TRANSMAG - A TRANSPORTABLE DE-GAUSSING RANGE

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ABSTRACT

Transmag has been developed by Ultra Electronics to meet the requirements of a low-cost transportable calibration range for all degaussing (DG) purposes. Transmag satisfies requirements of ease and speed of deployment, reduced ship ranging times, de-gaussed signatures at least as good as those achieved by present methods and accurate DG-on signature predictions. This paper describes the Transmag system and demonstrates its effectiveness by the results obtained from trials conducted in the UK.

INTRODUCTION

A typical Transmag periodic ranging requires only two DG-off runs, once a first of class(FoC) ranging has been completed for a vessel of the same class. This means that a typical ranging would be complete in approximately one hour. The present manual signature optimisation technique often takes one day for a frigate and up to three days for a MCMV.

In addition, the Transmag system offers a highly transportable low cost magnetic measurement range. An installed range comprises 3 or 5 magnetic sensors, which can be easily and speedily deployed. Utilisation of three axis magnetic modelling and high speed data processing permits real time displays of magnetic signatures, fast minimisation of magnetic signatures and reduced ship ranging times.

This paper presents an overview of the Transmag System which will be described in four sections:, methods of operation, modelling, the system and range deployment. The magnetic modelling and performance will be discussed and illustrated by results from trials in the U.K.

TRANSMAG OPERATION

A ship's presence will create a disturbance in the local earth's magnetic field, which provides a method for detecting that vessel. In order to reduce the threat of detection, a system of degaussing coils within the ship can be used to decrease the ship's magnetic signature by electrically generating a magnetic field of approximately equal magnitude and of opposite sign to the vessel's magnetic signature. The main functions of the Transmag software are to enable modelling of the magnetic state of the vessel, to determine the magnetic effect of the ships degaussing coils and to optimise the ship's DG-on signature by calculating the optimum degaussing coil current settings.

There are two principal modes of use for the Transmag redeployable range:
(i) First Of Class ranging in which the vessel degaussing coil effects are determined. For a given vessel type and class the coils are assumed to be of the same design, and hence the coil effects of one vessel are applicable to another in that class, and

(ii) routine optimisation, which utilises the coil effects determined in the FoC ranging.

The FoC ranging consists of:
(a) 2 DG-off runs,
(b) 1 to n coil effect runs where n is the number of de-gaussing coils,
(c) Computer calculation of optimum coil settings and setting of de-gaussing coils on-board,
(d) 2 DG-on runs may also be required to check the de-gaussed vessel's signature.
A typical coil effect will take 10 minutes to gather: five minutes to set the coil and five minutes to traverse the range.

A periodic ranging consists of:
(a) 2 DG-off runs,
(b) Computer calculation of optimum coil settings and setting of de-gaussing coils on-board,
(b) 2 DG-on runs may be required to verify the ships signature.
A typical periodic ranging could therefore be complete with in an hour. The time taken to change coil settings on the vessel may become the dominant factor in the total ranging time; this depends on the complexity of the coil set-up. This method of periodic degaussing obviously results in a large saving in ship on-range time when compared with traditional methods.

MODELLING

Prior to any ranging, the operator must input data relating to the ships dimensions, draught, the number and type of degaussing coils and the range of permitted Ampere-turns for each coil, and save the data on an archive disc. This information may also be inputted from a previous archive disc for that vessel class. During ranging, data is gathered as the ship makes two reciprocal intercardinal runs across the array from which the vessel's permanent and induced magnetisations are modelled. The magnetic and position data acquired during a run is used to generate a three-axis magnetic model, which is used in subsequent analysis. A run modelling error is calculated by comparing the predicted and measured field data. The error is defined as the root of the average squares of the total field error divided by the peak measured total field and typically exhibits values in the range 0.5%-3% for all vessel classes. The run model signature is displayed graphically in a format such that it appears that the vessel passed directly over the array. Typically the display is given in a longitudinal / transverse (athwartships) form; the longitudinal, vertical and athwartships field components and total field are displayed. A cursor enables viewing of different cross-sections through the signature. Other standard display formats are isometric plots of each axis, contour plots of each axis, horizontal and total field, and a Magnetic Anomaly Detection (MAD) total field display.

In addition, equipment status monitoring is available, which includes checks of power supply voltages and sensor alignment. There is a hard-copy facility for graphical displays and a ranging report creation facility to produce a record of the conditions of ranging and the ship's magnetic state. Data concerning a vessel class can be archived as can the raw and modelled data.

The software modelling capabilities have been shown to be highly stable. Figure 1 shows for a a real ship modelled data for two runs on similar headings across an array of five sensors of total width 54m at a depth of 20m. Figures 1(a), (b) shows DG-off signatures for runs made on a nominal heading of 150 degrees (actual headings 148 degrees and 147 degrees) made at depths of 20.87m and 20.23m. The vessel passed within 21.96m of the array centre for the run shown in Figure 1(a), and within 0.12m in Figure 1(b). The agreement between the models is clearly seen; and provides good evidence for the stability of the model; the field maxima agree to within 0.5%.

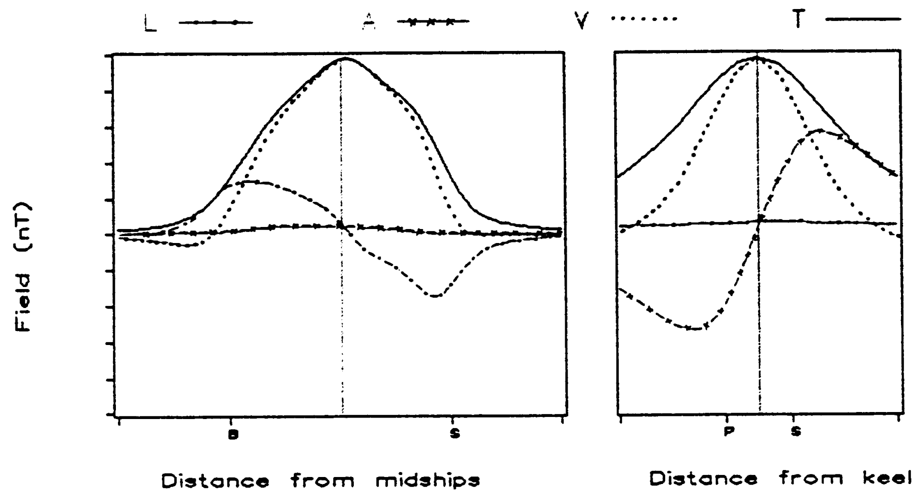

Figure 1(a)

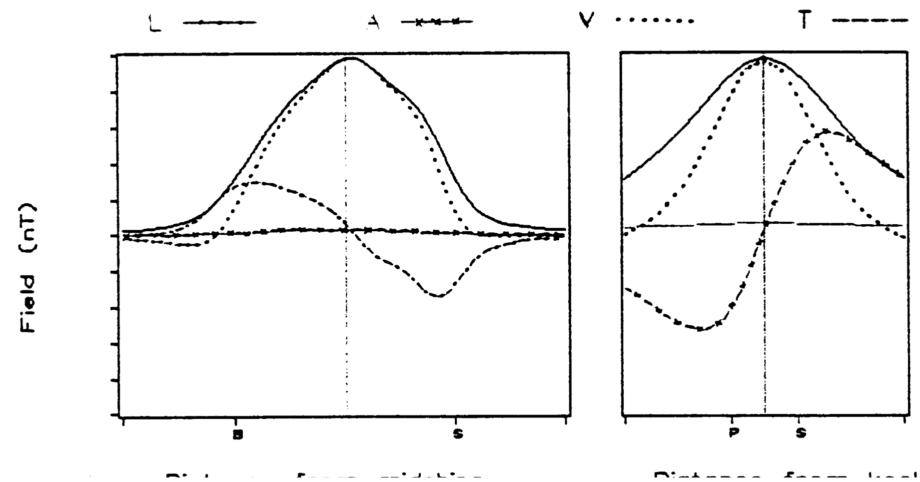

Figure 1(b)

FoC ranging requires two types of model to be calculated. Firstly that of the undeguassed vessel, and secondly the magnetic signature produced by the on-board degaussing coils. A pair of reciprocal intercardinal DG-off runs are used to calculate permanent and induced magnetisation models of the undegaussed vessel. The quality of such a model can be judged by it's ability to predict the magnetic field produced for a DG-off run on a different heading. Figure 2 shows a prediction made, from a pair of runs made on 315 degree and 120 degree headings, to the run shown in Fig 1(b) which was made on a 147 degree heading.

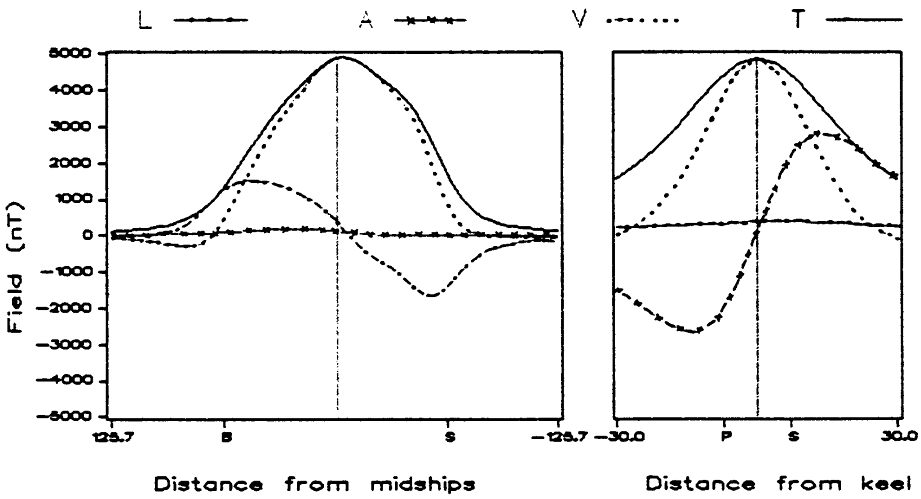

Figure 2.

In order to obtain models of the coil effects for each coil aboard the vessel one intercardinal run is made across the sensor array per coil with the coil under investigation energised; typically the maximum current for that coil is applied to the coil. The undegaussed vessel model is subtracted from the coil effect run in such a way as to extract the coil effect model of that coil. In order to predict the optimum coil settings to produce a minimised DG-on signature, the FoC coil effect models and stored Ampere-turn information are utilised. The resulting settings are relayed by radio to the vessel and are set on board. After the degaussing currents have been set to their optimised values on-board the vessel, two reciprocal intercardinal passes over the range are made to verify the DG-on signature and allow calculation of the DG improvement factor: the ratio of magnitude of the maximum DG-off to DG-on magnetic field. Figure 3 shows a comparison of the (a) measured and (b) predicted DG-on signature for a ship using FoC coil effects.

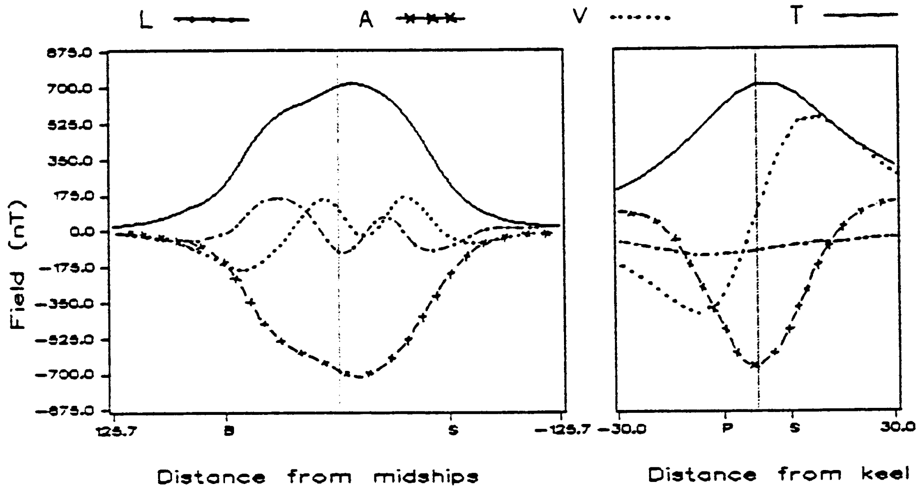

Figure 3(a)

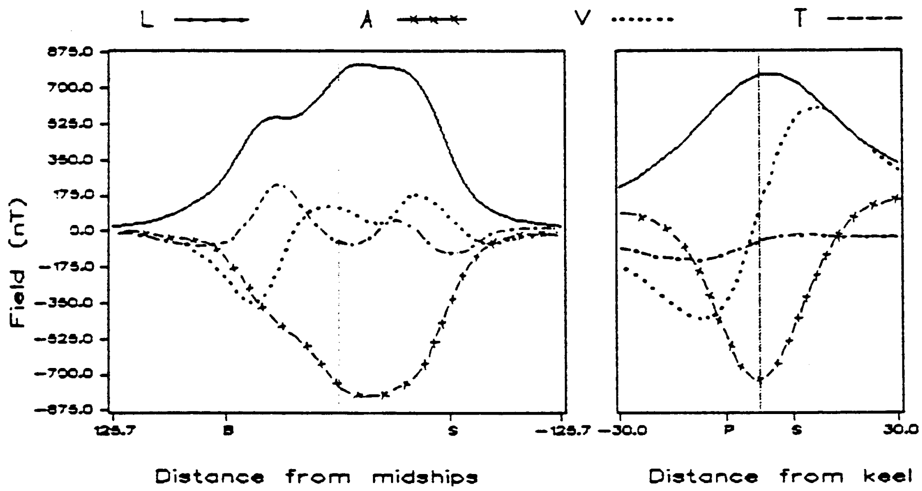

Figure 3(b)

When the vessel (or another from the same class) undergoes a subsequent routine periodic ranging, the operator is required to gather two intercardinal DG-off runs to determine the vessel's undegaussed state. Clearly a routine magnetic signature optimisation will require a much reduced on-range time for the vessel, because only two DG-off runs are required to predict the optimum coil settings. In comparison a traditional manual optimisation could require well over 20 runs depending on the initial magnetic state of the vessel.

In the event of a subsequent coil failure or changed threat, modelling can be utilised to recalculate the degaussing coil settings using archive data without the necessity of the vessel being present. (It is assumed that no variation in the vessel's permanent magnetisation has occurred.) The magnetic field of a vessel and its optimum coil settings at different latitudes can also be confidently predicted using this method.

SYSTEM DESCRIPTION

The Transmag system can be subdivided into the following subsystems: sensor, power, computer, tracking and Navaid (an abbreviation of Navigational Aid). The system is shown schematically in Figure 4. All the equipment which is required for full operational deployment of the Transmag Degaussing

Range can be fitted into a standard ISO container. However, the equipment can be made compact enough to be transported and operated from a Land Rover size vehicle with associated trailer. Two operators are required to run the system: one on-shore to control the ranging via the computer system and the other on-board the vessel.

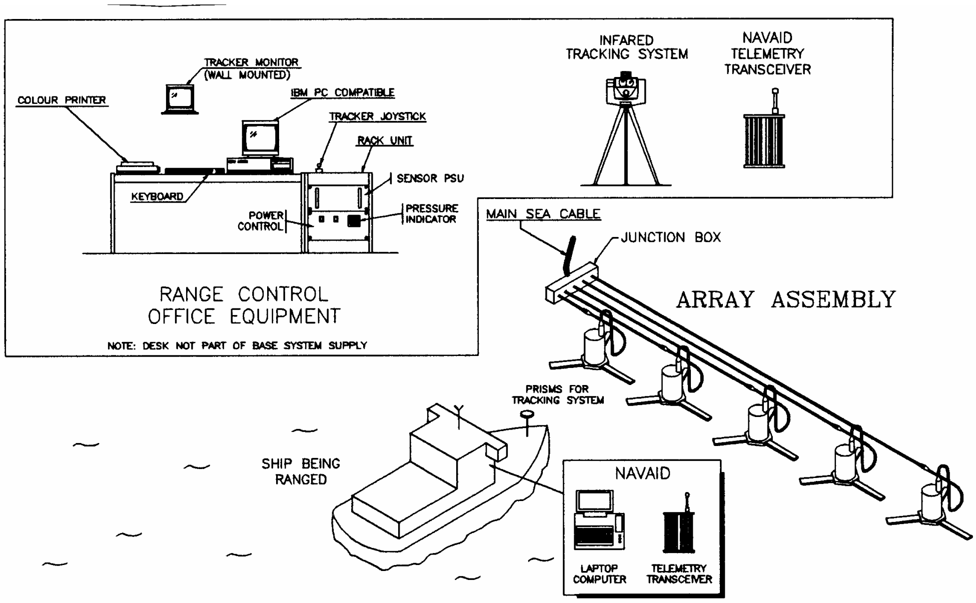

Figure 4

The sensor subsystem consists of an array of (typically 3 or 5) three-axis magnetic field sensors located in an approximate line on the sea bed. The inter-cardinal positioning of the array has several advantages over traditional ranges, which consist of two separate sensor arrays: one aligned north-south and the second aligned east-west. Firstly fewer sensors are required and secondly only one range is necessary to calculate both induced longitudinal and athwartships magnetisations. Each sensor is fitted to a specially constructed, non-magnetic tripod. The sensors are interfaced to a junction box via individual 5 core cables and in turn to the shore via a single 5 core cable. Each sensor is digitally interfaced to the on-shore system computer, and provides three axis magnetic field data and water pressure data. An Atmospheric Pressure Indicator (API) at the shore provides data to allow accurate determination of water depth at the sensors. The location and alignment of each sensor is not critical as sensor positions can be surveyed and entered into the system; sensor alignment is identified within the software.

The power subsystem provides a constant current to the magnetic sensors via the sea cable. The current is distributed at the underwater junction box to each of the sensors. Power is also supplied to the tracking and Navaid subsystems, and to a data converter which is part of the computer subsystem. Mains power is distributed to the computer, printer and API.

The computer subsystem consists of an IBM compatible PC fitted with an i860 co-processor card, an intelligent RS232 interface card and a non-intelligent RS232 interface card. The data from the magnetic sensors is interfaced to the intelligent RS232 card and the trackers, API and the Navaid transceiver interfaced with the non-intelligent RS232 card. Data processing is carried out at high speed by the i860 processor.

The tracking subsystem consists of two Geodimeter 140T infrared tracking and measuring instruments. These instruments are capable of tracking and measuring moving targets fitted with reflecting prisms at speeds of up to 10 knots at distances of over 100m giving centimetre accuracy. Range, elevation and horizontal angle data is output from each tracker to the system's computer. Manual control of each tracker is provided by individual joystick with the operator using visual feedback via video cameras fitted to the trackers. Two reflecting prism rings are fitted to the ranging vessel in positions, normally towards bow and stern, which are accurately known to the system. The prism positions are not critical within the limitations of maximised visibility on the required vessel headings.

The Navaid subsystem uses two radio transceivers, one on shore and the other on the ranging vessel, to transfer data from the system computer to a laptop computer located on the bridge of the ranging vessel. The vessel based computer and transceiver is normally powered from the vessels electrical supply, however a backup battery is provided. Positional data derived from each of the trackers is used to aid the Navigational Officer of the ranging vessel. By tracking the vessel as it approaches the range, abortive runs are minimised and ship ranging time is therefore reduced; this ensures that the vessel passes over the magnetic sensor array on the requested track.

TRANSMAG DEPLOYMENT

Deployment and recovery of the underwater equipment, without the aid of a diving team, has been successfully completed in shallow (7m) water using a small boat. Deployment in deeper water without a diving team should be as straight forward.

The magnetic sensor/tripod assembly is fitted with a cable tail much longer than the depth of water in which it is to be deployed. On selection of a suitable site for the magnetic sensor array, a buoy is used to locate the position. The sensor/tripod assembly and associated cable is loaded onto the boat and transported to the marker buoy. When sensor positioning is completed the cable to the shore may be deployed in sections. Cable ends may be buoyed temporarily while each cable section is handled. When all cables are in position the underwater junction box is connected at the marker buoy, a system test is performed and if successful the junction box is allowed to sink to the sea bed. The marker buoy is recovered and the system is ready for operation.

To recover the system the sea cable is followed from the sea surface to the underwater junction box. The junction box is raised to the surface and removed. Each sensor/tripod assembly is recovered in turn. The sea to shore cable may be recovered using the same method as deployment, and the marker buoy retrieved.

SUMMARY

This paper has demonstrated the ease of deployment and redeployment, and quality of modelling available using the Transmag transportable range. This system results in reduced on-range time for vessels, resulting from a high percentage of successful runs and the requirement for only two DG-off runs to be made for a routine magnetic signature optimisation.