

Oil spill issue and the capability of monitoring the problem by remote sensing

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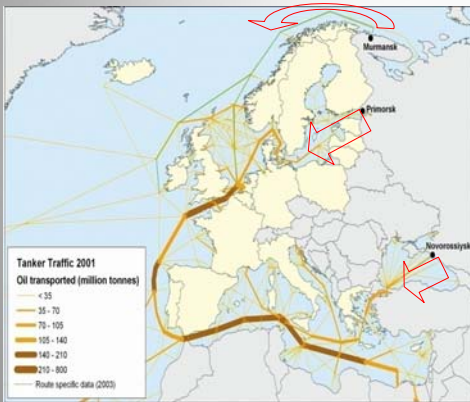
Content

- Oil spill problem
- Oil spill behaviour
- Techniques & methodologies for surveillance and detection
- Activities in Europe
- Outlook & Conclusions



Transport

- Oil spills are directly linked with ship movements
- Increase in maritime transport along European shipping routes



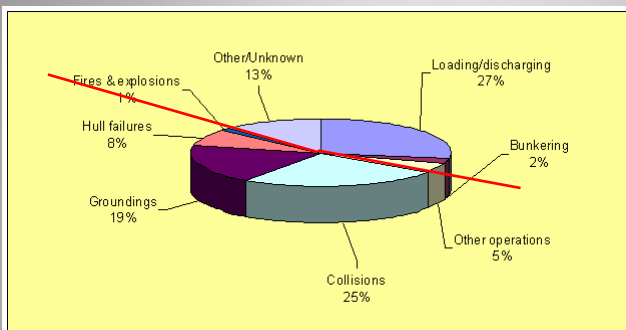
- We have already learnt at the conference:
- Mr. Hassel:
 - Primary energy demand is still growing (+160% in 20yr)
 - Oil transport from Middle East will increase
- Mr. Leemans:
 - The total shipping capacity and ship sizes will increase

O. Trieschmann

Int. Conf. "The World Ocean in Globalization", Oslo, 21-23 August 2008

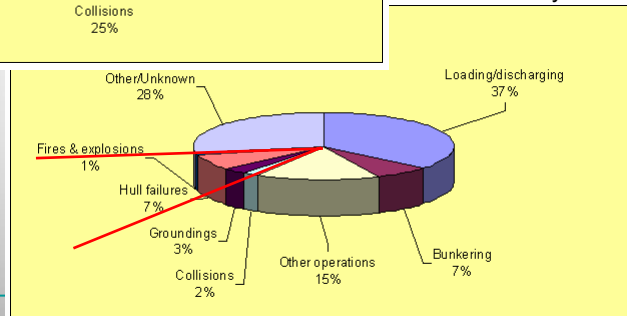
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Distribution of (illicit) spill incidents



Incidence of Spills
< 7t by cause

Incidence of Spills
7-700t by cause



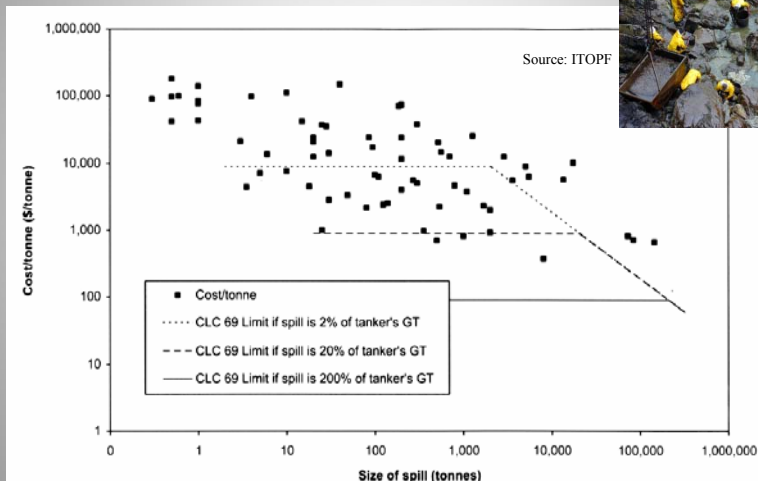
Data from 1974-2007
Source: ITOPF
www.itopf.com

Economic issue

- Some 270,000 to 6.3 mio. tonnes of oil are released into the ocean every year.
- UN led “Group of Experts on Scientific Aspects of Marine Environmental Protection (GESAMP):
1.2 mio. tonnes/yr.
- PriceWaterhouseCooper has calculated the annual costs (2005 prices) [3-6]:
 - European spills estimated to 50,100 tonnes/yr
 - for clean-up around €120 million
 - for environmental degradation and all other economic and societal costs €149,600 per tonne;
Multiplied with the estimated volume of oil spillage in European waters: €7.5 billion per year.

Costs of oil spills per tonne

(theoretical amount representing the actual or estimated total admissible claims)



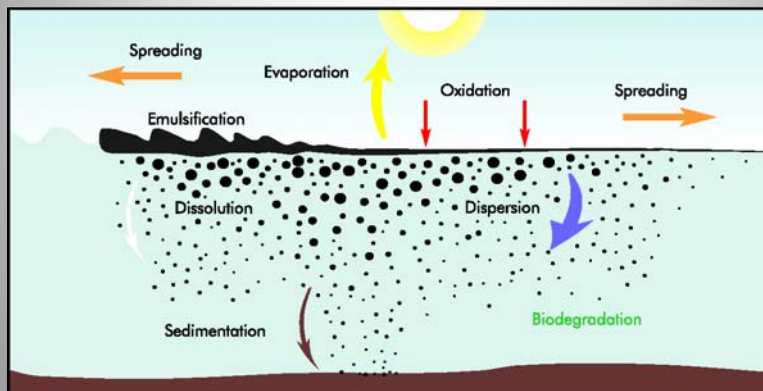
International law forbids deliberate pollution

- International laws require enforcement.
 - **MARPOL** [2]
 - the **European Union Directive on “Ship Source Pollution”** (EU/2005/35 [7])
- the EU Parliament claimed 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” [8]
- The OSPAR commission called to “move towards the target of the cessation of discharges, emissions and losses of hazardous substances by the year 2020” [9]

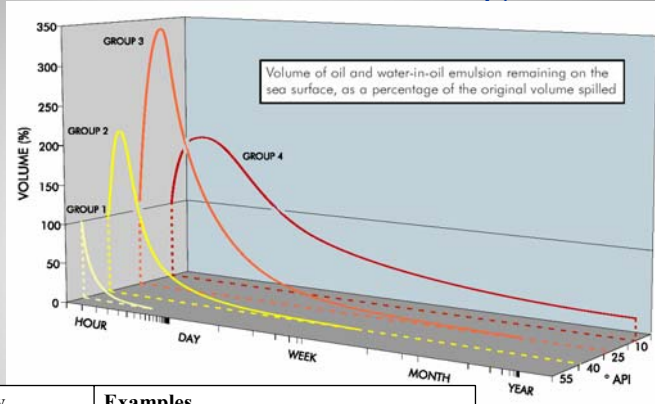
Oil spill behaviour: Processes

- Different processes take place after an oil release at sea

Source: ITOFF



Oil spill behaviour: Weathering



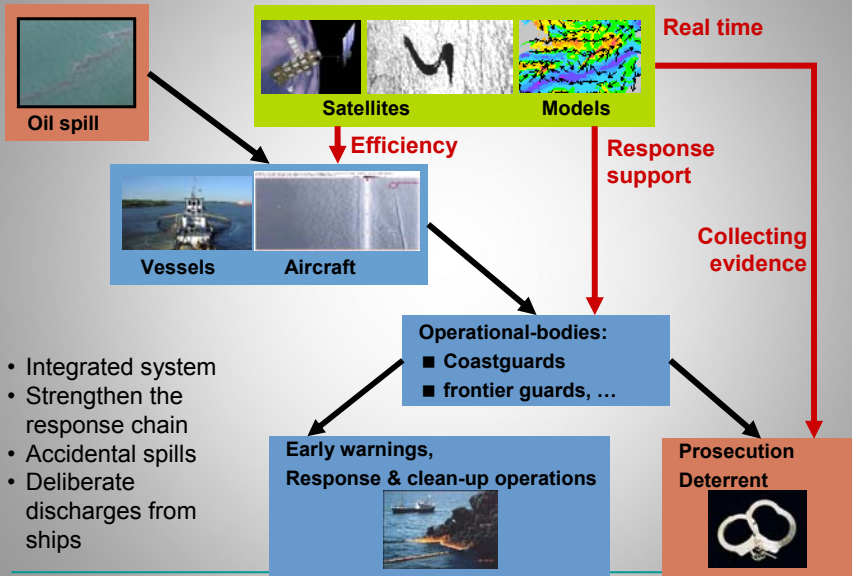
Group	Density	Examples
Group I	less than 0.8	Gasoline, Kerosene
Group II	0.8 - 0.85	Gas Oil, Abu Dhabi Crude
Group III	0.85-0.95	Arabian Light Crude, North Sea Crude Oils (e.g. Forties)
Group IV	greater than 0.95	Heavy Fuel Oil, Venezuelan Crude Oils

Illicit spill surveillance

- Illicit spills have to be detected and located
 - quickly after the release
 - across a wide area
 - during day and night and independent of the weather conditions.
- For decision making process
 - the pollution has to be classified and quantified with high accuracy.
 - As a secondary product, ecological conditions in coastal waters should be determined.
- Only remote sensing techniques are able to fulfil these demands from aircraft and from satellite.
 - Due to their wide area coverage with regular revisiting time,
 - Satellites allow a cost efficient surveillance per area.
- Observations from satellites complement and optimise the use of aerial surveillance by directing the aircraft to the location of the incident for further investigation.

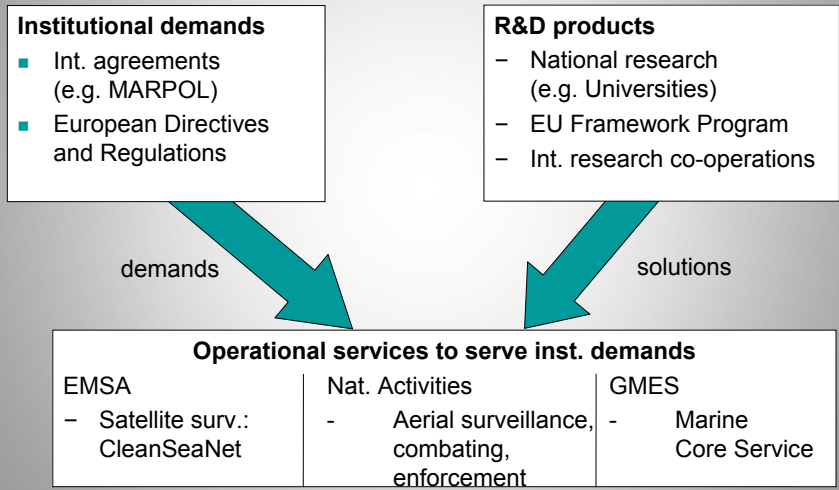
On the other hand aircraft provide the unique ability to carry multiple short range sensors to measure different physical parameters of a pollution incident.

Vision for an operational integrated system

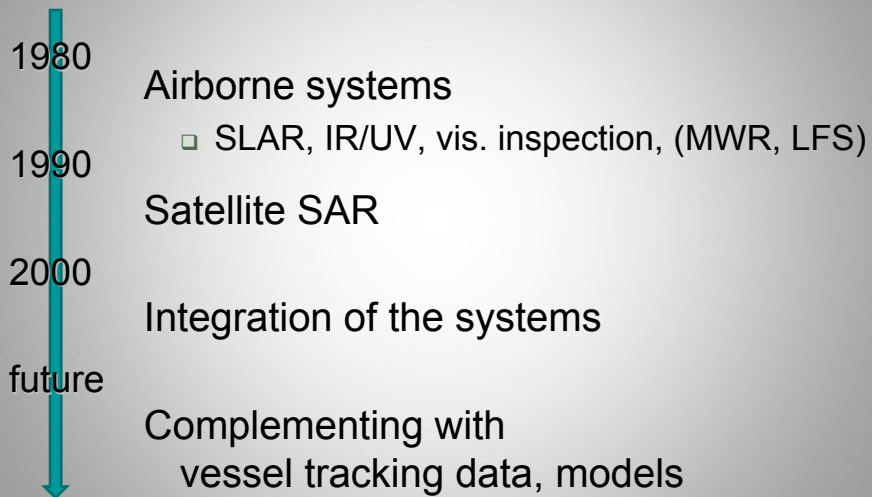


- Integrated system
- Strengthen the response chain
- Accidental spills
- Deliberate discharges from ships

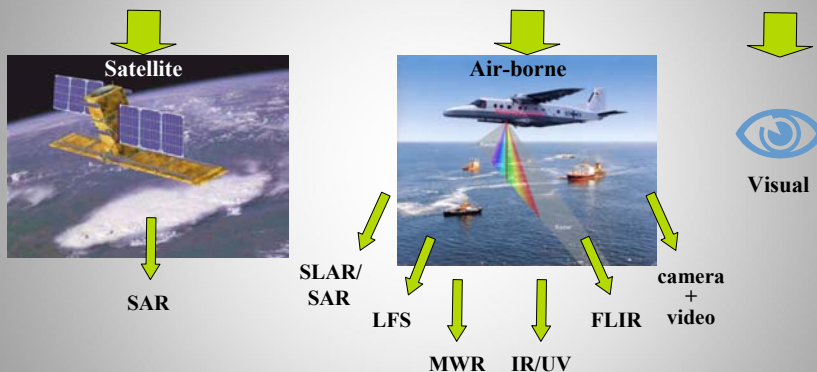
Transition from R&D to operational services



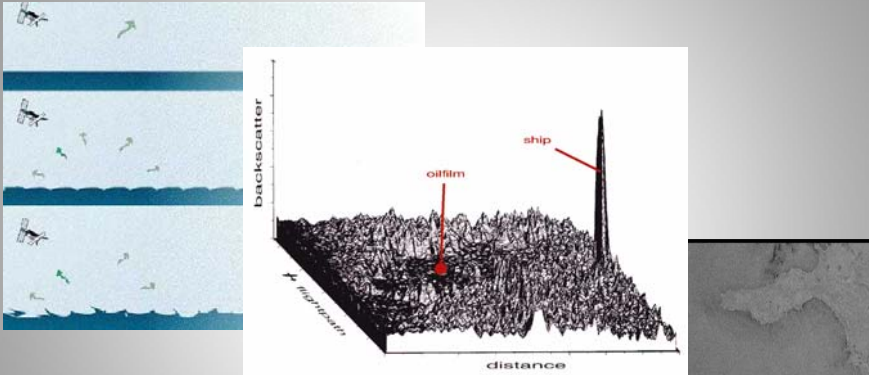
History



Techniques & methodologies:



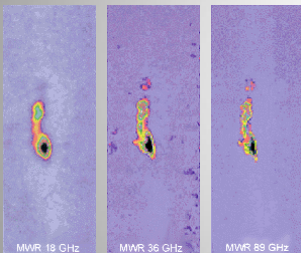
Radar



The presence of a **film on the sea surface damps out small waves and reduces the measured backscattered energy** which results in darker areas in the SAR image

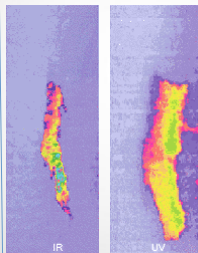
Passive airborne sensors

Determination of the oil layer thickness



MWR 18 GHz MWR 35 GHz MWR 85 GHz
18 GHz 35 GHz 85 GHz

Determination of the oil layer extension



IR UV

IR-Scanner

- Measuring the thermal contrast between oil and water
- The IR-channel is independent from daylight and is operating at night.

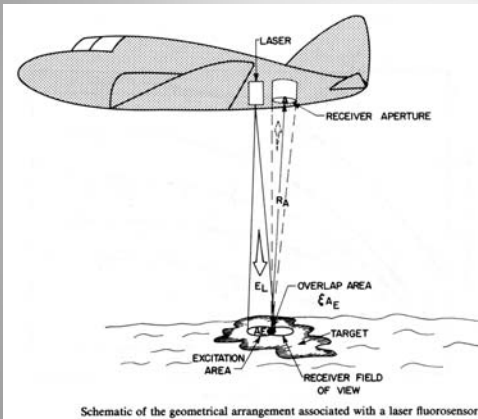
UV-Scanner

- The UV-channel determines the reflected sun-light at the sea surface.
- Very thin oil films of less than 0.1 mm can be determined due to the short wavelength of the UV.

Microwave-Radiometer (MWR)

- Oil layer thickness determination between 50µm to the mm range.

Active Laser-Fluorescence Sensor



- Determination of oil layer thickness within 0.1 to 20 mm,
- Identification and classification of the oil types
- Detection of oil quantities in the water column
- Concentration of algae and dissolved organic matter,

Techniques & methodologies: Overview "Sensor characteristics"

	Visual	SLAR	UV	IR	MWR	LFS	Satellite (RADARSAT)
Range @ 300m flight altitude	approx. ±3km	wide, ±30km	narrow, ±250m			narrow, ±75m	300x300km
Classification capabilities	no	no			yes	no	
sensitivity on oil film thickness	N.A.	N.A.	>0.1µm	>10µm	50µm to 2.5mm	0.1 µm to 20 µm	N.A.
Spatial resolution	high	60m by 30m (perp.)	3.5m	3.5m	>5m	10m pixel-to-pixel distance	50m
Detection of oil spills below surface	no	no			yes	no	
Operating at night	no	yes	no	yes	yes	yes	yes
Film thickness determination	Appearance of oil slick	no			yes, 50µm to 2.5mm	yes, 0.1 µm to 20 µm	no
Measuring geometry	visual	Line-by-line, 20 Hz			Conical, 5Hz	image	
Impaired by	no	no	clouds	clouds	no	clouds, flight altitude	no

FLIR for vessel investigation



- Access with the thermal IR-channel

- Recording of the vessel name by illuminating with a near IR Laser (not visible for the



Comparison of airborne and satellite data

Airborne:

- + High spatial resolution
- + Ground truth capability
- + Classification of oil species
- + Determination of layer thickness
- + Evidence ensuring
- + Communication link between aircraft and vessel
- + Directable
- Restricted spatial coverage
- Costly and man-power intensive

Satellite:

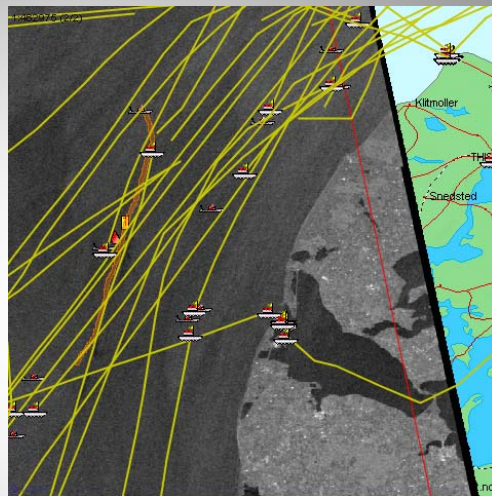
- + Large-scale coverage
- + Provides alert functionality
- + Independent of weather condition
- + surveillance of shipping routes
- + Providing long-term statistical data
- Low repetition rate and fixed overpass time schedule (sun synchronous orbits)
- Cannot determine volume of oil spill
- SAR data susceptible to oil look-alikes artefacts.

Modelling of oil spills

- To support the operational response chains
 - Forecasting models and oil weathering models for response and clean-up operations.
 - Backtracking and intersection with ship traffic information allow a more robust chain of evidence.
- Tailored for the specific sea areas is necessary.
- Requires high resolution models (~ 1km) capable of forecasting the evolution out to a forecast time of 72-96 hours in advance.
- Integration and interaction of global, regional and local models

Ship tracking

- VMS and VDS
- Automatic Identification System (AIS) ^[18]
 - Provides the vessel location and ship information via VHF to coastal receiving stations.
 - limited to ~ 30+ nm
- LRIT (Long Range Identification and Tracking) allows world wide coverage but access to data is limited.



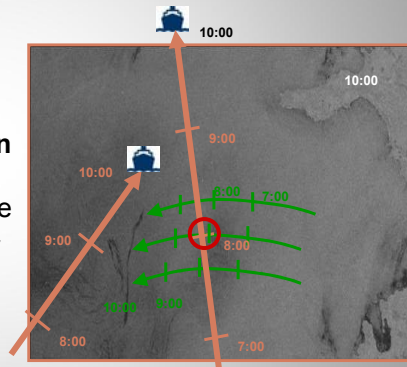
SAR, Spill,
AIS-vessels

+ Vessel
detection

+ AIS-tracks

Integrated system set-up

- “One-stop-shop” composed of
 - satellite systems
 - aerial surveillance
 - modelling and the intersection with ship tracking data
- A system that **links into the national/regional response chain** and strengthens operational pollution surveillance and response
 - Routine surveillance of the seas for illegal discharges in co-operation with Coastal States,
 - Support in case of an accidental spill,
 - Investigation of pollution ‘hot spots’ and development of statistics



Activities in Europe

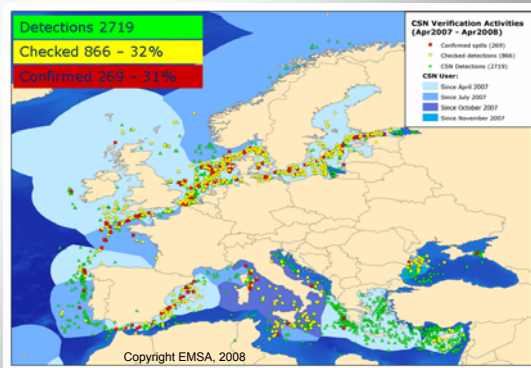
- The aerial surveillance, combating and prosecution is obviously a national responsibility
- More than 16 of the 24 European and EFTA Coastal States operate aircraft
 - aircraft are equipped differently
 - flight hours per year vary strongly from country to country
- The cross-border satellite images are provided and analysed by the European Maritime Safety Agency (EMSA) :
EMSA Clean Sea (CSN) Net satellite service is operational since 04/2007
- EMSA-CSN is providing approx. 2000 satellite SAR images per year for areas indicated by European coastal states with a growing tendency.
 - $2.5 \cdot 10^8 \text{ km}^2 = 646 \cdot \text{Area of Norway (387.000 km}^2)$

Activities in Europe

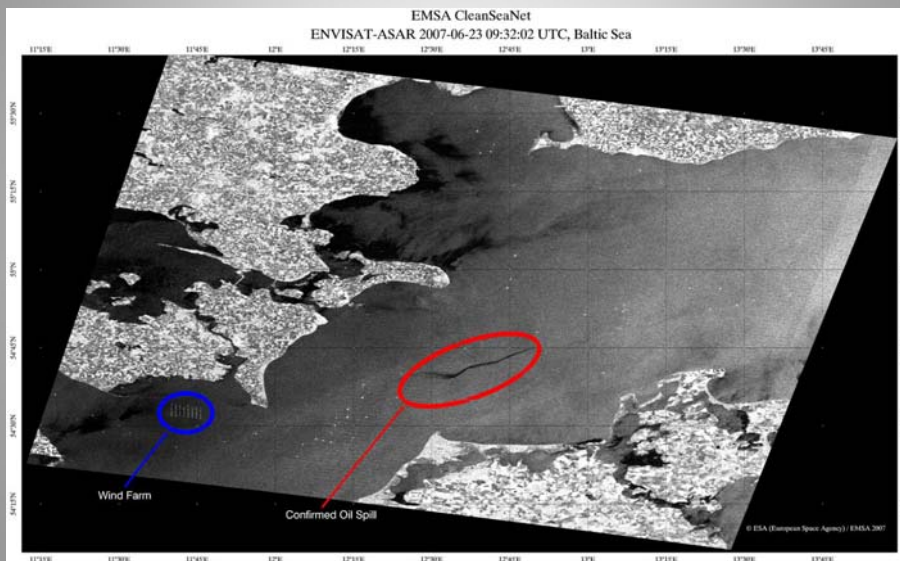
EMSA-CSN results of the first operational year

- 2719 potential in the 2010 images
- 31% spills confirmed (866 checked) [18]
- many of the detected potential spills could not be assessed correctly due to
 - evaporation and
 - physical degradation of oil

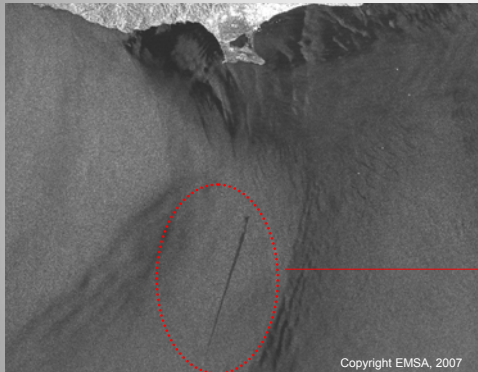
=> The time between the satellite overpass and the check via aircraft is crucial.



SAR images

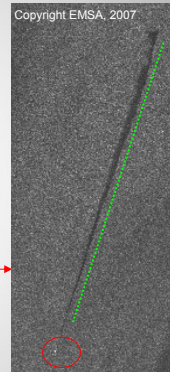


SAR images



Scene with
an oil spill indication

50 km in length

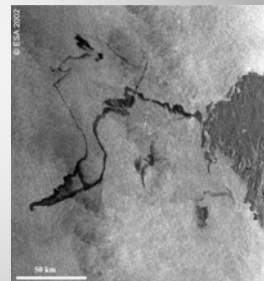


Spill connected to a
possible polluter

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- The 'Charter' is a mechanism to co-ordinate space based data acquisition and delivery to those affected by a natural or man made disaster anywhere in the world.
- Charter Members – CSA, CNES, ESA, NOAA, JAXA, ISRO ...
- The EMSA-CSN service acts within the framework of the Charter as project manager in case of oil spill disaster in European waters in co-operation with the Monitoring and Information Centre (MIC) of DG-ENV



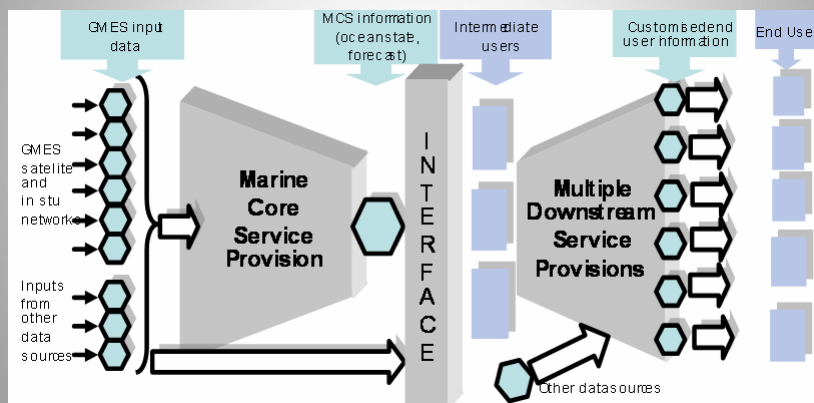
The PRESTIGE accident is a prominent example for charter activation

Room for improvements

- Better of spatial and temporal coverage
- Improved separation of oil slicks from other surfactants and look-alikes, improvement of the confidence level on the oil spills identified (e.g. making better use of ancillary data)
- Adaptation of automatic oil spill detection algorithms [20,22]
- Enhanced efforts to ground-truth
- Better harmonised, systematic reporting mechanisms
- Comprehensive statistics on a European scale
- A closer co-operation with law enforcement to improve enforcement and deterrence

GMES

- The future GMES marine services are expected to provide the relevant models.



From GMES MCS Implementation Group report by P.Ryder & al

Expectations on GMES

- Provision of basic oceanographic data to improve the quality of the spill identification
 - current, salinity, temperature analysis, wind and wave analysis and forecast profiles for regional seas, bathymetry
- Provision of state of the art combined drift, weathering and impact modelling using regional sea models with appropriate atmospheric forcing terms adapted to coastal zones.
- Sustainability for operational use

Outlook

Availability of remote sensing sensors

- New SAR satellites are available: RADARSAT-2, TerraSAR* and CosmoSkymed*
 - * focusing on high resolution image
- The GMES Sentinel-1 satellite will guarantee the future availability of a wide swath SAR data

Major technology step

- High altitude flying "Unmanned Airborne Vehicles" (UAV) for routine surveillance
 - deterrence effect will increase intensively
 - only affordable in combination with other tasks

Conclusions

- Oil spill surveillance is a cross border activity
- Remote sensing provides a unique technology to identify potential (illicit) pollutions, but with
 - integration of modelling and vessel informationthe systems become tools
 - to determine potential polluters,
 - to provide elements for the chain of evidence,
 - to support clean-up operations
- Satellite surveillance is an indispensable tool to achieve the basic European coverage.
- Co-operation and co-ordination with law enforcement has to be intensified to improve prosecution and deterrence

