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LEAST SQUARES FILTERING AND TESTING FOR POSITIONING AND QUALITY CONTROL DURING 3D MARINE SEISMIC SURVEYS

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ABSTRACT

Three-dimensional seismic exploration has been widely accepted as an integral part of the development of new oil and gas fields and as a fundamental tool in exploiting additional reserves in existing fields. Positioning is an important ingredient to the success of a 3-D seismic survey. In recent years the problem has become extremely complex, mainly due to the expansion of the type and quantity of survey data collected. Moreover it has become increasingly common for clients to require proof in real-time that the survey 'quality' specifications are being met.

This research project has aimed to develop a completely general, rigorous and integrated methodology which will enable multi-source surveying observables derived during offshore hydrocarbon prospecting, to be integrated to evaluate the relative position and quality measures of the seismic sources, hydrophones and associated hardware in real-time during modern multi-source, multi-streamer operations.

In order to achieve this, a unified algorithm has been developed in which Kalman filtering adopted as the basic stochastic process. The significant innovation of the method is centred upon its ability to cope with any geometrical configuration (i.e. any number of vessels, sources and streamers) while the number of states in the system is reduced to a minimum. The full system has been programmed and successfully tested using two sets of real marine positioning data. Substantial practical support including real data and detailed technical discussions on the subject has been offered by the exploration industry.

Analysis with real data has shown, for the first time, that a completely rigorous solution to the problem is feasible. More specifically, analysis showed that single polynomials can be adopted as a realistic representation of the seismic streamer shape. Source nodes and hydrophone groups deployed at modern single vessel configurations can be located with a positional precision of about 2.0-3.0 metre 2drms and 4.0-5.0 metre 2drms respectively. Maximum external reliability at any node in the network varies between 4.0-8.0 metre. Also, analysis showed that the computational cycle time is typically less than the shot interval.

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LIST OF CONTENTS

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