Master's project COSSE programme: optimized degaussing coil lay-out

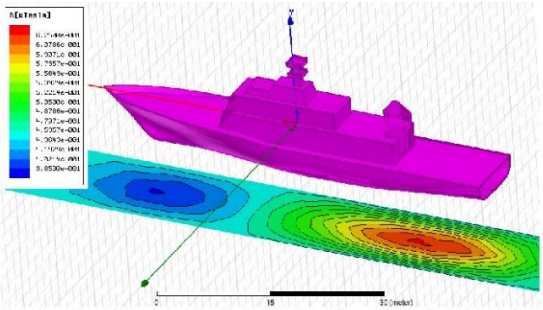
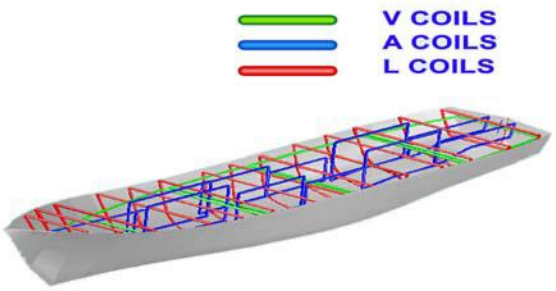


Fig. 5 The ship magnetic signature at reference depth induced by the



Steel ships disturb the local geomagnetic field. Through this mechanism, among other things, ships can be detected by modern sea mines that are equipped with a magnetic sensor. The magnetic disturbance field of a ship is also known as the magnetic signature. For naval vessels that must be able to operate in conflict areas, the mine threat, and therefore also the magnetic signature, is of great importance. That is why these ships have a coil system on board with which the magnetic signature can be minimized. This so-called degaussing system (for an example of such a degaussing system, see [1]) is a control loop: the position and orientation of the ship in the geomagnetic field are continuously monitored and with this information, the currents in the coils are controlled.

In order to have the lowest possible magnetic signature under all Earth's magnetic field conditions, two optimizations are necessary:

1) Coils plan design;
2) The (restricted) currents through the coils.

The first optimization concerns the design and construction of the ship, the second optimization is important during operational use, but both optimizations must work together to achieve the best result. Each degaussing coil also involves costs (installation and energy) so it is desirable to achieve the best signature reduction with the lowest possible number of coils [2]. The total magnetic signature of a ship can be described by

$$\boldsymbol{B}(\boldsymbol{r}) = \boldsymbol{B}^{\mathrm{perm}}(\boldsymbol{r}) + \sum_{i=1}^{3} B_i^{\mathrm{geo}} \boldsymbol{F}_i^{\mathrm{geo}}(\boldsymbol{r}) + \sum_{i=1}^{N} I_i \boldsymbol{F}_i^{\mathrm{coil}}(\boldsymbol{r}).$$

Here, $\boldsymbol{B}^{\mathrm{perm}}$ is the disturbance magnetic field of the ship in absence of a magnetic source, B_i^{geo} are the components of the Earth's magnetic field and I_i are the (restricted) currents through the N degaussing coils. The field distributions $\boldsymbol{F}_i^{\mathrm{geo}}(\boldsymbol{r})$ and $\boldsymbol{F}_i^{\mathrm{coil}}(\boldsymbol{r})$ are ship specific and are usually calculated on a plane at a certain depth below the ship using FEM. The challenge now is, for a given ship geometry and fixed number of coils, to develop a procedure to obtain a coil plan that achieves the lowest magnetic signature under all possible Earth magnetic fields with restricted currents. It is conceivable that the FEM calculation forms part of an optimization loop.

For more information about this assignment, please contact:

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[1] Polyamp. Magnetic and Electric Signature Control.
[2] V. Modagekar et al., Optimization in Tri-Axial Degaussing System Design and Estimation of Degaussing Coil Currents, IEEE. Trans. On Magn., Vol. 53, Issue 4, April 2017.