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Laboratory Experiments with an Optical Instrument for Measuring, Recording and Imaging Washover

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ABSTRACT

Washover is the condition of occasional, partial or complete inundation of the surface of a body floating in water. Washover is typically caused by wave and wind action. A knowledge of the 3-dimensional spatial and temporal parameters of seawater washover of towed bodies, fixed and free drifting buoys, and other maritime powered, tethered and free-floating bodies is extremely helpful in understanding and improving their hydrostatic and hydrodynamic performance under a wide variety of sea states. Here we discuss the theory, implementation and initial testing of a newly developed fiber-optic-based method for 3-D spatial and temporal detection, measurement and visualization of washover (patent pending). This system is intended to provide real-time 3-D spatial and temporal detection, measurement and visualization of washover in freshwater, seawater, and possibly other transparent or translucent fluids. The system permits simultaneous, noninteracting measurements of temporal and spatial washover dynamics, along with measurements of water wave/electromagnetic interaction measurements for near-sea-surface antennas. Data can be acquired and displayed in real time, as well as stored for post-processing and analysis. The principles of the system have been bench tested and show promise for open-ocean washover testing of near-sea-surface buoyant towed bodies. In addition, temporal and spatial optical-based washover measurement is expected to provide an empirically based benchmarking process for computational fluid dynamic assessments of turbulent flow around arbitrarily shaped surface-towed or self-propelled bodies.

INTRODUCTION

A knowledge of the 3-dimensional spatial and temporal parameters of seawater washover of near-sea-surface towed bodies, buoys and other maritime towed, tethered, and free-floating bodies is extremely helpful in understanding and improving their hydrostatic and hydrodynamic performance under a wide variety of sea conditions. Washover is the condition of occasional, partial or complete inundation of the surface of a body floating in water. Washover is typically caused by wave action, wind action, the dynamics of towing the body, or the interaction of these factors. Washover can adversely affect the performance of these classes of bodies equipped with electronic devices, such as antennas, photovoltaic arrays, or radio and visual beacons. For a near-sea-surface towed body, washover depth usually occurs within the range of less than 1 cm to 30 cm, and with inundation lasting less than 1 s. The ability to capture and visualize washover events in real time can lead to improved hydrostatic, hydrodynamic and hardware implementations, thus improving operational performance.

A system was developed to temporally and spatially quantify seawater wave interactions with VHF through microwave-frequency electromagnetic energy emanating from a low-profile towed body (Fig. 1). At these frequencies, the skin depth (a measure of the maximum depth to which electromagnetic energy penetrates) is on the order of 1 cm. Currently, no devices, systems or methods can provide this information in a noninterfering manner when washover patterns must be studied simultaneously with the evaluation of a co-located electromagnetic antenna. A technique using electronic electrodes (Yankielun and Clark, 2002) can make appropriate washover measurements. This system relies on an extensive network of metallic wired electrodes, which would interfere with electromagnetic radiation patterns when applied in the immediate proximity of an antenna under test. Accordingly, this system could not be used to perform simultaneous, noninterfering measurements. Here we discuss instrumentation developed for the purpose of noninterfering, real-time acquisition and 3-D mapping and visualization of washover using optical-based techniques.

Fig. 1 Low-profile submarine antenna

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