

Rapid Deployable HF RADAR for Norwegian Emergency Spill Operations

C.W. Whelan, D.E. Barrick & P.M. Lilleboe
CODAR Ocean Sensors, Ltd.
1914 Plymouth Street
Mountain View, CA 94043 USA

Ø. Breivik
The Norwegian Meteorological Institute
Allegaten 70
5007 Bergen, Norway

A. Kjelaas
CodarNor A/S
Edwardsvei 35
N-1450 Nesoddtangen Norway

V. Fernandez & A. Alonso-Martirena
Qualitas Remos
C/Toronga, 31
Madrid 28043 Spain

Abstract- The Norwegian company CodarNor A/S, with funding from the Norwegian Clean Seas Association for Operating Companies (NOFO) and from Innovation Norway through an industrial research and development contract, is developing a self-contained rapid deployment HF radar which can be deployed by helicopter or other means to remote and rugged locations along the Norwegian coast and operate autonomously, communicating surface current data in real time back to operators, the Norwegian Coastal Administration and drift modelers. Large-scale 2-D current maps collected from these rapid-deployable systems will be used to improve spill response efforts by blending data with drift model currents for improved drift predictions and cleanup vessel management.

I. INTRODUCTION

To be able to predict where an oil spill will reach shore it is vital to have real time wind and surface current data of high quality. For coastal systems dominated by tidal regimes the real time knowledge of current maps and circulation along with historical records is often sufficient to predict surface currents and drift pattern over the next several hours. Circulation patterns along the Norwegian coast are often

dominated by strong energetic mesoscale activity and passage of several fronts, eddies and severe storms. This complex physics requires more complicated forecast algorithms together with an accurate description of the surface current fields. Buoys cannot give the full picture of such a complex surface current and drifters are

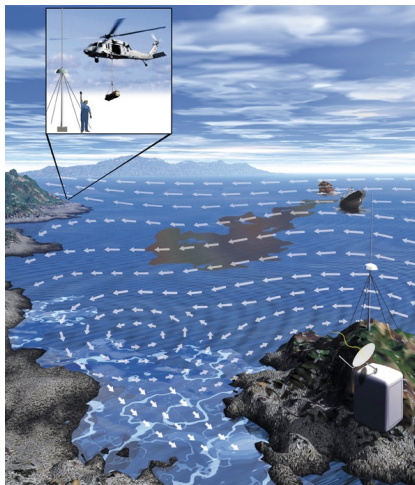


Figure 1. Artist's rendering of the rapid HF radar deployment concept.

expensive and inefficient to deploy in the numbers necessary to give a wide area measurement. HF radar is the only technology that can produce maps of surface currents continuous in space and time over the coastal area impacted by an oil spill. Recent experiments such as the NOAA sponsored Safe Seas 2006 exercise [1] and the Galicia HF Radar Experience [2] have shown that the ability of HF radar systems to map real time surface currents over large areas of coastal ocean can play a crucial role for the tracking and trajectory forecasting of oil spills.

Coastal HF radar networks are growing in size and scope in the U.S. and other nations. Unfortunately, events such as

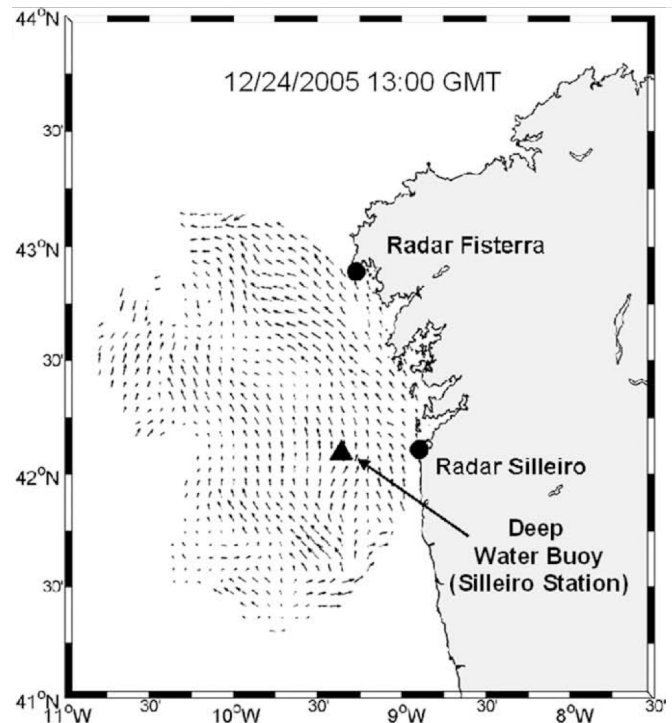


Figure 2. Example surface current map from the Galicia HF RADAR Experience [2].

spills do not always occur along a coastline that is well covered by HF radar. With substantial stretches of coastline in the U.S. having no HF coverage and with national networks just beginning to grow outside of the U.S., it will be some time before large, continuous networks in crucial areas are a reality. For emergency situations that occur outside of covered zones, having a rapid-deployable HF radar unit is desirable.

II. DESIGN CONSIDERATIONS

A. Prior Efforts

Outfitting an HF radar system in a mobile unit for quick deployment is not a new idea. Such units have already been built and tested in vehicle-towed mobile trailers by groups at Texas A&M University [3] and NOAA CO-OPS by integrating the compact SeaSonde® HF RADAR from CODAR Ocean Sensors with other off-the-shelf power and communications subsystems. Both groups have proven this type of integration and mobile setup successful over multiple deployments. Systems developed by NOAA CO-OPS are currently integrated in the IOOS National HF radar network [4].



Figure 3. Mobile SeaSonde developed by NOAA CO-OPS being deployed in Key Largo, FL, USA.

Towed trailers, however, have inherent limitations such as requiring sites that are only accessible by road and travel times that are dictated by road conditions. Many coastal areas in places such as Norway are fairly remote, lacking basic infrastructure and making a quick installation of an HF radar system difficult. In order to realize all the benefit and be able to utilize all the capabilities of HF radar in oil spill combat, it is necessary to develop a mobile unit with its own power supply and robust communication system, which can be easily deployed within hours to anywhere an oil spill has taken place.

B. Hardware Design for the Norwegian Coast

The hardware to support rapid deployment and robust operation along the Norwegian Coast must meet a different standard than previous systems. It must be lightweight and

compact enough to be deployable by helicopter or other means; operate autonomously and communicate surface current data in real time back to operators and drift modelers. A newly designed single compact transmit/receive (T/R) antenna for operation at 12 MHz will be erected alongside the autonomous unit, which will increase the number of potential sites and make setup faster and easier with the idea that a single technician could set it up and have it running in a half hour. In cases where additional range up to 15 km is needed, a parasitic antenna is being designed which can be mounted alongside the T/R antenna to direct the transmit energy seaward, but still remain isolated from the antenna as it receives, in order to maintain integrity of directional characteristics. Of course, all equipment must be designed for four-season operation. In order to increase the cost-effectiveness of the system, it should be possible to operate the units for longer periods in areas of strategic importance so that they can be rapidly redeployed during emergency situations.

III. QUALITY CONTROL OF REAL-TIME DATA

In addition to hardware considerations, the usefulness of the data output of a rapidly deployed system must be addressed. A single HF radar unit can only provide radial currents toward or away from it on a polar grid, so two or more must be paired. The observation area from a typical coastal HF radar is not limited by line of sight in the same manner as conventional microwave radars, but local coastline geometry may shadow observations close to shore due to hard-to-predict propagation losses. Azimuthal or range gaps in the radial currents due to other reasons (e.g. noise interference, antenna pattern distortion, etc.) may also be present. Gaps or shadows are more likely to be present in real-time data with the faster update rates than may be desirable in emergency situations. Methods have been developed to fill these gaps in surface current fields based on the technique of modal analysis [5] and have been refined into open mode analysis [6][7]. Not only does open mode analysis make it possible to fill spatial gaps, but gridded fields can be created outside of the traditional two site overlap region to enable the computation of particle trajectories where radial currents from only a single site exist.

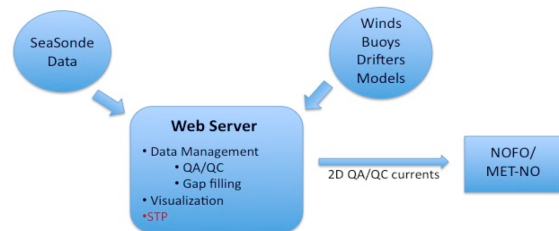


Figure 4. Flow chart of data through PORTUS information system during spill emergency operations.

A dedicated web server running the PORTUS® information system by Qualitas will accomplish three objectives with data sent from the mobile units: 1) serve as an interactive, user-friendly Google-based display of the data and the tailored outputs such as trajectory forecasting, 2) perform all the quality checking and modal analysis and allow import/export of the data between the partners and the end-users of the project. Figure 2 is a proposed flow chart of how the data will be managed.

The Google based web interface will integrate standard products such as hourly surface maps and error maps, daily averaged surface current maps, hourly surface current maps derived using the Open Modal Analysis (OMA) and error maps, observed 24-hour particle trajectories based on the OMA results.

IV. HF RADAR AND EXISTING SPILL OPERATIONS

The Norwegian Meteorological Institute already operates a 24-hour emergency oil spill service [8] for Norwegian waters. The service consists of a suite of operational ocean models, wave forecast models and numerical weather prediction models. The service is available to the end user through a web service as well as on demand from the forecaster.

The quality of the oil drift forecast output is highly dependent on the geophysical input data. In general, the wind fields and wave fields are far superior to the quality of the ocean current fields, although it is the latter which is most critical. The coastal current that flows along the coast of Norway creates very complex patterns with extensive eddy activity. The general lack of real-time observations means that there is normally substantial uncertainty about the actual quality of the modeled surface current fields. Attempts to assimilate HF current data have been tried [9], but the results thus far are that the improvement to ocean forecasts is generally short-lived and very localized in space. A more useful technique for this application may be to blend HF current fields with ocean model fields, where available, for use directly in the operational oil drift system. Recent studies have indicated that a variational approach to producing filled current vector fields may provide improved results [10]. The main difference between this style of blending and prior efforts is that the end product will provide smooth fields with a gradual transition from pure model to almost pure HF-derived currents where coverage is good.

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