Examination of the Effectiveness of Modelling Towline Response Using GPS & Strapdown INS Data Gathering Techniques

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ABSTRACT

In this paper we will look at the effectiveness of a non-invasive means of measuring key dynamic characteristics of a tug and tow system for complete voyages. Thereafter, we will use this information to drive a numerical simulation of the towline. A prototype, compact, and rugged test sensor suite was installed on both a tug and barge for an inshore waters tow on the West Coast UK. This data was post-processed and fed into a lumped mass numerical model of the system. Initially only GPS position data is used and the effects and importance of processing higher resolution surge, heave, and sway data will be checked. Conclusions are drawn which will be used to guide further research in this area.

KEY WORDS: lumped mass; GPS; towline; tension; strapdown; INS.

INTRODUCTION

The use of tugs drawn from the spot market for coastal tows is a well established practice. However the criteria governing the suitability of tug selection vary between approving authorities with disagreements evident on the effectiveness of smaller tugs below a bollard pull range of 50 Te. A technical review of these differing assessments is problematic due to a lack of comprehensive field data for such tows.

Extensive research has been carried out on various aspects of towline dynamics during such operations some of which is validated by full scale sea trials. However, a common feature of these full scales trials is the lack of a full dataset for the complete tug and tow system covering all 6 degrees of freedom (DOF) principally due to technology available at the time. In van den Boom (1986) the motions of the tug was captured by an on board, dedicated computer system however the motions of the tow were observed by the crew and in Thomas (1994), the range between the tug and tow was captured for finite durations on each day of towing by a hand held laser range finder.

It is proposed that a system that can be quickly and easily set up on tug and tow at short notice, commensurate with the window of opportunity typically presented for such marine operations would allow more extensive field data to be gathered. Thereafter, it would allow post-processing of the data gathered to review and draw conclusions on the means by which the suitability of tugs of varying sizes are judged for any specific tow. In addition to the specific research requirements of the author, further opportunities for the gathering of field data would be more likely to come to fruition with the development and adoption of such a process.

The maturing of strapdown Inertial Navigation Systems and increasing quality of low costs MEMS devices has been well documented. Moore et al (2008) commented extensively on the uses of such technology in marine navigation applications while Wagner and Kasties (2004) reviewed the potential for such technology in estimating the motions of large vehicles. All note that the development and improving accuracy coupled with low power consumption and physical footprint of such equipment presents many opportunities for the gathering of field data in situations that previously would have been extremely problematic. Therefore an opportunity exists to record, for the full duration of a tow, the full 6 degrees of motion of the tug and barge independently and against a consistent and matching timeline using such technologies.

This paper describes such a novel system and outlines early work in demonstrating the potential for such a process to generate the field data required for further study. Thereafter areas for future research are identified.

NUMERICAL MODELLING

A lumped mass system has been utilised for this investigatory analysis due to the flexibility for handling a wide variety of environmental and operational factors. The analysis of flexible marine cables using this methodology is widely adopted and extended upon with a brief history of the development various methods outlined by Gobat and Grosenbaugh (2005).

The numerical approach adopted here is based on the three dimensional model presented in Huang (1994) with minor alterations to suit the specific application herein.

In Huang (1994) the numerical procedure was based on a typical application where by a subsea unit is tethered to a floating vessel which excites the marine cable as a result of uncoupled motions fed into the system by means of a time series of spatial offsets applied to the upper end only.

The cable system is discretised into a series of equivalent masses lumped at nodal positions (not necessarily equally spaced) with each node having values of mass, added mass, buoyancy and drag equal to 50% of effects of the relevant properties of the cable segments on each side of the nodal position.