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Version: Accepted Version

Book Section:
Carpenter, A orcid.org/0000-0002-1030-5866 (2015) Role of Galileo satellite technology in maritime security, safety and environmental protection. In: Hoerber, T and Stephenson, P, (eds.) European Space Policy: European Integration and the Final Frontier. , pp. 239-252. ISBN 9781317383604

https://doi.org/10.4324/9781315675916

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The role of Galileo satellite technology in the GMES for security, safety and environmental protection in EU maritime regions

Dr Angela Carpenter

1. Introduction

This chapter discusses how the European Space Agency (ESA) and European Space Policy (ESP) can offer significant benefits and synergies with a traditionally considered to be an unrelated area, that of European Union (EU) maritime policy and the marine environment. Since the establishment of the European Maritime Safety Agency (EMSA) in 2002, ESA and ESP have provided support to enable EMSA to carry out its work. This chapter identifies how institutional actors have sought to promote satellite technology, and the crucial role it can play in improving the security, safety and environmental protection of the EU's maritime regions.

There is a wide body of literature, using the concept of framing, to explain how EU policy areas have developed over time. Policies development may be in response to the bias or opinions of policy actor, individually or collectively, resulting in policy areas being transferred from the national to the supranational level (Dudley and Richardson, 1999). This might depend, for example, on whether that policy is one-dimensional or multi-dimensional, and is the result of individual or collective action to push forward that change (see Baumgartner and Mahoney, 2008); on the role of institutions and actors working towards institutional change and how such change meets the preference of the actors driving it forward (see Kohler-Koch, 2000); and on how despite the European Commission being viewed as a coherent and strategic actor, it is a complex organisation which has complex relationships with external actors in areas (see Morth, 2000).

This chapter is also set in the context of Hoerber's hypothesis (2012) that Europe has developed beyond the guiding ideals of European integration for the purpose of peace and prosperity post world war two, and has now entered a phase of consolidation and exploration. This idea was supported by Manners (2002), who identified an evolution from post-war nationalism towards a Europe of pooled resources and common principles. Similarly, Vogler and Stephan (2007) noted that the EU pursues collective action and advances its own regional integration to establish an identity for itself as an actor on the global stage.

Multilateral action and cooperation in the area of space policy would, garner respect for Europe as a global partner, raise the EUs political standing in the world, improve EU economic competitiveness and also enhance its scientific reputation (European Commission (2003a). The European Commission (2005), in setting out preliminary requirements for an EU space policy, emphasized the vital role space can play in EU policies such as transport, environment and security, and integration of space and terrestrial components in areas such as monitoring and communication.

The area of ESP provides a clear example of the peaceful integration of European activities over the last few decades, and shows how the development and exploitation of technology is an area where ESA can contribute towards the prosperity of European Member States (Hoerber, 2012, p 78), despite economic problems and other regional and social disparities, which still exist across Europe. The ESP, particularly through the cooperative activities between ESA and the EU, for example through the creation of the Global Monitoring for Environment and

Security (GMES) initiative, can also be viewed as a move towards greater integration and consolidation through development of a European identity in space policy (see Hoerber 2012, pp 78-79).

Complementing the above literature, this chapter examines how the area of space policy can be implemented and applied to the maritime policy arena – a more recently defined policy area of the EU (see for example European Commission, 2006, pp 31-33; European Commission, 2007, pp. 5-7). By considering synergies between the two policy areas, it is apparent that they are both multi-dimensional, with many diverse aspects of space policy able to support and benefit marine policy. That support occurs in areas including environmental protection, weather forecasting and route planning, and in supporting both national and supra-national agencies in actions as diverse such as security, policing, fisheries and transport, and in different ways in different EU maritime regions.

2. Synergies between space and maritime sectors

Under the guiding principle of peaceful cooperation between European states, the purpose of the 1975 ESA Convention was to promote space research and technology, with that technology to be used for scientific purposes and for operational space applications systems (see ESA, 2003, p 10). Recently, the Director General of ESA set out, in 2007, a Resolution on ESP providing a common political framework for space activities in Europe which recognised the need for stronger cooperation between ESA and the EU to promote a unified approach to space, highlighting the significant contribution ESP can make to an independent, secure and prosperous Europe (see ESA, 2007a, p 9).

The European Commission (2011a) identified the importance of space activities and applications for the growth and development of society by promoting the well-being of its citizens, providing economic benefits, and by cementing the EU's position as a major player on the international stage (p 2). In space policy a strong European/EU political identity is particularly important where the EU represents its Member States on the international stage. The European Commission (2003b) also emphasized the need for the EU to increase its participation in the governance system and activities of the United Nations (UN), in areas such as supporting the UN in combating terrorism, drug trafficking and organised crime (pp 7-8), all areas where there is the potential for synergies between space and maritime policy actions.

The application of space research and technology has been beneficial to the EU and its wider marine environment for many years in the areas of marine environmental protection, maritime safety and security. ESA has been actively involved in the maritime sector for over 25 years (see ESA, 2007b) while access to a wide range of natural and human-activity data to enable strategic decision-making on maritime policy was one area identified by the European Commission (2007) as a key component of its Integrated Maritime Policy (IMP) (p 6).

Topics for shared action and collaborative projects between EU institutions using Earth observation in the area of marine science and technologies have included coastal zone research (exploration and exploitation of resources), ocean currents and water circulation studies, and polar (ice thickness) research (Contzen and Ghazi, 1994, p 102). One method identified to achieve better knowledge and understanding of Earth system interactions was through remote sensing activities and analysis of time series multi-satellite data from joint projects and cooperative activities between the European Commission and ESA (*ibid,* p 102). The European Commission (2010) identified how observation of the sea and oceans can provide knowledge vital for sustainable growth in the maritime economy, assist in spatial planning and improved maritime surveillance, while application of knowledge can assist in ensuring the health of marine ecosystems and protecting coastal communities. In support of these activities ESA also works with the secretariats of various international conventions and treaties to provide satellite based services to support the operational requirements of those bodies (see ESA, 2012).

Satellite data for Earth observation, with tools such as remote sensing satellites, have come to play a significant role in monitoring a state's compliance with its international obligations under environmental agreements and for conducting environmental research (see Peter, 2004, pp 189-190). It also provides the EU with a tool to meet its commitments to a range of international treaties and conventions (*ibid,* p 190-193).

3. ESA, ESP and the European Maritime Safety Agency

The European Maritime Safety Agency (EMSA) was established in 2002 following the sinking of the *Merchant Vessel Erika* in December 1999[1]. It is the EU Agency with responsibility for ensuring uniform and effective maritime safety, and prevention of pollution from ships operating in EU waters (see European Commission, 2002). EMSA was tasked with providing objective, reliable, and comparable information and data in those areas which would enable Member States to take steps to improve safety and pollution prevention by collecting, recording and evaluating data on maritime safety, maritime traffic, and both accidental and deliberate pollution (*ibid*, Article 2, Task (f), p 4).

[1] For an overview of the sinking of the *MV Erika* and the subsequent actions of the EU, see Carpenter (2012), Section 3, pp260–263

While the use of satellite imagery and Earth Observation to obtain such data was not stated explicitly in its establishing Regulation, it appears implicit that EMSA should obtain data from any source possible and that the work of ESA and ESP will assist EMSA in fulfilling its tasks. However, even prior to the establishment of EMSA, satellites were used for Earth Observation in different maritime policy areas including oil slick detection, with ESA (2007c) indicating that, in 2002, the newly-launched ENVISAT was able to acquire images of the *Prestige* oil spill off Spain (see Figure 1).

<FIGURE 1 HERE>

ESA (2008) highlighted three areas where space technologies are being used in the context of IMP: (1) providing monitoring and support to Arctic operations; (2) marine environmental protection; and (3) integrated vessel surveillance (for both safety and security). ESA has undertaken many such activities, including water quality monitoring, sea ice monitoring, ship detection, and providing continuous time series of oceanographic measurements over many years (see ESA, 2007c).

Advanced Synthetic Aperture Radar (ASAR) imagery from ENVISAT has been used in conjunction with other systems to identify ice coverage enabling ship operators to better plan their routes to avoid hazards such as icebergs or sea ice threats to commercial shipping in the Baltic Sea (see ESA, 2004a). Figure 2 shows an ENVISAT image of ice, up to 80 cm thick, covering parts of the Gulfs of Bothnia, Finland and Riga. This has had implications both for safety and search and rescue activities in the event of an accident, while accurate route planning data has enabled ships to take advantage of ocean currents or avoid severe weather, can result in faster voyages and a reduction in fuel consumption, and can potentially reduce greenhouse gas emissions from ships (see ESA, 2004b).

<FIGURE 2 HERE>

Ensuring the safety of ships sailing in EU waters is vital as, in the event of an accident, irrespective of whether the ship sinks or not, there is the potential for injury or loss of life for those on board and for accidental pollution to occur. When an accident occurs out at sea it can be difficult to undertake rescue operations. A system which can identify the position of a vessel, provide information on the number of people on board, and also information about any hazards faced by rescue teams, is particularly useful.

Automatic Identification Systems (AIS) for vessel tracking and identification can support search and rescue activities and can also play a significant role in ensuring the security of the EU's borders with maritime security. ESA (2008) noted that this is an area where it has responded to requirements for improved vessel identification and location tracking, not just so that EU coastal states can better control and manage access to their territorial waters and exclusive economic zones for fisheries, but also to counter illegal activities such as people, drugs and weapons trafficking. ESA has therefore been involved in the provision of operational satellite technologies for vessel tracking as part of the over-arching International Maritime Organization's (IMO) Long Range Identification and Tracking of Ships (LRIT), part of a global system administered by the International Maritime Organization under Safety of Life at Sea Convention 1974[2], the EU component of which is managed by EMSA.

[2] International Convention on the Safety of Life at Sea (SOLAS), 1974, as amended in May 2006. Further details available at:

Two further operational tasks and services of EMSA[3] which use satellite technologies are: Satellite oil spill monitoring through *CleanSeaNet* (CSN); and Vessel traffic monitoring in EU waters under *SafeSeaNet* (SSN). CSN is a system which uses radar satellite images to: identify oil pollution on the sea surface; monitor accidental pollution during emergencies; contribute to the identification of polluters. Member states are alerted about possible oil spills and, if a spill is confirmed, the polluting vessel may be identified by vessel tracking through the SSN system. That system seeks to enhance maritime safety, port and maritime security, marine environmental protection, and efficiency of maritime traffic and maritime transport through a centralised maritime data exchange platform that monitors ships operating in EU waters.

4. Satellite systems and Maritime Safety and Security

There are many different actors including general law enforcement, customs, marine environment, maritime safety and security, defence, fisheries control, and border control (European Commission DG-MAF, 2010) with an interest in, or responsibility for, aspects of maritime safety and security. In each of those areas, there are a range of (sometimes overlapping) issues to be dealt with.

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http://www.imo.org/About/Conventions/ListOfConventions/Pages/International-Convention-for-the-Safety-of-Life-at-Sea-%28SOLAS%29%2c-1974.aspx LRIT is a requirement of 1986 amendments of SOLAS at Chapter V. For further details see: http://www.imo.org/OurWork/Safety/Navigation/Pages/AIS.aspx

[3] For details of all the operational tasks of EMSA see http://www.emsa.europa.eu and select Operational Tasks

The AIS vessel tracking and identification systems can assist civilian and military agencies, as well as EMSA, to monitor the position of up to 17,000 ships in and around EU waters daily (EMSA, 2012a). SSN can identify the current position of all or a single ship in and around EU waters, display specific vessel types, and show their historical positions (see EMSA, 2012b). By combining satellite imagery with AIS, it may be possible to exclude known vessels from images and identify those without AIS transmitters which might be involved in illegal activities. AIS data could also support monitoring of compliance with regulations or enforcement operations, and aid in the identification of illegal fisheries and fish landings (see European Commission DG-MAF, 2010, Annex, p 23).

Under the SSN system, information is also held about ships carrying hazardous materials, dangerous and polluting goods, or substances that can cause environmental damage or pose a hazard in the event of an accident. This information is essential in case of an accident, if hazardous materials are spilt, as it can enable search and rescue agencies to identify potential hazards faced during rescue operations. In addition, it provides pollution monitoring and prevention agencies to monitor high-risk vessels sailing in EU waters (see Carpenter, 2012).

Using positioning information in combination with SSN information on number of persons on a ship and whether there are any specific hazards, search and rescue teams can act to ensure the safety of crew and passengers. Satellite positioning is particularly vital where an accident occurs while a ship is sailing far out at sea when it will take time for land-based search and rescue vessels to reach a ship. In those circumstances, EU LRIT, SSN and AIS data may be used to identify nearby vessels and request they move to a position to render assistance to a vessel in distress.

There are a number of maritime security challenges facing the EU according to the European Commission (2006), including: illegal immigration by sea; smuggling and drug trafficking; terrorism; and piracy and armed robbery at sea (pp 29-31). In the case of smuggling and drug trafficking, for example, Griffiths and Jenks (2013) indicate that containerised sea transport offers a simple, convenient and cost effective mode of transport for drug smugglers (p 37) while the UN Office on Drugs and Crime (UNODC) 2008 identify that many of the drugs entering Europe are transported by sea from the Caribbean and South America (p 11).

The main EU and national agencies with responsibility for maritime security include general law enforcement bodies, customs and excise, security services and defence agencies. SSN provides those services with the opportunity to obtain satellite tracking information about ships to determine whether there is sufficient evidence that they pose a security threat. For example, ships carrying liquefied natural gas (LNG), a highly flammable substance in its gaseous form, may be a potential terrorist target while at sea or in port (see Testa, 2004; McNicholas, 2008, p 248). Using tracking information, it is possible to identify whether a ship has followed the most appropriate route to its specified destination port, whether it has unexpectedly stopped at sea for any length of time without good reason (for example, due to mechanical failure), or if it has visited a different port to its notified destination without good reason (for example, because of mechanical failure or adverse weather conditions). If there is no clear reason, then the ship may be inspected at sea or in port.

As a result of the establishment of the European Border Surveillance System (EUROSUR) (see European Commission, 2011b), information from satellites and from the SSN system should contribute to both maritime security and maritime safety and enable the EU and national agencies to obtain surveillance information on EU external borders (*ibid,* p 17). However, in the case of illegal immigration, a particular problem in the Mediterranean region (see UNODC, 2011, p 21), current systems are unlikely to help as migrants often travel in small, overloaded boats which sink with consequent loss of life (see Pugh, 2004, p 56). Those small boats do not carry AIS on board and so rescuing the victims of such sinking is unlikely to occur unless it happens within sight of another vessel. This is supported by the Centre for Strategy and Evaluation Services (2011) which identified a number of shortcomings relating to the use of satellite surveillance for maritime security (p 5) including a lack of wide-area maritime surveillance, only partial coverage of the open seas, and that surveillance systems have mainly been developed for maritime safety purposes. This is an issue also identified by Coppini et al. (2011) in relation to the use satellite data collected for environmental monitoring (p 141).

5. Satellite systems and Marine Environmental Protection

There are many examples of Earth Observing Missions undertaken by ESA using satellites including ENVISAT, ERS (Earth Remote Sensing satellites), Meteosat European weather satellites and MetOp polar orbiting satellites. The ESA website[4] identifies a range of areas where space technology is used in relation to the marine environment including satellite observation and satellite telecommunication links for vessel trafficking or as a navigational aid. As noted previously, radar equipment on board ESA's ENVISAT satellite is used to support the routing of ships operating in ice-affected areas (see ESA, 2008).

[4] For details of ESA's Earth Observing Missions see: http://www.esa.int/Our_Activities/Observing_the_Earth (last accessed 18 December 2013) and select the missions from the list on the left side of the webpage.

Monitoring marine habitats to ensure adequate water quality and to maintain biodiversity is economically significant to EU prosperity with fisheries, tourism and other activities within 50 kilometres of EU coastal states generating around €3.5 trillion (35%) of total EU GDP (see European Commission DG MAF, 2009, p 3). Satellite data can make a significant contribution in assessing the health of the marine environment through monitoring of pollutants entering the marine environment. They can also monitor naturally occurring biological hazards as in the example of ENVISAT images used to monitor algal blooms of the phytoplankton *cyanobacteria.* Algal blooms can have a detrimental effect on aquatic plants, invertebrate and fish habitats and which poses a particular threat in the Baltic Sea (see Paerl and Huisman, 2008, p 57).

Clark (1993) identifies 4 categories of pollutants: physical, including sediments; chemical, including toxic and acidic waste and oily waste; biological, including sewage and dissolved organic compounds; and thermal, where industrial discharges or the cooling requirements of power stations can raise the water temperature (pp 361-365). Clark (1993) indicated that oil is well suited for remote sensing investigation (p 362). It is one of the main pollutants for which satellite imagery has been used to protect the marine environment. There is a range of space-borne and airborne remote sensing devices, with satellite sensors being used for preliminary oil spill assessment and airborne ones for more detailed analysis of an oil spill (see Jha et al., 2008, p 236). Such remote-sensing devices can, according to Coppini et al. (2011), provide substantial support to routine surveillance for oil slicks in both the open-ocean and in coastal areas, as well as observing oil spills in remote and inaccessible areas (p 140). Coppini et al. (2011) concluded that satellite observing products provide robust operational information during an oil spill incident, more accurate prediction of oil spill drift, identification of where oil may come ashore, and that a system using optical sensors and SAR on board satellites can also aid in developing international action plans to clean up such spills (pp 152-153).

As noted previously, *CleanSeaNet* is the EMSA service from which EU Member States can obtain (additional) satellite images to identify potential polluters and follow up on incidents using aerial surveillance. This covers all EU waters and images of possible intentional spills and accidental spills are produced several times a day.

CSN data has been used in both the North Sea and Baltic Sea regions to support oil spill detection and monitoring activities since 2007. In the case of the North Sea, oil slick data had been collected in that region since the 1980's under the aegis of the Bonn Agreement[5] and, for the period 1986 and 2004, there was evidence of a decline in the number of oil spills in the North Sea using aerial surveillance only (see Carpenter, 2007). Data from aerial surveillance had also been collected since the 1980's in the Baltic Sea region, under the aegis of the Helsinki Convention. In both regions, as no satellite observation data was available prior to 2004, monitoring was conducted using a system of aerial surveillance, and mainly confined to daytime hours.[6] Since 2004 both the Bonn Agreement and the Helsinki Commission annual

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[5] *Agreement for cooperation in dealing with pollution of the North Sea by oil and other harmful substances, 1983*. The 2002 version is available at: http://www.bonnagreement.org/eng/html/welcome.html

[6] *Convention on the Protection of the Marine Environment of the Baltic Sea Area, 1974*. For further details see: http://www.helcom.fi/helcom/en_GB/aboutus/

reports[7] have included information on satellite observations, emphasizing increased accuracy of oil spill data, and the ability to observe oil spills during the hours of darkness or in bad weather. To highlight the magnitude of the problem, Konstianoy et al. (2008), citing the Finnish Environment Agency in 2004, indicates that there are around 10,000 oil spills in the Baltic Sea each year (p 71), and so the Helsinki Commission's (2010) suggestion that AIS can be used to back-track from a detected oil spill and match a spill to a particular ship's track should increase the likelihood that a polluter will be identified and prosecuted (p 36).

This illustrates the importance of satellite observation in that region, and the benefit that can be gained from CSN. In addition, CSN operates within the International Charter for Space and Maritime Disasters (ICSMD) [8] and, in the event of a major oil spill in EU and adjacent waters that Charter provides a unified system for space data acquisition and delivery for those affected by both natural and man-made disasters (EMSA, 2010).

While Coppini et al. (2011) identified a limitation of the use of SAR, i.e. the long revisit time and limited width of area covered by the sensors on board satellites such as ERS-2, RADARSAT-2 and ENVISAT (p 141), the use of satellite imagery in conjunction with the CSN service has already made a positive impact through increased levels of observation of spills in Europe's maritime areas. It has provided EMSA and Member States with more

[7] For Bonn Agreement Aerial Surveillance Reports go to http://www.bonnagreement.org/eng/htm/welcome.html and select publications. For HELCOM Aerial Surveillance reports go to: http://www.helcom.fi/shipping/waste/en_GB/surveilance/

[8] For further details of the ICSMD Charter and charter activations see: http://www.disasterscharter.org/web/charter/home (last accessed 18 December 2013)

complete, accurate and verified oil spill information, allows observations to be made during the hours of darkness or periods of bad weather, and increases the potential to identify and prosecute the owners of vessels which intentionally discharge oil at sea. This is significant as, based on data from EMSA (2011) which identified oil spills using satellite detection under CSN for all EU Member States with a maritime border, the implication is that the vast majority of confirmed oil spills are the result of intentional activities. The use of satellite images and SAR, when combined with the CSN and SSN services of EMSA, should provide a valuable tool in identifying the sources of such intentional pollution and should also provide a deterrent against that activity as awareness of those systems increases.

6. Conclusions

Satellite technology and Earth observation plays a significant role in supporting the operational tasks of EMSA. In the area of environmental protection of the marine environment, satellite observation provides a crucial tool in monitoring for pollution. If we fail to monitor the marine environment to identify intentional pollution then some ships' owners or captains will choose to deliberately dump oil and other substances at sea, irrespective of whether there are regulations in place or voluntary agreements to stop them from doing so.

Satellite observation of ocean currents, weather patterns and ice formation also play a role in ship safety, ensuring that they are not sailing into hazardous conditions, and in assisting with route planning.

Continued cooperation between ESA, EMSA and other EU agencies in policy areas relevant to the marine environment is vital to the continued security, safety and economic prosperity of the

EU. Satellite technology can support a range of EU policy areas, from border security to identifying vessels that potentially pose a security threat, by monitoring areas where drug smugglers operate, or by excluding vessels with AIS equipment on board to identify small boats potentially carrying illegal immigrants from West and North Africa. Satellite technology can also help monitor the biodiversity of Europe's seas and ocean regions, and more widely monitor for impacts of climate change, providing the EU with evidence to support future actions and policies in those areas. There is, therefore, clear evidence that the synergies offered between space, marine and other EU policy areas will greatly benefit cooperation between European Member States both at the current time and in the future.

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Abstract (200 words)

Satellite technology offers many benefits to Europe's maritime regions and marine environment and to the wider global marine environment. Satellites enable the EU and the European Maritime Safety Agency to monitor large numbers of ships sailing in EU waters and to enhance security by enabling member states to evaluate the risks posed by individual ships and take action to reduce that risk. Satellites can also enhance vessel safety, to improve the efficiency of maritime traffic, and support search and rescue activities. Radar satellite images can detect potential oil spills in EU waters, assist in tracking ships to ensure they do not intentionally pollute the marine environment, and help member states respond to maritime accidents and pollution incidents. In collaboration with regional agreements, satellite surveillance can help identify illegal pollution taking place under the cover of darkness. The EU Global Monitoring for Environment and Security Initiative offers a significant tool for monitoring climate change, atmospheric and marine pollution, and for sea-ice mapping and maritime surveillance. This paper concludes that satellite technology plays a crucial and ongoing role in improving the security, safety and environmental protection of the EU's maritime regions and in supporting the work of the European Maritime Safety Agency.

Keywords

Marine environment; maritime policy; monitoring; surveillance; maritime security

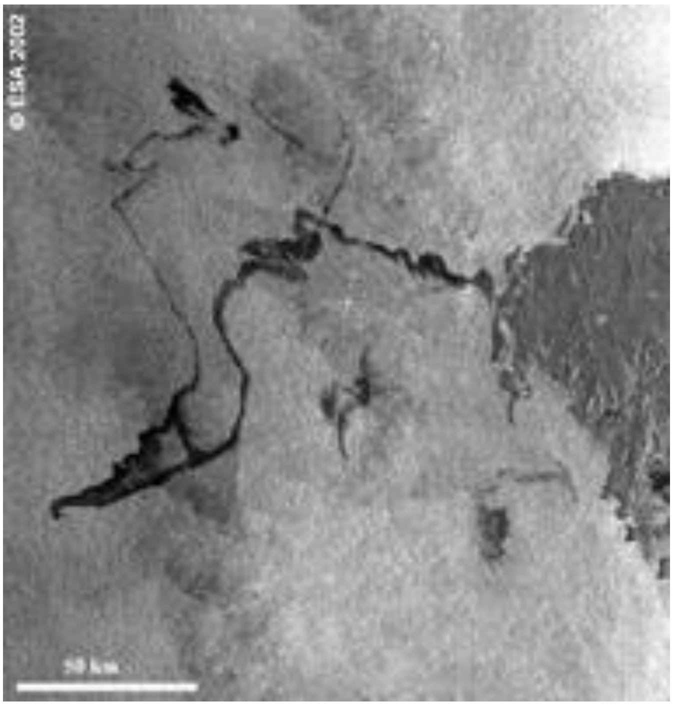
Acronyms

AIS	Automatic Identification System
ASAR	Advanced Synthetic Aperture Radar
CFSP	Common Foreign and Security Policy
CSN	CleanSeaNet
DG-MAF	Directorate General for Maritime Affairs and Fisheries
EMSA	European Maritime Safety Agency
ERS	Earth Remote Sensing
ESA	European Space Agency
ESP	European Space Policy
EU	European Union
EU NAVFOR	European Union Naval Force
EUROSUR	European Border Surveillance System
FRONTEX	European Borders Agency
GDP	Gross Domestic Product
GMES	Global Monitoring for Environment and Security
ICSMD	International Charter for Space and Maritime Disasters
IMO	International Maritime Organization
LNG	Liquified Natural Gas
LRIT	Long Range Identification and Tracking of Ships
REMPEC	Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea
SAR	Synthetic Aperture Radar
SSN	SafeSeaNet

UN	United Nations
UNODC	United Nations Office on Drugs and Crime

Figure Titles and Captions

Figure 1 – ENVISAT image of the Prestige Oil slick, November 2002



ENVISAT ASAR wide swathe image of 17 November 2002 showing oil spill from the Prestige tanker, lying 100 km off the Spanish coast. ESA Multimedia Gallery ID number: 197294.

Source: ESA Multimedia Gallery - available online at:

http://spaceinimages.esa.int/Images/2002/11/ASAR_wide-swath_image_acquired_November_2002

Figure 2 – ENVISAT image of Baltic ice coverage, April 2011

ENVISAT image of 19 April 2011 ice coverage in the Baltic Sea. ESA Multimedia Gallery ID number: 231435. Source: ESA Multimedia Gallery - available online at: http://spaceinimages.esa.int/Images/2011/04/Baltic_ice