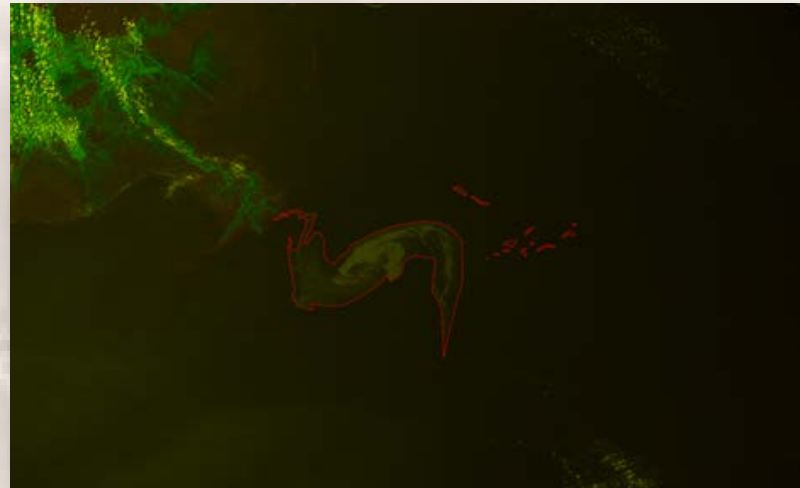


DESIRE

SIMULATION TOOL TO DEMONSTRATE DATA PRODUCTS FOR SECURITY APPLICATIONS



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Presented by Federico Letterio

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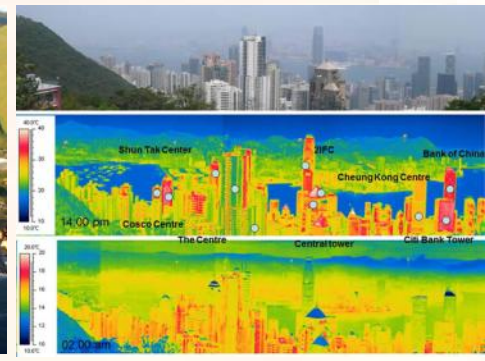
- **Developed as part of ESA funded activity**
 - Design and development of a simulation tool to demonstrate data products for security applications
- **Objective**
 - Demonstrate the added value of including TIR imager within different space-borne architecture options comprising different capabilities i.e. SAR, optical, etc.
- **Intended end users**
 - System architects that need to assess the added value of infrared data when they are combined with other data
- **Target mission scenarios**
 - Addressing the three priority areas identified in the Copernicus services focused on security
 - Border security
 - Maritime Surveillance
 - Support to European Union External Action

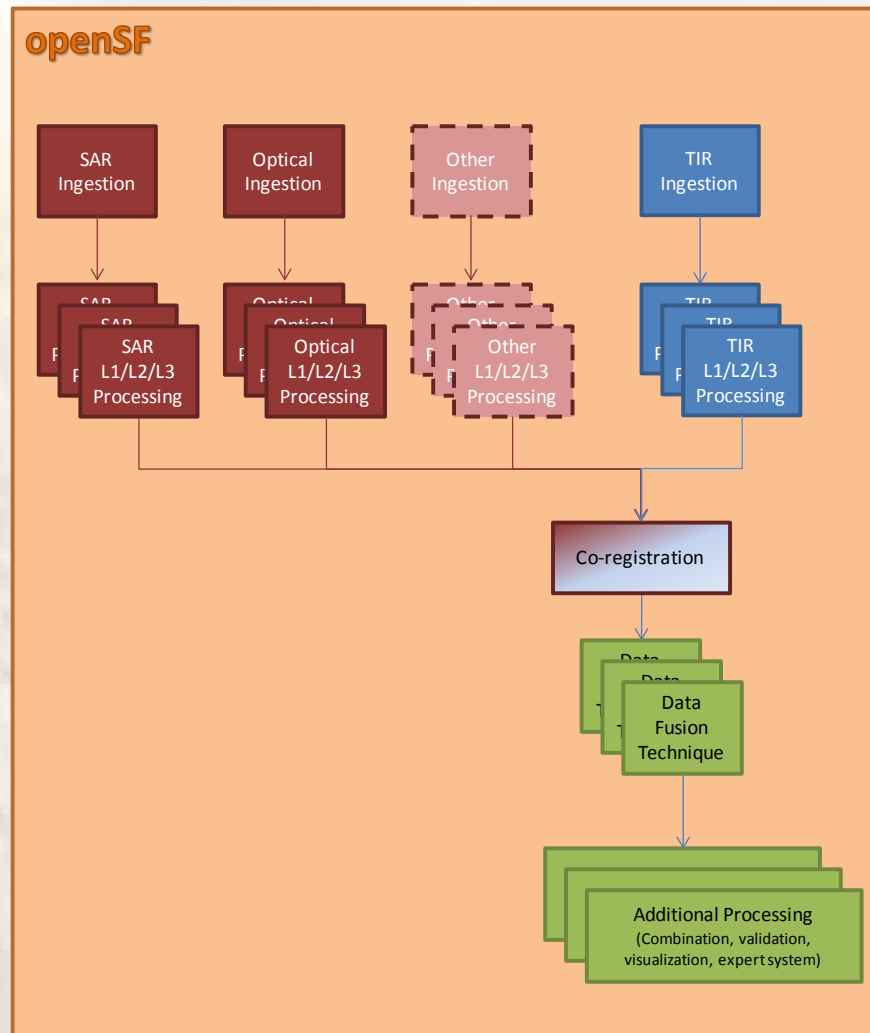
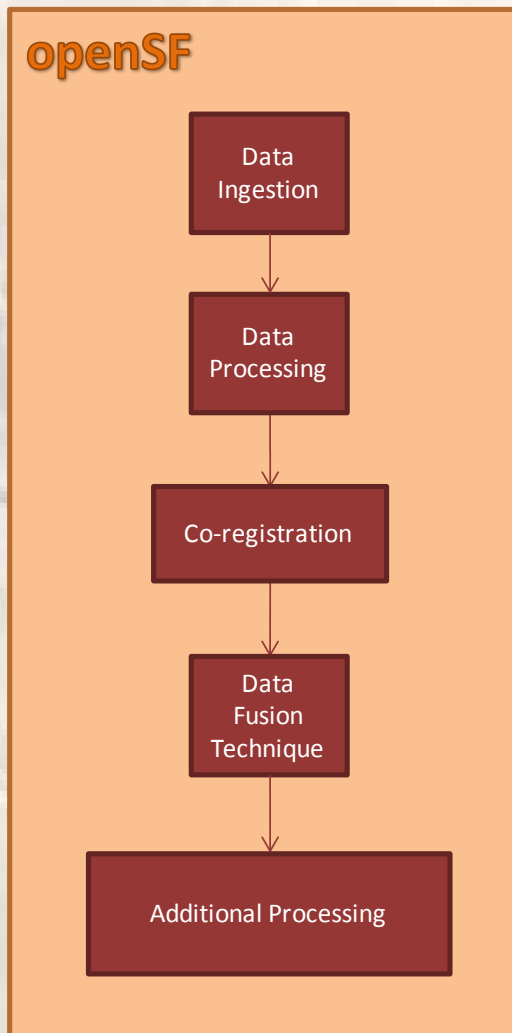
Application	Processing Level	Spatial Resolution	Radiometric Accuracy	Radiometric Resolution	TIR Spectral Resolution	Sensors
Border Security	2 (TOA Brightness Temperature -BT)	< 5 m	Undefined	0,5 - 1 K	10-12 µm	SAR
Maritime surveillance (smuggling, drug trafficking, illegal immigration)	3 (Sea Surface Temperature - SST)	< 10 m	Undefined	0,5 - 1 K	10-12 µm	Optical, SAR
Maritime safety	3 (SST)	< 15 m	Undefined	0,5 - 1 K	10-12 µm	Optical, SAR
Non EU Maritime Surveillance (piracy, illegal fishing)	3 (SST)	< 15 m	Undefined	0,5 - 1 K	10-12 µm	Optical, SAR
Monitoring of Volcanoes (ash)	3 (Land Surface Temperature - LST)	1-3 km	1 K	0,5 - 1 K	10-12 µm	Optical
Trafficability	3 (LST)	30 m	1 - 2 K	0,1 - 0,3 K	10-12 µm	SAR
Oil Spill Detection/ Monitoring	3 (SST)	50 m	1 K	0,1 - 0,5 K	10-12 µm	Optical, SAR
Industrial / Power Plant Monitoring	3 (SST)	5 - 30 m	1 - 2 K	0,5 - 1 K	Spectrometry	Optical
Urban Heat Islands	3 (LST)	< 500 m	1 K	0,1 - 0,3 K	Spectrometry	Optical
Monitoring of Refugee Camps	2 (TOA BT)	< 10 m	Undefined	0,5 - 1 K	10-12 µm	Optical, SAR
Treaty Compliance / Non-Proliferation Treaty	3 (SST, LST)	5-30 m	Undefined	0,5 - 1 K	10-12 µm	Optical, SAR

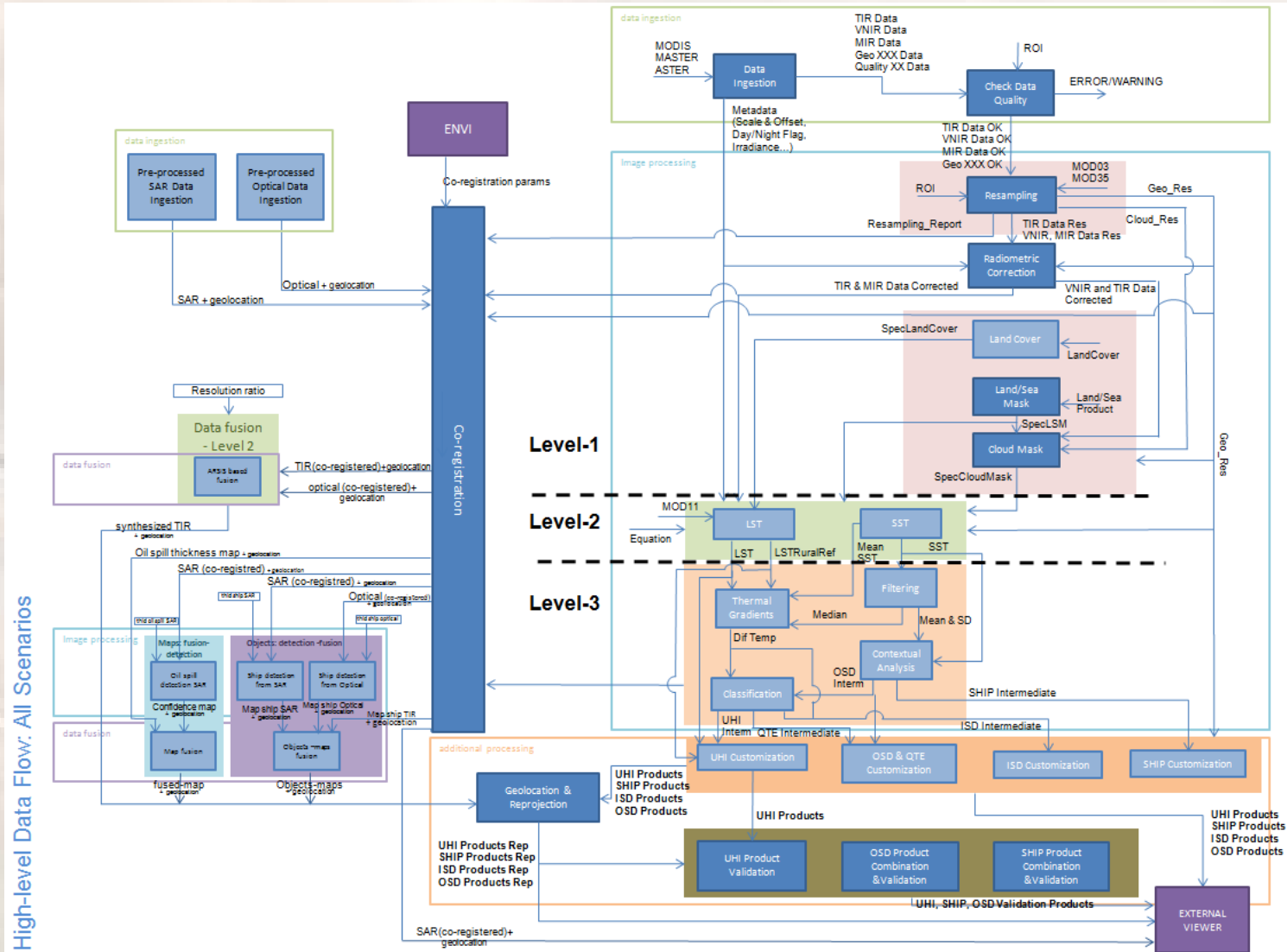
Scenarios	TIR Relevance			Selection
	Sensitivity	Usefulness	Overall	
BORDER SECURITY				
Border Security	0	1	Low	
Transport Routes	0	1	Low	
Port/Harbour Monitoring at Night	0	2	Medium	
MARITIME SURVEILLANCE				
Vessel Tracking / Lost Vessels / S&R	1	2	High	X
Situation Awareness around Off-shore Platforms	1	1	Medium	
Icebergs Detection and Tracking	1	1	Medium	
Debris Detection	0	1	Low	
EU EXTERNAL ACTION				
ONSET OF CRISIS				
Hurricane Disasters	1	1	Medium	
Monitoring of Volcanoes	1	2	High	
TRAFFICABILITY AND NATURAL RESOURCES				
Trafficability	0	1	Low	
Natural Resources	1	1	Medium	
ENVIRONMENTAL COMPLIANCE				
Detection and Monitoring of Oil Spills	1	2	High	X
Industry Activity Monitoring	1	2	High	X
PUBLIC HEALTH				
Urban Heat Island Monitoring	1	2	High	X
Urban Expansion/Sprawl	1	1	Medium	
OTHERS				
Monitoring of Refugee Camps	1	1	Medium	
Treaty Compliance/Non-proliferation Treaty (NPT)	1	2	High	
Minefield Detection	0	1	Low	
Support to War Crimes Detection	0	1	Low	

- **Four scenarios have been selected as case studies**
 - Oil Spill Detection and Monitoring
 - Maritime Ship Surveillance
 - Industrial Site Monitoring
 - Urban Heat Island Monitoring

Application	TIR Spatial Resolution	Geographical Coverage	TIR Temporal Resolution	Other Bands and Spatial Resolution		Other Needs
Maritime Surveillance	10 – 20 m	Local and Regional	2 – 6 h	SAR 10-20 m	VIS 10-20 m	Timeliness < 15 min
Oil Spill Detection & Monitoring	50 m	Regional	12 – 24 h	SAR 50 m		Co-registration with SAR < 30 min
Industrial Sites Monitoring	5 – 30 m	Local	24 h	VIS 5-30 m		
Urban Heat Islands	20 – 100 m	Local	24 h			





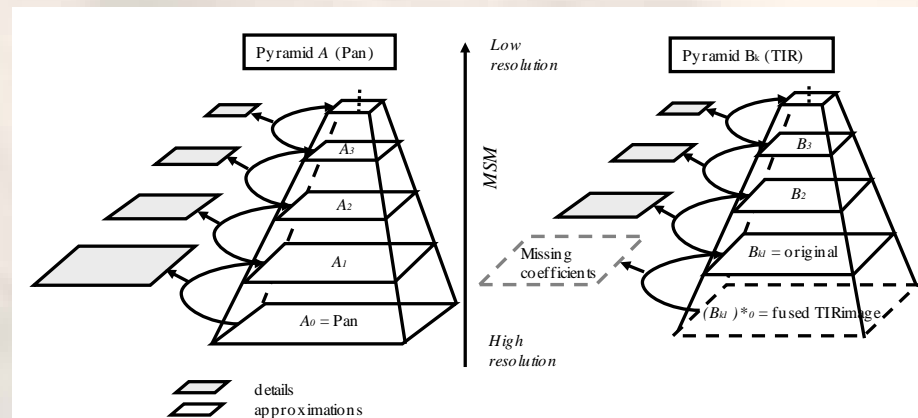


High-level Data Flow: All Scenarios

DESIRE - Simulation Tool to Demonstrate Data Products for Security Applications

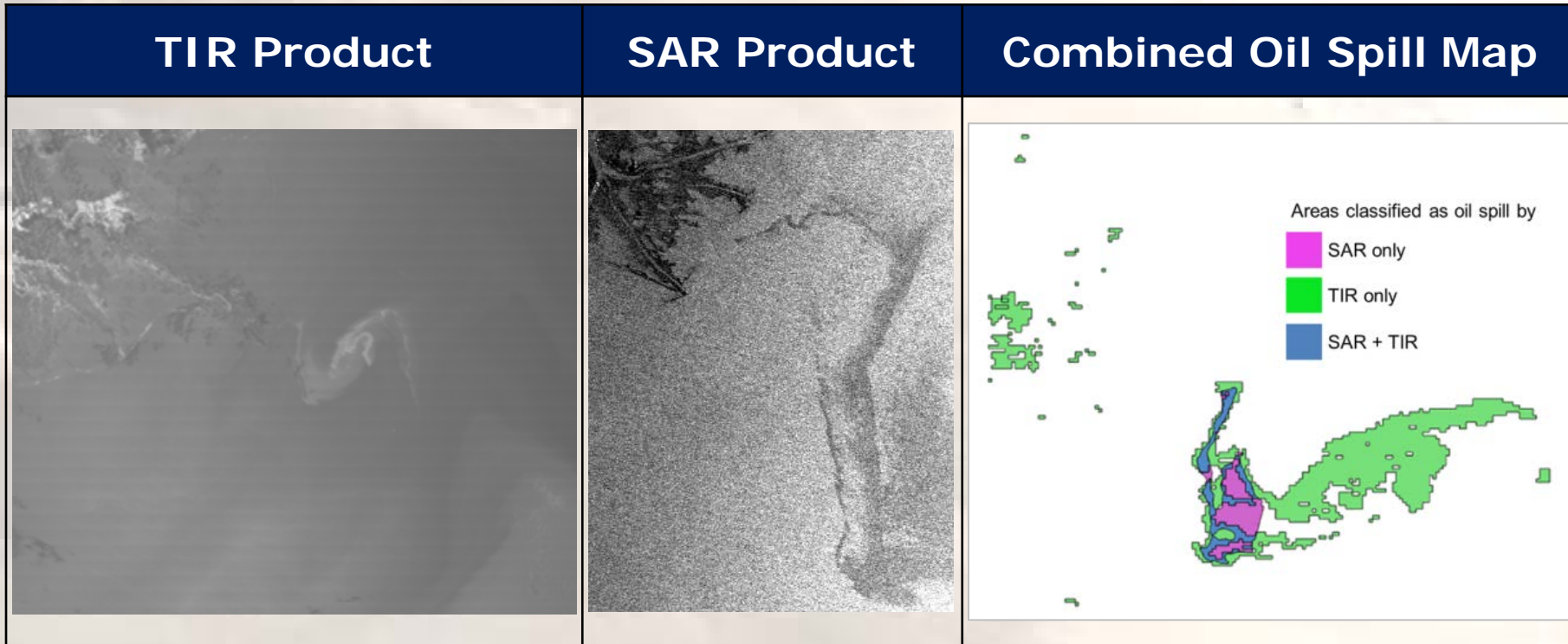
- **Three stages processing chain for TIR data**
 - Level 1 → ingesting and preprocessing
 - Level 2 → generating geophysical variables (LST and SST)
 - Level 3 → extracting, classifying, customizing and validating
- **TIR input data**
 - MODIS - MOD02 → 15 TIR channels
 - from band 20 to 36 (except 26); spatial resolution of 1 km
 - ASTER - AST_L1B → 15 bands
 - 3 VNIR up to 15m; 1 NIR, 6 SWIR with 30m; 5 TIR with 90m
 - MASTER - MASTERL1B → 50 bands
 - multispectral airborne instrument
- **SAR & VIS: simpler and more generic processing chain**
 - Pre-processed Level 1 data
 - Extracting and classifying information
 - Ships detection from optical and SAR data
 - Oil spills detections and confidence level from SAR data

- **Different data fusion techniques**
 - Image fusion (at pixel level)
 - Object fusion (of information extracted from different data)
- **ARSIS (Improving Spatial Resolution by Structure Injection)**
 - TIR resolution promoted up to the optical one
- **Object detection merged maps**
 - From TIR, SAR and VIS → ship detection
 - From TIR and SAR → oil spill detection



- **Oil Spill Detection & Monitoring**

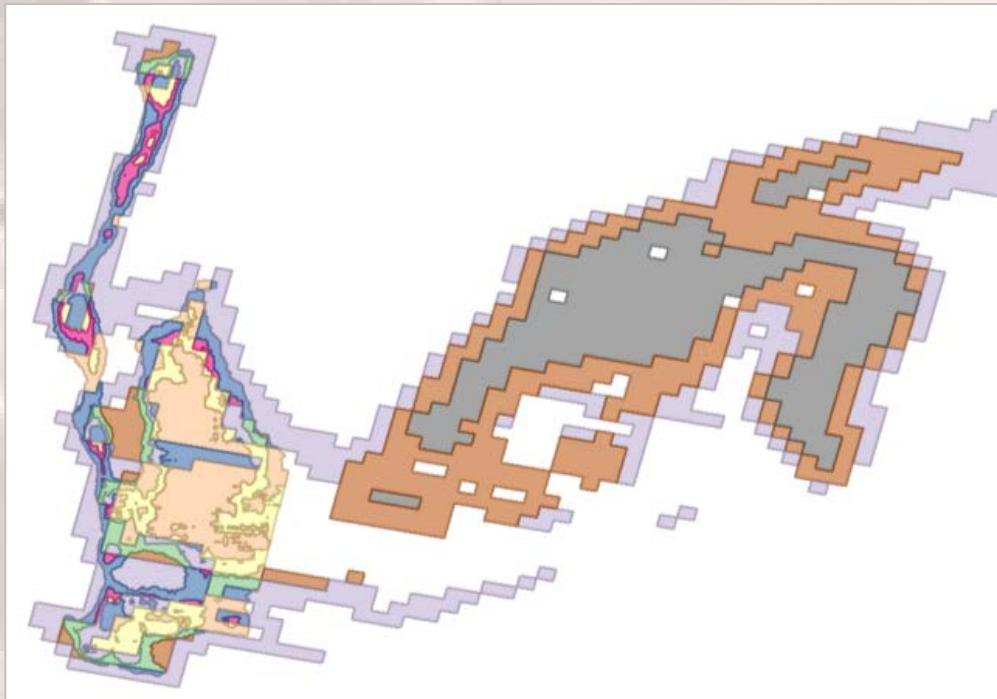
- Fusion of information extracted from different data sources
 - Oil spill detections and confidence level from SAR
 - Oil spill perimeter and thickness estimation from TIR



- **Oil Spill Detection & Monitoring**

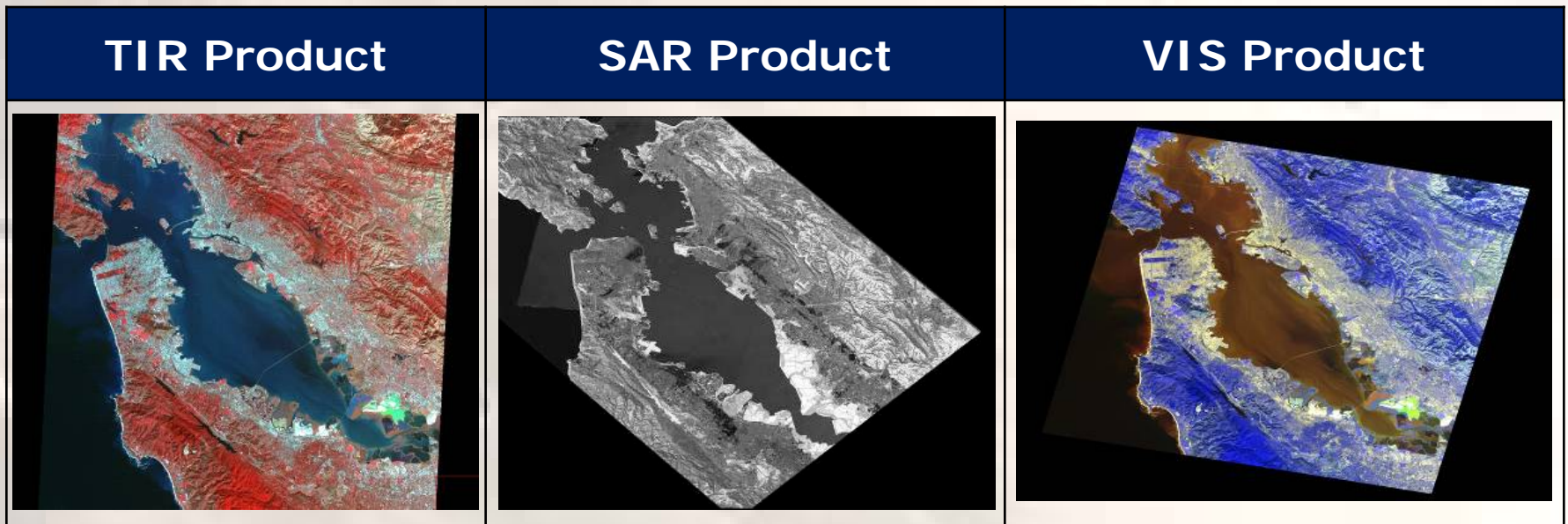
- Fusion of information extracted from different data sources

- Oil spill detections and confidence level from SAR
- Oil spill perimeter and thickness estimation from TIR



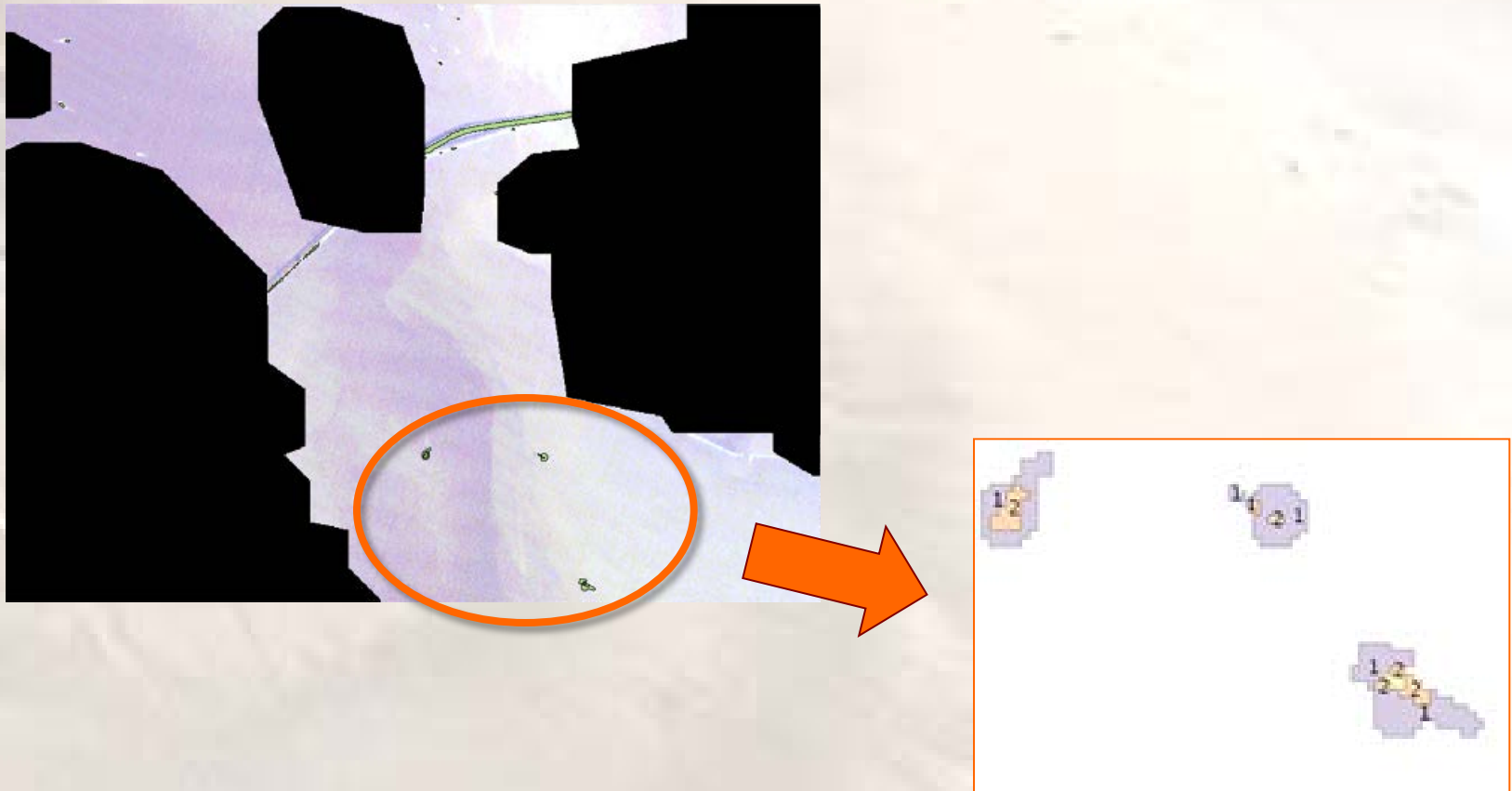
- Thickness low / Confidence No
- No Thickness / Confidence low
- No Thickness / Confidence medium
- Thickness low / Confidence low
- Thickness low / Confidence medium
- Thickness medium / Confidence low
- Thickness high / Confidence No
- Thickness medium / Confidence low
- Thickness medium / Confidence medium
- No Thickness / Confidence high
- Thickness low / Confidence high
- Thickness medium / Confidence high

- **Maritime Ship Surveillance**
 - Fusion of detections performed on different data sources

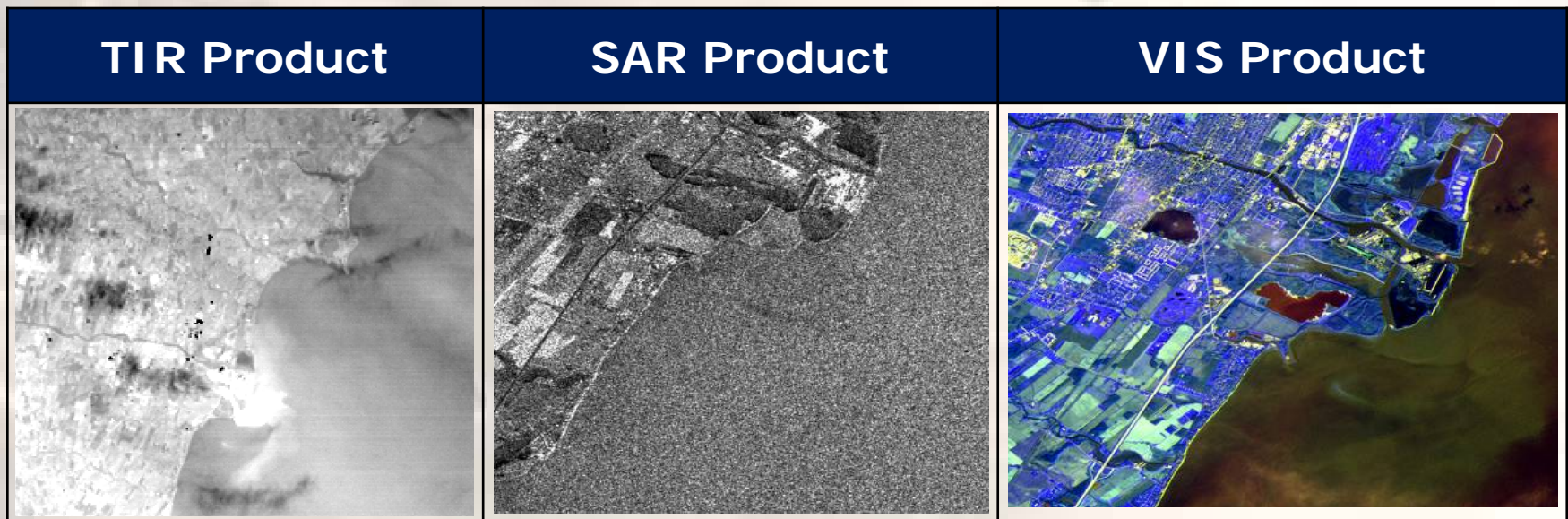


- **Maritime Ship Surveillance**

- Fusion of detections performed on different data sources

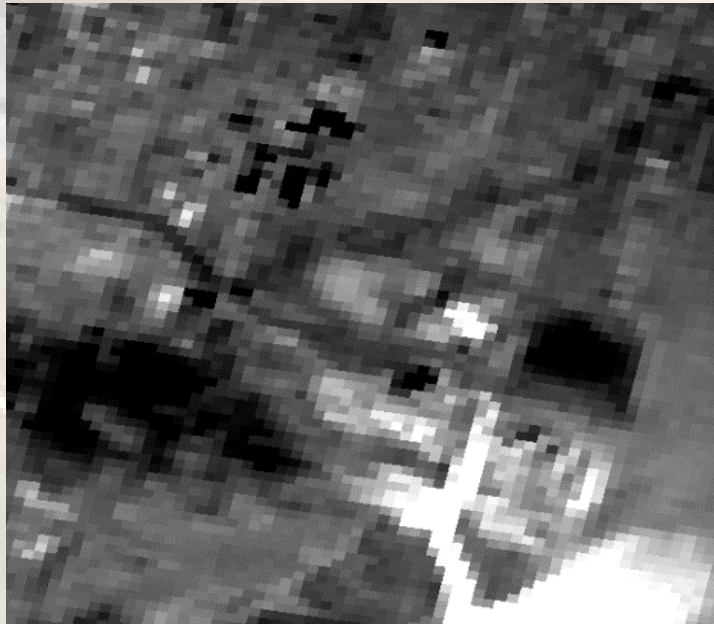


- **Industrial Site Monitoring**
 - TIR-optical fusion, for increasing TIR resolution
 - Characterized TIR on water

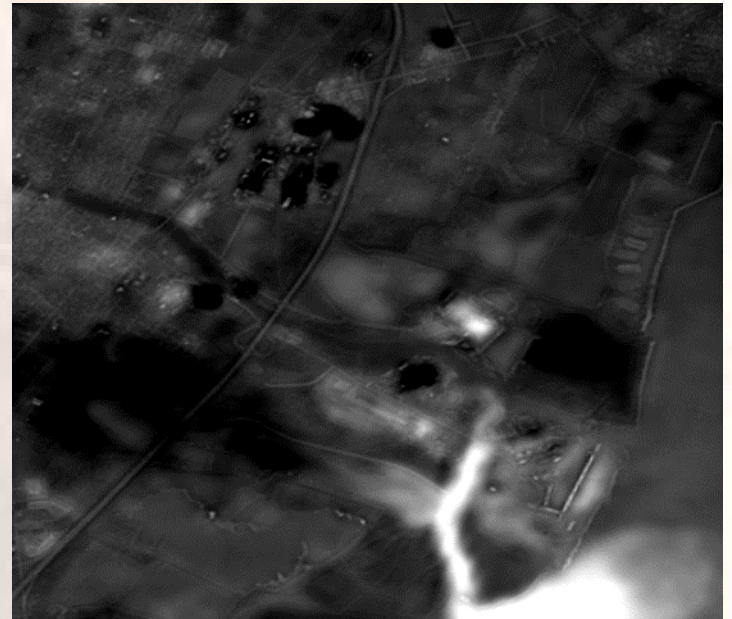


- **Industrial Site Monitoring**
 - TIR-VIS fusion, for increasing TIR resolution
 - Characterized TIR on water

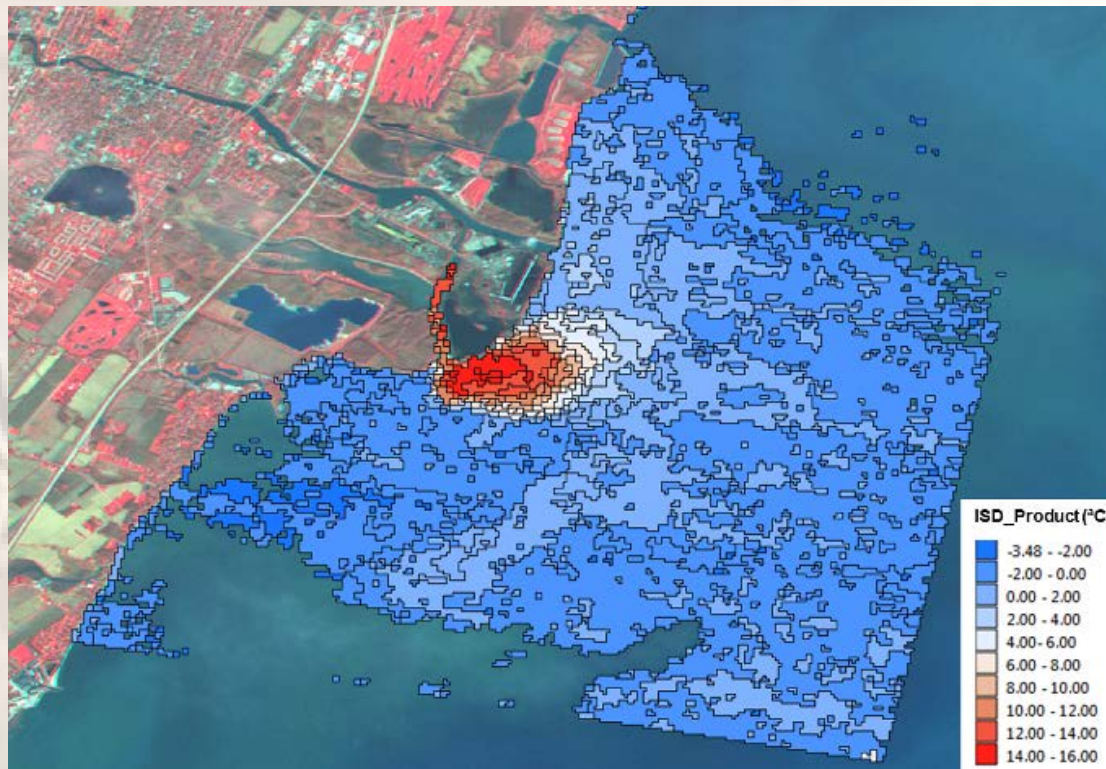
TIR data



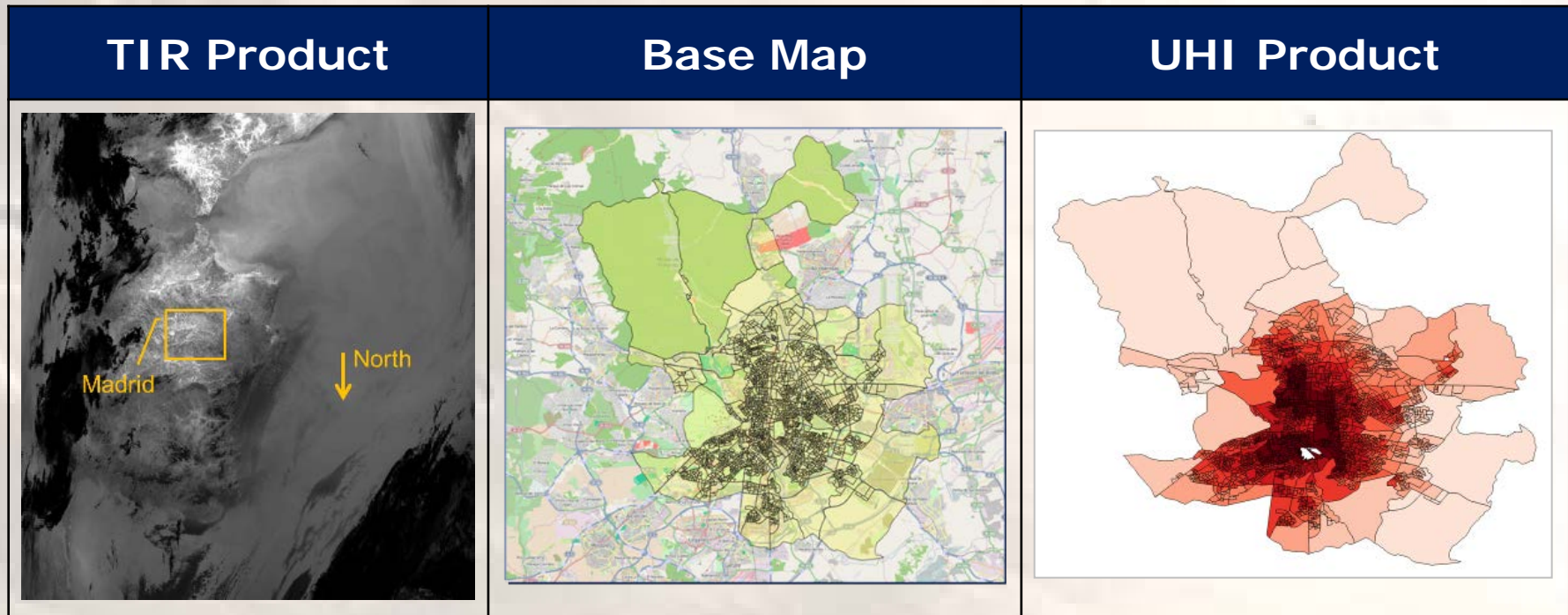
Synthesized TIR



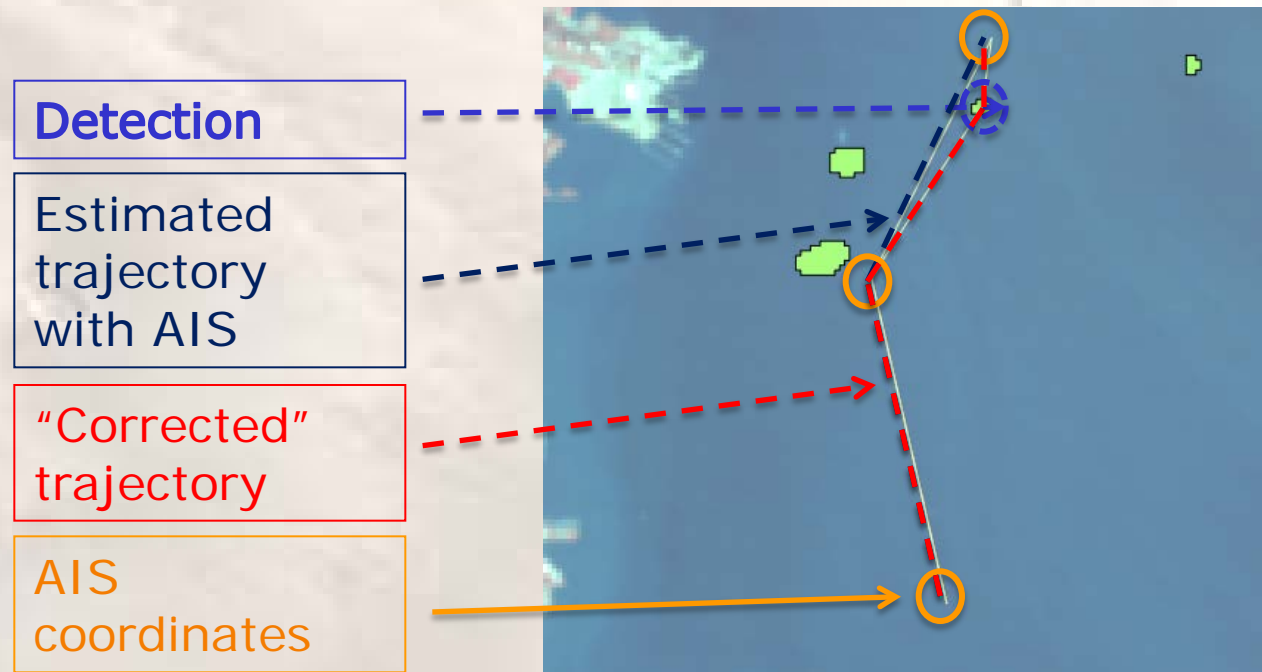
- **Industrial Site Monitoring**
 - TIR-VIS fusion, for increasing TIR resolution
 - Characterized TIR on water



- **Urban Heat Islands**
 - Multiple TIR data fused
 - Base map applied



- **Validation has been performed using ground truth**
 - AIS for ship detection
 - NOAA reports and photointerpretation from High Resolution VIS data for oil spill detection
 - Weather stations measurements for urban heat islands
- **VIS/AIS integration**

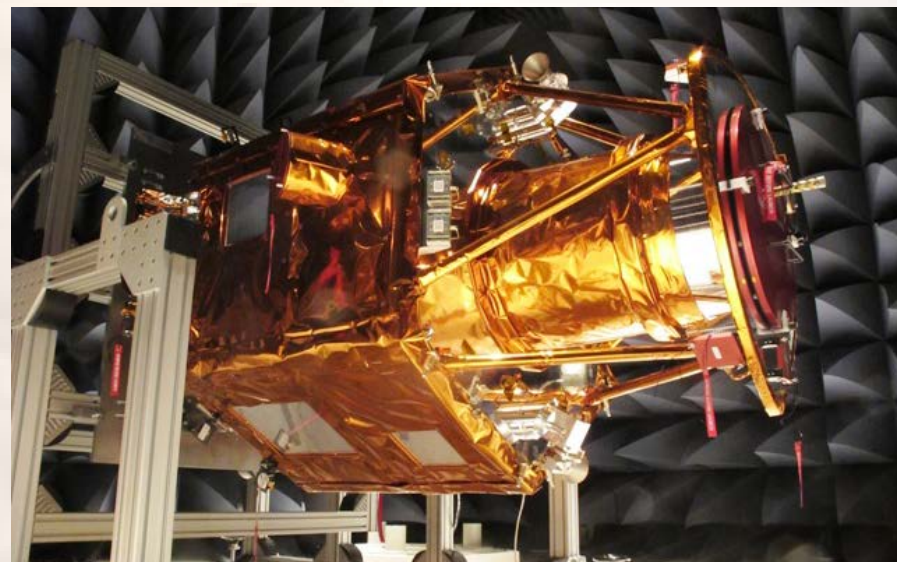


- **Preliminary results using real data – TIR added value**
 - Oil Spill Detection and Monitoring (TIR + SAR)
 - Gives estimation of the slick thickness
 - Provides additional information on the probability of detection
 - Maritime Ship Surveillance (TIR + SAR + VIS)
 - No increase of detection capability
 - No refinement of the detection of false positives/negatives
 - except under certain conditions (e.g. sun-glint)
 - Reduces the revisit time
 - Improves the monitoring of large vessels' trajectories
 - Industrial Site Monitoring (TIR + VIS)
 - Increases the contextual understanding of the scenario
 - Helps to detect thermal activity with improved accuracy
 - Urban Heat Island Monitoring (TIRs + Base map)
 - Increases the contextual understanding of the scenario
 - Enables the detection of UHI
 - within critical population areas of an urban environment

- **A simulator tool has been designed and developed**
 - To help system designers to assess the added value of TIR data when combined with SAR and optical images
- **Four scenarios have been selected as case studies, addressing the priority areas identified in the Copernicus services for security**
 - Oil Spill Detection and Monitoring
 - Maritime Ship Surveillance
 - Industrial Site Monitoring
 - Urban Heat Island Monitoring
- **The openSF simulation framework has been used**
- **The TIR processing chains are able to ingest three different data products:**
 - MODIS, ASTER and MASTER sensors

- **The optical and SAR chains have been designed to be more generic**
 - Not designed for specific products
- **The data fusion has been addressed using different techniques**
 - Image fusion
 - Object fusion
- **All the scenarios processing chains end with customization and validation modules**
 - To assess the TIR added value wrt SAR/VIS data
 - To validate the simulation results against a ground truth

THANK YOU!



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