CONSIDERATIONS REGARDING THE UNDERWATER POSITIONING OF THE *NETROV* MINIVEHICLE

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ABSTRACT

Performing underwater utilitarian activities by means of underwater remote-control vehicles implies knowledge of their position in absolute coordinates (geographical).
In the case of NETROV underwater vehicle it is used an USBL hydroacustic positioning system composed by an omni directional transponder mounted on the vehicle and a tracking hydroacustic unit mounted on the surface ship from which the vehicle is launched. In order to determine the underwater vehicle's position in geographical coordinates, two supplementary equipments are connected to the hydroacustic unit: a flux gate compass (as heading reference unit) and a GPS receiver.

KEY WORDS : ROV, hydro acoustic positioning systems, USBL, GPS receiver, flux gate compass

INTRODUCTION

The hydro acoustic positioning systems based on ultra short base line principle (USBL) has been used in "offshore" applications for about 30 years. This system's development was determined firstly by the requirement of underwater drilling industry, among which the need of independent positioning and localizing systems needed for dynamical positioning of ships, platforms and underwater drilling installations which were found in a great number at the beginnings of the 70ies in the North Sea. At that time, before the GPS/DGPS system was introduced, the radio positioning systems in use (hyperbolic radio navigation systems DECCA, Loran, Omega) weren't capable to assure the necessary precision for underwater drilling operations in the North Sea.

The USBL positioning method occupied a free niche in the domain of positioning methods, due to the fact that it is a simple and effective method that can be used with a maximum of efficiency for applications in which it is necessary the positioning of an object in the water mass (sensor, instrument, underwater vehicle and so on) in relation to a surface or submersible vessel.

Even after the development of the GPS/DGPS positioning system, the USBL positioning systems remain superior regarding the precision of measurements, especially in tropical areas, where the performances of the GPS/DGPS system are seriously affected by ionosphere scintillation phenomena.

The major deficiencies of USBL positioning system are low upgrading data speed (rate) and the fact that the target's position in the water mass is given in relative coordinates against the surface vessel on which determinations are made. To obtain the position in absolute coordinates (geographical) of an underwater remote-controlled vehicle it is necessary to integrate a hydro acoustic positioning system with a global positioning system (which will give the vessel's absolute coordinates on which the USBL system in mounted) and with a direction sensor (heading unit) to indicate the direction towards north. So, on the hydro acoustic tracking unit's monitor the underwater vehicle's position and trajectory in time can be displayed at the same time, in geographical coordinates as well as in relation with the north direction of the surface vessel.

The measurement of the vertical acoustic angle, under which the transducer located on the surface vessel "sees" the transponder mounted on the tracked underwater vehicle, has to be done taking into consideration the surface vessel's attitude; more precisely taking into consideration the hydro acoustic transducer's inclination located on the vessel's keel, or on one of the sides.

The correct relation between the transducer's position mounted on the surface vessel and the transponder mounted on the underwater vehicle can be obtained by knowing the two movements (angles) of the vessel – pitch and roll - (reported to the horizontal axes Ox and Oy on the vessel's reference system), and also the movement on horizontal plane (the direction of the longitudinal axe which is perpendicular on the vertical axe Oz of the vessel's reference system).

In order to obtain the additional information concerning the attitude of the hydro acoustic transducer, mounted on the surface vessel from which the underwater vehicle is tracked, usually it is used a vertical reference unit (VRU – motion sensor). This is one of the measuring subsystems used in USBL hydro acoustic positioning, to minimize measuring errors.

The classical method to determine the pitch and roll angle consists in the usage of accelerometers. This method, due to technological processes recorded in the last 3 decades, has the advantage of great precision in determining the inclination angles and having sensors with low weight, size and power consumption.

A method of compensating and minimizing measuring errors which has been highly used lately by constructors of hydro acoustic USBL equipments consists in the integration in the same housing of hydro acoustic sensors the attitude (motion) sensors (tilt sensors or pitch & roll sensors) and heading sensors also. The process of miniaturizing these sensors and their more compact and robust construction due to technological accomplishments, make this solution extremely practical. In this way, the attitude and heading of the hydro acoustic sensor (transceiver) on the surface vessel can be measured in real time, with no need of complicated calibration operations.

This paperwork presents some theoretical and practical aspects concerning the positioning of NETROV underwater remotely operated minivehicle in shallow water.

GENERAL DESCRIPTION

The componence of the positioning system (Fig. 1):

1. A hydro acoustic tracking unit located on the surface vessel from which the underwater vehicle is launched and tracked. This unit contains:

- *a hydro acoustic transceiver* mounted in one of the surface vessel's sides;

- *a PC (notebook)* - to operate the hydro acoustic positioning system - equipped with a dedicated software and drivers for the integration of hydro acoustic system with additional positioning equipment that are necessary to determine the position of the underwater remotely operated vehicle in absolute coordinates (geographical).

2. *An omni directional transponder,* placed on the remote controlled underwater vehicle. It sends the reply signals when it receives the interrogation signals emitted by the surface vessel transceiver.

3. *The additional equipments* necessary to determine the underwater vehicle's position in the water mass in absolute coordinates (geographical):

- a *flux gate compass* KVH, model Azimuth 1000, used as heading reference unit (HRU), which provides the heading of the surface vessel towards the magnetic north. The 19 bytes heading data sentences are transmitted using a standard NMEA 0183 interface, in HCHDM, format, trough a serial communication RS 232. The update rate is 10Hz.

- a *GPS receiver* Garmin, model GPS 18-5Hz, to provide the absolute position (in geographical coordinates) of the surface vessel from which the ROV is tracked. The data strings are transmitted in NMEA 0183 standard, in

GPGLL format through a serial communication RS 232. The update rate is 5Hz.

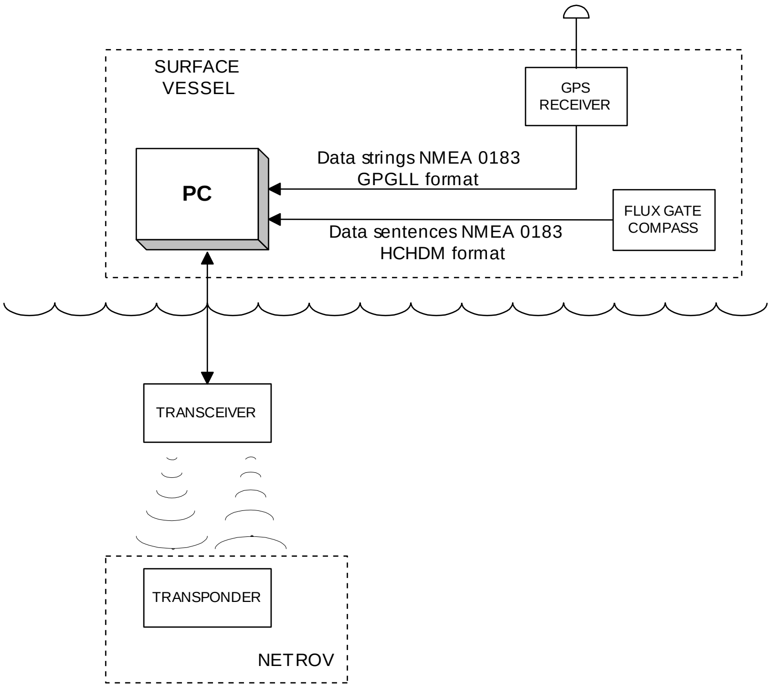


Fig. 1 - The block diagram of the integrated USBL navigation and positioning system used in NETROV project

In this phase of experimenting, due to practical and economic factors, a vertical reference unit (motion sensor) wasn't used because NETROV mini vehicle belongs to the LCROV class and the precision needed to determine its position in water mass is not essential for the purposes it will be used for.

EXPERIMENTAL RESULTS

The tests development "in situ" with the hydro acoustic positioning system for the NETROV minivehicle, had two scenarios:

- *First scenario:* the underwater vehicle is launched and it moves from the surface vessel's vicinity to an arbitrary location, making it's way back on a different range.

- *Second scenario:* the underwater vehicle is in the water at a certain distance from the surface vessel and it moves in a predetermined perimeter.

In order to accomplish the two scenarios, two boats were used – one for tracting the transponder in the water mass, and the other for locate the hydro acoustic tracking unit (transceiver unit).

To mount the transceiver the *out-board* solution was chosen, using a support bar with a length of 2.5m fitted with a flange for fixing the transceiver unit.

In the case of first scenario, the boat that tracts the transponder in water mass is moving with a speed of aprox. 1-1.5 Nd around the boat (at anchor) from which the target is tracked, the transponder being immersed at bigger depths, as it moves away from the transceiver. In this way is simulated the movement of the underwater vehicle on which the transponder is placed, from surface to the bottom. The transponder's route is tracked and plotted permanently on the notebook found in the boat on which the transceiver is mounted.

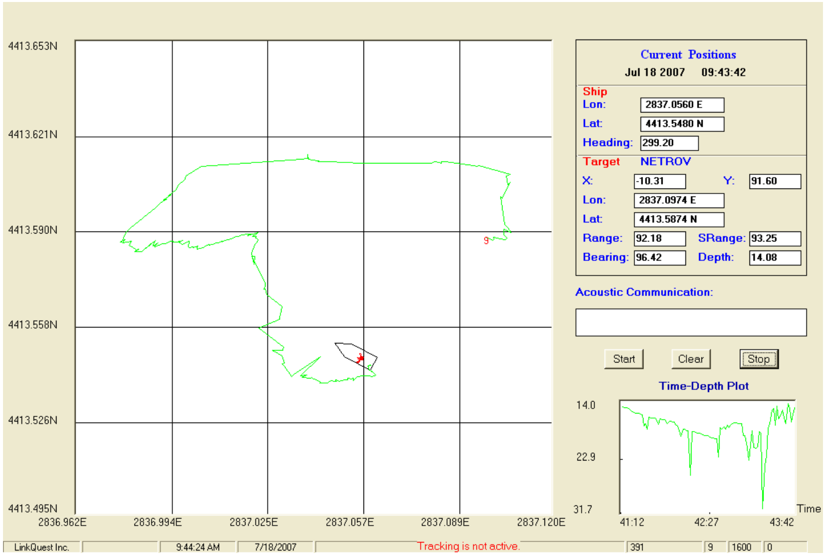
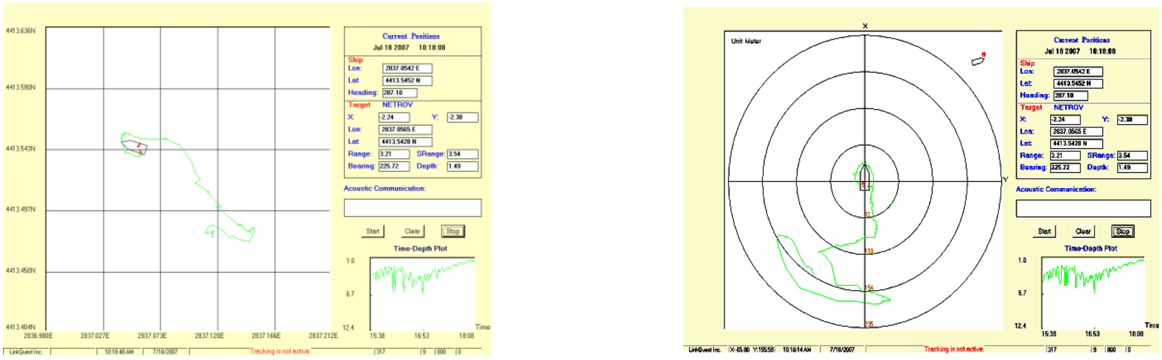


Fig. 2 - The history of a test made following the 1st scenario



a) b)

Fig. 3 - The history of a test made after the 2nd scenario
a) bow reference; b) magnetic north reference.

In the case of the second scenario the boat that tracts the transponder is at a distance of about 100-120m from the boat on which the transceiver is mounted. With the transponder immersed as close to the bottom as possible, the boat that tracts the transponder is moving at random in a perimeter of about 50x50m. This 2nd scenario is meant for bigger working depths than the first application, to avoid the risk of transponder's signal emergence out of the transceiver's radiation pattern.

In figure 2 is presented the history of a test made after the first scenario, and in figure 3 a test made following the 2nd scenario.

CONCLUSIONS

The tests carried out "in situ" in shallow water evidenced more quantitative and qualitative aspects that determined some conclusions, if which the following are the most important:

Due to the transceiver's hydro acoustic transducer radiation pattern, that has an operating beam width of about 120°-150°, some situations may occur in which the target evolves at sufficiently low depths for the reply signal transmitted by the transponder to be received at this radiation diagram limits or even outside of it (Fig. 4).

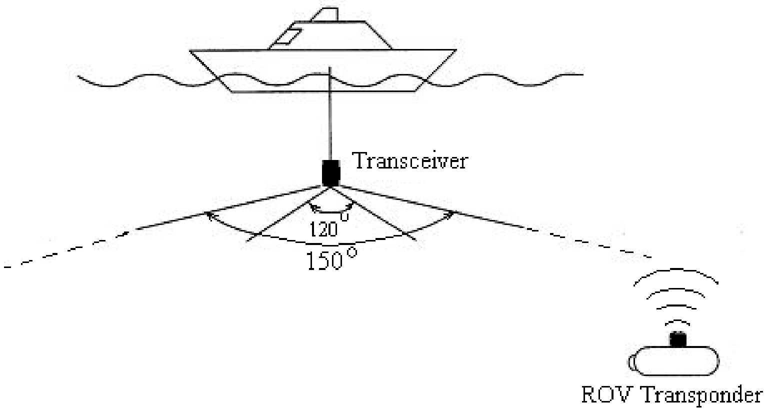


Fig. 4 - Explanation regarding the emergence of the signal sent by the transponder out of the transceiver's pattern

In situations like these (shallow water), simulated as the tests evolve, there might be the following risks:

1. The transceiver can't "see" the transponder, situation in which obvious discontinuities appear in the target's track diagram, recorded on the monitor (Fig. 5).

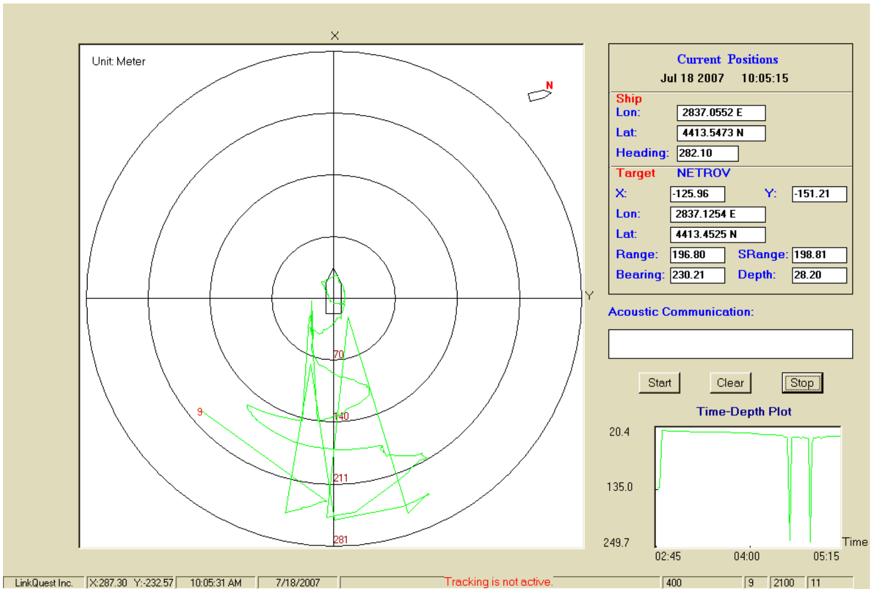


Fig. 5 - Diagram in which appear discontinuities in the track followed by the tracked target, due to signal loss

2. The transceiver “sees” the target but the indication regarding the transponder’s depth is erroneous, the indicated depth being much bigger than the real one on which the target (transponder) evolves (see Fig. 5, *time-depth* graphic on the diagram’s low right side).

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