USING HF SURFACE WAVE RADAR AND THE SHIP AUTOMATIC IDENTIFICATION SYSTEM (AIS) TO MONITOR COASTAL VESSELS

John F. Vesecky[1], Kenneth E. Laws[1] and Jeffery D. Paduan[2]

[1]Electrical Engineering Dept., University of California at Santa Cruz,
1156 High St., Santa Cruz CA 95064 USA
831-459-4099, fax 831-459-4829, vesecky@soe.ucsc.edu

[2]Oceanography Dept., Naval Postgraduate School,
1 University Circle Monterey, CA 93943 USA
831-656-3350, fax 831-656-2712, paduan@nps.navy.mil

1. INTRODUCTION AND OBJECTIVE

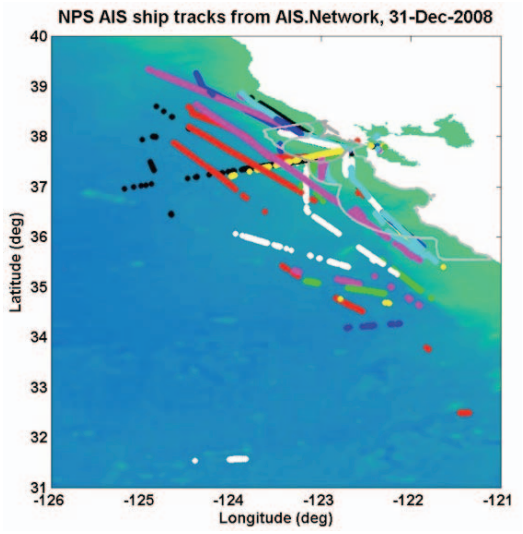
In this paper we compare the ship detection capabilities of the Automatic Identification System AIS (installed on some ships) and coastal, surface wave HF radars and show how to use both systems together to enhance ship detection performance in coastal regions. There are many practical reasons to want better real-time awareness of the location, velocity and type of vessels along coasts, e.g. for vessel safety, protection of the coastal environment and national security. Example applications of such vessel information are monitoring marine sanctuaries and protected areas in terms of fishing vessel activity, monitoring tanker standoff distances from coastlines and discovering vessels that may pose a security risk. While satellite sensors can provide snapshots during overpasses and aircraft can give a continuing operational picture when they are deployed, inexpensive persistent observation of both small and large vessels in coastal regions is not currently available outside of some harbors. AIS monitoring stations and HF surface wave radar are strong candidates to become components of any wide coastal area, vessel-monitoring network. A combined system has the potential to track moderate to large vessels out to distances around 200 km, a sizeable fraction of national Exclusive Economic Zones (EEZ's).

Our objective here is to characterize and compare the capabilities of AIS and HF radar in a ship monitoring/ tracking role. The characterization and comparison are done in terms of such quantities as probability of detection P_d and false alarm rate FAR as functions of observational parameters, such as range, azimuth and frequency, as well as vessel type and size. We focus on a Bayesian network methodology and demonstration, using both observational data and model-based estimates. We conclude that AIS and HF radar are complementary and that a combined AIS/HF system has significant advantages in terms of cost and effectiveness.

2. AIS & HF CAPABILITIES FOR SHIP DETECTION

AIS and HF radar have supplementary capabilities in that each compensates for some deficiencies in the other or enhances capabilities in the other. AIS uses VHF radio interrogators and transponders to allow ships to pass information between ships and to shore stations to provide for collision avoidance and other applications. For ships that are AIS equipped and in range AIS (class A) provides a wealth of information, such as location, course and speed, rate of turn, angle of heel, pitch and roll and a unique ship identification (MMSI) number. GPS accuracy is achieved for the ship location and activity parameters. AIS is designed to cope with a large number of vessels within range, providing for automatic contention resolution between stations even in overload situations. The range of AIS is highly variable with reliable (line of sight) propagation to only about 20 km, depending on antenna height, but with intermittent propagation to large distances due to ducting, e.g. below a temperature inversion. Elevated antennas, such as used at sites near Monterey Bay, California, observe maximum AIS range varying from 50 km on poor days to over 1000 km during very favorable conditions. Example ship tracks from AIS stations in the Monterey Bay region, see http://www.oc.nps.edu/~cwmiller/AIS/, are shown at right below.

Ship-tracking capability for HF radar has not been comprehensively evaluated. Experimental results from Gurgle et al. in 2008 [1] and Ponsford in 2000 [2] show practical ranges out to 200 km (50 W avg. power on 8 MHz, 260 m antenna aperture) and to 350 km (3.5 kW avg power on 6 MHz, 600 m aperture) respectively. Range is dependent on antenna performance, frequency and average transmitter power. Typical information is location (about 2 km) and radial speed (0.5 knot or better).



Comparing AIS and HF we see relative advantages for each. AIS provides superior information, but is a cooperative system that is not carried by all ships. Most vessels over 65 ft in length or 300 gross tons on international voyages or in Vessel Traffic System area are required to carry AIS. Thus, larger ships generally have AIS, but many smaller vessels do not. HF radar is able to detect most ships over a period of time, but missed detections do occur for a variety of reasons (see Vesecky et al 2008 [3]). Gurgle shows a comparison of HF and AIS in which some ships are detected by both AIS and HF radar, but some are detected only by AIS or by HF. The full aperture HF systems referred to above require extended coastal real estate while AIS is very compact. Compact HF systems, e.g. Codar SeaSonde, also have very useful ship detection capability.

3. COMBINING AIS AND HF FOR COASTAL SHIP OBSERVATIONS

To combine the AIS and HF radar observations of ships we use a Bayesian networks approach. This approach clarifies connections between observations and interpretations as ship detections. The main advantage of such an approach is to make the best use of all the information available (including a priori knowledge from previous observations) to make the decision as to whether a ship is present or not. An example of the use of a priori knowledge would be where ships typically travel, i.e. where the shipping lanes and other high probability areas are. Thus, a target in such a region would have enhanced a priori probability and detection would be declared with a lower signal to noise radar echo than elsewhere. Data collections from the AIS (see figure above) and HF radar stations in the Monterey Bay area supply the data that establishes such a priori probabilities. This network of HF radars and AIS stations supplies the test bed for this ship detection system. We present comparisons of AIS and HF detections of ships and examples of the application of Bayesian networks to use both data types together to construct a better picture of vessel activity in the area than either system alone.

4. CONCLUSIONS

We conclude that AIS monitoring stations combined with HF radars provide a cost effective way to provide maritime situation awareness in coastal regions. Both HF and AIS can operate from the same locations – as they do in the Monterey Bay region. Such a system would gain the benefits of the very excellent information on ship location, speed and course as well as ship identification provided by AIS as well as the detection capability of HF radar for smaller vessels that are not required to have AIS and vessels operating illegally without AIS in operation.

REFERENCES

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