Calculation of the EM Signatures of Marine Vessels due to Corrosion and its Countermeasures.

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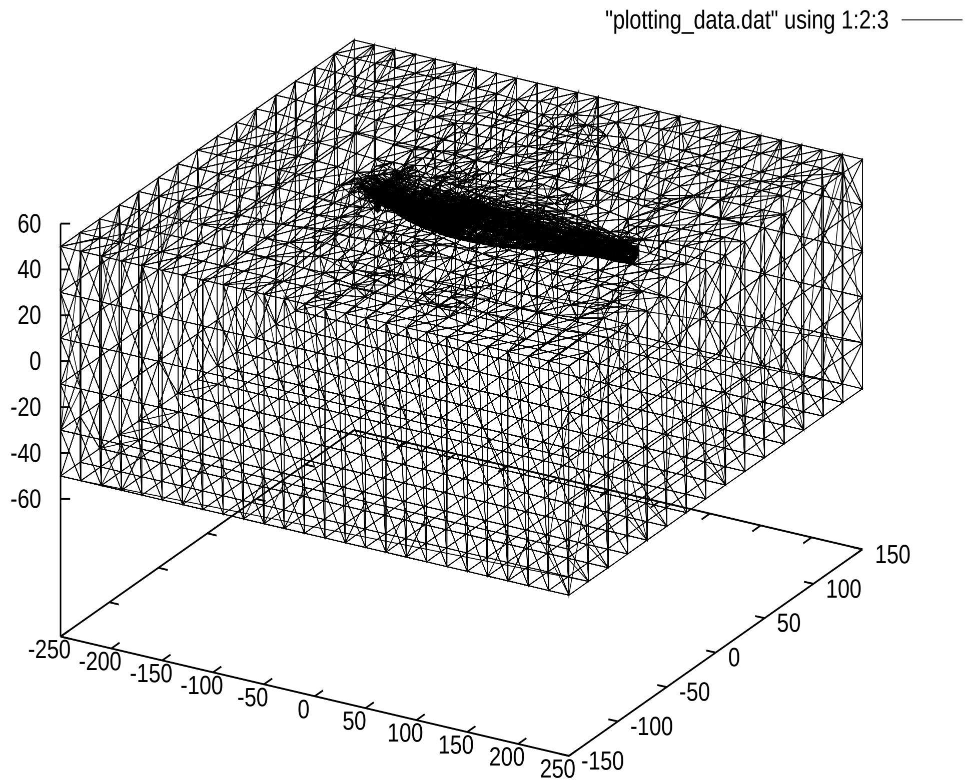
Summary

1. Outline of Physical Problem
2. Boundary Element Method
3. Solving the BEM equations
4. Calculation of electromagnetic fields
5. Calculations
6. Conclusions
7. Thanks

Physical Problem

- Basically a galvanic cell
- Boundary conditions control the type of boundary
  - Potential on boundary zero implies a conducting boundary
  - Normal component of electric field on boundary zero implies insulating boundary
- Numerical analysis so surface meshed

Mesh of the Model



Boundary Element Method

- Domain could be semi-infinite, and is homogeneous
- If $\mathbf{u}$ denotes the potentials over the elements, and $\mathbf{q}$ the outward normal derivatives of the potential
$$H\mathbf{u} = G\mathbf{q}.$$
- $G_{ij} \propto \int_\Gamma \frac{1}{R_{ij}} d\Gamma$ and $H_{ij} \propto \int_\Gamma \frac{\partial}{\partial \mathbf{n}} \frac{1}{R_{ij}} d\Gamma$.
- Solve for the unknown $\mathbf{u}$ and $\mathbf{q}$ values.

The PSOM

- The Point Successive Over-relaxation Method is used to solve the BEM equation

$$\tilde{u}_i = u_i + \frac{r}{H_{ii}} \left((H\mathbf{u})_i - (G\mathbf{q})_i \right).$$

- PSOM more commonly used in other areas such as deconvolution of images
- PSOM allows good control over boundary conditions such as polarization data, and ICCP Anodes.

Calculation of EM signature

- Both **u** and **q** known on the boundary.
- Possible to calculate the Electric and Magnetic fields from these boundary values.
  - Electric field at a point p within the domain can be calculated numerically from

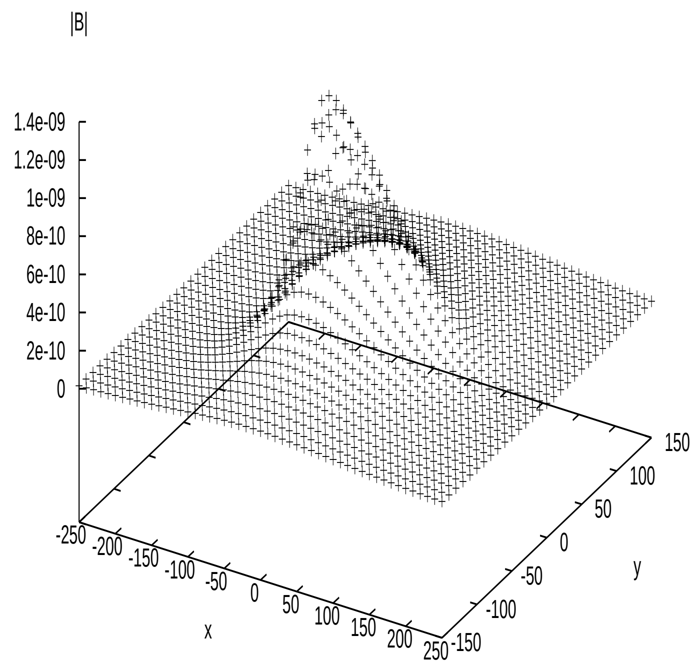
$$\mathbf{E}_p = -\nabla u_p.$$

  - Magnetic field at a point p within the domain can be calculated numerically from potentials on the boundary using

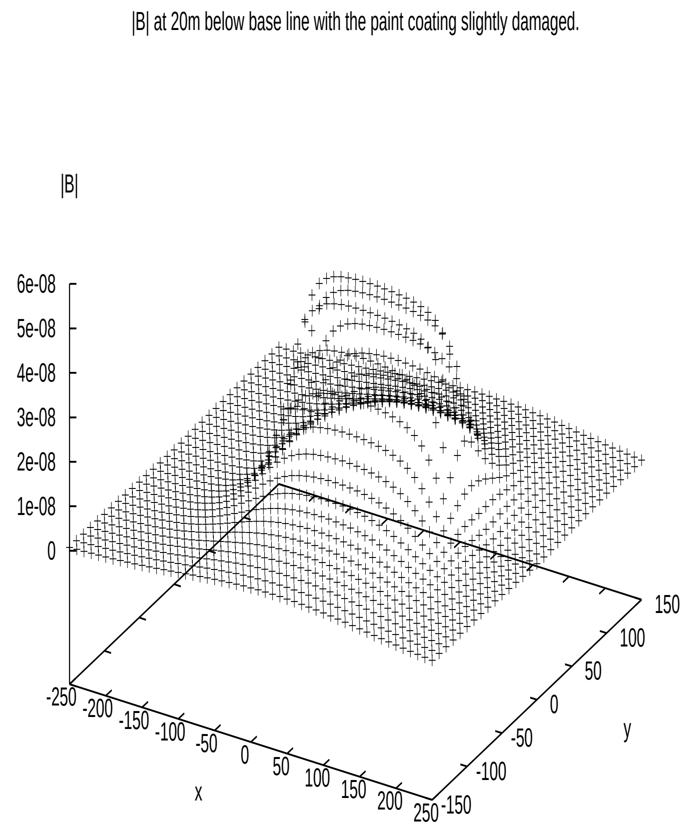
$$\mathbf{B}_p = -\frac{\mu_0}{4\pi}\sigma \int_\Gamma \frac{u}{R^3} d\mathbf{\Gamma} \times \mathbf{R}.$$

|B|-Perfect Paint

|B| at 20m below base line with a perfect paint coating.

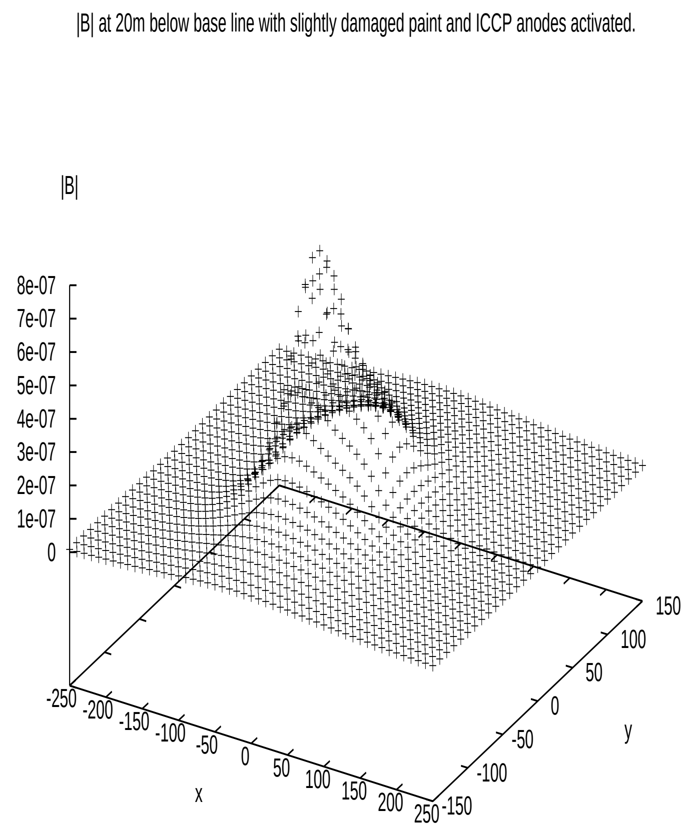


|B|-Damaged Paint



- Paint damage in region $133.8m \leq x \leq 153.8m$.

|B|-Damaged Paint, ICCP anodes on



- Anodes supplying $1A$ and are located either side of the hull at $x = -27m$ and $x = 60.67m$.

Conclusions

- Early Indications that the methods used operate as expected
  - Magnitude of magnetic fields are reasonable, and are effect of paint damage and anodes are as predicted.
  - Shapes of the plots behave as expected with the variation in paint damage and implication of anodes.
- Further calculations required. These should include more realistic polarization relations on the hull.
- Attempts shall be made to use the methods to control the fields.

Thanks

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