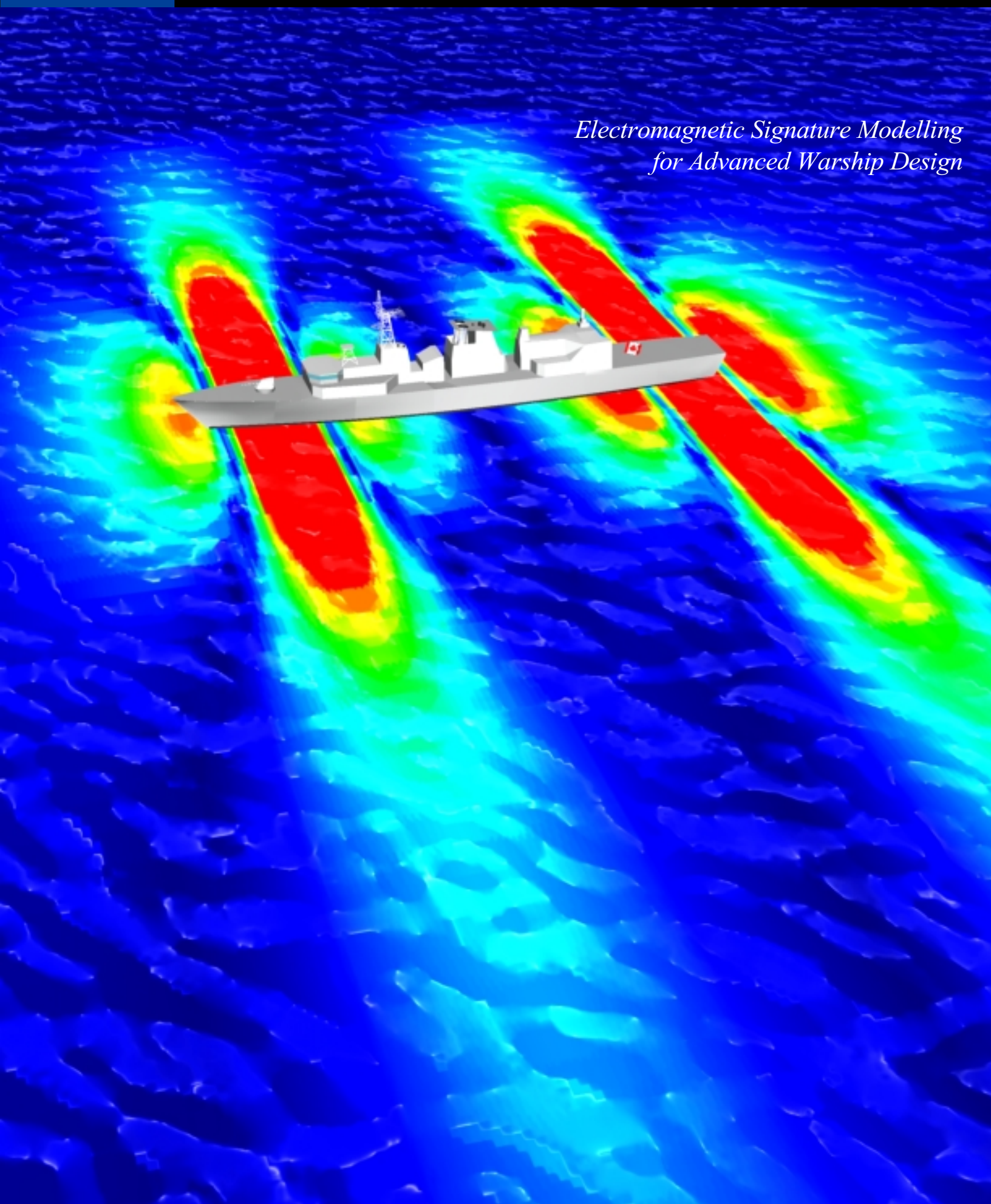


*Electromagnetic Signature Modelling
for Advanced Warship Design*



Electromagnetic Signature Modelling

One of the most effective threats in marine warfare is the naval mine. In recent years, this threat has increased as mine manufacturers have modified standard magnetic influence mines to include electric field sensors. An unprotected ship is now threatened by its electric field signature, in a manner similar to a magnetic or acoustic signature. As a result, navies around the world are today placing increasing importance on the reduction of the underwater electric field signatures of their ships.

SOURCE

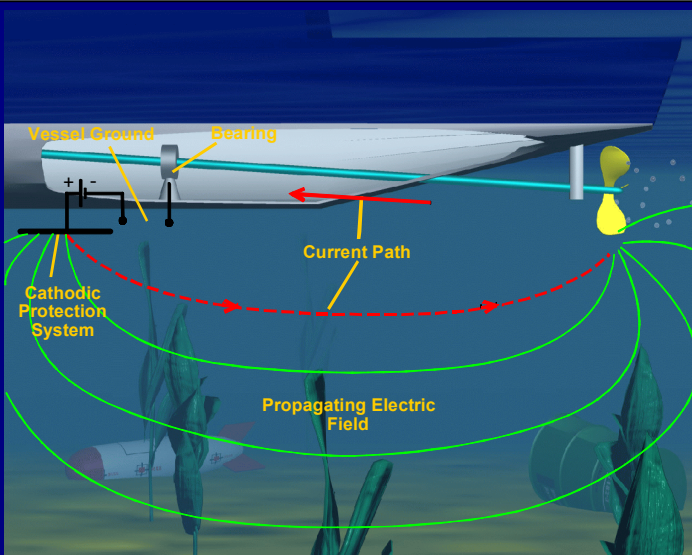
Ship electromagnetic signatures arise from several sources, including Passive Cathodic Protection (PCP) and Active Cathodic Protection (ACP) systems, structural ferromagnetic materials, and, to a lesser extent, onboard ancillary electrical equipment. Although considerable advances have been made in degaussing systems to reduce the signature from ferromagnetic materials, until recently no similar defensive technology was available to counter the electric field signature.

The electric field is produced by the passive corrosion currents and more specifically by the ACP systems, which are found on a majority of naval vessels. The ACP system passes a large

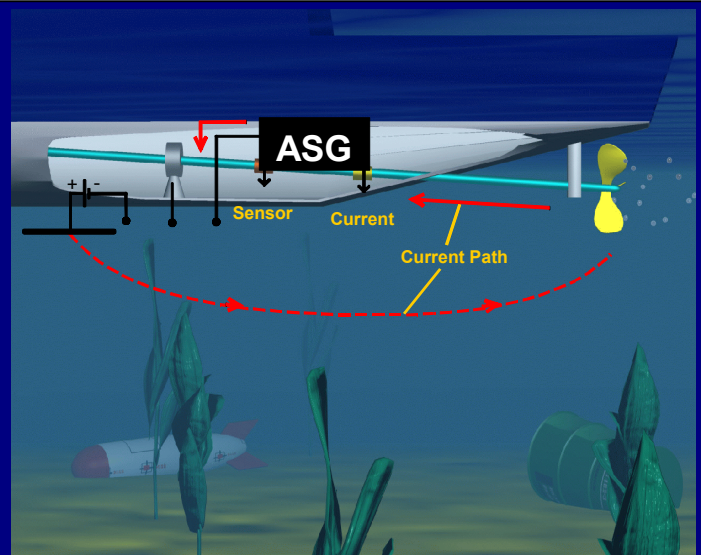
current through the water surrounding the vessel, creating a large static electric (SE) field and an associated static magnetic (SM) field. The rotation of the ship's propeller shafts and variations in the ACP power supplies cause fluctuations in this current, leading to large alternating electric (AE) and alternating magnetic (AM) signature components. This modulation of the current broadcasts electromagnetic fields into the water around the ship at its power frequency and also its shaft rate and blade rate. PCP systems using sacrificial zinc anodes do not have power frequency components, but still have shaft and blade rate components.

There are two possible paths for the ACP current. Although an electric current can flow from the ACP anode to the hull, if the hull coating is in good repair this current will be nearly zero. Instead, the high current caused by ACP systems almost always flows between the positive ACP anode and the negative propeller, which is typically fabricated of uncoated bronze. This high static and modulated current which is the source of the electromagnetic signature, can be modelled by an electric current dipole (product of current strength and physical separation). A twin-shaft ship is modelled by two such dipoles.

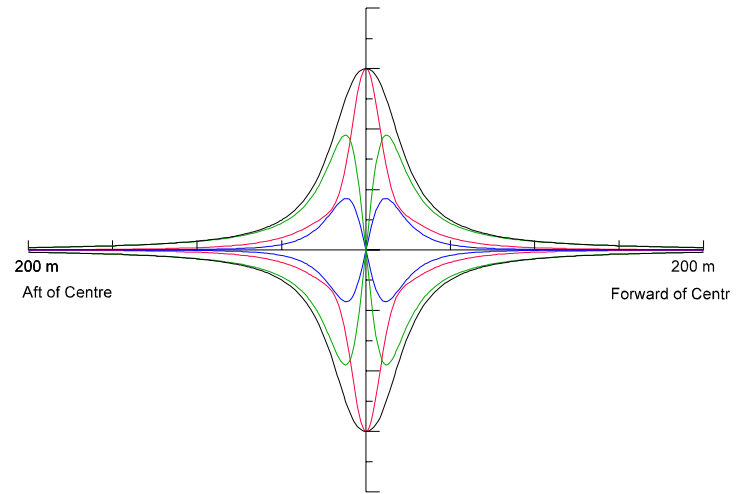
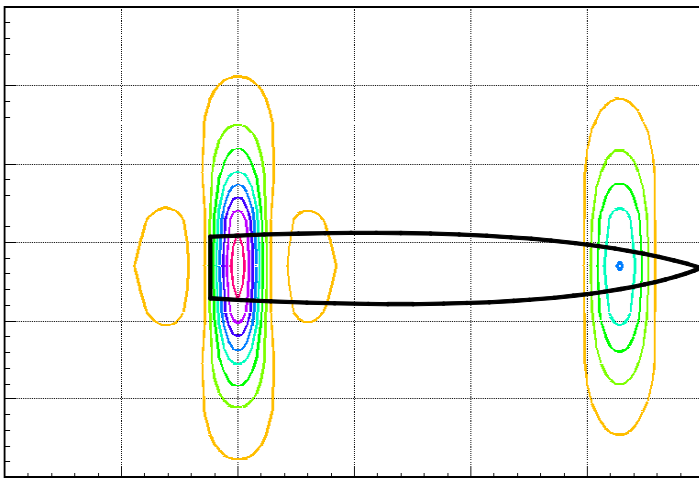
Schematic Diagram showing the origins of the AE signature and reduction of the signature using ASG.



Origin of Electric Signature



ASG Countermeasure



MODELLING

To improve electromagnetic signature through good design practice, DAVIS uses state-of-the-art computer models of underwater electric currents developed by the Defence Research Establishment Atlantic. Through the application of modelling techniques, that have been validated on underwater electric field ranges, the electromagnetic signature of a proposed design can be minimized while other performance specifications are maintained. This model can account for water depth, salinity, seabed conductivity and other factors.

The electric field signature can be reduced through good design practice and active countermeasures. Since, in general, the ACP system or corrosion currents cannot be eliminated, the next-best design procedure is to reduce the strength of the main current dipole from the ACP anode to the propeller, by reducing either the physical separation or the magnitude of the current. Moving the ACP anode closer to the propeller reduces the dipole length, but there are definite limitations. Too small a separation causes the blade rate to become more pronounced, and also reduces the corrosion protection for the hull. Coating the propeller is an obvious method to reduce the current, but this is difficult to maintain over time.

Active countermeasures, such as the DAVIS Active Shaft Grounding (ASG) and ACP Filtering systems, are additional effective

means of reducing a ship's electromagnetic signature. These systems, which virtually eliminate AE and AM signature components related to the shaft rate and power frequencies respectively, can also be included in the computer model. The final result is the prediction of the expected electromagnetic signature based on proposed design and countermeasures. This can then be compared to the target signature for the ship.

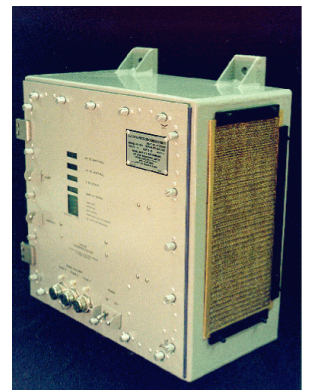
In a similar fashion, DAVIS can model the ferromagnetic signature component. This model predicts signature based on different designs and analysis of the effects of different types of degaussing countermeasures. The extra benefits of an Advanced Degaussing System can be determined. The Advanced Degaussing System includes multiple degaussing coils (20 to 80), a single power supply per coil, and more complex degaussing control algorithms, including closed loop degaussing.

SUMMARY

Electromagnetic signature prediction allows the designer to predict the signature of the vessel before it is built, and enables electromagnetic signature management to be included in the design phase. Both static and alternating, electric and magnetic components of the signature can be modelled. The effect of design changes and the addition of countermeasures can be included in the model and their effect on the total ship signature predicted.

Above Left: A contour signature plot prediction for an ACP protected vessel indicating total SE field magnitude.

Above Right: An AE field magnitude plot prediction for an ACP-protected vessel.



An ASG device used for minimizing AE signature.

Davis

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