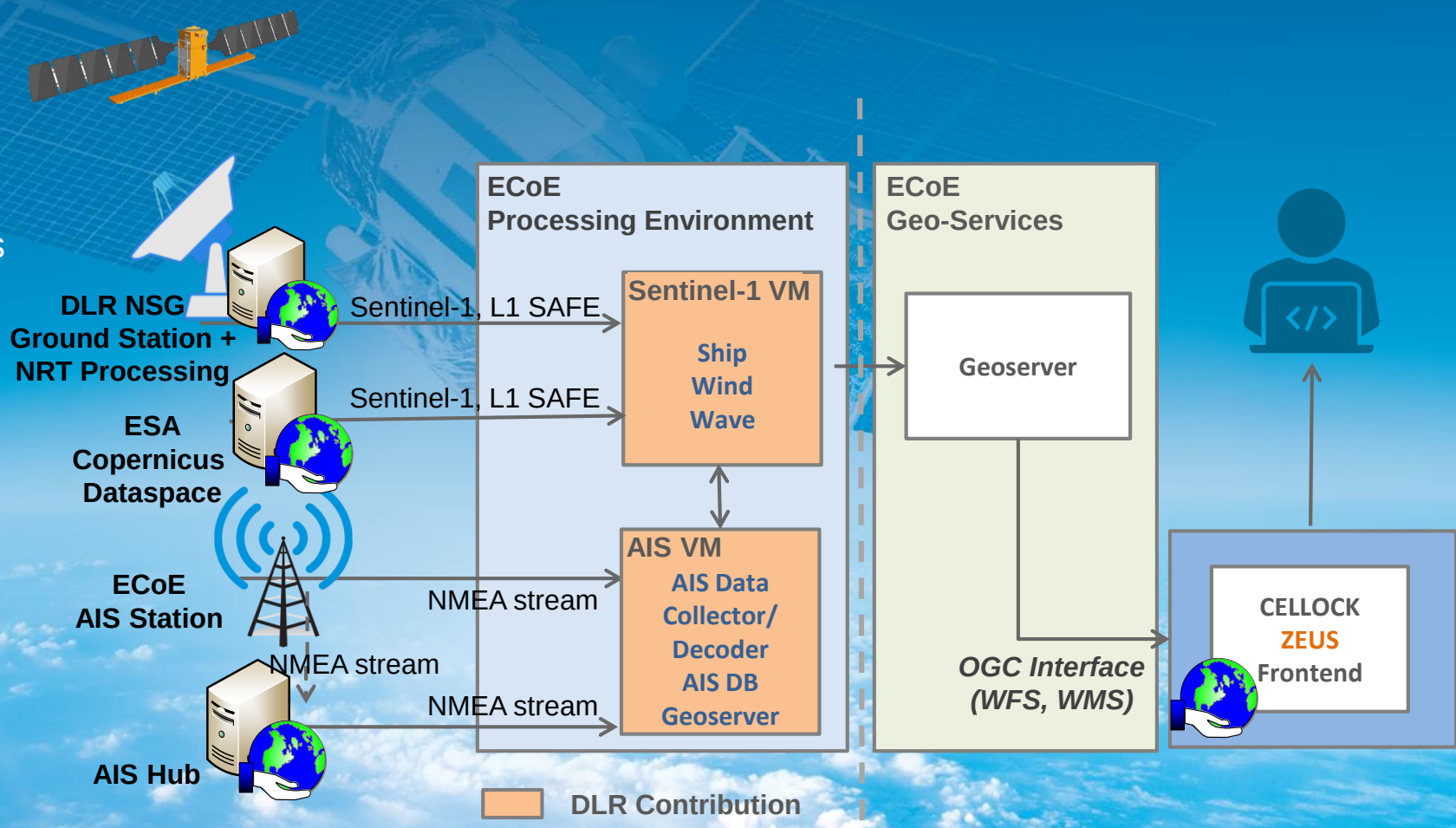


- This research capacity demonstration aims to provide the end-user(s) with SAR-derived maritime surveillance information to support the maritime domain awareness around Cyprus or for a specific area defined for this trail.
- The demonstrator, mainly based on the Sentinel-1 processing chain, will be deployed and operated at the ERATOSTHENES Centre of Excellence

ECoE Maritime Demonstration

First stage of Development

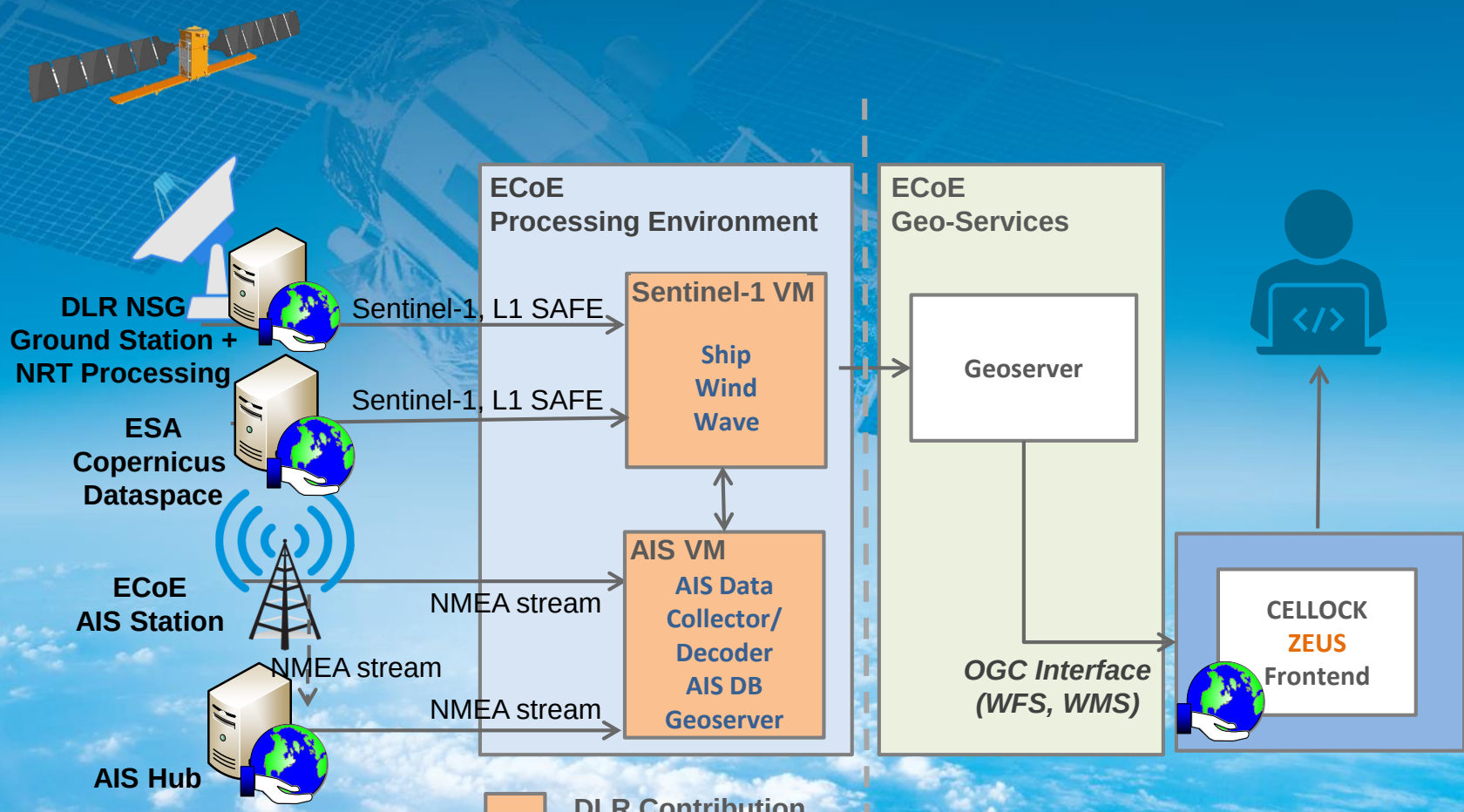
- Sentinel-1 (SAR)
  - Data supply via Ground Station Neustrelitz
  - Data download from Copernicus Dataspace
  - Ship detection
  - Wind speed and direction
  - Significant wave height
- AIS (ECoE)
  - Collection and decoding
  - Data base
- GeoServer
  - Product dissemination



ECoE Maritime Demonstration

First stage of Development

- ECoE AIS Antenna & Receiver installed early 2024
- Next step: fix network issues and start data streaming
- DLR AIS Module at ECoE
  - Collection and decoding
  - Data base
- AIS Database deployed



ECoE Maritime Demonstration

First stage of Development

- Sentinel-1 (SAR)
  - Data supply via Ground Station Cyprus
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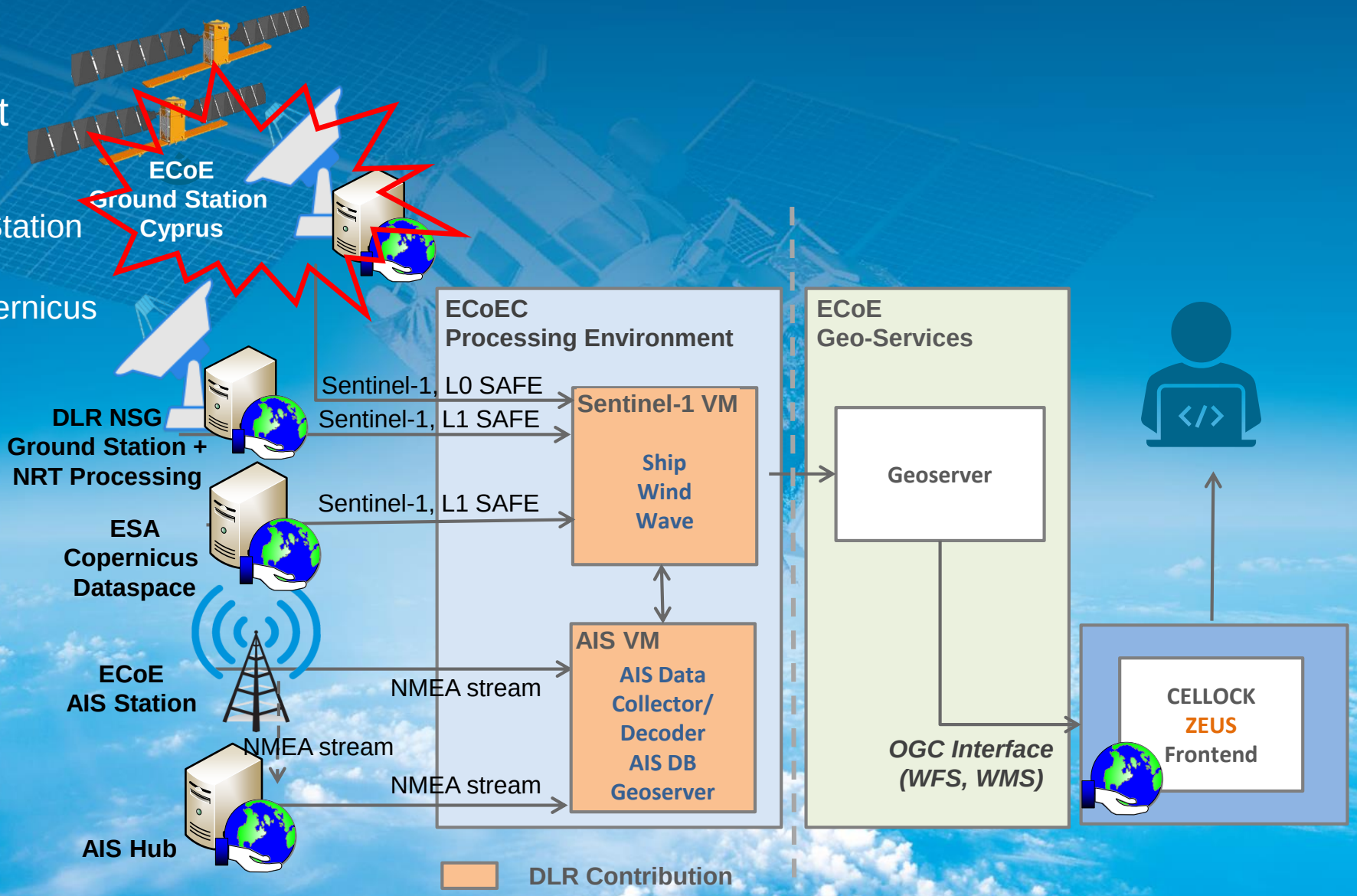
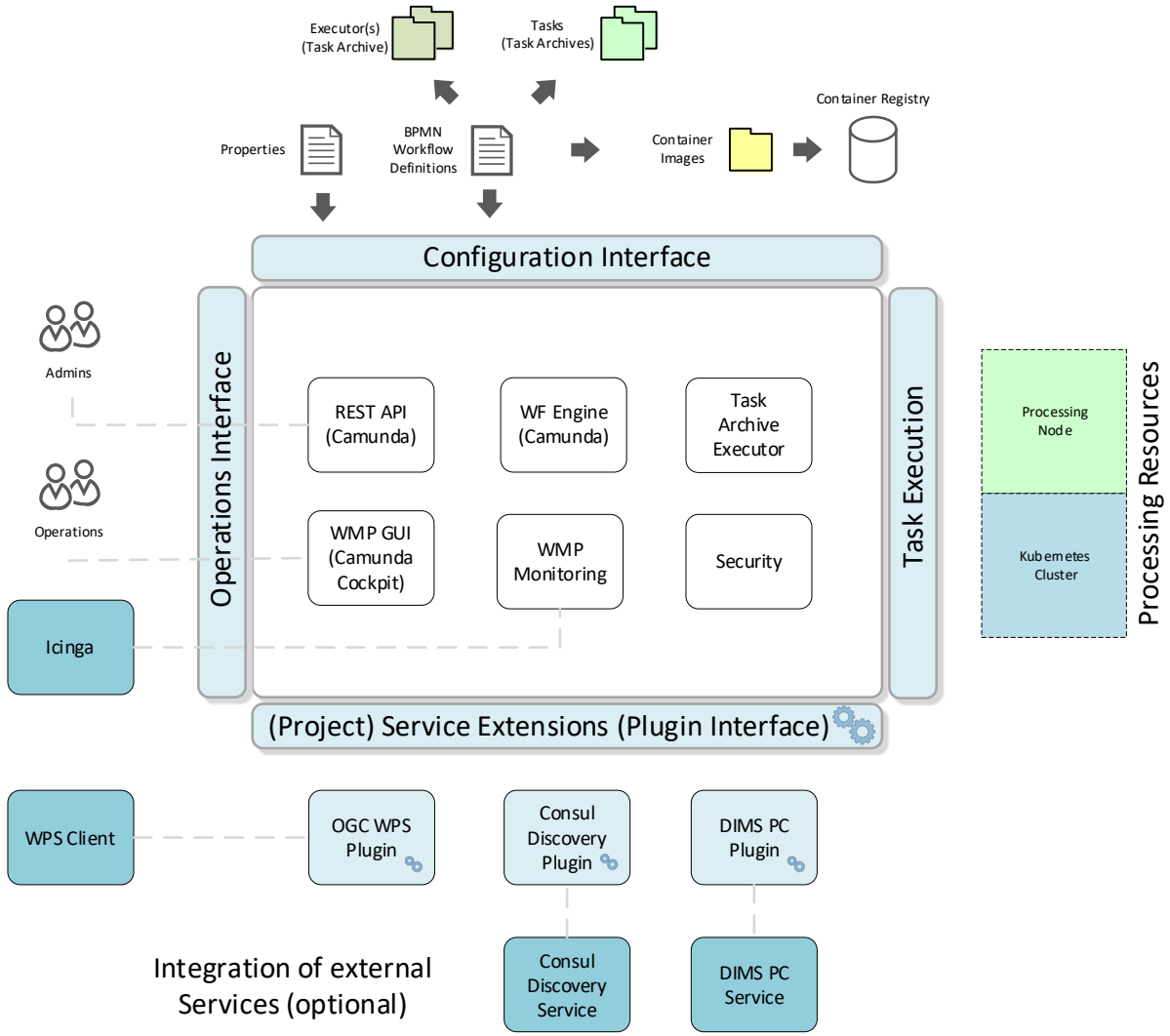


Sentinel-1 Workflow Management Platform
WMP Framework Architecture

- Java 17 + SpringBoot
- Camunda Workflow Engine
- Workflows are modeled not programmed
- REST APIs
- Monitoring via Metric Interfaces to connect e.g. Prometheus
- Automated versioning (Workflows, Task archives)
- Container und Kubernetes
- Web UI



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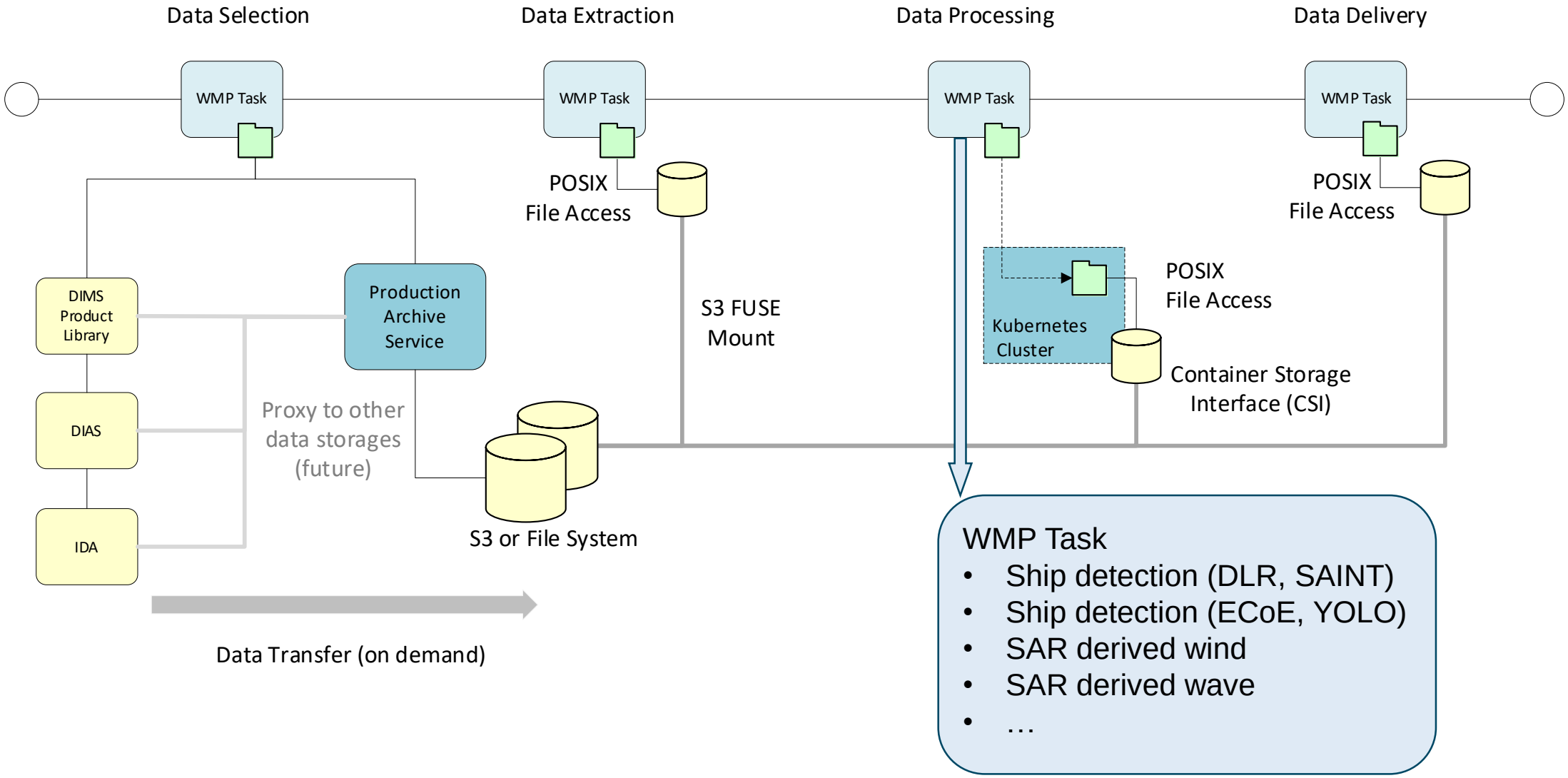
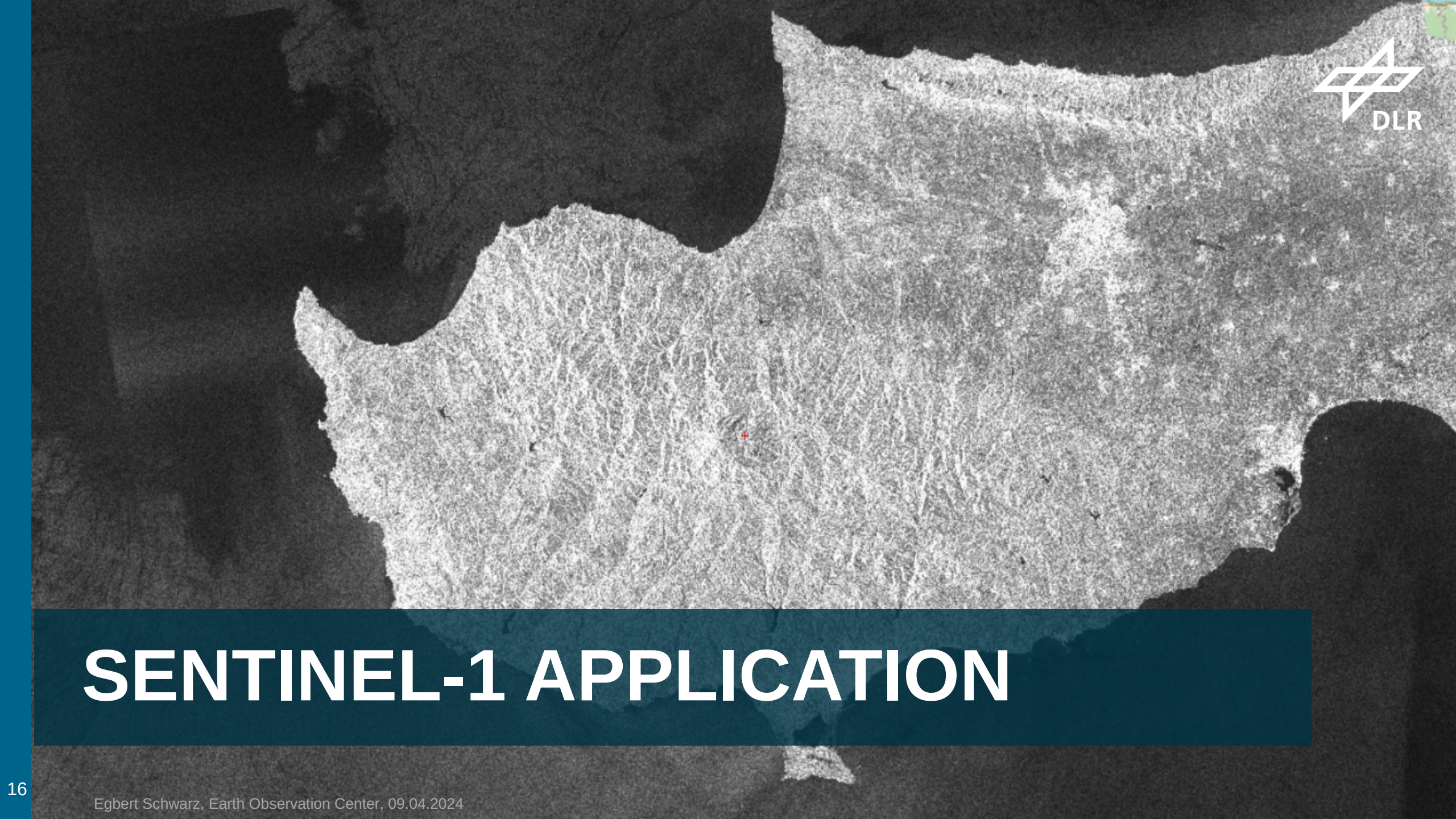




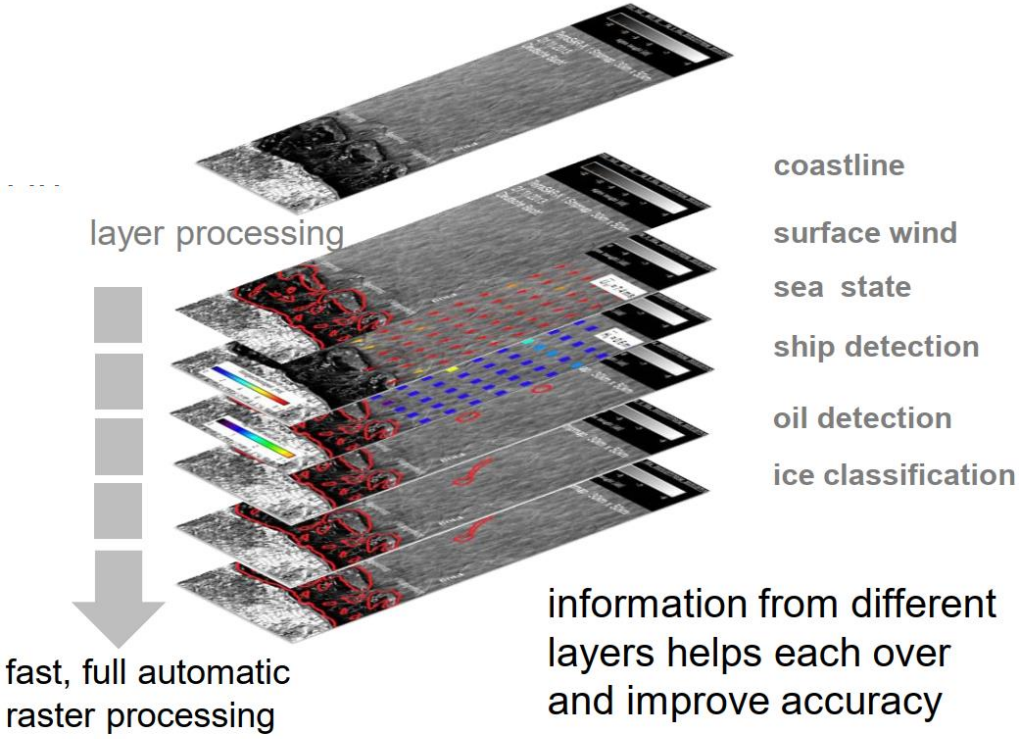
SENTINEL-1 APPLICATION

Modular Software Suite SAINT

DLR Maritime Security Labs have developed the near-real time (NRT) processing suite SAINT that is operated at DLR ground stations and provides maritime information in ~20 minutes after satellite downlink commencement

Unique:

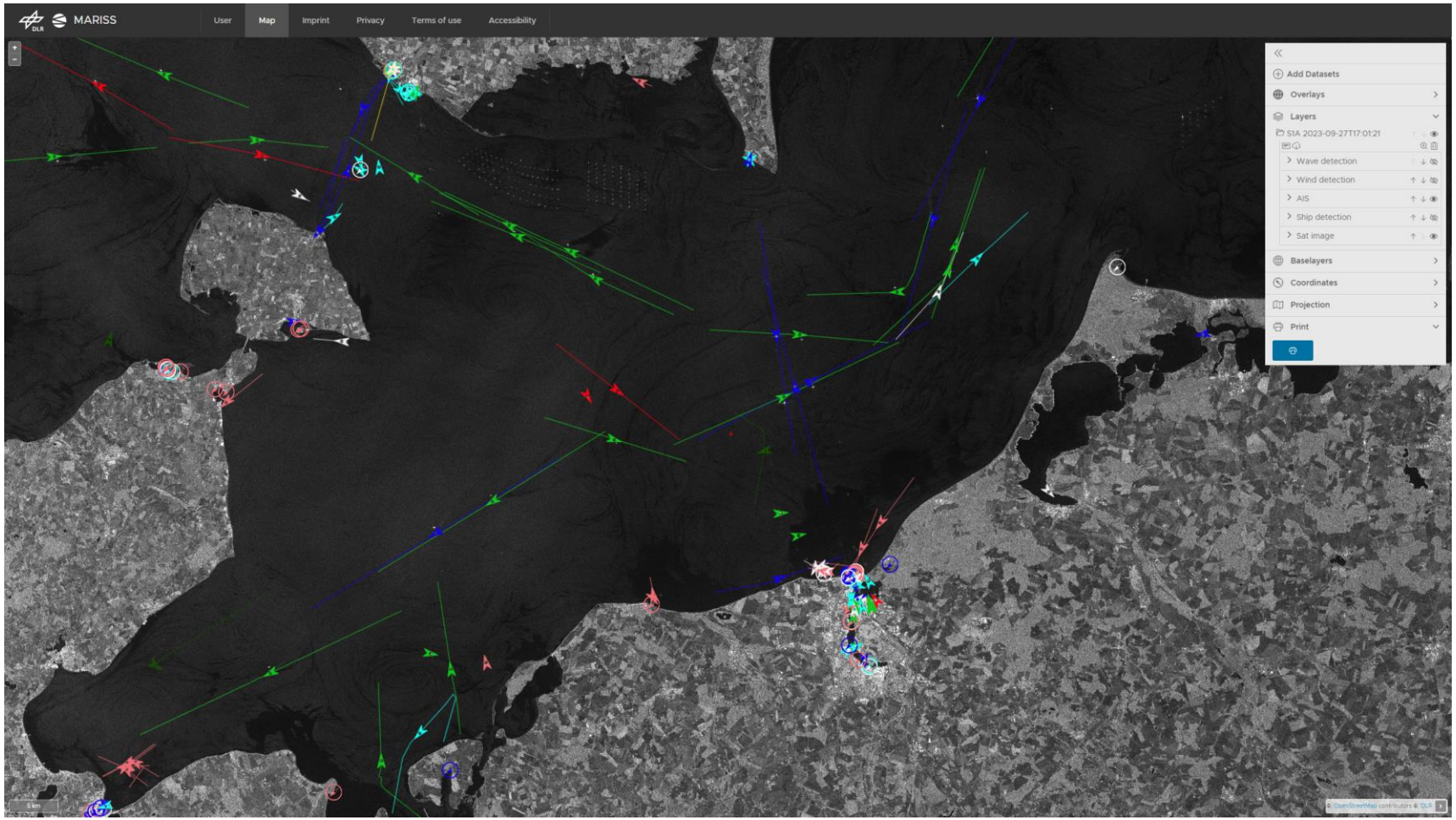
- Information generated in ONE
- Software
- Data fusion during processing
- Couple with context information to
- improve results



Modular design unique and it improves efficiency and accuracy

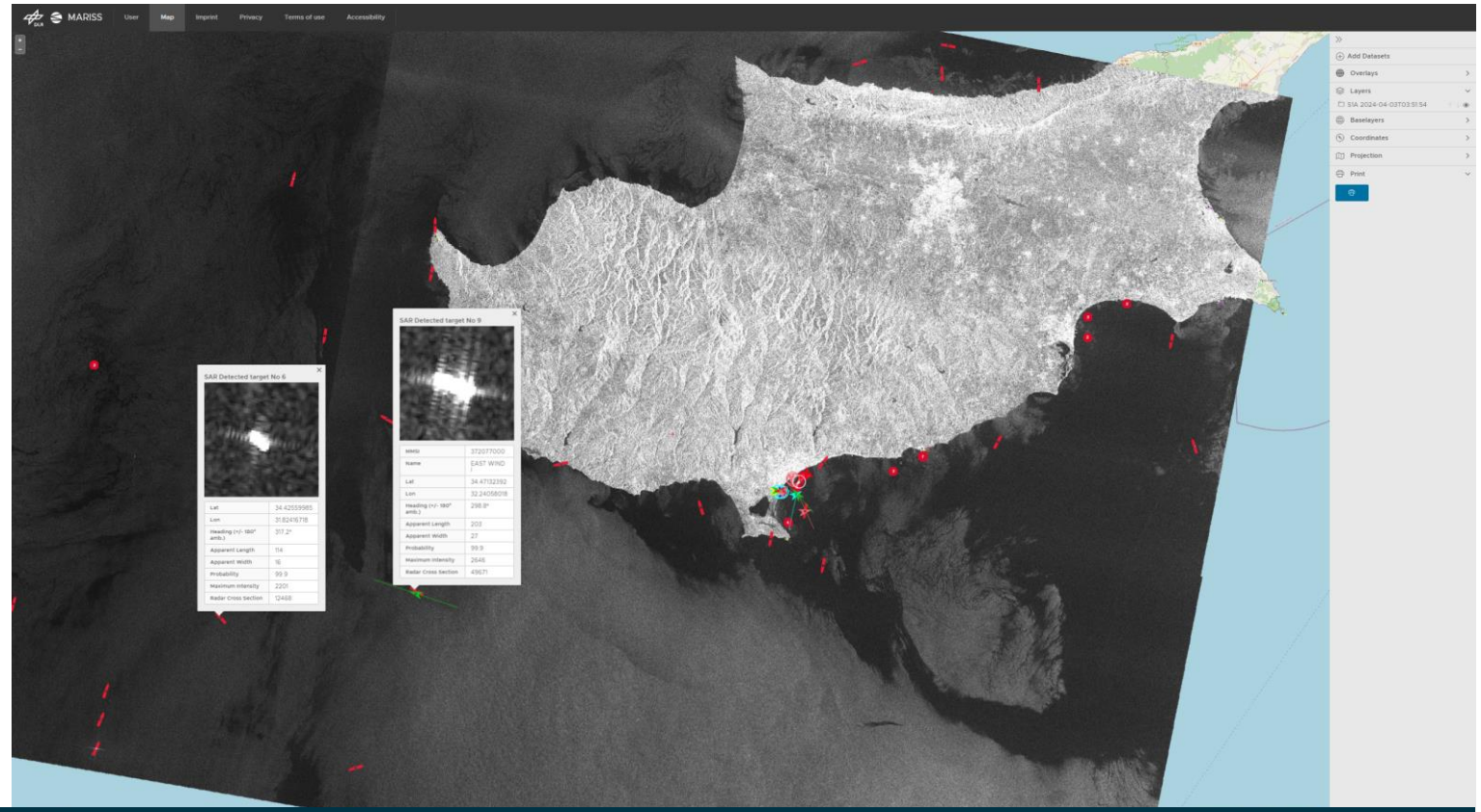
SAR | AIS Vessel Detection Application (SAR)

- Near real time ship detection application based on SAR images
- currently developed for: TerraSAR-X, TanDEM-X, Radarsat-2, Sentinel-1, DLR, Björn Tings
- Application and SAR | AIS fusion, licenced to AIRBUS DLR, Sergey Voinov



Result of SAR | AIS Vessel Detection Application

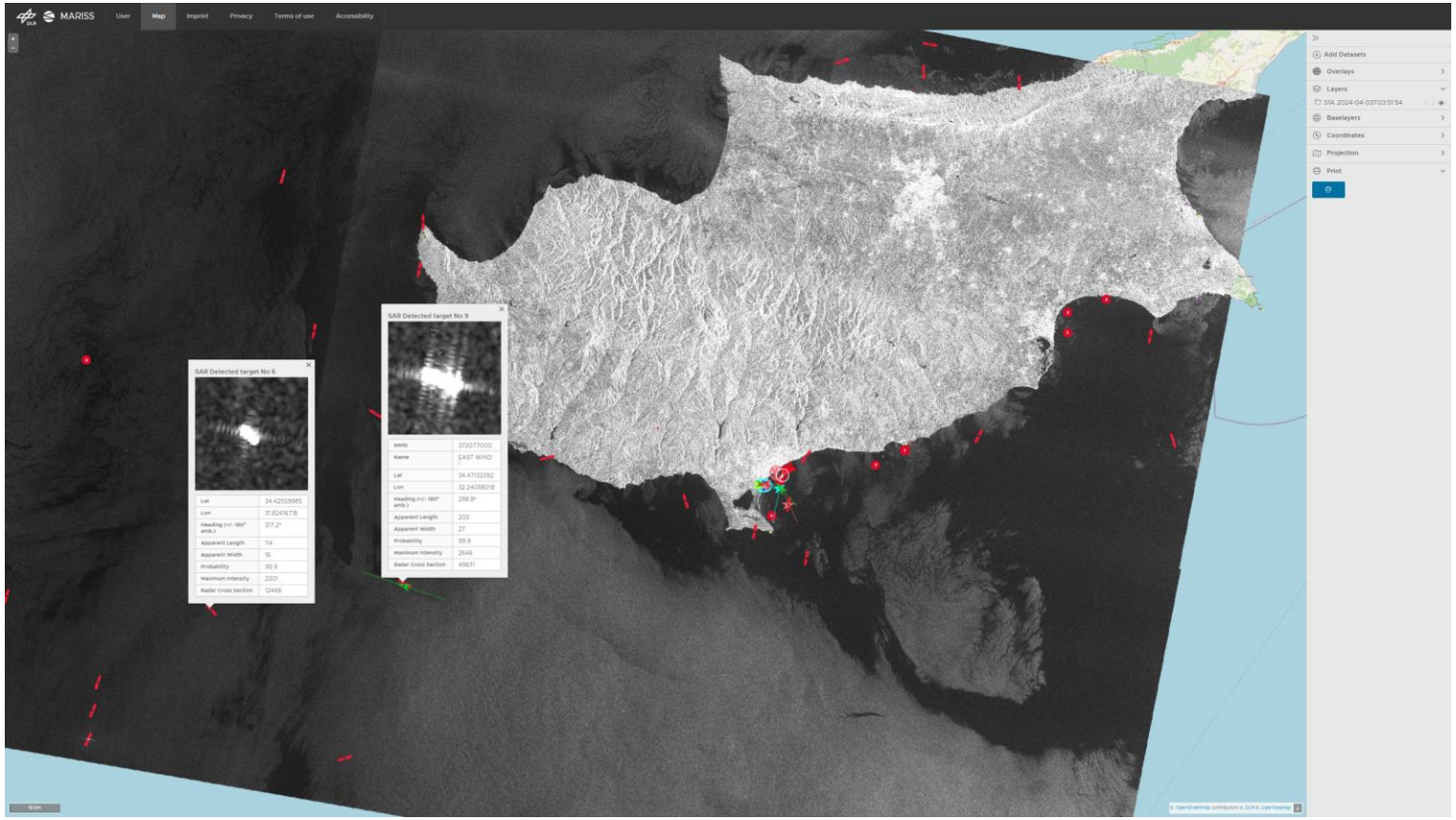
- Depends on resolution, wind speed, incidence angle, etc.
- Estimated Length, width and heading
- Facilitates dark vessel identification
- AI based Ship Classification(currently under development)



Ongoing development to include ship wakes which helps to detect and identify ships
Promising results for differentiation of ship types based on AI classification
Helps to identify dark vessels

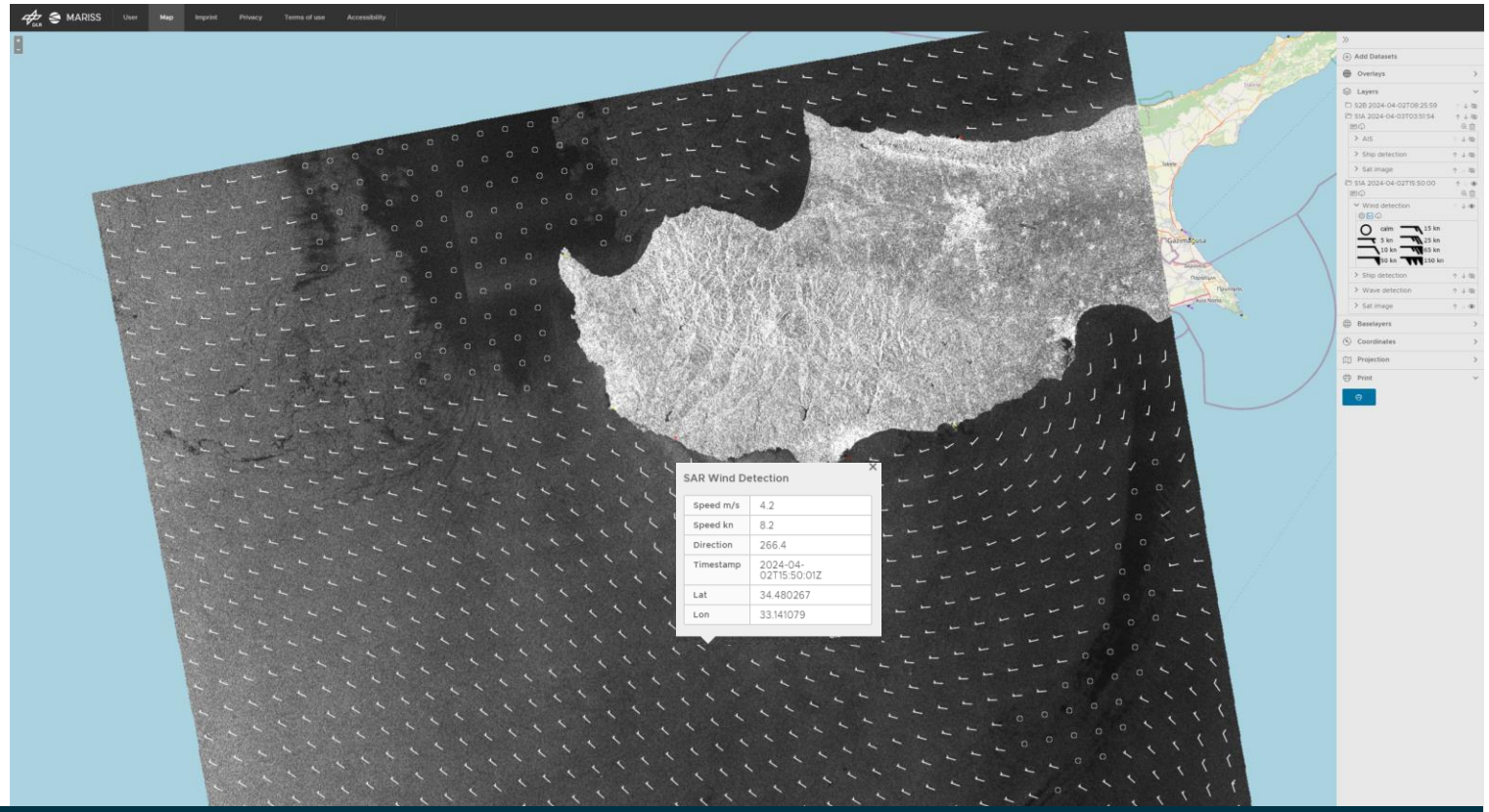
SAR | AIS Vessel Detection Application (SAR)

- Near real time ship detection application based on SAR images
- currently developed for: TerraSAR-X, TanDEM-X, Radarsat-2, Sentinel-1, **DLR**, Björn Tings
- AI based new development for: Sentinel-1, (YOLO) **EcoE**, George Melillos
- Application and SAR | AIS fusion, licenced to AIRBUS Ltd. **DLR**, Sergey Voinov



Result of SAR derived Wind Application

- Available for C- and X-Band
- Accuracy of ~1.3 m/s within range 2m/s - 25 m/s
- Very high resolution data possible (up to 50m)
- Lateral variability, gusts, fronts, etc. well visible
- Very accurate for low heights



Most beneficial as supplement to NWP model prediction as source of daily accuracy

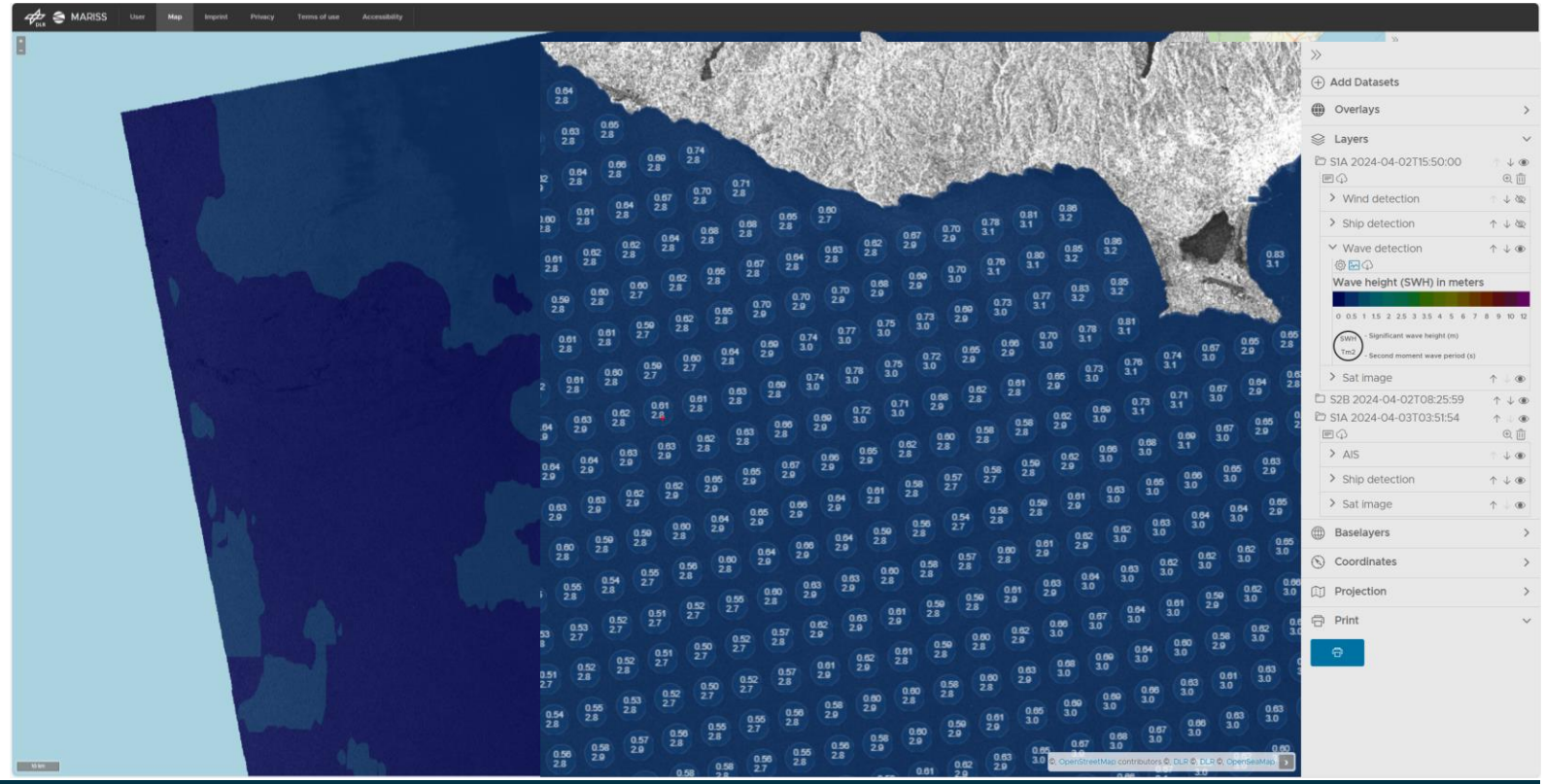
Result of SAR derived Sea State (wave) Application

- Semi-empirical algorithm
- Over 100 parameters (statistical, spectral, texture, geophysical) fitted with regression and AI (SVM)
- Available for X- and C-Band
- Experience in training for new sensors

No waves need to be „visible“ on SAR image
Most beneficial as supplement to NWP model prediction as source of daily accuracy

Result of SAR derived Sea State (wave) Application

- Compared to model and buoy data
- Woldwide training and validation data
- Covers all conditions (calm or storm)
- Experience in training for new sensors
- Yields many parameters (heights,periods, two swell systems + windsea)



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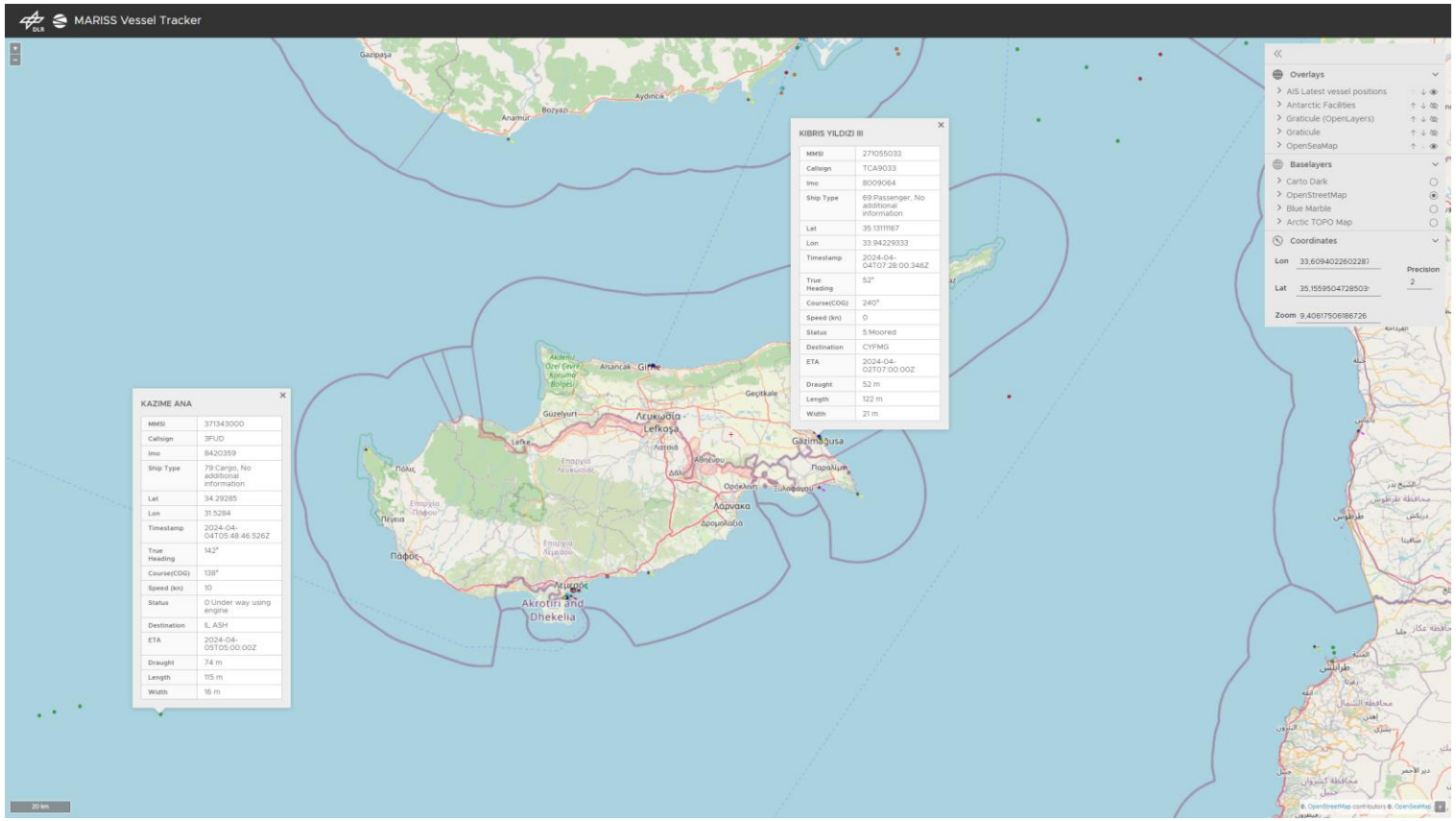
Most beneficial as supplement to NWP model prediction as source of daily accuracy

SAR | AIS Vessel Detection Application (SAR)



- AIS DB installation finished
- ECoE AIS Antenna installed in Limassol
- Integration ongoing

First Results on ECoE GeoServer

Stores

Manage the stores providing data to GeoServer

Add new Store Remove selected Stores

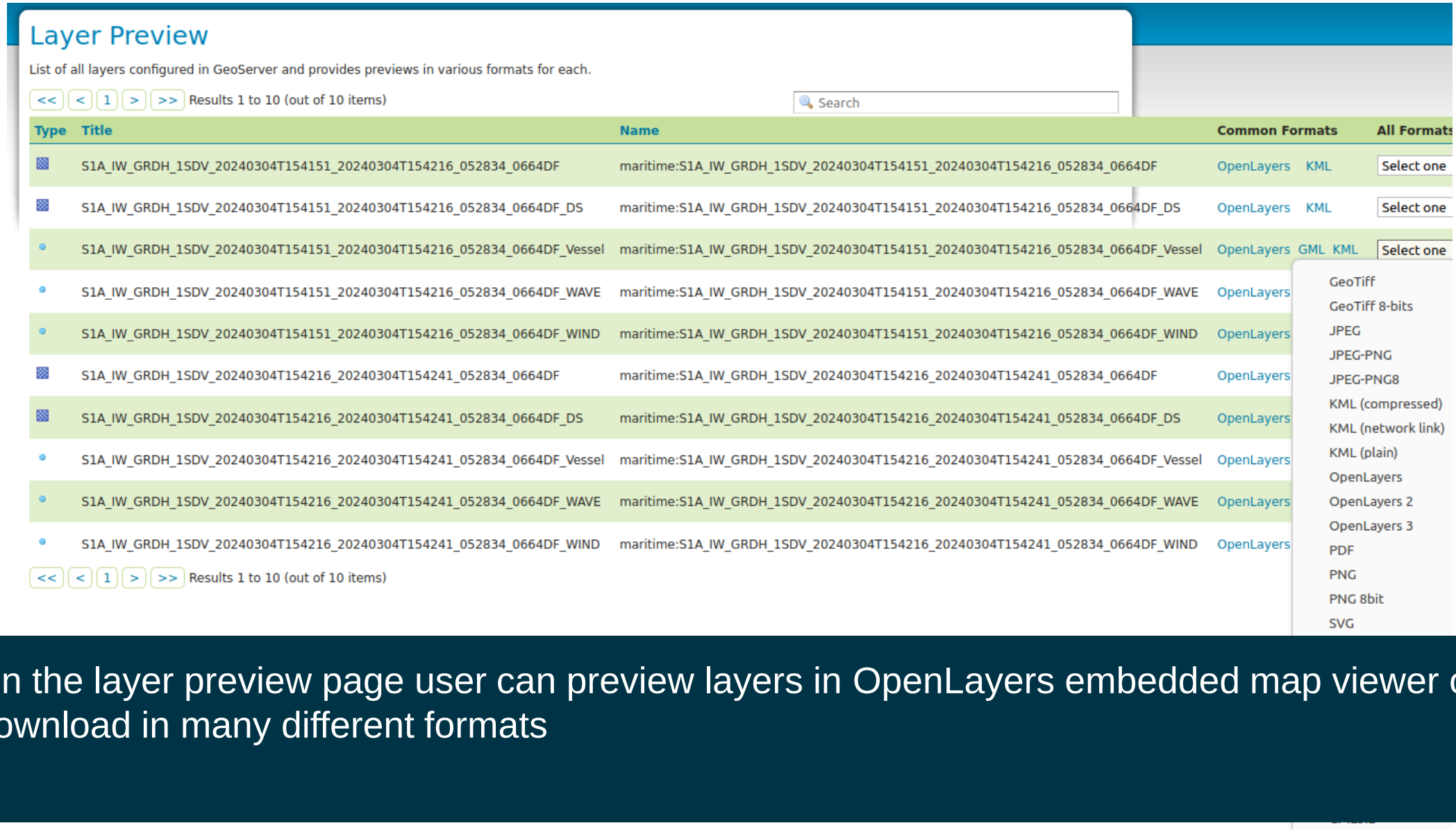
<< < 1 > >> Results 1 to 10 (out of 10 items) Search

Data Type	Workspace	Store Name	Type	Enabled?
	maritime	S1A_IW_GRDH_1SDV_20240304T154151_20240304T154216_052834_0664DF	GeoTIFF	✓
	maritime	S1A_IW_GRDH_1SDV_20240304T154151_20240304T154216_052834_0664DF_DS	ImageMosaic	✓
	maritime	S1A_IW_GRDH_1SDV_20240304T154151_20240304T154216_052834_0664DF_Vessel	GeoPackage	✓
	maritime	S1A_IW_GRDH_1SDV_20240304T154151_20240304T154216_052834_0664DF_WAVE	GeoPackage	✓
	maritime	S1A_IW_GRDH_1SDV_20240304T154151_20240304T154216_052834_0664DF_WIND	GeoPackage	✓
	maritime	S1A_IW_GRDH_1SDV_20240304T154216_20240304T154241_052834_0664DF	GeoTIFF	✓
	maritime	S1A_IW_GRDH_1SDV_20240304T154216_20240304T154241_052834_0664DF_DS	ImageMosaic	✓
	maritime	S1A_IW_GRDH_1SDV_20240304T154216_20240304T154241_052834_0664DF_Vessel	GeoPackage	✓
	maritime	S1A_IW_GRDH_1SDV_20240304T154216_20240304T154241_052834_0664DF_WAVE	GeoPackage	✓
	maritime	S1A_IW_GRDH_1SDV_20240304T154216_20240304T154241_052834_0664DF_WIND	GeoPackage	✓

<< < 1 > >> Results 1 to 10 (out of 10 items)

Satellite images and corresponding VA layers:
“*_WIND” – Wind detection
“*_WAVE” – Wave detection
“*_Vessel” – Vessel detection
“*_DS” – Vessel thumbnails (for visualization)

First Results on ECoE GeoServer



On the layer preview page user can preview layers in OpenLayers embedded map viewer or download in many different formats

Conclusion

- Significant progress has been made in recent months
- First system for processing Sentinel-1 SAR data and AIS has been developed and deployed
- First results will be new AI based Ship- detection development
- Initial results for the derivation of wind, wave and ship detection information will be generated using the DLR processors provided.
- Validation of AI-based ship detection models developed at ECoE in preparation
- In parallel with the procurement of the DAS antenna infrastructure, the NRT chain is being set up to be able to process data received in Cyprus directly in the future.

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THANK YOU

Paphos, Copernicus Sentinel-Data [2024] für Sentinel-2