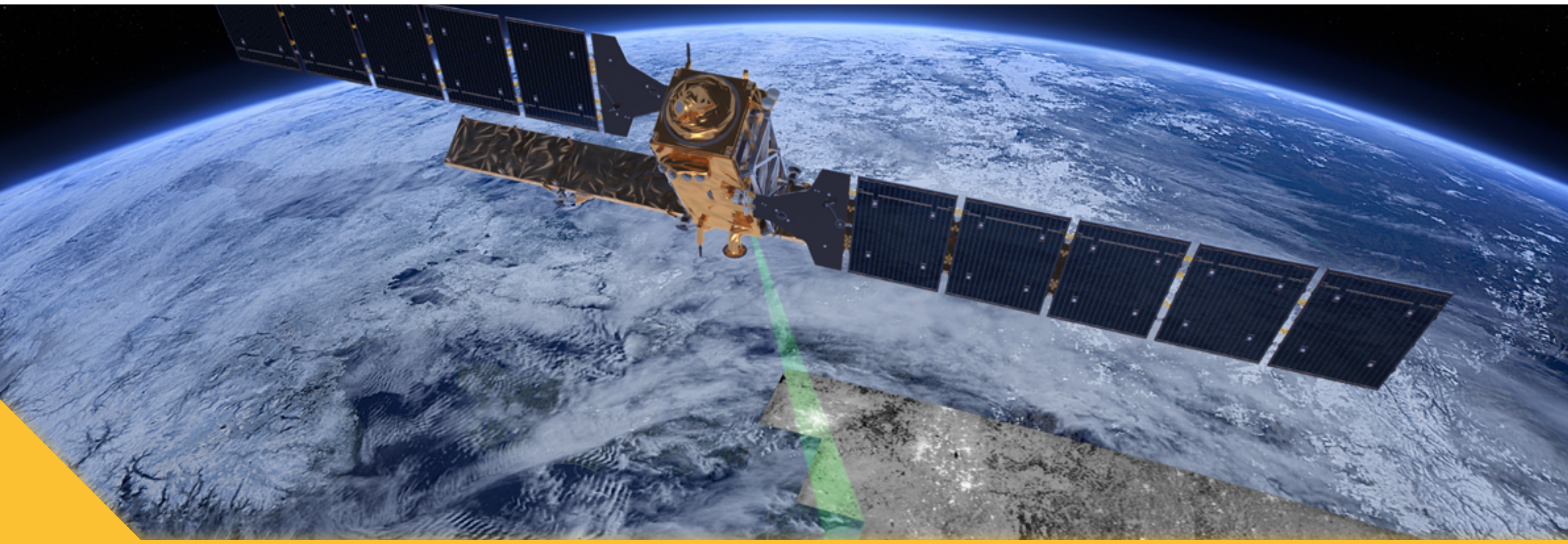
On-board Data Analysis and Real-time Information System (ODARIS)

DLR



On-board Data Analysis and Real-time Information System (ODARIS)

Earth observation with remote sensing technologies is essential for collecting information about our planet. It helps to understand physical or biological processes, to forecast weather, to track changes such as climate changes or land-use changes and to monitor natural disasters like fires, floods, landslides, etc. Nowadays, also maritime surveillance becomes more and more important. Earth observation satellite data is a valuable source of information. With optical and radar satellite images, vessels can be detected, and Earth observation can contribute to detect illegal maritime activities such as piracy, illegal fishery, ocean dumping or refugee transportation.

Illegal activities by moving maritime objects and natural disasters require fast detection and fast reaction. However, Earth observation satellite data is typically analysed long after data acquisition. Many remote sensing satellites are located in Low Earth orbit with orbit periods of about 90 minutes with short contact times of about 8 minutes with the ground station. Depending on the amount of data, sometimes more than one pass is needed for the complete downlink. The delay between image capture and detection of anomalies in the data can take hours or sometimes even days.
For reducing the time between acquisition of data on-board and the delivering of meaningful information to a user on ground like a maritime safety agency, a system for on-board data analysis and real-time information is under development at DLR. The main idea is to perform data processing already on-board of satellites and to use existing satellite communication services like for example Orbcomm or Iridium for transmission of the result to users on ground. It also supports alarm services and user queries.
The system is called ODARIS (On-board Data Analysis and Real-time Information System).
Earth observation is a possible application, but ODARIS is not restricted to the reaction on events detected in Earth observation images. ODARIS can be used for any kind of data processing on-board of spacecraft, for detection of anomalies of any payload or in the satellite housekeeping data. ODARIS shortens the time between the occurrence of an event and the reaction on it. Missions mainly in Low Earth Orbit with non-permanent ground contact can benefit from this technologies. But ODARIS can also be used on HAPS (high altitude pseudo satellites) that gained importance during recent years especially for Earth observation allowing for monitoring a defined region of interest continuously. In contrast to conventional remote sensing missions, the ODARIS system does not rely on any direct link between ground station and Earth observation platform. Product information can be communicated to any device on ground with a connection to the internet, independent of the location of carrier platform and user.

Highlights

- On-Board Data Analysis
- Real-Time Information System
- Space application hosting platform

Read More

- Schwenk, Herschmann (2022) On-Board Data Analysis And Realtime Information System - Status & Outlook. Deutscher Luft- und Raumfahrtkongress 2022 (2022)
- Schwenk, Herschmann (2020) On-Board Data Analysis and Real-Time Information System. Deutscher Luft- und Raumfahrtkongress 2020
- Willburger, Schwenk und Brauchle (2020) AMARO - An On-Board Ship Detection and Real-Time Information System. Sensors (2020)"

Point of Contact

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Table of Contents

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2. Real-Time Information System

The On-board Data Analysis and Real-time Information System ODARIS will provide information about time-critical events within a few minutes after the image acquisition. ODARIS is a current research project at DLR.

A prototype of a real-time information system has been developed. Its main features are:
- Analysis of sensor data on-board,
- Response to user queries,
- Generation of alarms when predefined events happen.

ODARIS needs a data source as input, for example images of an Earth observation camera. Especially for maritime surveillance also an AIS (Automatic Identification System) receiver and an AIS antenna can be integrated as a second data source additionally to a camera. AIS is a cooperative system, primarily intended for avoidance of collision of ships. Ships send out their identification, position, course, speed and other traffic-relative data. The data is received by other ships and ground stations. Nowadays, also satellites can receive AIS data.

ODARIS requires communication hardware, like an Orbcomm or Iridium modem and a corresponding antenna to communicate with the network of communications satellites such that user queries can be received and user alarms can be sent.

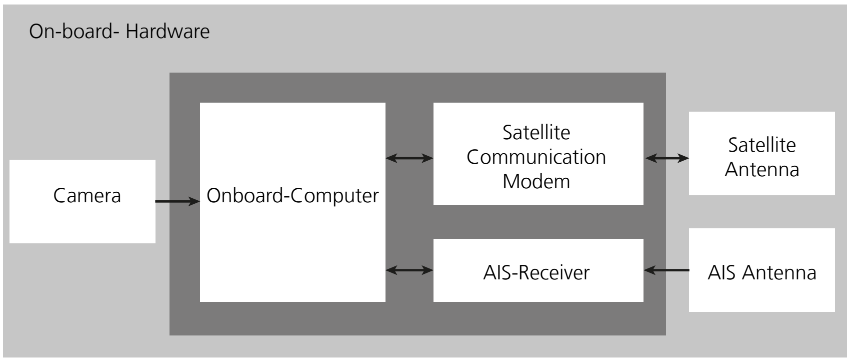
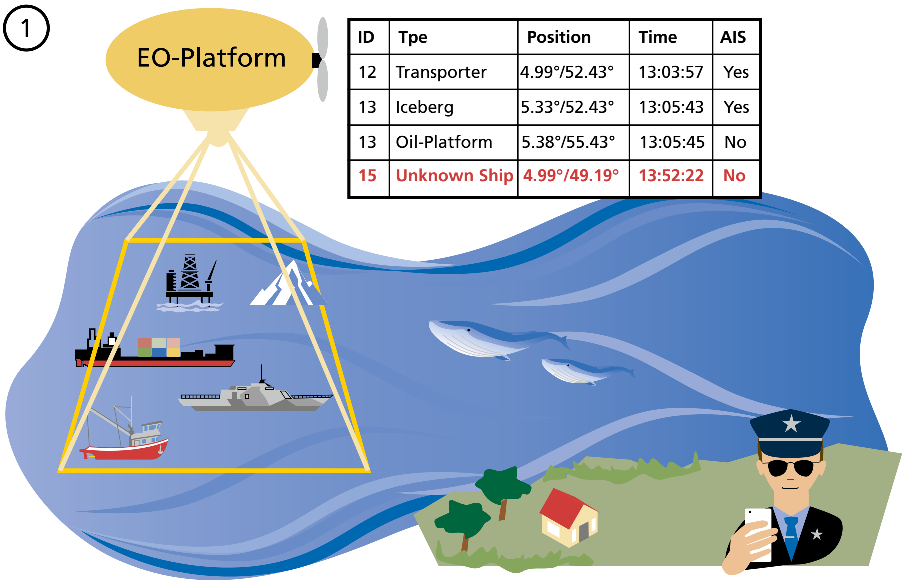


Fig. 2-1 Overview on the on-board components

The onboard computer computes both the data analysis and performs the request and alarm service.



ID	Tpe	Position	Time	AIS
12	Transporter	4.99°/52.43°	13:03:57	Yes
13	Iceberg	5.33°/52.43°	13:05:43	Yes
13	Oil-Platform	5.38°/55.43°	13:05:45	No
15	Unknown Ship	4.99°/49.19°	13:52:22	No

Fig. 2-2 Images are captured and processed automatically.

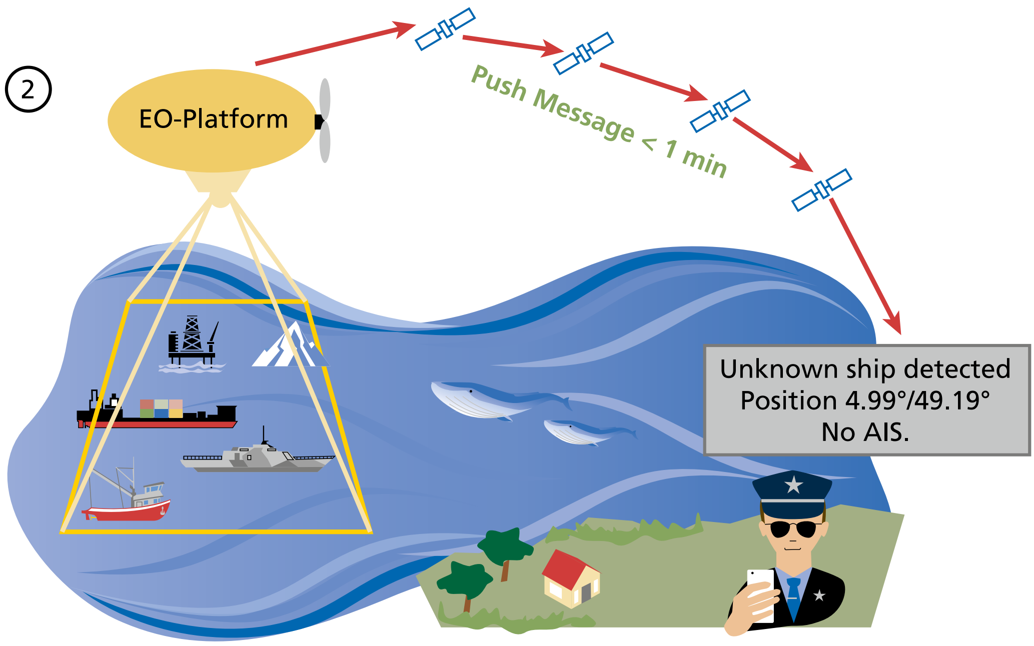


Fig. 2-3 The user, which has requested automatic notifications, is informed about an unknown ship.

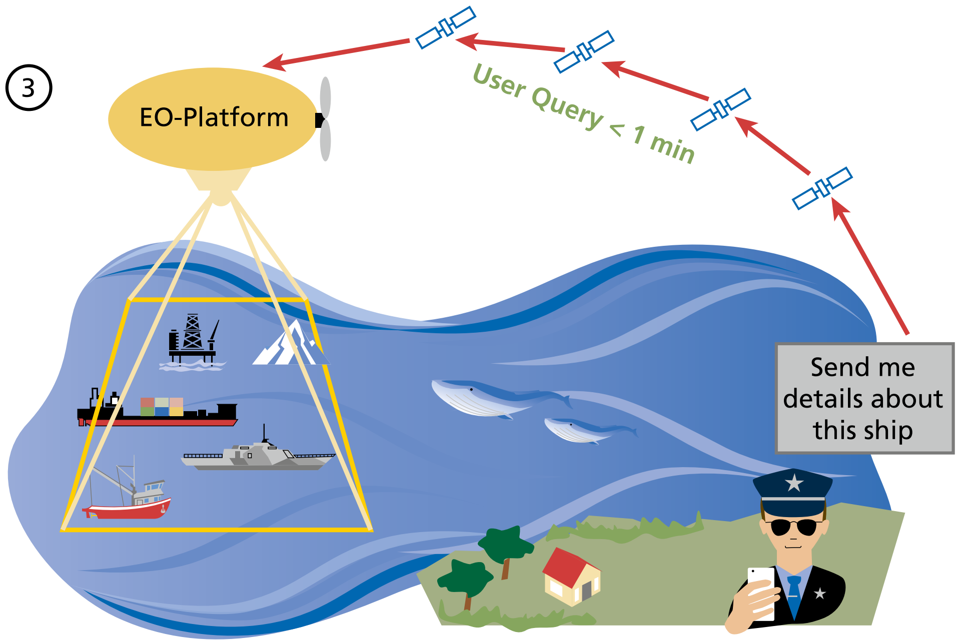


Fig. 2-4 The user requests detailed information.

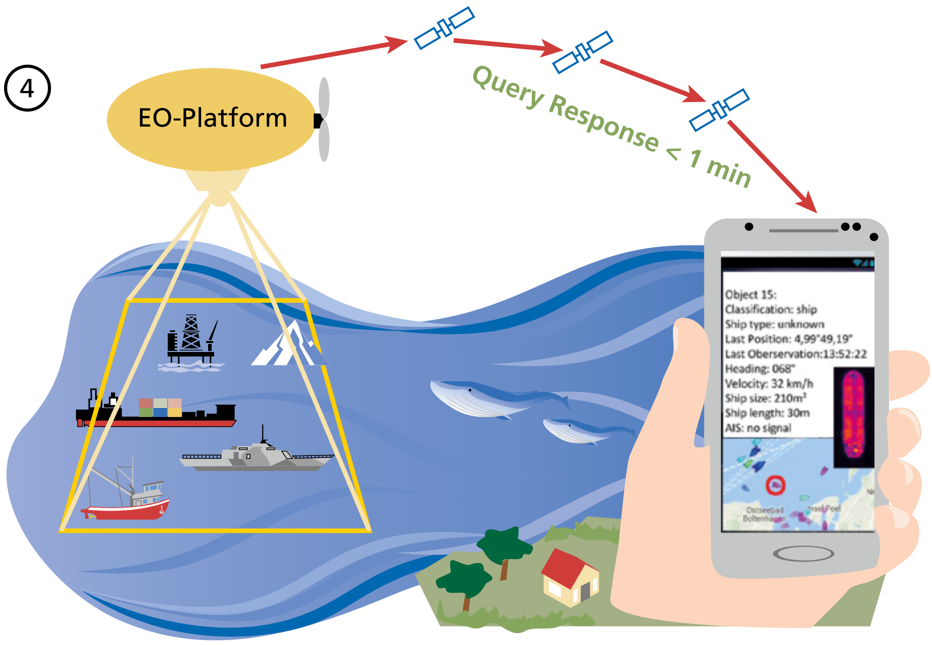


Fig. 2-5 The user receives detailed information.

Figures 2-2 - 2-5 visualize the principle and the main features of ODARIS with an exemplary application. An Earth Observation platform like a satellite or a HAPS captures images of an area and an on-board data processing system detects several objects. The geographical position of the objects is stored in a database together with other information like the time to which the position correlates, its velocity, the length, and information about the AIS signal. A push message is sent to a user on ground via the satellite communication network to inform about an unknown ship that does not send any AIS signal. The user sends a user query and asks for more details about this ship and receives detailed information a few minutes later.

3. Implementation

The ODARIS software system is based on a Linux software stack and mainly programmed in C++.
Its main tasks are the execution of data analysis and the communication with the ground, like answering user requests and sending alarm messages. The software consists of several independent working applications (services) communicating over a database, as illustrated in Figure 3-1. Using a service based modularised software system architecture offers two main advantages. First, high system responsiveness for communication services can be achieved, by, at the same time, providing large computing capacity for the data processing services. Second, in case of a software failure, only the erroneous service is affected directly. The erroneous service can be reinstated independently, while keeping the rest of the system operable.

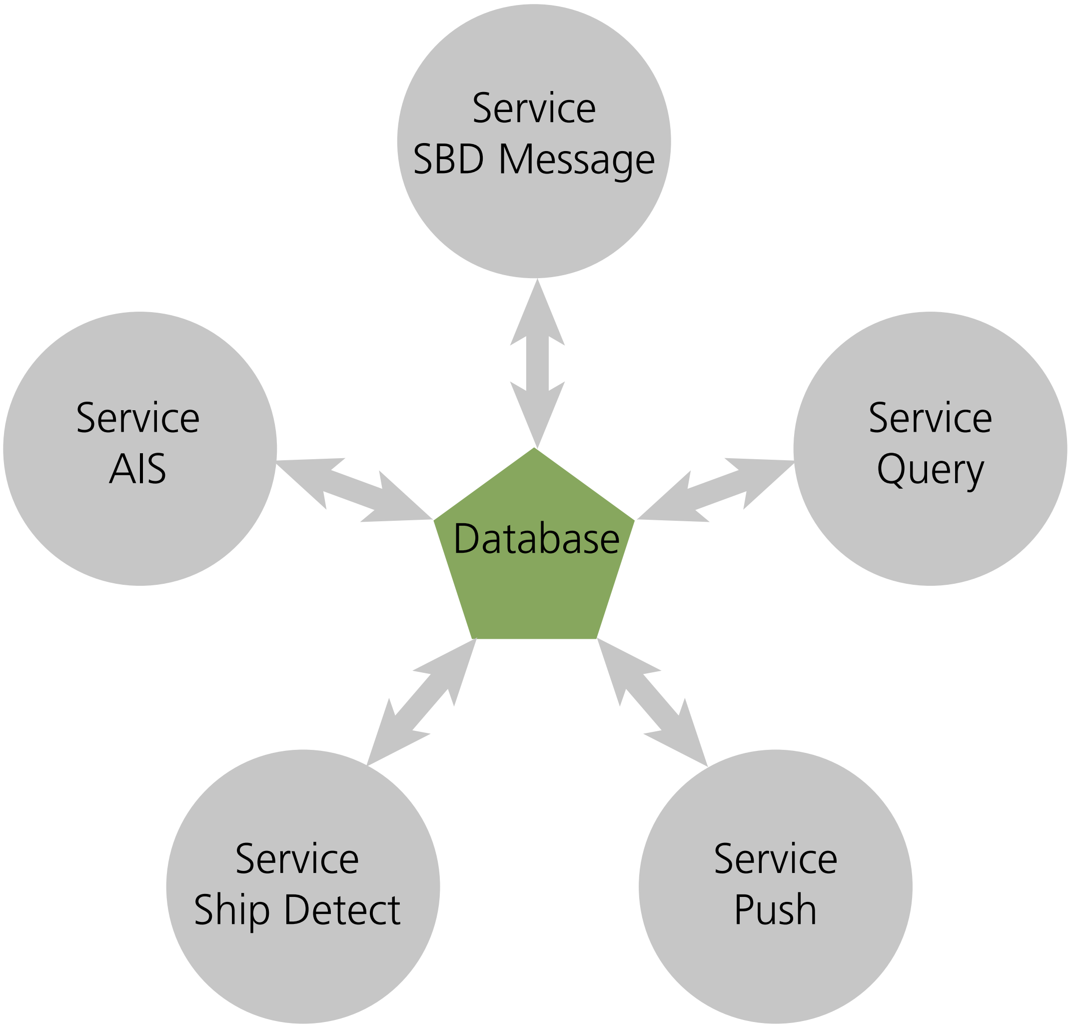


Fig. 3-1 ODARIS service based modularized software architecture

At the current state, a user can query data from the system's internal database by sending SQL requests via e-mail over the Iridium IOT (Internet of Things) service. For the future, a user application with a user-friendly application with a GUI (graphical user interface) is going to be developed, that can be installed and used on mobile devices.

4. Example: The AMARO Flight Experiment

The first demonstration of the on-board data analysis and real-time information system was done within the AMARO (autonomous real-time detection of moving maritime objects) project. During an aircraft flight experiment campaign the prototype system was tested and its performance, especially regarding real-time information capability, was investigated. The prototype was designed and built using commercial-off-the-shelf hardware adequate for aircrafts. The flight experiment over the North Sea took place in April 2018.

As camera of the AMARO experiment, the instrument MACS (modular aerial camera system) of the DLR institute of optical sensor systems in Berlin was used.

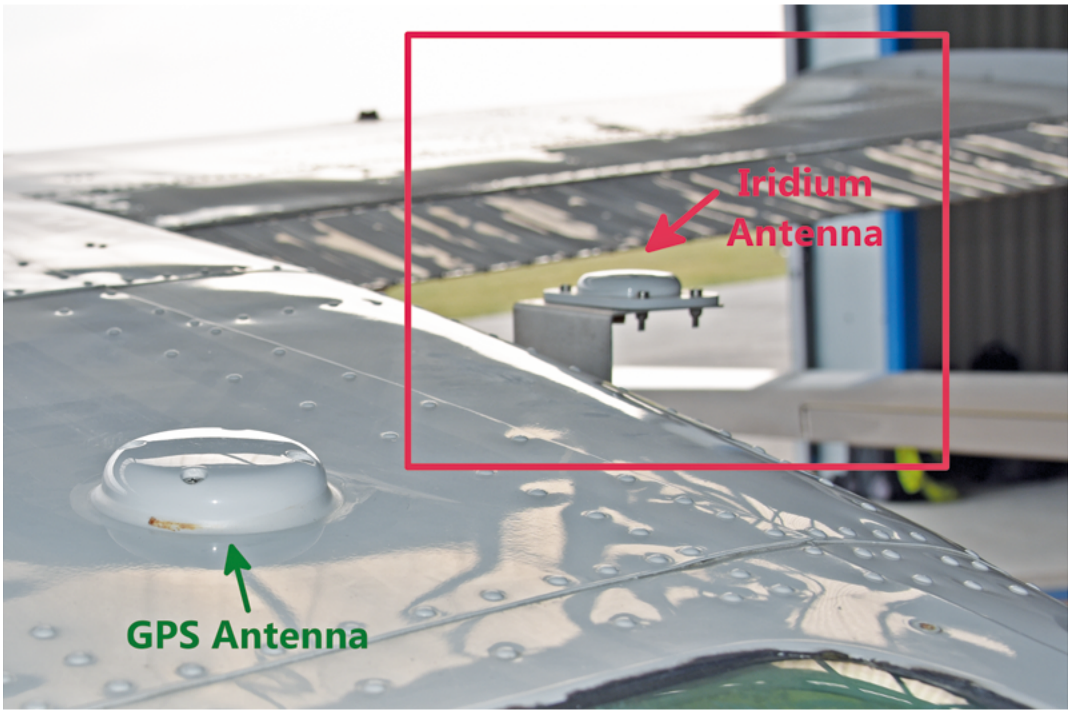


Fig. 4-1 Figure: Cesna airplane with installed Iridium antenna.

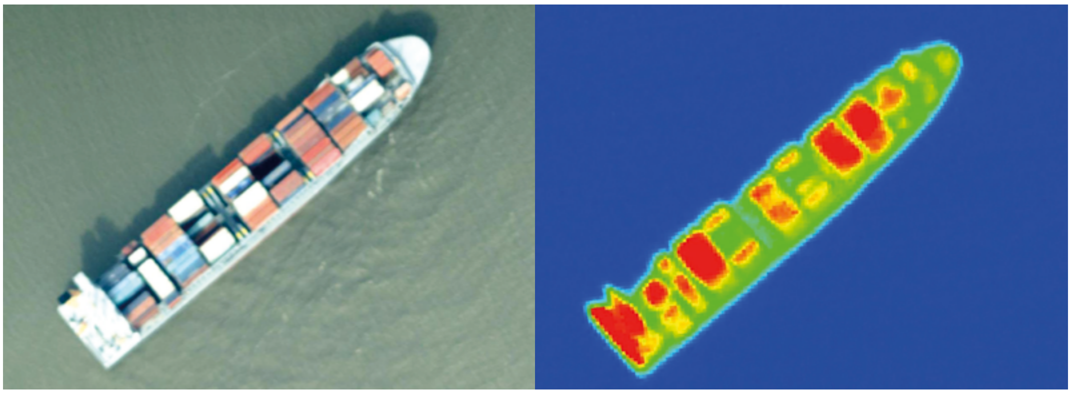


Fig. 4-2 Ship detected by AMARO at 12th April 2018, 11:45 UTC at the mouth of the Elbe, Hamburg.
Left: RGB image, Right: Thermal Image.

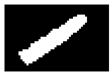
	Content	Response
query	Send information about detections 1320, 1321, 1322, 1323, 1324 and 1325. Split into 3 messages if needed.	1320 Cap_2018-04-12T11:45:32.966Z CAT_ SHIP OBJ_PENDING 1321 Cap_2018-04-12T11:45:33.964Z CAT_ SHIP OBJ_PENDING 1322 Cap_2018-04-12T11:45:34.962Z CAT_ SHIP OBJ_PENDING 1323 Cap_2018-04-12T11:45:35.960Z CAT_ SHIP OBJ_PENDING 1324 Cap_2018-04-12T11:45:36.958Z CAT_ SHIP OBJ_PENDING 1325 Cap_2018-04-12T11:45:37.956Z CAT_ SHIP OBJ_PENDING
query	Send quicklook image of object 1322. Split into 5 messages if needed.	
query	Send geographic coordinates of the 4 corners for the datatake with captureID= Cap_2018-04-12T11:45:33.964Z	Latitude/Logitude: Upper left corner: 53.872534°/9.123720° Lower left corner: 53.872793°/9.138797° Lower right corner: 53.884518°/9.13821° Upper right corner: 53.884363°/9.123402°

Table 4-1 Example of a query and respond during the AMARO flight experiment

With the AMARO experiment, the ODARIS system was demonstrated for the first time on an aircraft. It was successfully demonstrated that the Iridium service can be used for message exchange. More than 84% of the user queries were answered in less than five minutes with an average of less than two minutes.

5. Way forward

The ODARIS prototype is based on the system developed for the AMARO project. Currently, the ODARIS system is prepared for an application and experiment for a DLR technology demonstration satellite mission in Low Earth Orbit. DLR launched the project ScOSA (Scalable On-Board Computing for Space Avionics) where a new on-board computer is developed. The on-board computer consists of several independent computing nodes: reliable computing nodes (RCN), high performance nodes (HPN) and interface nodes (IN). RCNs are very similar to classical on-board computer, using certificated space hardened hardware components. The focus is reliability and endurance. The current version of the RCNs uses a radiation hardened LEON3 system on a chip accompanied by a flash-based FPGA (field programmable gate array). The RCN offers a 50 MHz dual LEON3 processor, a 64 MiB error correcting RAM and non-volatile memories. It is primary used for critical system management and surveillance tasks which are less computational demanding. For execution of computationally intensive tasks, the HPNs are used. To achieve high computing performance and keep system costs down, commercial off-the-shelf hardware is used.

Part of the ODARIS software like the ship detection algorithm is already implemented and tested with the ScOSA framework using the HPNs. Future usages on satellites will make use of this new class of on-board computer that paves the way for image analysis and image processing tasks executed on-board of spacecraft.