Application Information

Title: Search & Detection of Marine Wrecks Using Airborne Magnetometer

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Essay on:

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ABSTRACT

Magnetic Anomaly Detection (MAD) is used for decades to detect wrecks of sunken ships and submarines. The concept of MAD is to detect the magnetic field produced by the wreck. An aircraft seems to be the preferred platform to carry the magnetometer because of its ability to cover rapidly large areas. However, to take advantage of an airborne platform, efficient reduction of the aircraft's magnetic noise is crucial. The objective of this research is to improve detection ability through effective cancellation of platform interference, exploiting some recent technological advances: (1) Development of highly accurate optical pumping magnetometers that are not sensitive to sensor orientation; (2) Modern adaptive noise cancellation algorithms that run on up-to-date DSP processors; (3) Emergence of Unmanned Air Vehicles (UAVs) as a very promising platform because of its low magnetic 'profile'; (4) New generation of GPS receivers, providing real time precise measurement of aircraft's location. In light of the above, a mathematical model of the interferences will be constructed. Based on this model, various methods of interference compensation will be tested by computer simulation. The next step will comprise a physical modeling with a rotating table being used to simulate platform maneuvers. Analysis of mathematical and physical modeling results will presumably allow us to elaborate advanced methods of platform interference compensation. The proposed compensation method will be tested on a total field magnetometer installed on a UAV.

Key words: MAD, Geomagnetism, Adaptive noise cancellation.

INTRODUCTION

The necessity to detect underwater wrecks and sunken ships arose a long time ago. However the major progress was made during the World War II, when the Allies ships were attacked by German U-boats, in what was called the 'Battle for the Atlantic'. The need to detect underwater targets became urgent during the 'Cold War', where it led to several detection techniques, one of which was the Magnetic Anomaly Detection (MAD). The MAD is based on the ability to sense the DC magnetic field produced by the target. In contrast to active detection methods, the MAD is a passive technique, with an advantage of not being discovered by the target.

An aircraft seems to be the preferred platform to carry the magnetometer because of its ability to rapidly cover large areas. Remarkable recent progress in Unmanned Air Vehicle's (UAV's) design has set them as a leading candidate for MAD platform. The UAV is rather inexpensive platform with relative low magnetic 'profile', which results in a reduced level of platform interference.

The total interference (Ash, 1997) comprises two main sources: (1) Natural environment noise – which is caused by natural phenomena (Campbell, 1979); (2) Platform maneuver noise (Hardwick, 1984)– which is mainly due to platform produced magnetic field. The platform maneuver noise can be represented by three separate components (Bickel, 1979): Permanent magnetization, Induced magnetization and Eddy currents. This work will concentrate on the compensation of the platform maneuver noise only, with the intention to deal with other kind of noises in the future.

Measures should be taken in order to extract the target's magnetic signature out of the noise. The first step in noise cancellation is the estimation of noise parameters. Several methods were proposed to estimate noise parameters: The Least Squares method (Leach, 1980), the LMS algorithm (Freire, 1993), and the small signal analysis (Bickel, 1979). Noise parameter estimation paves the way to effective noise reduction by methods such as Finite Impulse Response (FIR) filters (Inaba, 2002).

The early works dealing with noise compensation were done when computation power was scarce. That is why the estimation of the noise was made usually at post flight stage. Nowadays high processing speed of computers can be used to apply real time adaptive noise cancellation techniques. The combination of a noise cancellation algorithm with a detection algorithm, both running in a real time mode, can lead to new search strategies.

Precise estimation of the aircraft's position is vital for successful noise compensation. The new generation of GPS receivers such as Novatel's

Black Diamond System (Novatel), can be used to precisely locate the aircraft and thus reduce the noise level (Bobb, 1997).

Recent developments of highly accurate, optical pumping magnetometers / gradiometers, such as the GSMP-30GS (GEM systems), which are not sensitive to sensor orientation, can significantly increase the detection range.

RESEARCH OBJECTIVES

In light of the aforementioned technical advances, we intend to improve the detection ability of the airborne MAD. To this end in view, mathematical model of platform noise will be constructed and analyzed at the first stage of the work. Based on this model various methods of noise compensation will be tested by a computer simulation. The next step will comprise a physical modeling with a rotating table (Figure) being used to simulate platform maneuvers. Analysis of mathematical and physical modeling results will presumably allow us to elaborate advanced methods of platform interference compensation. These methods will be tested using an optically pumped magnetometer installed on a UAV.

CURRENT STATUS OF WORK

- The GSMP-30GS was chosen as a magnetometer / gradiometer for MAD application. It was accommodated to on-board UAV installation.
- Several GPS receivers have been examined to meet the accuracy and real time requirements.
- Preparations for physical simulation (data acquisition, rotating table and accessories) have been carried out.
- Methods that are presently in use for MAD noise compensation have been reviewed and analyzed.
- Initial tests of UAV have been performed.

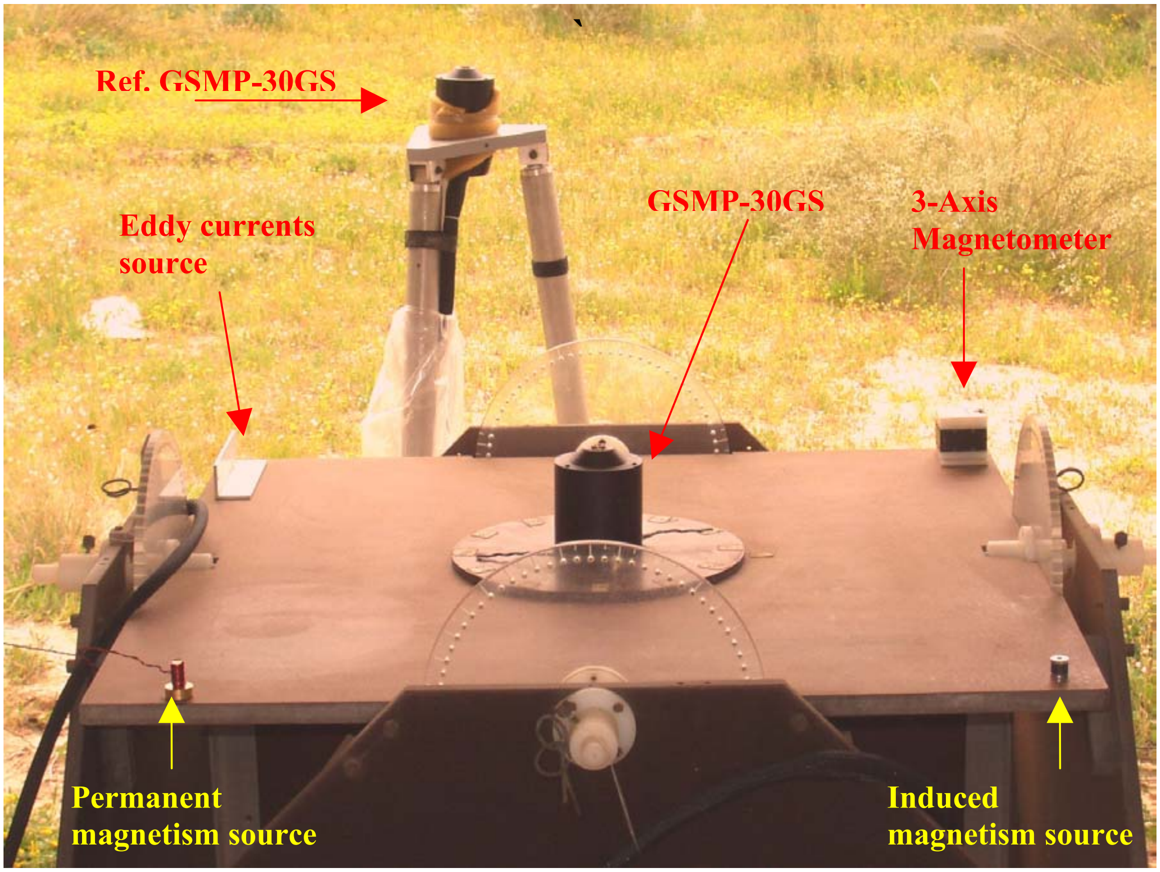

Figure – Picture of physical modeling with non-magnetic rotating table.

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