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ADVANCED SHIP DETECTION SOFTWARE FOR MARITIME SURVEILLANCE

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SUMMARY

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- EDISOFT activities presentation

- Work done in the context of R&D and operational European projects in terms of ship detection by EDISOFT in collaboration with ISEL-IT: EDISOFT VDC software

- Seabilla project: short presentation

- Conclusions and future work

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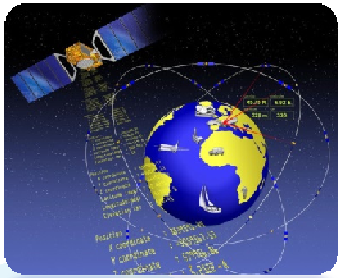
Founded on May 23, 1988, EDISOFT has occupied a prominent position within the Portuguese Defense Industry;

EDISOFT develops activities in the following domains :

- **Command and Control Systems for the Defence Industries**
- **Naval Platforms**
  - Combat Systems;
  - Integrated Information Systems;
- **Maritime Security**
  - VTS/VTMIS Solutions for Coast Surveillance ;
  - Situational Awareness;
  - Maritime Surveillance using Earth Observation Satellites;
- **Space Systems**
  - Tracking Ground Station (satellites and launchers);
  - Satelite Navigation (EGNOS / Galileo);
  - Satelite Communications;
  - Earth Observation;
- **Air Trafic Control Systems and Global Solutions for Airports**
- **Geographic Information Systems and Strategic Collective Security Systems**



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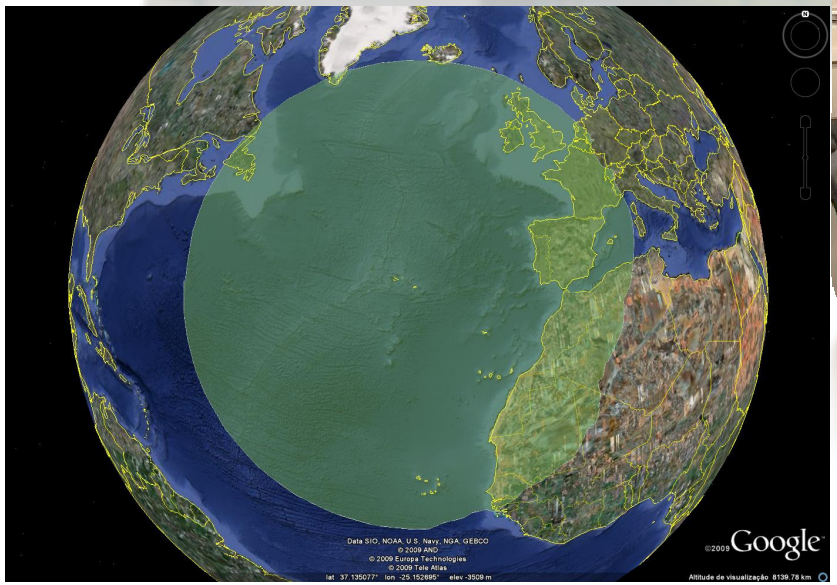
Ground station for Earth observation

Santa Maria - Azores
PORTUGAL



Maritime Monitoring context

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• The increase of maritime traffic requires monitoring at a global scale for marine environment management in terms of safety, security and fisheries. It resulted in more stringent requirements:

- Capability to detect small and fast boats;
- Capability to track targets of interest in open seas;
- Capability to provide the maximum informative content (size, orientation, velocity, classification)

•Particularly useful is the synergy between the operational and research aspects. This synergy was exploited in the R&D projects (Dolphin, SEABILLA) and in the operative MARISS and CleanSeaNet projects

VDC software

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- The VDC software integrates different usefull tools for maritime monitoring, exploiting the SAR data informative content for improved ship detection/classification

- The implemented modules of the VDC software for maritime surveillance purposes are the following:

1. Ship detection;
2. Ship classification (velocity estimation);
3. SAR data simulation of ships in maritime environment.

VDC software

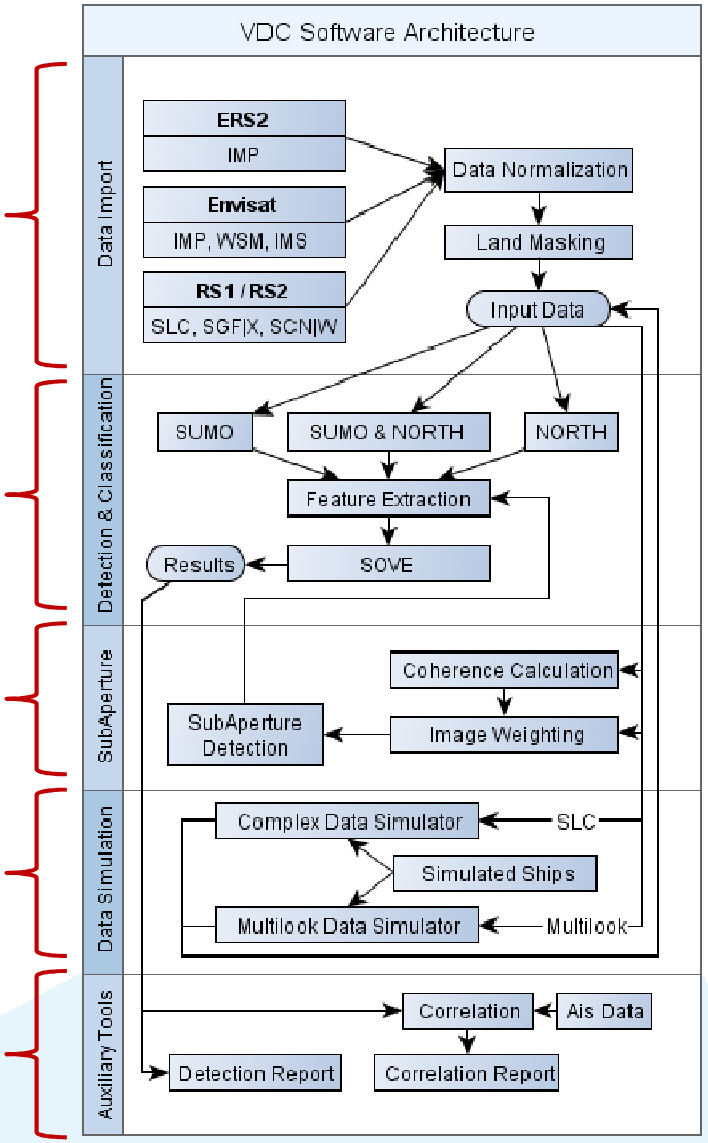
Reading of the auxiliary information and the data of ERS, Envisat, Radarsat 1-2

Ship detection on multilook data through the algorithms SUMO and NORTH; ship classification through the SOVE algorithm

Ship detection on SLC data through the sub-aperture processing

SAR data simulation for the insertion of moving ships signatures in real SAR data

Auxiliary tools for AIS correlation, report generation, image navigation etc.



VDC software: User Interface

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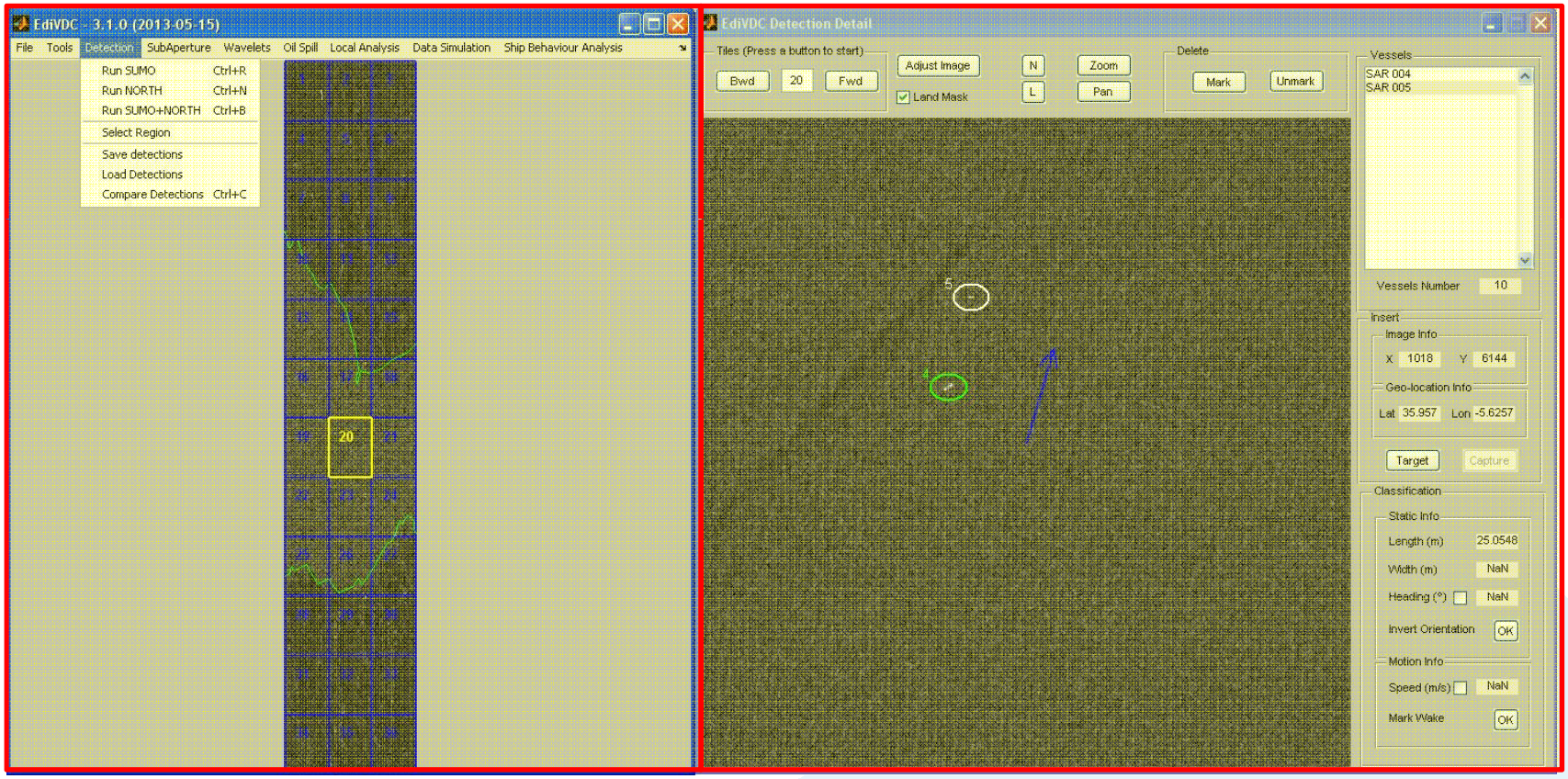
Main window with image quicklook and functionalities menu

Secondary window with detailed tile visualization. The characteristics of the detected ships are here shown



VDC: Detection & Classification

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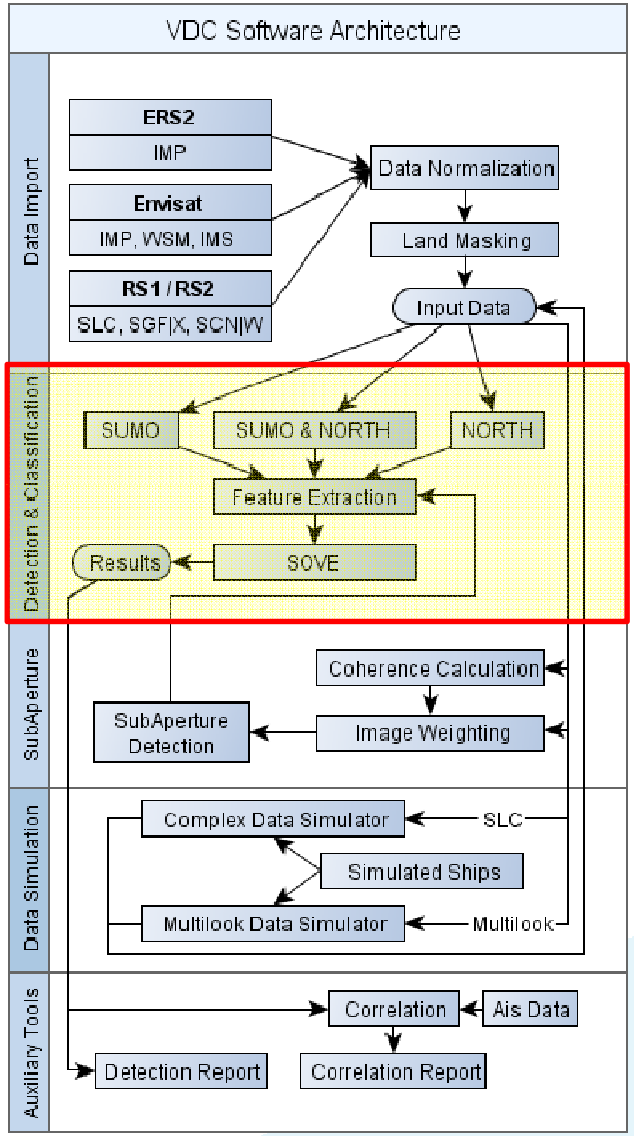

VDC: Detection & Classification

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- SUMO: detection algorithm working on multilook SAR data and based on the use of a template moving window which is applied over all the pixels. The moving window consists of a high threshold core (T1) surrounded by pixels with lower thresholds values (T2 greater than T3)

- NORTH (Normalized Threshold): detection algorithm based on single threshold obtained normalizing the range data columns. The big advantage is the simplicity, speed and low memory consumption

- SOVE (from Ship Orientation to Velocity Estimation): velocity estimation algorithm which estimates the velocity using the ship orientation and the Radon transform to detect the wake and to calculate the shift between moving target and wake

VDC: Sub-aperture processing

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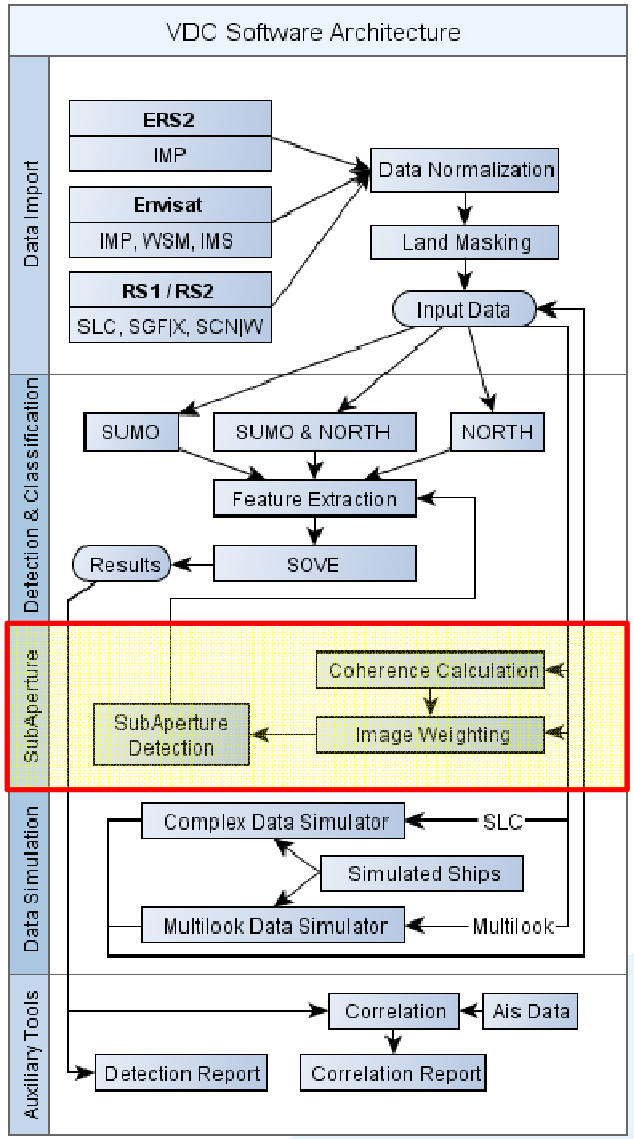

VDC: Sub-aperture processing

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- Detection algorithm working on Single Look Complex Data (SLC) multilook SAR data.
- The main purpose of the algorithm is the ship detection improvement, increasing the performance in case of small boats and complex meteorological conditions
- The objective of the algorithm is to filter the Sea Clutter through the coherence concept, taking into account that the sea has an incoherent behaviour during the integration time in comparison with the ships

Sub-aperture processing results

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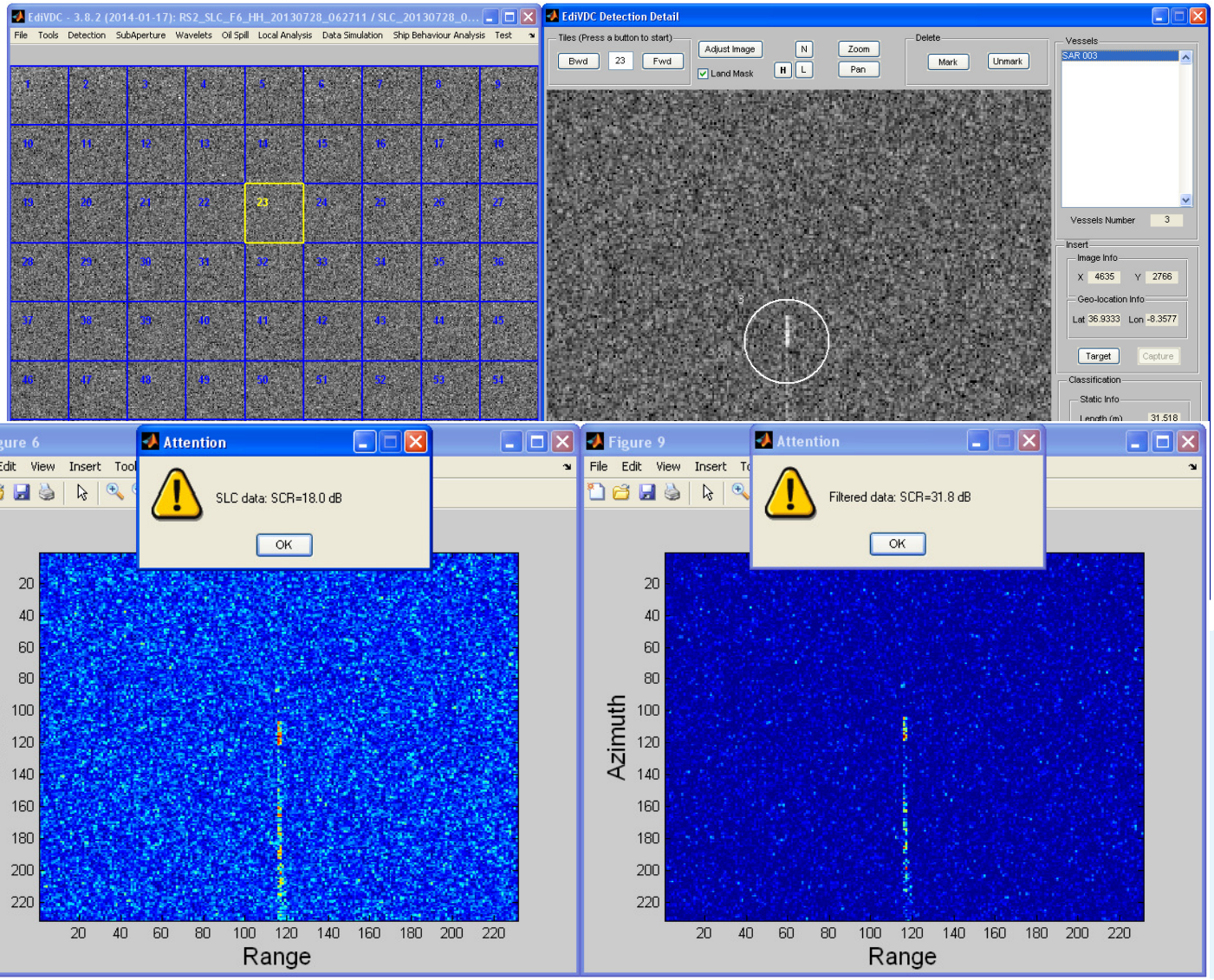

GNR rubber boat
10 m lenght
3 m width
40 kts speed
Track: 0°

VDC: SAR data simulator

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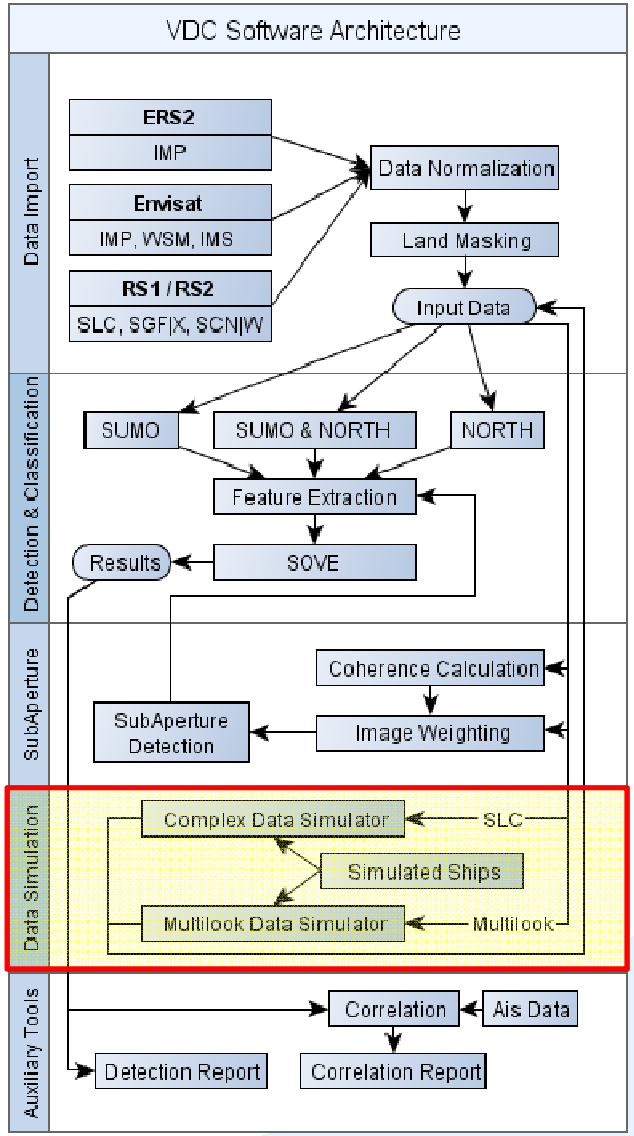

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VDC: SAR data simulator

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- The simulator is able to insert synthetic signatures of moving ships in the image, simulating the acquisition of the target directly from the radar.
- It works on SLC data The main purpose of the algorithm is the ship detection improvement, increasing the performance in case of small boats and complex meteorological conditions
- The main purpose of the simulator is to complement the real data for algorithm development and demonstration building. It was used for validation of the sub-aperture algorithm and for the demonstration campaign in Seabilla project.

VDC: SAR data simulator

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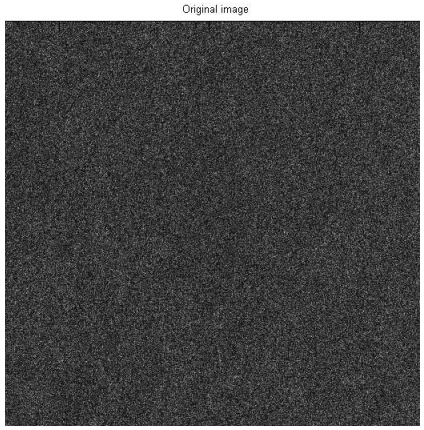
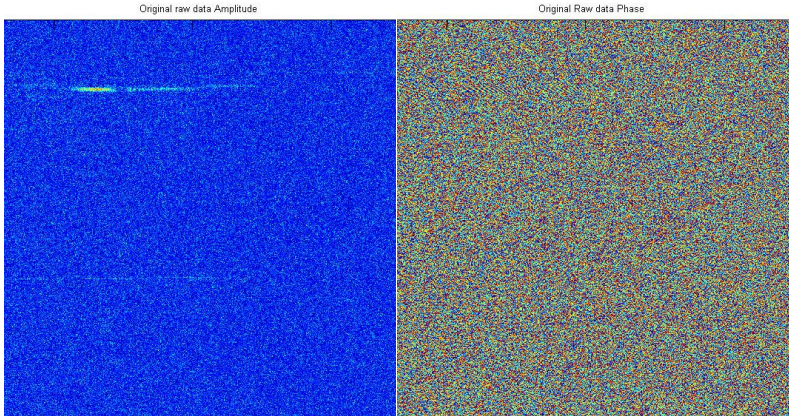


SAR data simulator

The raw data signal is retrieved by defocusing processing



Defocusing

Data

SpectrumShift to Doppler Centroid

Image defocusing

\+

Ship Raw Data

The raw data signal of the moving ship is inserted in the real raw data, simulating the real acquisition of the ship

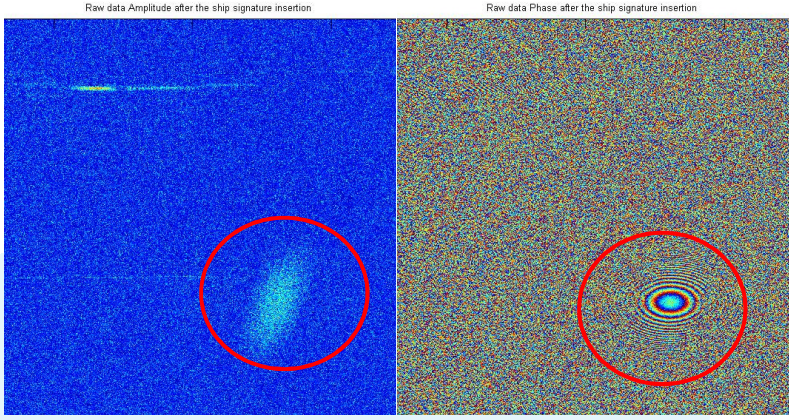
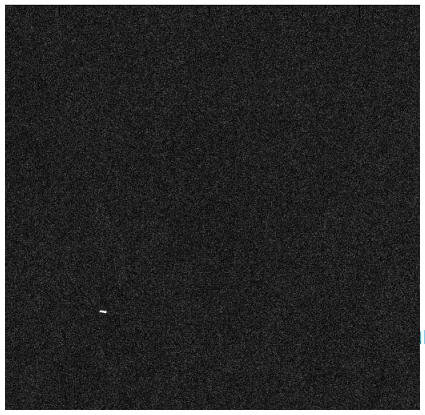


Image focusing

Spectrum To Data

Refocusing

Data with simulated ships



The raw data is refocused to generate the original data with the inserted ship

VDC: Auxiliary tools

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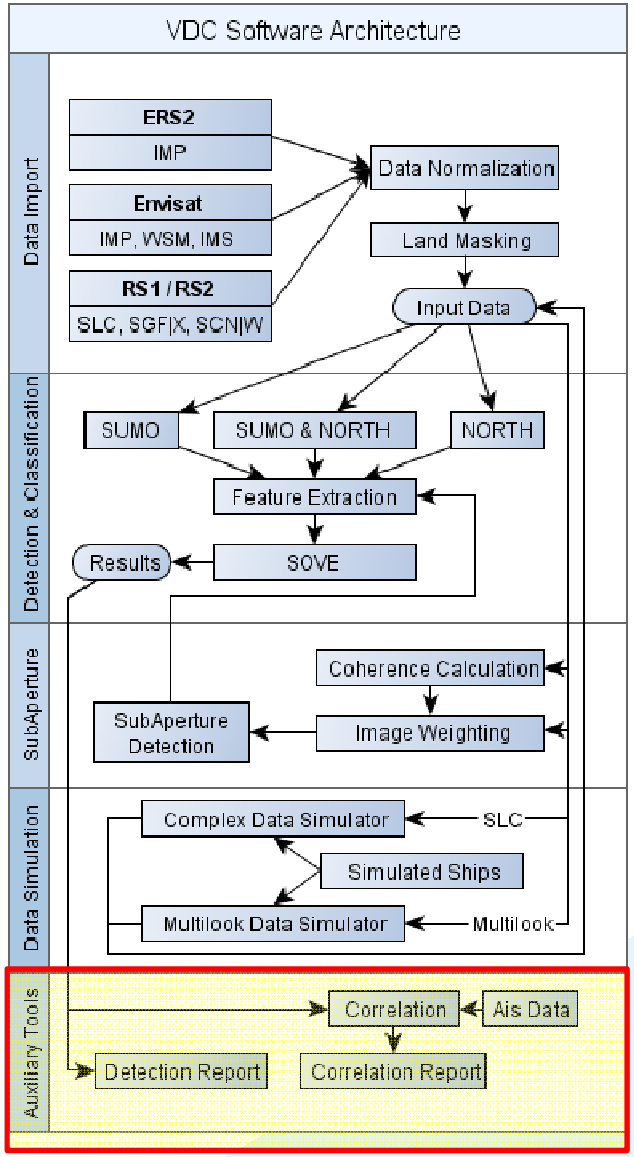

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Auxiliary tools: Data correlation

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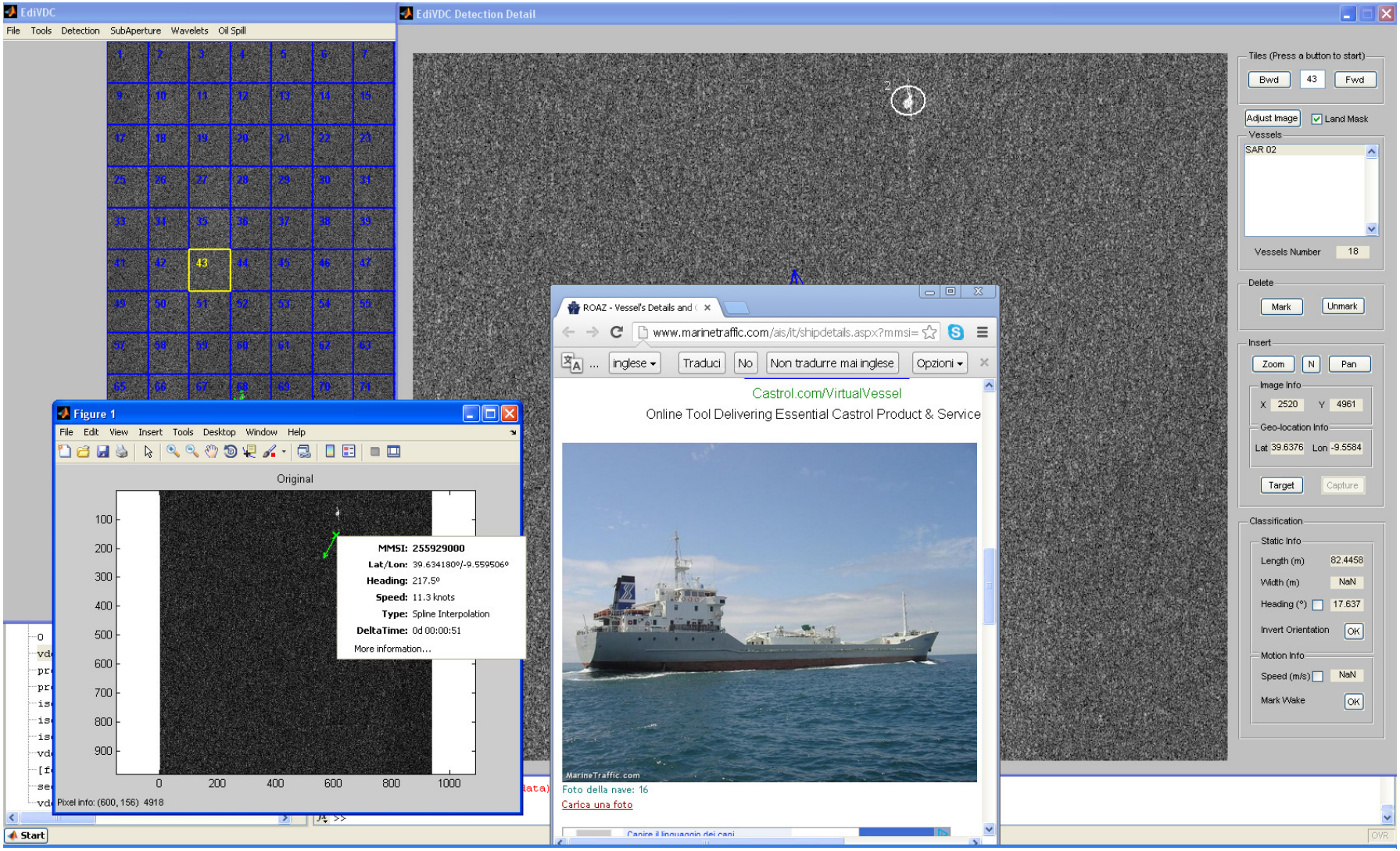
Ingestion of AIS data directly in the VDC software and correlation process



Auxiliary tools: Data correlation

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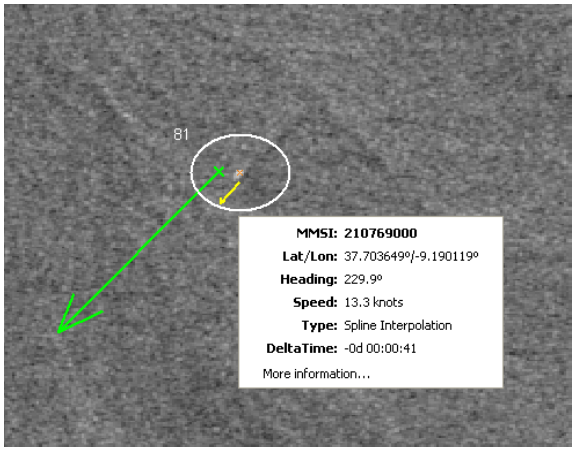
- **AIS correlation:** The detected vessels are correlated with AIS data through spline interpolation
- **Forward Tracking**: If all AIS information is before the time instant then a Forward Reckoning is performed, considering that the vessel maintains the same course and speed as in the last known position
- **Backward tracking:** If all AIS information is after the time instant then a Backward Reckoning is performed, considering that the vessel had maintained the same course and speed as in the first known position



Auxiliary tools: Report Generation

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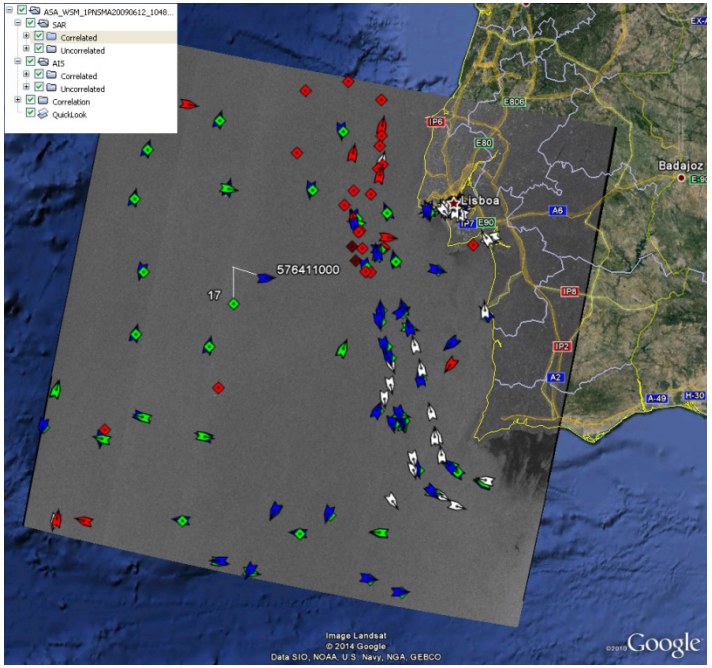
Report format: The report is provided in KMZ, XML and TXT format

Correlation categories: After correlation, the outputs are divided in 3 categories:

a) ***correlated*** when there's a matching between a vessel detection and a AIS position report;
b) ***undetected*** when an AIS position report doesn't have a corresponding vessel detection;
c) ***suspect*** when a vessel detection doesn't have a corresponding AIS position report



Seabilla results

- **Programme: FP7 – Security**
  - Area: Sea border surveillance system
- **Demonstration objectives**
  - Surveillance capabilities enhancement through integration of different sources and development of advanced processing techniques
  - Organization of demonstration campaigns for illegal activities detection and alert:

1. Immigration monitoring;
2. Drug traffic monitoring;
3. Terroristic activities monitoring.

- **Consortium**
  - 26 partners from 9 countries
- **Timing**
  - Project duration: 45 months
  - Start/End date: 1st June 2010 – 28th February 2014

Seabilla results

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Demonstrate how sea border surveillance can be improved through:

- ad hoc **enhancements** for selected surveillance systems and sensors (SAR images, optical images, coastal radar systems)
- **non-conventional** sensors, such as Unmanned Air Systems and Passive Sensors, as gap fillers
- innovative sensors **networking architecture** and **information fusion**

These technical objectives will be:

- checked for full respect of **legal** and **normative** constraints;
- challenged for **cost-effectiveness** and **performances**;
- **evaluated** in terms of measurable improvements **by** a community of **users** on a suite of critical scenarios.

Seabilla results: detection algorithm improvements

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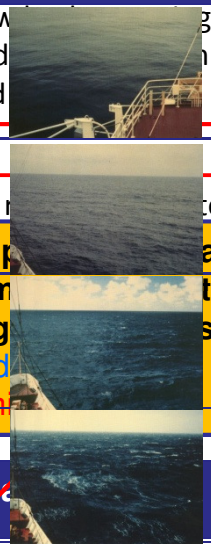
- Performance parameters: Results summary

SCR (dB)	Length (m)	Width (m)	Speed (Knots)	Standard algorithm: Detection rate %	Advanced algorithm: Detection rate %
30	40	10	0	100	100
25	40	10	0	100	100
20	40	10	0	90.6	100
15	40	10	0	20	95
30	30	8	0	100	100
25	30	8	0	100	100
20	30	8	0	72.2	100
15	30	8	0	0	81.8
30	20	6	0	100	94.4
25	20	6	0	94.1	100
20	20	6	0	8.3	86.1
15	20	6	0	0	47.2
30	10	3.5	0	11.1	80.5
25	10	3.5	0	0	77.7
20	10	3.5	0	0	19.4
15	10	3.5	0	0	8.3

SCR (dB)	Length (m)	Width	Speed (m/s)	Standard algorithm: Detection rate %	Advanced algorithm: Detection rate %
30	20	6	10	88.8	94.4
25	20	6	10	69.4	94.4
20	20	6	10	2.8	88.9
15	20	6	10	0	22.2
30	10	3.5	10	19.4	58.3
25	10	3.5	10	0	50
20	10	3.5	10	0	13.9
15	10	3.5	10	0	8.3

Standard algorithm	Advanced algorithm
30 relative low … while the ad … has good …	Very calm sea, very low sea wind
25 The velocity …	Calm sea with small waves, low sea wind
20	Slight sea, medium sea wind
15	Very slight sea, high sea wind



The comp… algorithm… advantag… BLUE: Ad… RED: Lim…
…ature of the analyzed …trated by the …s of each algorithm.

Standard …	Advanced algorithm
Robust algorithm	In very noisily areas more sensitive to false alarms
Very fast	Despite the optimization, is relative slow
Not sensitive to small and fast moving boats	Sensitive to the small and fast boats
Not very adapt for high resolution SAR images	Adapt for high resolution SAR images

Future Work

- Integration of new SAR systems (Sentinel1, TerraSAR-X, CosmoSkyMed);
- Validation of the implemented algorithms used in operational projects;
- Integration of velocity estimation algorithm and classification algorithm implementation in SLC data;
- Implementation of more complex moving target simulation by considering non-linear velocity, reflectivity changing during the illumination interval, ship representation as more complex object;
- Adaptation of the developed algorithms for using onboard of Unmanned Aerial System (UAS), with the purpose of an operational use in local contexts.

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THANK YOU

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