Applications for Maritime Situational Awareness

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Knowledge for Tomorrow
Presentation Outline

Introduction

DLR Maritime Application Development
  – Ship detection
  – Wind and Wave
  – Oil Detection

Project example
  – Real Time Service for Maritime Security
    (Echtzeitdienste für die Maritime Sicherheit – Security; EMSec)

Current Development
  – Real Time Service for Navigation on Ice

Conclusion
German Aerospace Center, DLR


Space Agency

Project Management Agency

~ 8000 employees

39 research institutes and large test facilities at 20 sites across Germany

2 Ground stations in O’Higgins (AQ), Inuvik (CA)

5 Liaison offices in Berlin, Brussels, Paris, Tokyo, Washington DC,

4 Maritime Security Lab’s
Earth Observation Center – EOC

2 Institutes, German Remote Sensing Data Center (DFD) & Remote Sensing Technology Institute (IMF)

Bremen
Maritime Security Lab

Neustrelitz
National Ground Segment
Maritime Security Lab

Berlin

⇒ Appr. 350 employees at 4 sites
⇒ Chairs at 2 universities (Würzburg, Munich)
Neustrelitz Ground Station

- Ground Station and Processing Facility Neustrelitz support of currently 21 different Satellite missions
- **Main reception and processing facility for SAR Mission TerraSAR-X (TerraSAR-X/ TanDEM-X)**
- Collaborative Station for European Copernicus mission Sentinel-1 (Sentinel-1A/ Sentinel-1B)
- Radarsat-2 Regional Ground System
- Landsat-8 Global Network Station, United States Geological Survey (USGS)
- CartoSAT, ResourceSat, Oceansat supporting Gesellschaft für Angewandte Fernerkundung (GAFAG)
- Kompasat 3, 3A, 5 supporting Korea Aerospace Research Institute (KARI)
TerraSAR-X Capabilities

- Morning and evening timeline upload for a 12 h desirable / 12 h critical timeline with order deadline a few hours before
  - for data take at end of timeline: allow about 17 hours for tasking
  - based on satellite TSX or TDX acquisition

- Near real time product latency after downlink: about 15 – 30 minutes

- No orbit information available in X-band downlink
  - usage of predicted orbit information only

- NRT ground station pool (Neustrelitz, Svalbard)
  - online raw data transfer to Neustrelitz

- Mission planning uses next possible pool contact for NRT downlink
Objective of the Maritime Security Lab Neustelitz

Research and development of integrated applications enabling specific value added **Maritime Information Products for the Maritime Situational Awareness** in Near Real Time

Application

- Ice
- Oil
- Ship
- Wind
- Wave
- Activity
- Change
Architecture of Service Chain

DATA Collection

Processing Rules and Processors

Processing environment

Product Dissemination
Space Capabilities

Optical

- Worldview-1
- Worldview-2
- Worldview-3
- GeoEye-1
- Deimos-2
- Landsat-8
- Firebird
- Worldview-4

Synthetic Aperture Radar (SAR)

- Sentinel-1A
- Sentinel-1B
- TerraSAR-X
- TanDEM-X
- Radarsat-2

Automatic Identification System

- Terrestrial AIS
- Satellite AIS
Space Capabilities

- Number of Satellites and Satellite Constellations increase

- Higher Number of small satellites, with lower costs of manufacture, launch, and operations

- Increased revisit time and flexibility

- Higher Coverage update and higher image resolution

- Higher service reliability
  - More data
  - New Products
  - Shorter response time

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sats-orbit 2015 | 2016 http://www.pixalytics.com
Merit and Constrains of Remote Sensing using Synthetic Aperture Radar (SAR)

- SAR satellite data enable day/night monitoring independent from weather (clouds) and semi automated feature extraction
- Increasing number of satellite resources
- Different types of sensors and sensor modes (coverage, resolution)
- SAR processing enable fast processing of large volumes of data and information delivery within 15 - 30 minutes of image acquisition
- Data quality and false alarms constraints require operator supervision e.g. for vessel detection application
- Manly dusk dawn orbits
- Tasking nominal twice per day
- SAR instrument orbit duty cycle, revisit and coverage capabilities
- Order (static planning cycle | user competition | dual use)
- Pricing e.g. emergency tasking and very high resolution

Alos-2
CosmoSkymed
Kopsat-5
Raddarsat-2
Risat
Sentinel-1
TerraSAR-X
TanDEM-X
Merit and Constrains of Remote Sensing using very high resolution optical data

- Very High resolution up to 31 cm panchromatic, up to 1.24 m multispectral resolution, 3.7 m short-wave infrared resolution
- High agility and flexibility, e.g. acquisition of coastlines
- Increasing number of satellite resources and satellite constellations e.g. Digital Globe, AIRBUS, Deimos, Kompsat, Planet
- Monitoring dependents on weather situation clouds
- Order, e.g. user competition and dual use
- Limited near real time capabilities compared to SAR
- Pricing, expensive

GeoEYE-1
Deimos-2
Pleiades
Planet
Kopsat-3, 3a
Worldview 1-4
Thematic Processing Chain

- Automated processing
  - Target detection
  - Data fusion
  - Wind
  - Wave
- Semi automated algorithms
  - Target detection
  - Activity detection
  - Change detection
  - Data fusion
- Operator Interface
  - GUI with 3D viewer
Thematic Processing Chain

- Automated algorithm
  - Target detection
  - Data fusion
  - Wind
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- Semi automated processing
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  - Activity detection
  - Change detection
  - Data fusion
- Operator Interface
  - GUI with 3D viewer
Ship- Detection Application (SAR)

Near real time
ship detection application
based on SAR images and AIS

currently developed for:

– TerraSAR-X,
– TanDEM-X
– CosmoSkyMed
– Radarsat-2,
– Sentinel-1A,
– Sentinel-1B

Value added products

– **SAR/ AIS merged products** (in case of available AIS Data)
– ASCII ; KMZ, GML; DER (EMSA); ESRI shape; JSON;
– GeoTIFF (MRES_L1b; HRES_L1B)
Ship- Detection Application (SAR)

Partner:

AIRBUS DEFENCE & SPACE

exactEarth®

JAKOTA Cruise Systems GmbH
Ship- Detection Application (Optic)

Near real time ship detection application based on optical data. Core processor currently being developed by the Maritime Security Lab Neustrelitz

Value added products in near real time based on high and very high resolution images

- Value added products
  - **OPT/ AIS merged products** (in case of available AIS Data)
  - ASCII; KMZ, GML; VDS (EMSA); ESRI shape; JSON; GeoTIFF
Optical Satellite Services for the European Maritime Safety Agency EMSA (OpSSERVE) | partner: EUSI (contractor) and DLR (subcontractor)

Project summary: rapid access to satellite data and derived information for use in maritime situational awareness based on WorldView - (1, 2, 3, and 4), GeoEYE-1, Deimos-2, Landsat-8

Direct delivery of information to EMSA Earth Observation Data Centre (EO-DC)

- Derive Value Adding Information
  - Vessel detection
  - Vessel activity detection
  - Change detection
Near real time Wind detection application based on SAR images core function is the XMOD, CMOD processor developed at the Maritime Security Lab Bremen currently developed for: TerraSAR-X, TanDEM-X Radarsat-2, Sentinel-1A, Sentinel-1B

Ackn: S.Jacobsen; DLR- IMF

Image: S1A_IW_GRDH_1SDV_20170724T0527

DLR SAR WIND product (rectangles) derived from the Sentinel image and Level 1 quicklook product as background.
Near real time Wave detection application based on SAR images core function is the XWAVE, CWAVE processor developed at the Maritime Security Lab Bremen currently developed for:

- TerraSAR-X, TanDEM-X
- Sentinel-1A, Sentinel-1B

DLR SAR WAVE product (rectangles) derived from the TerraSAR-X StripMap image, L1 quicklook product as background.

Ackn: A. Pleskaschevski; DLR- IMF
Near real time oil spill detection application based on SAR images core function is the qualification algorithm developed by the Maritime Security Lab Bremen based on Neural Network currently developed for:
- TerraSAR-X, TanDEM-X
- Sentinel-1A, Sentinel-1B
- Radarsat-2

Ackn: S. Singha; DLR- IMF

Value added products
- ASCII ; KMZ, GML; OSN (EMSA); ESRI shape; pdf;
- GeoTIFF (MRES_L1b; HRES_L1B)
Project Real Time Services for Maritime Security
Echtzeitdienste für die Maritime Sicherheit – Security - EMSec

Objective

Situational Awareness
– improve revisit time and near real time capabilities
– deliver SAR/ Optic derived target detection information
– deliver SAR derived wind and wave information
– improve data fusion methods and anomaly detection
– improve detection quality of hazardous materials and classification
– development of HMI interfaces

Navigation
– improve secure navigation
– protection of navigation systems (spoofing, jamming)
Project Real Time Service for Maritime Security

Echtzeitdienste für die Maritime Sicherheit – Security - EMSec

Real-time Maritime Situational Awareness System (RMSAS)

AIRBUS DS

AIRBUS
DEFENCE & SPACE

ATLAS ELEKTRONIK

Technisches Hilfswerk

Universität Rostock

VDI

Deutsches Zentrum für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft

Bundesministerium für Bildung und Forschung

Bodenkontrollstation

Bodenstation

AIS

Radar

Satelliten

RY AIS

Bodenstation

AIS DLR-RY Referenznetz

AIS & Radar auf Flugzeug Diamond (CAS)

AIS & Radar auf Flugzeug

Kamera auf Flugzeug Do 228

CAS Bodenstation

Flugplanung/ Status Plattform

Verbundadaptives Command & Control

Human Machine Interface HMI

ATLAS

AIS-Jakota DB-Service Modul

Optische Sensorsdaten

Command & Control

Radar Daten

AIS Daten

AIS Daten

AIS Daten

Satelliten Bodenstation

RY AIS Bodenstation

CAS Bodenstation

Bodenkontrollstation „Luftgestützte Dienste“

Flugplanung/ Status Plattform

Verbundadaptives Command & Control

Command & Control

Optische Sensorsdaten

Command & Control
Project Real Time Services for Maritime Security
Echtzeitdienste für die Maritime Sicherheit – Security - EMSec

Real-time Maritime Situational Awareness System (RMSAS)
AIRBUS DS

1. Radar Satelliten Daten
2. AIS Daten
3. Flugplanung/Status Plattform
4. Human Machine Interface HMI ATLAS
5. Bodenstation
6. AIS Daten
Project  Real Time Services for Maritime Security
Echtzeitdienste für die Maritime Sicherheit – Security - EMSec

Test Scenarios

– vessel monitoring and detection of anomaly behavior, simulation of hijacked ferry

– detection of people who have gone overboard based on AIS-Search And Rescue Transmitter (SART)

– observing pollution of hazardous substances

– jamming and spoofing – suppression of interference and decoy signals at sea
Project Real Time Services for Maritime Security
Echtzeitdienste für die Maritime Sicherheit – Security - EMSec
Example: Optical Sensor based Hazard Detection

Demonstration Event for the EMSec Project Cuxhaven (North Sea), 8th of September 2016

- Real-Time data exchange
- Data fusion capabilities
- Detection of liquid hazardous materials
- Tracking of detected materials
- Validation of drift models provided by BSH (Federal Maritime and Hydrographic Agency)

http://www.dlr.de/dlr/desktopdefault.aspx/tabid-10081/151_read-19273/
Example: Optical Sensor based Hazard Detection

- Validation of drift models provided by BSH (Federal Maritime and Hydrographic Agency)
Outlook SAR Iceberg Detection

Near real time iceberg detection application to Support Maritime Situation Awareness
- Ice Service Center
- Support Exploration Management and Resource planning
- Route management

TerraSAR-X ScanSAR Mode, Polarisation: HH, 150 km range,


Ackn: A. Frost; DLR- IMF
Outlook SAR Ice Classification

Near real time Ice drift application to Support Maritime Situation Awareness

Core processor currently being developed by the Maritime Security Lab Bremen

Planned value added products based on TerraSAR-X (DualPol)

Ackn: S. Singha; DLR- IMF
Outlook SAR Ice Drift

Near real time Ice drift application to Support Maritime Situation Awareness

Core processor currently being developed by the Maritime Security_Lab Bremen

planned value added products in near real time based on TerraSAR-X, Sentinel-1 and Radarsat-2

TS-X ScanSAR • 10.10.2010 01:10 UTC

TS-X ScanSAR • 11.10.2010 09:53 UTC

Driftvektorfeld

123.2°W 123.1°W

76.575°N 76.550°N 76.525°N

10.10.2010

11.10.2010
Conclusion

✓ SAR Applications like Oil Spill Detection or Ship Detection based on SAR Satellite images and AIS for Maritime Domain Awareness are proven and established.
✓ Optical Satellite Services based on very high resolution images being developed.
  ➢ Operator supervision still required

✓ Near Real Time Services are one of the Key Performance Indicator

✓ New Satellites / Satellite Constellations enable
  ✓ Advanced revisit time and update rates
  ✓ New and innovative Products
  ✓ Enhanced availability of data

✓ Complimentary Airplanes and/ or RPAS Solutions extends the monitoring capabilities