UDT
Undersea Defence Technology
13-15 May 2019
Stockholmsmässan, Sweden

Works toward closed loop degaussing system on board new MCM vessels

P. Polański, F. Szarkowski and M. Czarnowska
R&D Marine Technology Centre S.A., Gdynia, Poland

#UDT2019

Agenda

1. Introduction
2. Test stand, PSM
3. Models
4. Simulations and measurements
5. Conclusions

Introduction

Four main sources of ship's magnetic field signature within dc to several hundred Hertz band:

- Permanent and induced magnetization of hull and on board equipment
- Eddy currents induced in conducting hull and equipment
- Corrosion related and cathodic protection processes
- Electric equipment and ship's power distribution system

Introduction

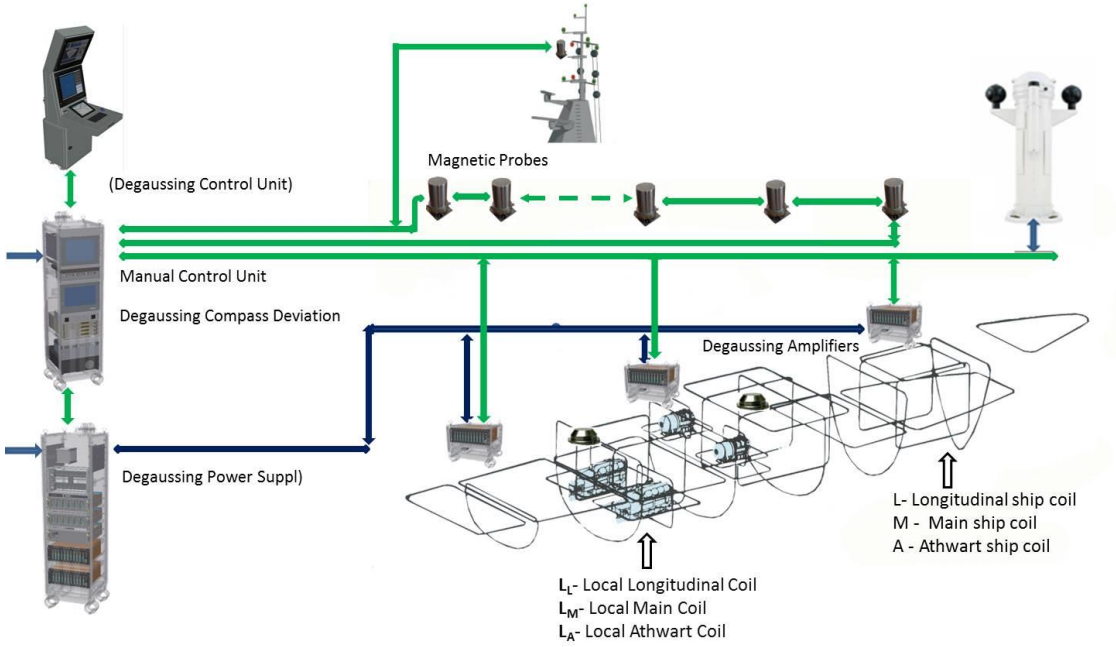
Passive reduction of magnetic field

Works toward closed loop degaussing system on board new MCM vessels

P. Polański, F. Szarkowski and M. Czarnowska - R&D Marine Technology Centre S.A., Gdynia, Poland

Introduction

Active reduction of magnetic field

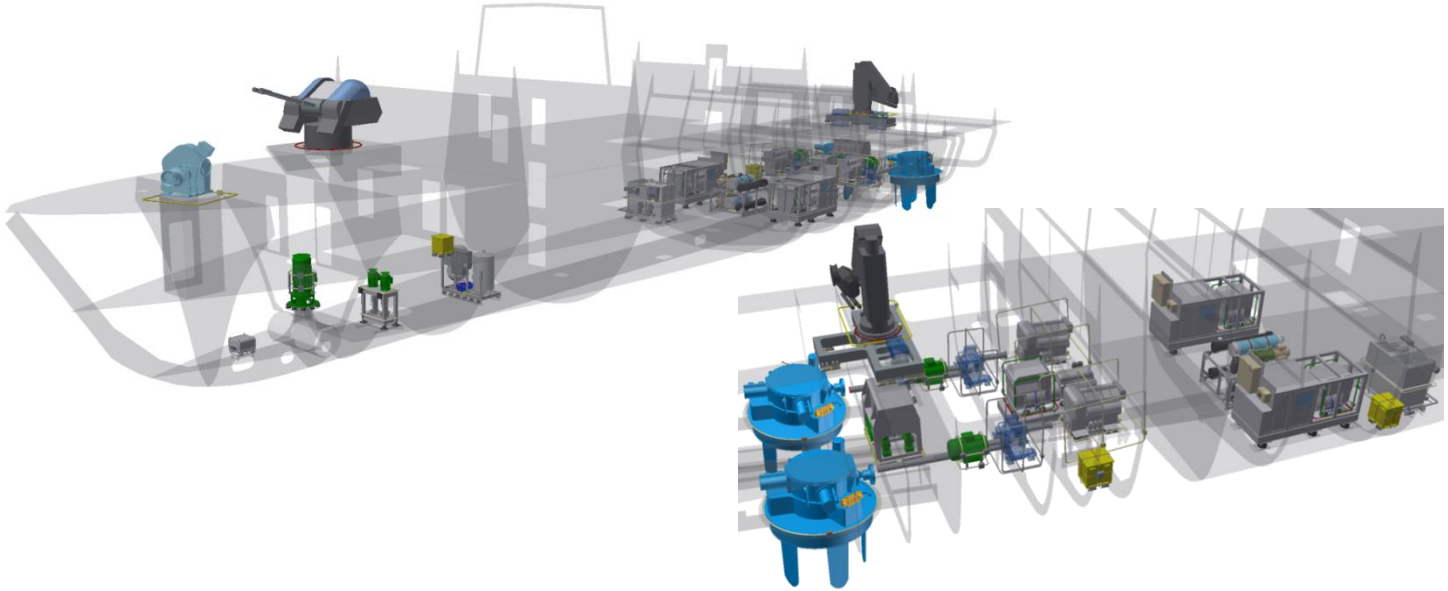


Works toward closed loop degaussing system on board new MCM vessels

P. Polański, F. Szarkowski and M. Czarnowska - R&D Marine Technology Centre S.A., Gdynia, Poland

Introduction

Active reduction on board non-ferromagnetic hull vessels with number of magnetic field sources

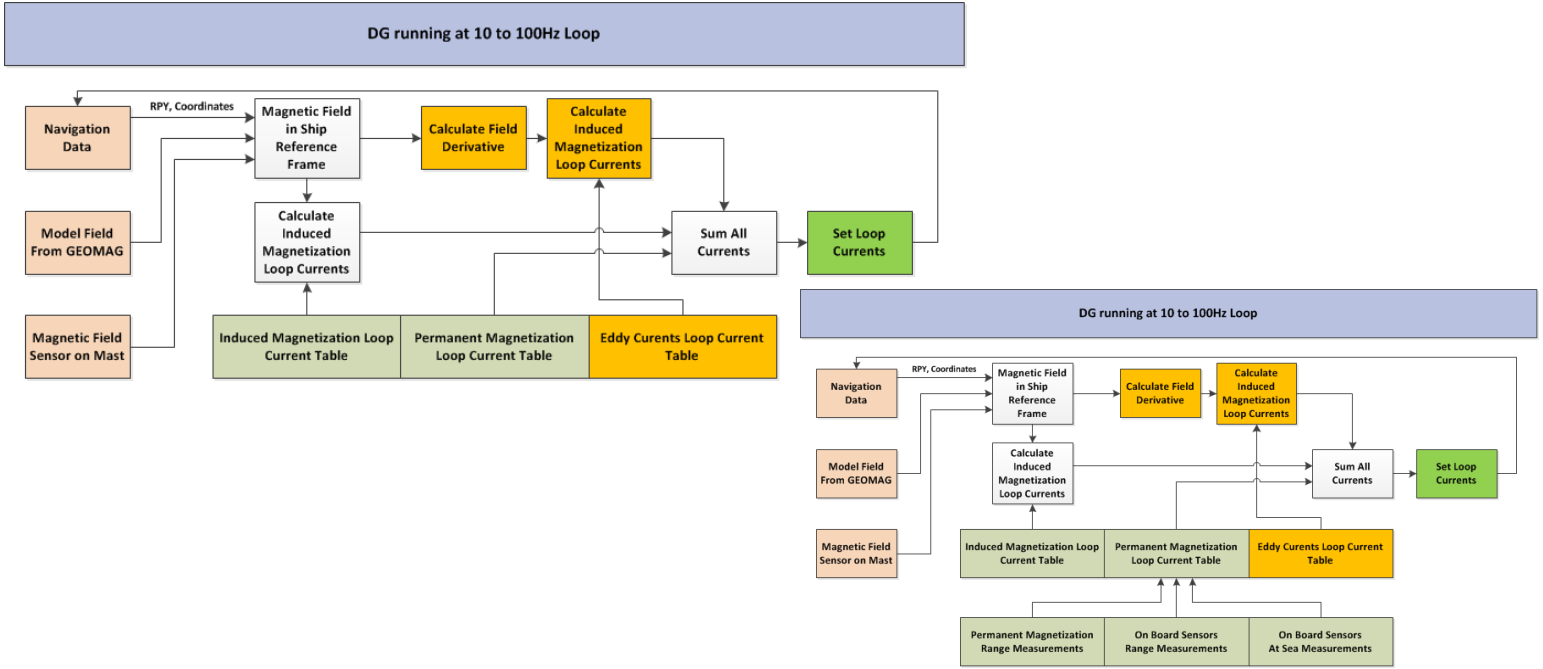


Works toward closed loop degaussing system on board new MCM vessels

P. Polański, F. Szarkowski and M. Czarnowska - R&D Marine Technology Centre S.A., Gdynia, Poland

Introduction

Open vs Closed Loop Degaussing System (OLDG vs CLDG)



Works toward closed loop degaussing system on board new MCM vessels

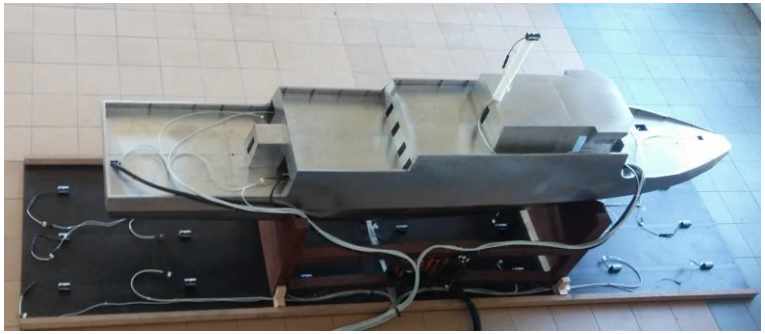
P. Polański, F. Szarkowski and M. Czarnowska - R&D Marine Technology Centre S.A., Gdynia, Poland

Introduction

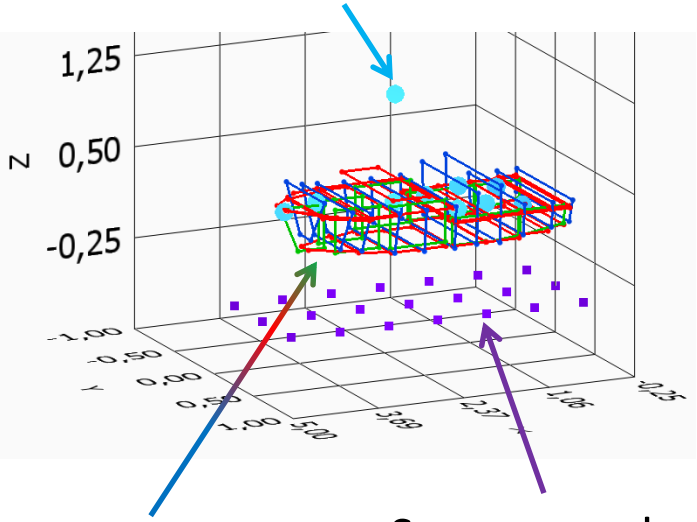
Benefits of CLDG:

- Detection of changes in slowly varying permanent magnetization
- Possibility to self range away from fixed ranges
- Update of DG currents while at sea
- Cost reduction

Test Stand and PSM



Sensors on board



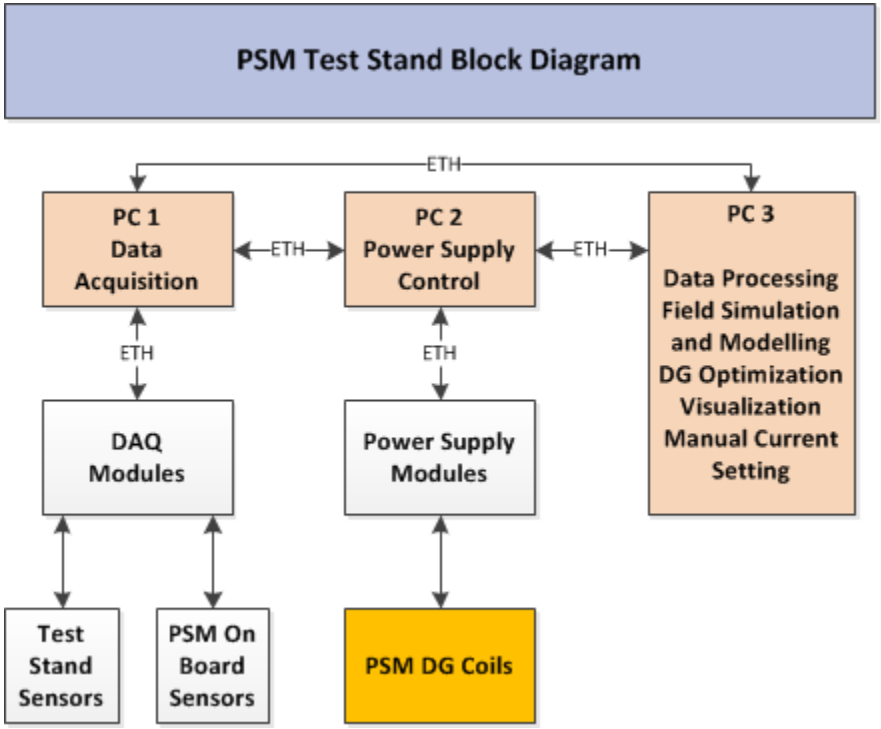
Coil model

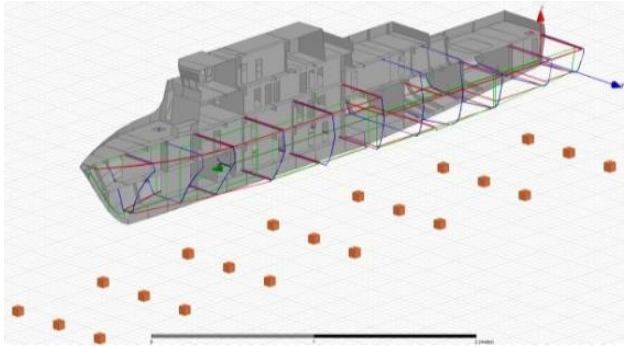
Sensors under PSM

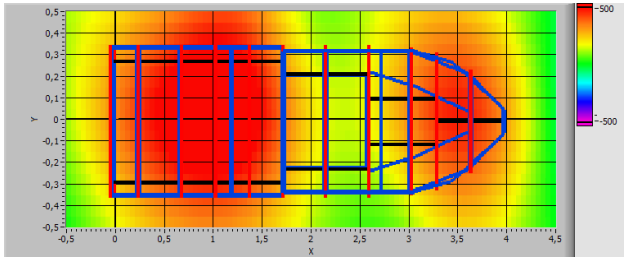
Works toward closed loop degaussing system on board new MCM vessels

P. Polański, F. Szarkowski and M. Czarnowska - R&D Marine Technology Centre S.A., Gdynia, Poland

Test Stand and PSM







Works toward closed loop degaussing system on board new MCM vessels

P. Polański, F. Szarkowski and M. Czarnowska - R&D Marine Technology Centre S.A., Gdynia, Poland

Models

- Division of field's components due to permanent and induced magnetizations

$$\boldsymbol{B_j = B_{jp} + B_{ji}}$$

- Further division of induced source with respect to external field

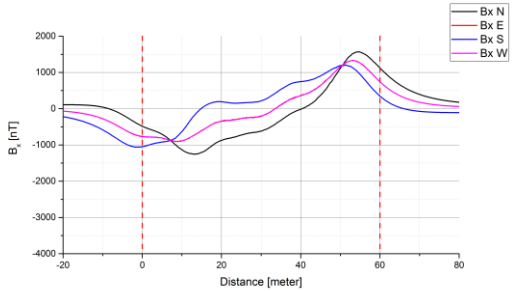
$$\boldsymbol{B_j = B_{jpx} + B_{jpy} + B_{jpz} + B_{jix} + B_{jiy} + B_{jiz}}$$

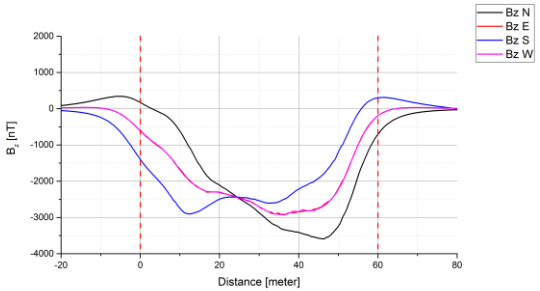
- Coefficients estimation basing on field measured on cardinal courses

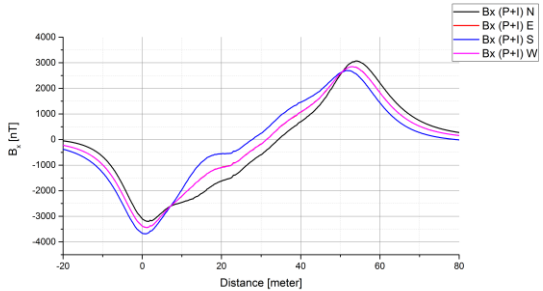
$$\boldsymbol{B_{jn} = B_{jpn} + X_{jxn} * B_x + X_{jyn} * B_y + X_{jzn} * B_z}$$

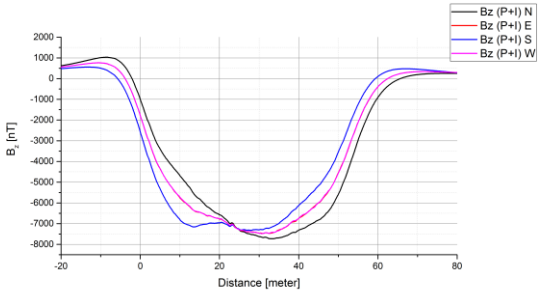
Models

FEM modelled induced (top) and total (bottom) fields change with course



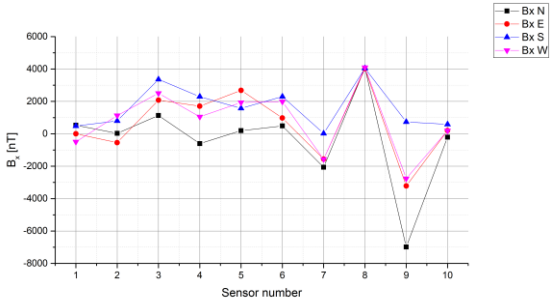


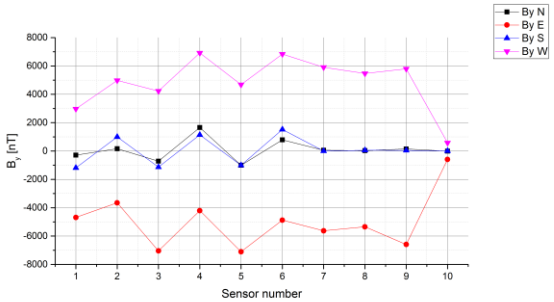




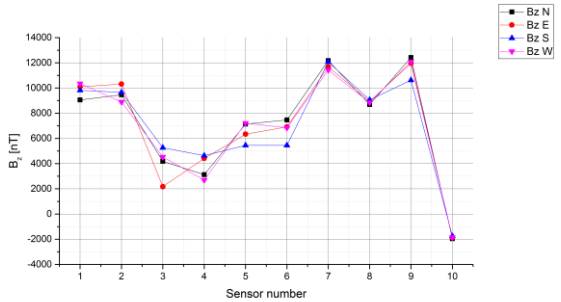
Models

Magnetizations' fields change measured by sensors on board





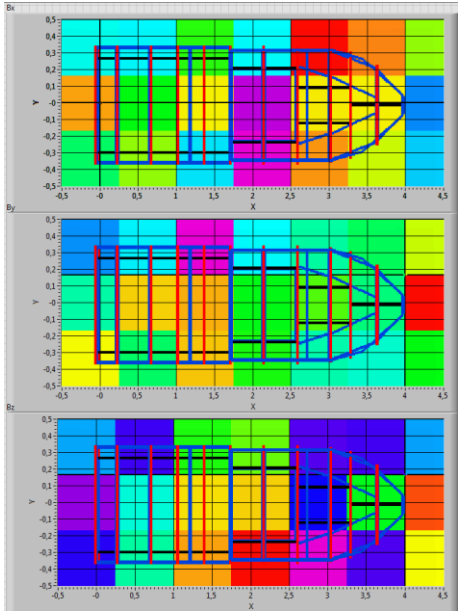
Longitudinal, athwartship and vertical magnetic field components change with course measured by sensors on board



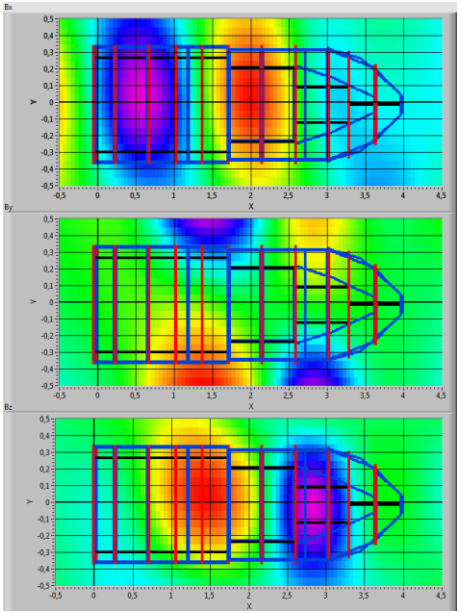
Works toward closed loop degaussing system on board new MCM vessels
P. Polański, F. Szarkowski and M. Czarnowska - R&D Marine Technology Centre S.A., Gdynia, Poland

Models

Using PSM for calculations



Coarse raw data measured by limited number of sensors



Fine reconstruction of the signature

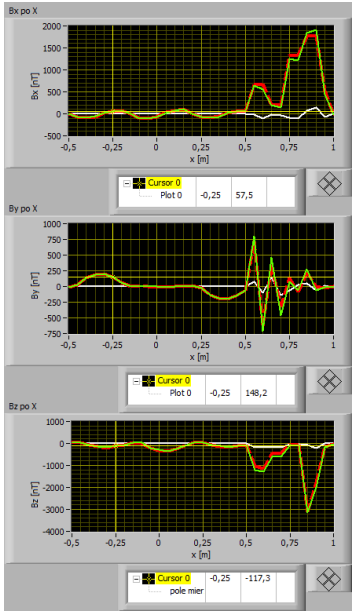
Simulations and measurements

Using PSM for calculations

- Permanent and induced magnetizations simulated using PSM's DG coils
- Example using M and L coils
- Induced magnetization is varied from -0,6*P to +0,6*P with 0,1*P steps giving total 12 sets of equations (plus one for only permanent longitudinal magnetization)

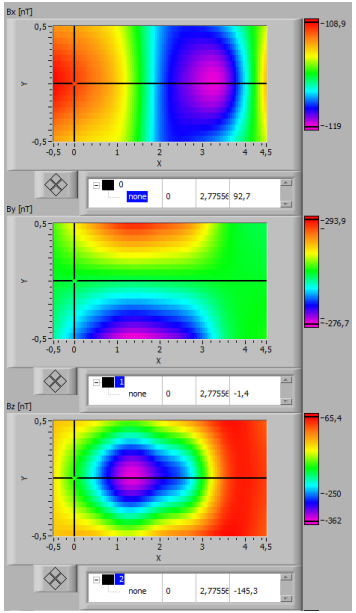
Simulations and measurements

Using PSM for calculations – example source field



Raw data measured by sensors under and on board PSM

(green – measured
red – calculated
white - difference)



Interpolated signature

Works toward closed loop degaussing system on board new MCM vessels

P. Polański, F. Szarkowski and M. Czarnowska - R&D Marine Technology Centre S.A., Gdynia, Poland

Simulations and measurements

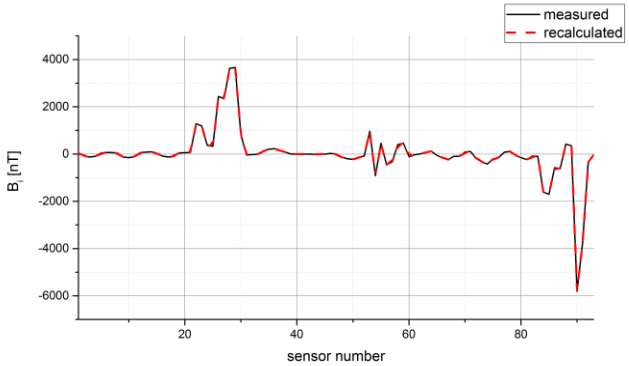
Using PSM for calculations

- Creating overestimated set of equations
- Solving for parameters relating range and on board sensors to external field components
- Extracting permanent component
- Forward/inverse calculation

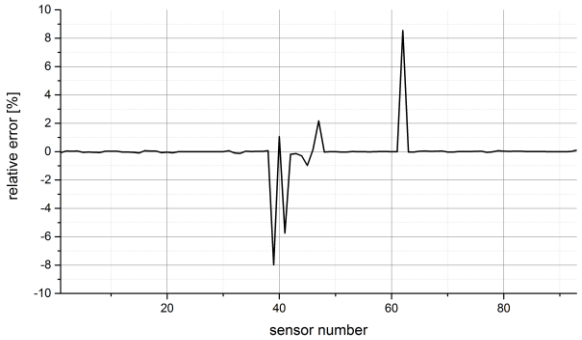
Simulations and measurements

Using PSM for calculations

Reconstruction of raw field using calculated parameters



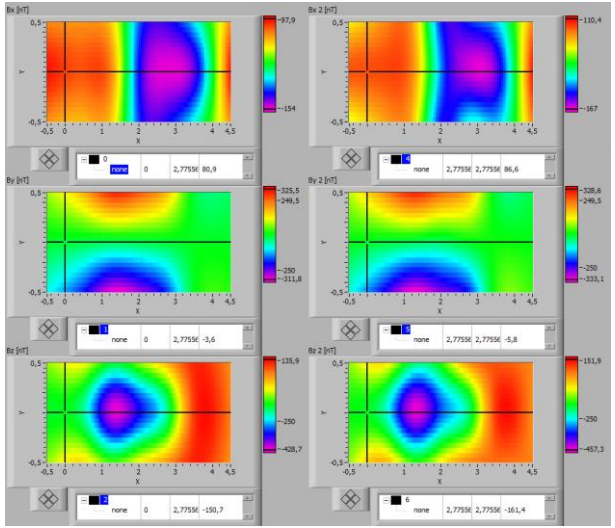
Comparison of measured and recalculated raw signature



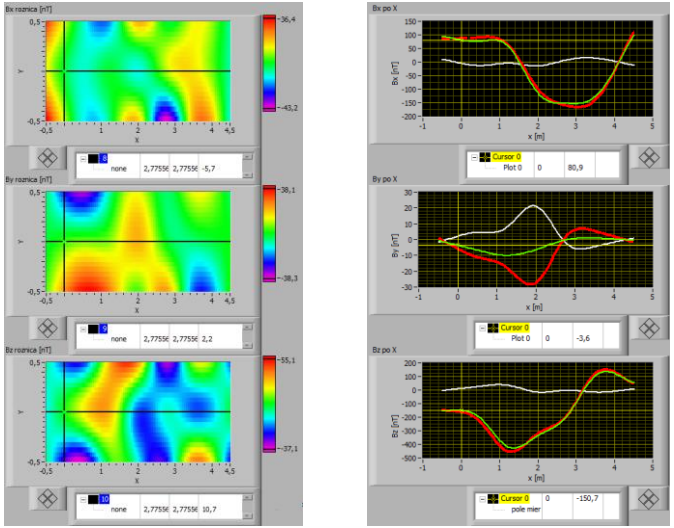
Relative error of recalculation

Simulations and measurements

Using PSM for calculations



Comparison of measured (left) and recalculated (right) signature



Recalculation error on surface under PSM (left) and under the keel (right)

(green – measured, red – calculated, white - difference)

Works toward closed loop degaussing system on board new MCM vessels

P. Polański, F. Szarkowski and M. Czarnowska - R&D Marine Technology Centre S.A., Gdynia, Poland

Current and future work

- Measurement campaign is underway and will be continued throughout late spring and summer
- Forward/inverse models (coils, dipoles, ellipsoids and mix)
- Works are continued using synthetic data, PSM's and ship's measurements
- Ferromagnetic hull PSM model will be available soon

Conclusions

- It is possible to reconstruct field from each magnetization component using on board combined with range data
- Forward/index model complexity is strictly related to available number of sensors and thence possible number of equations
- Non-ferromagnetic hull vessels are quite easily modelled
- Sensors of DG/CLDG can be used during selected time to provide high quality data (i.e. not always and not in real time)

Conclusions

- Software tests and simulations were performed and calculations using real data from PSM's sensor system were done with first solutions proving the approach.

- Data gathered on board the ship was processed and shows promising results.

- Works are part of extensive project around underwater signatures management (regarding DG, eddy currents, electric, thermal and hydroacoustic signatures)