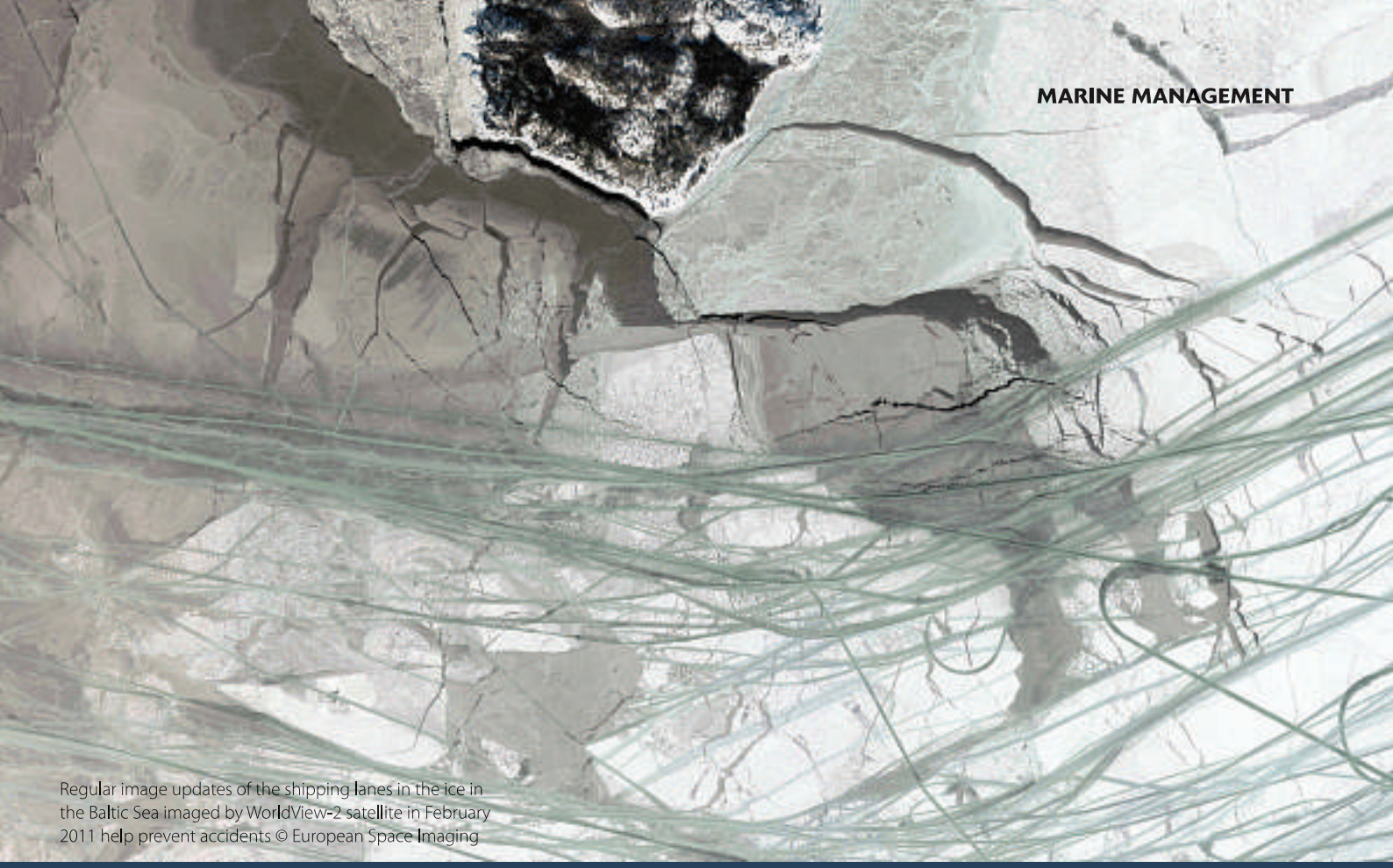


Regular image updates of the shipping lanes in the ice in the Baltic Sea imaged by WorldView-2 satellite in February 2011 help prevent accidents © European Space Imaging

HIGH FIDELITY

PENELOPE RICHARDSON LOOKS AT SOME OF THE NEWEST APPLICATIONS OF VERY HIGH RESOLUTION SATELLITE IMAGERY IN THE MARITIME SECTOR

The disappearance of Malaysia Airlines flight MH370 on the 8 March 2014 showed the world the difficulties of looking for objects at sea. Huge efforts were made to locate the plane within hours of its disappearance. Following every tipoff, optical and other satellites were used to collect imagery across the globe, and it became the biggest sea search using satellite imagery on record. This event made everyone aware of the size the world's oceans and the difficulties of finding things in them.

Traditionally, radar satellite imagery, such as synthetic aperture radar (SAR) data, has been used to identify ships or other objects, to improve shipping schedules and navigation security. The European Maritime Security Agency (EMSA) uses SAR images to support its Earth Observation Data Center (EODC) service, which tracks polluting ships and finds environmental hazards. SAR imagery is particularly suitable for identifying metal objects and water surface, but the images can be difficult to interpret. Other drawbacks are that SAR images have a slow refresh rate and can only really be used to identify vessels bigger than 20m long and when the water surface is relatively calm.

With the increase in availability of very high-resolution (VHR) data (30cm-50cm) from optical satellites, there has been growing uptake of this data in Europe. In 2012, EMSA launched the Optical Satellite Services for EMSA (OpSSERVE) pilot project to explore the benefit of using near real-time (NRT) optical satellite imagery to reduce the risk of accidents, pollution from ships and loss of life. The project's challenge was to deliver imagery within an hour of an 'NRT1' emergency activation and three hours of an 'NRT3' activation. The project results were so successful that it became a fully operational service in 2013 and was then renewed again as OpSSERVE 2 in 2015, with access to the WorldView-3 satellite and the challenge to deliver analysed imagery within 45 minutes.

OpSSERVE sought to verify the benefit of using VHR optical satellite data for detecting ships at sea, for which European Space Imaging (EUSI) provided the satellite access and ground station technology. They then worked together with their technical and scientific partner, the German Aerospace Agency (DLR), to improve the availability of imagery products to meet user requirements. Additionally, DLR developed software modules to detect vessels and activity, to enable fast analyses supporting pollution control, anti-drug trafficking measures, border control and emergency response.

Early research has indicated that VHR imagery from the WorldView3 satellite, used in conjunction with DLR's specially developed algorithms for OpSSERVE 2, has the extra potential to measure a ship's speed, sailing direction and type, better recognise ship names and numbers, and better count heads on open boats.

Timeliness

As ships at sea are mainly on the move, timeliness is an important factor – the sooner an annotated, georeferenced image is available to maritime authorities, the sooner they can clearly understand the situation of a vessel and take action.

"Flexibility is the key to being able to react quickly and deliver imagery in almost near real-time. Operating our own ground station gives us direct access to the satellites," says Adrian Zevenbergen, managing director, European Space Imaging.

Of major interest to maritime projects are cost-savings, safety and rapid access to data, especially for planning and reconnaissance surveys. Satellite-derived bathymetry services for the coastal and maritime sector are a specialisation of EOMAP, a geospatial-information company based near Munich, Germany. It develops services for the coastal and marine industry incorporating multispectral, eight-band, VHR satellite imagery, which already has found its way into official charting maps, reconnaissance surveys, planning and engineering phases of the offshore industry.

"Many clients do not immediately understand the benefits of using satellite imagery in an application," says Knut Hartman, head of the bathymetry and seafloor group at EOMAP. "They are looking for solutions that often cannot be met with standard survey/mapping methods. When they see how easy satellite-derived image information can be implemented in the day-to-day workflow, and its importance as a vital source of information and budget-saver, they return to it again and again."

Looking through shallow water

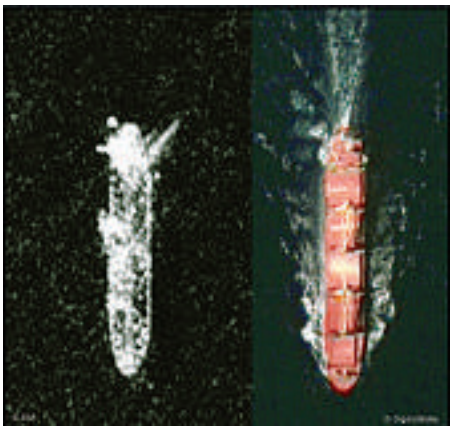
Specific areas where EOMAP has applied VHR imagery is in shallow water bathymetry mapping of underwater topography and habitats in shallow waters less than 30m deep, ranging from the Caribbean to the turbid Caspian Sea. The imagery enables rapid access to data, so that almost 90% of the projects for mapping shallow water bathymetry and seafloor properties have a turn-around time of less than two weeks.

Compared to conventional survey methods, it's a saving in cost and time of 90-95%. Although it can be seen as a single product, it is important to understand that satellite-derived bathymetry services also greatly supplement acoustic and LiDAR survey methods in the shallow water zone.

In addition, other coastal services benefit from the detailed spectral information found in WorldView-2 and WorldView-3 imagery, such as environmental-impact studies exploring the influence of dredging on mangrove and coral health, monitoring algal blooms, or mapping sandbank movements. The services have now reached a maturity that doesn't require of the client any specific understanding of the technology.

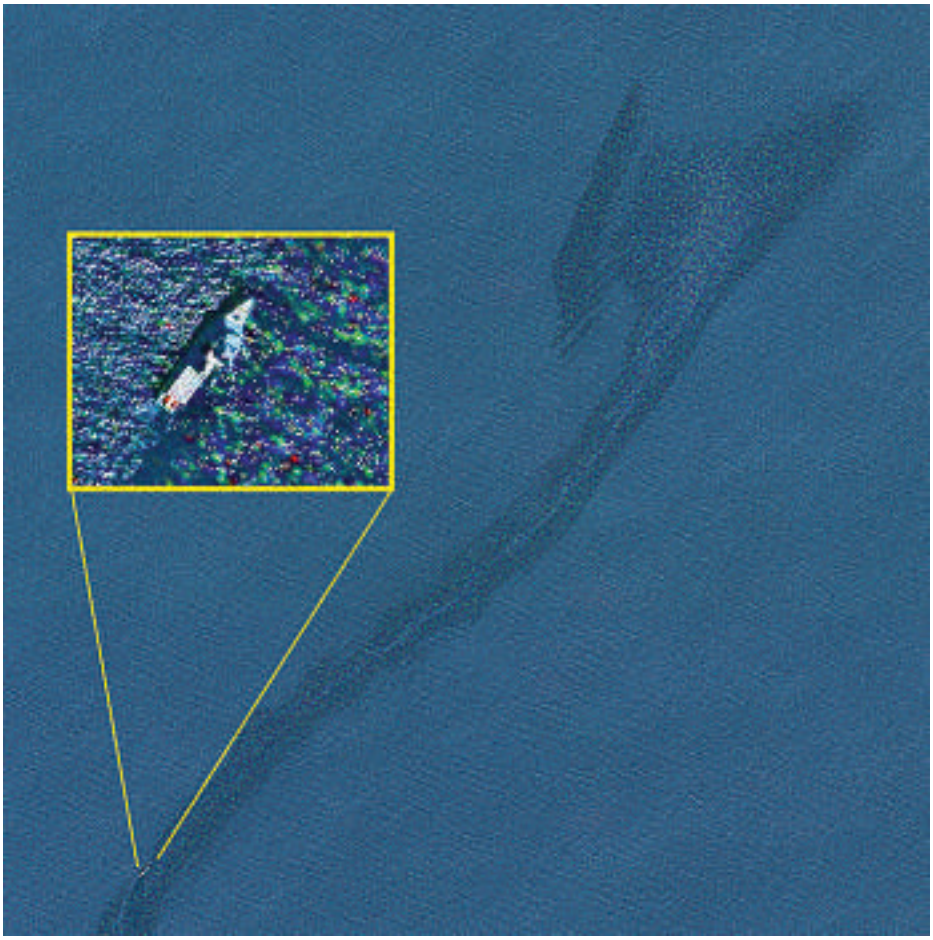
A valuable archive

A unique feature of satellite data is the ability to map history. No other method can go back into the past and detect changes and trends the way satellite-based methods can. A recent project focused on the coral atolls in the South China Sea known as the Spratly Islands. Using historical data, bathymetric shallow water information was derived for the period before current infrastructure was built and made available in support of an

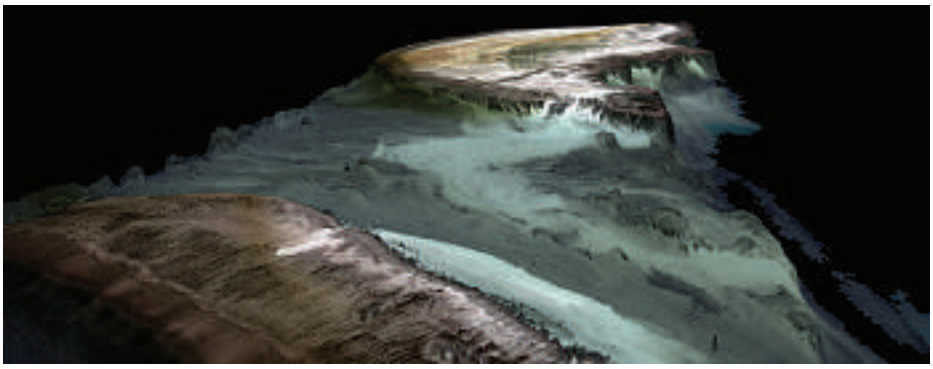


Radar satellite image (L) very high-resolution (R) image from WorldView-2 satellite ©DLR; © European Space Imaging/DigitalGlobe

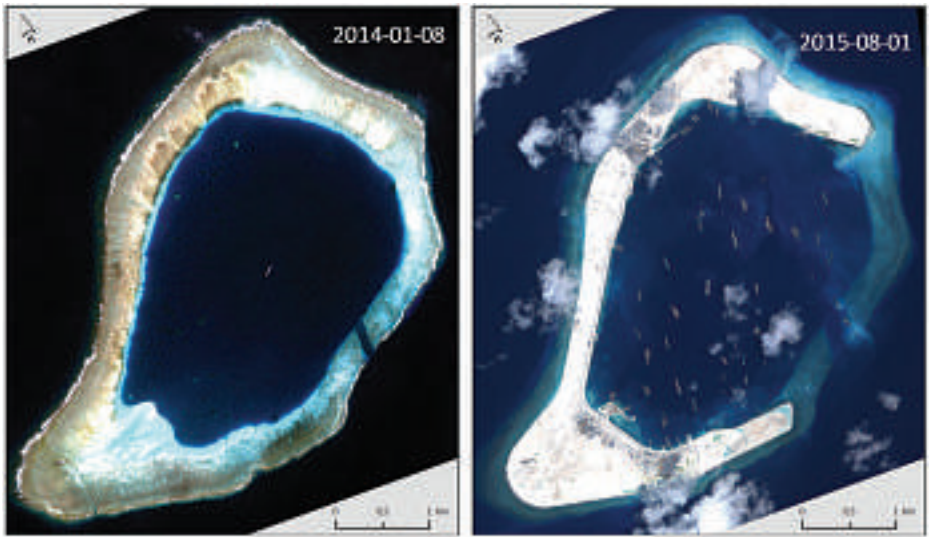
VHR satellite image from WorldView-2 analysed by DLR identifies a potential pirate ship behind the tanker at sea © European Space Imaging/ DigitalGlobe



Oil spill off the Canary Islands imaged by GeoEye-1 satellite on 23 April 2015 © European Space Imaging



Seafloor reflectance image draped over satellite derived underwater topography of Herron Reef, Australia – mapped and modelled within two days using VHR data © EOMAP 2015, includes copyrighted material of DigitalGlobe 2015



Subi Reef VHR image data on January 2014 (left) and August 2015 (right) ©DigitalGlobe, 2016

international court case. Satellite image data represents the only method allowing the mapping of the past in this way.

Having more visual and spectral information leads to more accurate models. Using archive data coupled with new eight-band data improves the method of physics-based inversion, which is used to extract bathymetric data in a meaningful way for underwater visualisation. Using WorldView-2 and WorldView-3 data enables detailed mapping of the seabed at the highest resolution in the spectral bands.

"Satellites are imaging parts of the world every day, meaning there is a huge amount of historical data available," says Hartman. "This is a fantastic resource for projects that require three layers of data – historical information, up-to-date data and new data for online monitoring."

Safety at a distance

During the upgrade of port facilities in Darwin Harbour, Australia, the protection of more than 250km² of environmentally protected mangroves was of high priority. This huge area is hard to monitor in-field and, because the mangroves are full of salt water crocodiles, it also makes field mapping a life threatening activity, a factor influencing the choice to use VHR imagery. Because of the company's experience in mapping sensitive coastal habitats, such as mangroves and corals, EOMAP was contracted to support the monitoring of the impact of dredging in the Ichthys nearshore environmental monitoring program. For three years, the company monitored the mangrove environment using VHR image data, which it used to derive meaningful vegetation health information and its statistics.

EOMAP first derived a vegetation health baseline from the time before the offshore work, to understand the natural situation in the harbour and river. Then, as construction and dredging got underway, the company captured, analysed and modelled quarterly VHR imagery, to ensure there was no significant impact on the mangroves.

In this case, the area to be monitored was too big for drone or aerial imagery coverage, so satellite imagery provided the perfect information solution for all levels of the project giving regular access to inaccessible areas and as well as providing for worker safety.

Safe sailing

Huge areas of the world have no or outdated information on water depth, and this regularly leads to naval accident. Using satellite image data to derive information on the location and depth of shoal complexes and sandbanks is essential to fill these data gaps for the shallow water zone, which is the water depth of greatest importance for navigation.

Optical imagery combined with the information from SAR data can also be vital in understanding the movement of ice in shipping lanes during winter. The knowledge gained from having a clear visual idea of an area can be used by ships to plan more efficient and safe routes to port.

Again here, the use of satellite image data can benefit navigation safety and help deliver up-to-date nautical maps. Satellite-derived services can be delivered to conform to the standards of the daily routine, and be directly implemented in electronic navigational charts, for example.

The future for European shipping

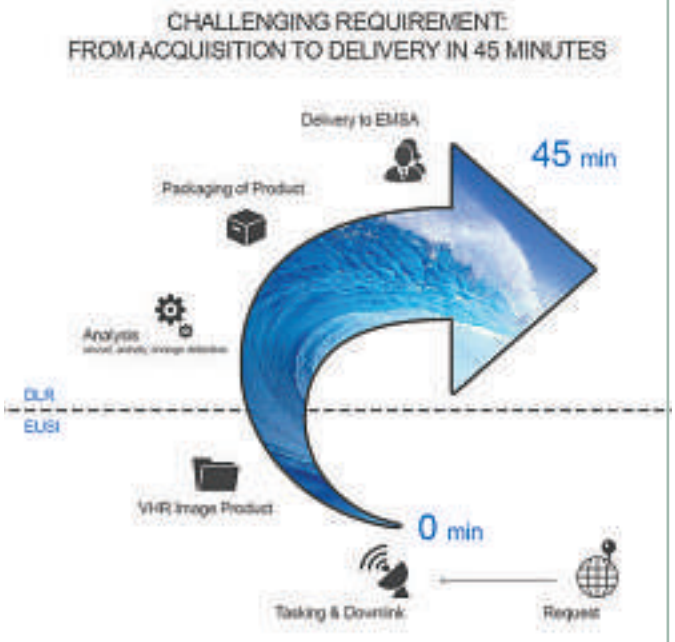
With increased access to commercial satellite data and the availability of data from the first of the Copernicus Sentinel satellites launched in 2014, instead of maintaining parallel systems, there is a need to integrate all data services within the existing maritime service workflows, to gain the most benefit from earth observation (EO) information.

"I believe there is potential for the EO industry to offer integrated, more user-

OPSSERVE ACTIVATION PROCESS

For a near real-time (NRT) request, activation to delivery normally takes less than 45 minutes and involves the following steps:

- An NRT request is made by EMSA for an area limited to 200km² (1,000km² possible with delivery in 120 minutes), which will focus on a point target, an individual vessel or piece of coastline.
- EUSI checks the feasibility of collecting the data and manually ingests the order into its collection tasking system.
- The image is collected by the satellite and directly downlinked to the ground station. The image is generally delivered and ready for post-processing by the DLR team within 30 minutes of acquisition.
- The DLR team analyses the imagery using its vessel and activity detection algorithms and annotate the data.
- Data and analysis package is created by DLR and delivered it to EMSA.



friendly and sustainable services to the maritime industry," says European Space Imaging's Adrian Zevenbergen. "Companies currently creating services are exploring ways of working together to integrate existing service offerings and develop new EO-based information products for the maritime industry."

VHR imagery is finding a place in many areas of the maritime and coastal industry, from helping to improve search and rescue or pollution elimination to understanding the sea bed to help preserve the natural coastal environment. A growing interest in integrating the services used by the maritime industry could lead to a gamut of new applications incorporating EO data.

A GROWING INTEREST IN INTEGRATING THE SERVICES USED BY THE MARITIME INDUSTRY COULD LEAD TO A GAMUT OF NEW APPLICATIONS INCORPORATING EO DATA

Penelope Richardson is marketing manager at EU Space Imaging (www.euspaceimaging.com)

One of the Spratly Islands in the South China Sea showing building works underway imaged at 40cm resolution on 28 Dec 2015 by WorldView-2 satellite © European Space Imaging/DigitalGlobe

COMMERCIAL OPTICAL SATELLITES VERSUS UAVS

As image sensors improve, the growth in the use of optical satellite imagery in the maritime sector has occurred parallel to growing use of unmanned aerial vehicles (UAVs) to collect imagery at sea. Satellite imagery continues to offer many benefits over UAVs when it comes to collecting imagery at sea.

- Optical satellites are located in space, so there is no need to request permits to fly in special zones.
- The satellite gear is stable, and not vulnerable to wind and adverse weather conditions guaranteeing efficient and regular image delivery without the loss of the equipment.
- They can collect as much as 65,000km^2 of imagery in one pass.
- Satellites have flexible collection options – large areas up to 100km x 100 km or multiple small areas of interest (AOI) of 15x15 km each, for example.
- Due to the satellite's altitude, the field of view (FOV) is much wider. For example, optical VHR satellites normally have a FOV of 13km to 20km at nadir.
- The ability to tilt the satellite in every direction gives it a larger field of regard than a UAV. For example, with an orbit over Denmark, AOIs over the coast of the UK or the Baltic Sea or both can be imaged on the same flyover.
- Satellites operate globally meaning image collections can be made worldwide and are not restricted to certain regions.
- When applying constellation tasking – that is, using multiple satellites to collect an area or point of interest – the revisit time is reduced to daily or multiple accesses per day.
- Some satellites have the ability for direct uploads and downloads in near real time from their sensors to ground stations. This means that last-minute changes in orders can be taken into account when the weather or situations alter.
- In the case of emergency, analysed data deliveries can be made in less than an hour.
- With the release of super spectral 30cm imagery from the WorldView-3 sensor, the image detail and quality is comparable to aerial imagery.