# The integrated European Satellite-Based and Aerial Oil Spill Surveillance and Vessel Detection Services

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## ABSTRACT

Monitoring of European waters for discharges of oil from ships and other sources is particularly challenging as the European Union is an inundated peninsula with an extensive coastline and several semi-enclosed seas. The European Marine Safety Agency provides the operational satellite monitoring service, CleanSeaNet, to support spill response activities of European coastal states. The CleanSeaNet service is based on analysed satellite Synthetic Aperture Radar images, enriched oil spill identification and vessel detection information, and provides alerts to the national users in 26 coastal states in nominally less than 30 min.

Nations which are party to MARPOL 73/79 have the obligation to follow up any possible violation against the regulation and therefore to verify potential spills. The verification procedure differs from coastal state to coastal state according to available means. Most common in Europe is the use of aerial surveillance aircrafts equipped with specialized sensor systems. These aircrafts are on stand-by or have scheduled missions often harmonised with the satellite overpass. Besides the verification of possible spills their task is identifying possible polluters.

The yearly analyses of over 2,000 CleanSeaNet images support the national response activities in terms of greater consistency, efficiency and effectiveness. The CleanSeaNet service and the coastal state verification provide information for decision making processes and a traceable first element of the different chains of evidence needed for prosecution within the Coastal States. The paper will provide an overview of the European activities in the field of oil spill monitoring, polluter identification and the follow up by Coastal States in order to obtain the first elements of evidence for prosecution of the potential polluter.

## INTRODUCTION

About 457,000 tonnes of oil are released by shipping into the ocean every year, impacting water quality and, marine and coastal ecologies (GESAMP, 2007). The largest single cause of pollution from maritime transport is deliberate dumping of oil at sea. Marine oil spills, both illicit and accidental, pose a severe risk in terms of ecological damage and socio-economic losses for European coastal areas. Europe has a coastline of 70,000 km along two oceans and four seas: the Atlantic and the Arctic Oceans, and the Baltic, North, Mediterranean and Black Seas. The disasters involving the vessels ERIKA off the French coast in 1999 (spilling 20,000 tonnes of oil) and PRESTIGE in 2002 off the Spanish coast (spilling 63,000 tonnes of oil),

severely impacted the environment in the affected coastal areas and led to a substantial political discussion, which contributed to the decision to establish the European Maritime Safety Agency (EMSA).

The EU Parliament has requested that "*Member States shall take the necessary measures to achieve or maintain good environmental status in the marine environment by the year 2020 at the latest*" (EP, 2007) in the framework of the Marine Strategy Framework Directive, and the strategy of the OSPAR commission is to "*move towards the target of the cessation of discharges, emissions and losses of hazardous substances by the year 2020*" (OSPAR, 2003). International law (e.g. MARPOL, 73/79) forbids deliberate pollution, but laws require enforcement. With the entry into force of Directive 2005/35/EC on ship-source pollution and on the introduction of penalties, including criminal penalties for pollution offences (as amended by Directive 2009/123/EC) EMSA is tasked to "*work with the Member States in developing technical solutions and providing technical assistance in actions such as tracing discharges by satellite monitoring and surveillance*". In line with this, the Agency has set up and provides a European operational system for oil spill and vessel detection called CleanSeaNet, which is based on the analysis of synthetic aperture radar (SAR) images from satellites.

The CleanSeaNet service offered to authorities in European coastal states supplements existing surveillance systems at national and regional level and supports the response of Coastal States for locating polluters and mitigating the impact of accidental spills. The follow up to CleanSeaNet detections is then the responsibility of each Coastal State, but the responses vary considerably from one country to the other. In some countries, each time a satellite acquisition is planned an aircraft is either in flight or on standby, thus increasing the chances of catching a polluter in the act. Some European Member States are now imposing fines of many hundreds of thousands of Euros for deliberate pollution in violation of MARPOL regulations.

Coastal States can also use CleanSeaNet detections to trigger inspections in port when vessel traffic monitoring systems and AIS information allow the identification of the possible source. A number of polluters have been fined on the basis of evidence collected during such inspections. Directive 2005/35/EC as amended does not establish any legal reporting obligation on administrative or judicial follow-up, and it is therefore hard to establish how often this occurs.

## THE CLEANSEANET SERVICE

CleanSeaNet uses Synthetic Aperture Radar (SAR) satellite sensors which "illuminate" the ocean surface and process the back scattered signal. This signal contains information on the level of roughness of the sea surface. The damping effect of floating oil films reduces the back scattered signal and appears as black patches in the images, which enables SAR sensors to detect oil slicks. Satellite SAR imagery has proven to be an effective tool to detect oil spills at sea as it has the capacity to cover large areas day and night and is almost unaffected by cloud cover.

The SAR satellites primarily used are ENVISAT ASAR from the European Space Agency, RADARSAT-1/RADARSAT-2 from the Canadian Space Agency and MDA, and COSMO SKYMED from the Italian Space Agency. Looking to the future the planned GMES Sentinel-1 mission series will be important for routine monitoring, while other X-band radar data from TerraSAR-X (DLR) could potentially be used for specific campaigns and in case of an oil spill emergency. After acquisition by the

satellite, SAR data are transmitted to a network of contracted ground receiving stations (CLS, Edisoft, E-Geos, KSAT), where the data is processed and the image interpreted by image analysts. The shortest possible delay between detection and alert is essential for a rapid response by the Coastal State and to increase the likelihood of catching a polluter in the act. It is a CleanSeaNet contractual obligation that SAR images, results of oil spill analysis and ancillary information are delivered and made available to Coastal States shortly after the time of the satellite acquisition. For satellite images covering 400 km by 400 km, the analysis is provided in maximum of 30 minutes. For images of different dimensions the time varies slightly. In case of a detected oil slick, an alert message to the end user is transmitted by phone call as well as e-mail.

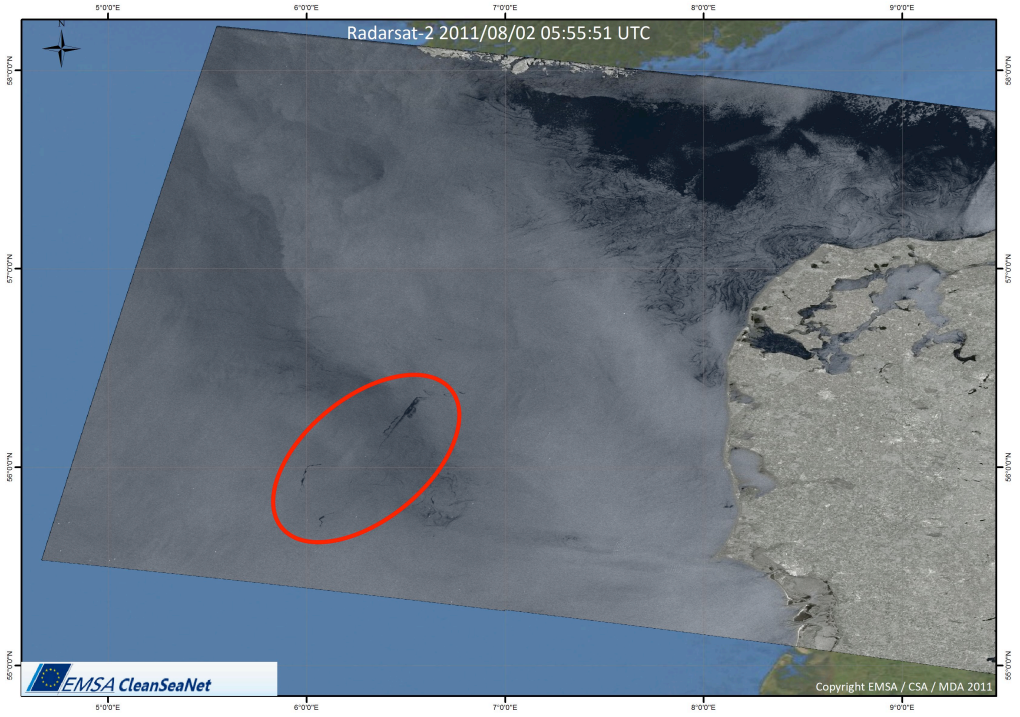


**Figure 1:** CleanSeaNet RADARSAT 2 image - 2 August 2011 covering Danish and Norwegian coastal area – showing clearly released oil patches

CleanSeaNet began operating in April 2007 and the oil pollution response authorities of 26 European Coastal States have now access to the service. Between the beginning of the service and January 2011, over 1,000 million km$^2$ of European seas (approx. 2,800 times the area of Germany) were monitored, equivalent to more than 50,000 flight hours with aerial surveillance aircraft. More than 8,800 possible oil slicks were detected, but not all of these detections were oil. On average, the trend is a global reduction in the number of potential spills detected in the images: from 10.77 possible spills identified per million km$^2$ in 2008 to 5.68 per million km$^2$ in 2010 (EMSA, 2011). A study showed that the percentage of detections checked on-site by aircraft within 3 hours and confirmed as oil varies from one region to another and reach values up to 80%.

SAR image data is able to detect ships and quite often their wakes. Therefore CleanSeaNet has been further developed to also provide a vessel detection service. In order to identify vessels suspected of causing pollution, traffic monitoring information from AIS (Automatic Identification Systems) data is necessary.

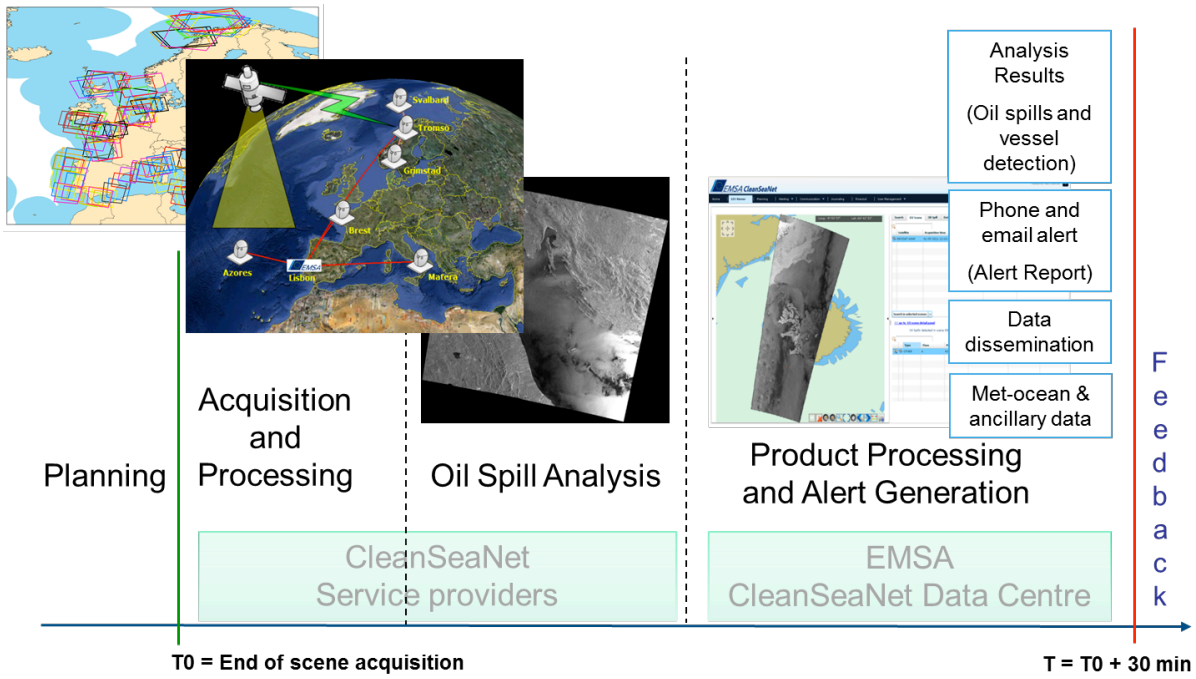


**Figure 2:** CleanSeaNet – the steps of a 30 min. near real time service performed at different locations: image planning (EMSA), satellite acquisition and image processing, oil spill analyses (service providers), harmonised product dissemination to coastal states and alert generation (EMSA).

CleanSeaNet provides vessel track information via the EMSA SafeSeaNet service as an added layer on top of the SAR image. SafeSeaNet is a pan-European electronic information system which harmonises the way maritime data on ship movements and cargoes is exchanged and which provides vessel tracking information throughout Europe. It is therefore possible to link a recent spill to a vessel if either the vessel is attached to the spill or the vessel track matches the pattern and shape of the spill, and if there is no ambiguity between the different potential polluters observed in the vicinity of this spill.

Oil spill modelling tools further assist in the identification of vessels responsible for illegal discharges (spill backtracking) and for prediction of spill drift and fate (spill forecasting) to support decision making for pollution response activities. Backtracking of spills and the intersection of the spill trajectory with vessel tracking data can limit the number of potential polluters and allows authorities to carry out more in-depth checking of suspicious vessels. Complementing the information provided to the Coastal States users CleanSeaNet includes additional sets of information, such as wind and swell information derived directly from the SAR data, sea surface temperature maps, surface chlorophyll maps, and reference data sets including nautical charts. All information is provided via a tailored web user interface and as “web services” following the standards and recommendations of INSPIRE (Infrastructure for SPatail InfoRmation in Europe) and OGC (Open Geospatial Consortium) with regard to architecture, catalogues/metadata, sensor planning, ordering, web mapping services, data access and dissemination amongst others.

During an accidental oil spill EMSA can place emergency orders for fast delivery of satellite radar imagery for the affected area and provide emergency pollution reports to the relevant authorities at Member States. In case of major accidental spills the International Charter for Space and Major Disasters provides a

unified system of space data acquisition and delivery to those affected by disasters including marine pollutions. The Charter can be activated by civil protection, rescue, defence or security bodies from the country of a Charter member. The Monitoring and Information Centre (MIC) operated by the European Commission in Brussels is one of the authorised users and may request the activation of the Charter in support of a major marine pollution incident. In that case, EMSA is the foreseen Project Manager and coordinates the delivery and analysis of radar and optical satellite images made available through the Charter to monitor the evolution of the spill.

## COASTAL STATE ACTIVITIES

The EMSA CleanSeaNet service triggers national surveillance activities which can take different forms, e.g. surveillance aircraft, helicopter, or patrol vessel. In addition to the verification of potential spills, their task is to identify possible polluters and if necessary to optimize response operations to minimise the environmental impact. By complementing national aerial and vessel surveillance with satellite images, a more cost effective use of these expensive resources is achieved.

Within Europe, use of aerial surveillance aircraft equipped with specialized sensor systems is common. Within the BONN Agreement and HELCOM regions an common equipment standard has been agreed. This includes Side-looking Airborne Radar (SLAR) as wide-range sensor system and InfraRed/UltraViolet (IR/UV) line scanner as narrow-range sensor system. Photo and video cameras for documentation purposes complement the arrangement (BONN Agreement Aerial Surveillance Handbook, 2009). These aircraft are on stand-by or have scheduled missions, often harmonised with the satellite overpass. Some member states plan flight missions with their aircraft to be in the area covered by the satellite imagery at the same time or shortly after to verify possible detections made by the radar sensors of the satellite. By planning the reception of satellite images at least one month or more in advance it is easily possible to align the national surveillance activities with the satellite overpass in order to have the national means available on scene as soon as possible if needed.

Oil pollution from ships which is observable by satellite can constitute a MARPOL violation, which therefore needs to be verified by the relevant coastal state. The verification of CleanSeaNet detections is vital as a radar sensor only identifies the effect on damping of the wave system. Reasons for this damping might be e.g. glassy sea due to low wind areas, an algae boom, ice on water or, of course, oil on the water. By using visual observation methods or specialized sensor systems like IR/UV line scanner, Forward Looking Infrared Camera (FLIR) or Laser Fluoro Sensors (LFS), oil spills can be differentiated from natural phenomena.

Having identified an oil spill, the next challenge is the identification of the (possible) polluter by combining the information provided by CleanSeaNet with the information retrieved by national means, and any jurisdictional follow-up activities. Once a possible polluter has been identified, the amount and type of necessary evidence needed to be collected by the authorities in order to effect a prosecution differs a lot within Europe.

In France for example, photographic evidence collected by a spotter aircraft is enough to bring an offence to court (Laurent Huet, 2011). Additional evidence to prove the offence, e.g. radio contact with the vessel, control of logbooks, Port State Control results assists the case.

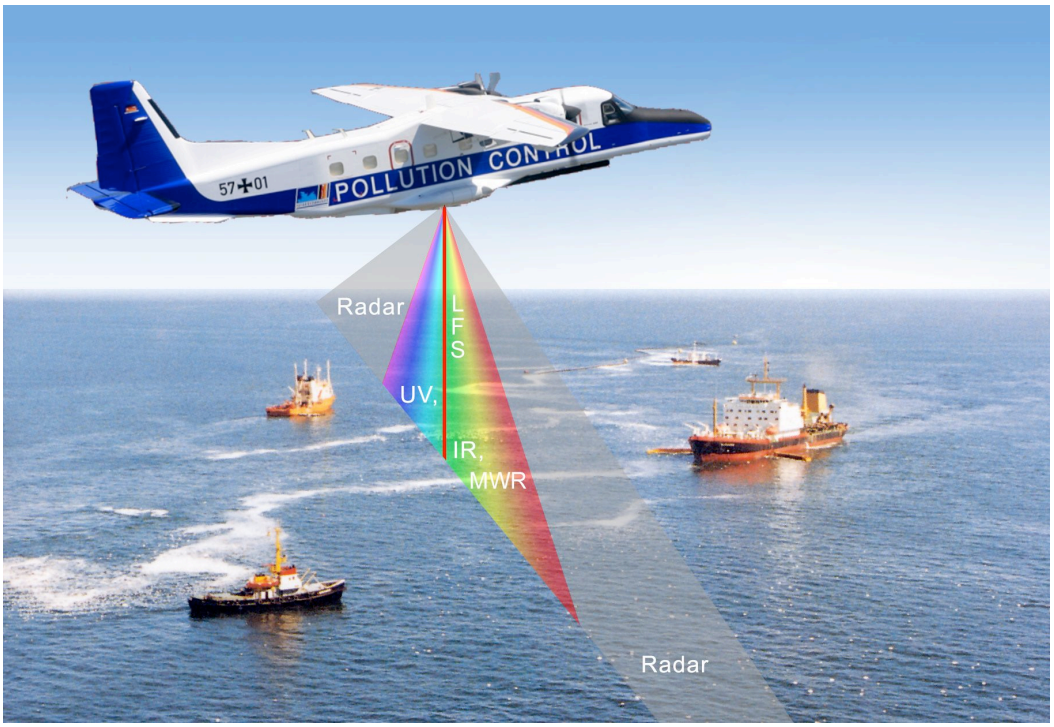


**Figure 3:** Schematic demonstration of the different line sensors on board of an aerial surveillance aircraft (example from Germany)

In other countries, such as Germany matching samples taken from the pollution and the polluter are mandatory for bringing an offence to court. The additional evidence mentioned above is also requested for a complete “body of evidence” (German Criminal Code).

Having identified the polluter and brought the offence to court, the judgment and penalties also differ as well. In some countries the judgment and penalties are focused on the ship crew (e.g. in Germany) while in other countries also the shipping company might be judged. In Norway for example the shipping company might be judged due to the reason that an effective safety management system on board of the vessel established by the company would have prevented the violation (Else Heldre, 2011). This has also an effect on determining the fines or penalties, which would be higher for a shipping company then for a single crew member.

## CONCLUSION

The intention of the European Member States and the European Union to set up an end-to-end surveillance chain in order to detect oil pollutions occurring in European seas, to identify the potential polluters and to collect the necessary evidence for judicial follow up are supported by CleanSeatNet and its integration into national activities. Besides routine surveillance activities satellite imagery provides a near real time trans-boundary overview of the actual situation at sea focused on possible oil pollution. It has been demonstrated that satellite services allow co-ordination of surveillance resources operated at a regional level and thus an improvement in cost efficiency for aerial and vessel assets. Certainly the purchase of a large volume of imagery and services creates a cost reduction due to economies of scale.

However, discrepancies between legal systems (e.g.: evidence admitted in court, level of penalties) might encourage ships routinely engaged in illegal

discharges to pollute in areas with a reduced risk of being observed. Therefore successful enforcement relies on the mutual understanding, exchange of information, coordination and cooperation of maritime surveillance, port inspection, and enforcement authorities within and between coastal States. This will definitely lead to an increased deterrence effect. The statistics shows already a reduction in the amount and size of the spills which might be caused by the higher frequency of surveillance of the European seas by combined national means and satellite surveillance, but also in the cooperation activities by Member States in enforcing pollution free seas.

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