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VERY HIGH-RESOLUTION SIDE-SCAN SONAR FOR UNDERWATER ACOUSTIC IMAGERY

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1. INTRODUCTION

Nowadays, observing the sea bottom has become an absolute necessity for civilian needs (classification of the sea bottoms, debrits surveillance, underwater works, ...) as well as for military purposes (surveillance, anti-intrusion, mine detection,...).

This paper describes THOMSON SINTRA UWA's new IBIS 43 surveillance system which is one of the most effective and modern sonars designed to perform these tasks. Its vehicle is towable at high-speed, thus allowing to cover wide areas with a decimetric resolution. Its multibeam side-scan sonar is provided with digital signal processing enabling a fully electronic beam stabilization for immediate correction of ship's movement.

In addition to the towed vehicle, IBIS 43 system includes a high-resolution visualization console for real time presentation of sonar images, a high-density recording device, powerful operator's aids for both detection and classification of objects, and, as an optional extension, a data base allowing real time comparison of images being displayed and previously recorded images.

This paper presents the general characteristics of IBIS 43 system, focuses on side-scan sonar performances and reports results obtained during evaluation tests.

2. OPERATIONAL ASPECTS

Side-scan sonars are generally involved in so-called SURVEILLANCE SYSTEMS. This surveillance concept was introduced over 15 years ago, especially for route surveillance purposes. It consists mainly in detecting any new object in channels, route or areas which have been thoroughly surveyed by previous operations. Use of high-resolution multibeam side-scan sonar allows to considerably increase effectiveness and rapidity of operation compared with traditional front-looking sonars. The most powerful advantage is certainly brought by the a priori knowledge of the area under imagery. Sonar data are usually recorded and processed either in quasi real time on board the surface ship or at a shore based data center.

IBIS 43 SIDE-SCAN SONAR FOR ACOUSTIC IMAGERY

3. IBIS 43 SURVEILLANCE SYSTEM CHARACTERISTICS

3.1 Operational Requirements

IBIS 43 system must be able to detect objects over bottom depths from 6 to 200 meters at a bottom speed from 4 to 15 knots. The sonar range has to cover 2 x 100 meters. These specifications must be obtained at sea state of up to 5 and current speed of up to 2 knots.

3.2 System description

IBIS 43 design is mainly characterized by its high-level of modularity which offers an easy way to particularize the system for specific requirements and platforms. Different options allow an easy extension of its possibilities. A base line system, required for civilian or military applications, is composed of the following equipment:

- towed vehicle which contains the sonar arrays and their acquisition electronics, navigation sensors, obstacle avoidance sonar and piloting electronics,
- towing cable,
- a winch,
- a deployment and recovery system,
- an on board electronic cabinet for signal and image processing,
- a high-resolution display console,
- a magnetic recorder.

It can be proposed a more powerful system allowing a real time on board data processing with the following options:

- Computer Automatic Detection (CAD),
- Computer Automatic Classification (CAC),
- Database for comparison of incoming pictures with previously recorded pictures.

In addition to the side-scan sonar, a gap filler sonar can also be proposed in order to provide shadow pictures from the objects located under the vehicle. Such a complete configuration is more decicated to military surveillance missions.

3.2.1 Vehicule and towing cable. The general characteristics of the vehicle are:

- length : 3 m
- wing span : 1.6 m
- weight : 300 kg

The vehicle houses an automatic pilot which allows different piloting modes: bottom or immersion tracking with active pitch and roll control, manual control and emergency mode. The operational bottom tracking mode requires very severe specifications to ensure proper operating conditions for the sonars:

- vehicle altitude : from 4 to 15 ± 10%
- pitch angle : < 5°
- pitch speed : < 2°/sec
- roll angle : < 2°
- yaw speed : < 1°/sec

IBIS 43 SIDE-SCAN SONAR FOR ACOUSTIC IMAGERY

These specifications must be fulfilled 99% of the time. The vehicle is equipped with the following navigation and safety sensors:

- bottom speed and water speed sensors
- obstacle and oblique sounder
- altitude acoustic sounder
- immersion sensor
- magnetic heading sensor
- inertial attitude sensors
- pinger and flash light

The automatic pilot acts on front wings to keep a constant altitude relative to the bottom or a constant immersion and on two differential rear wings for pitch and roll control.

The tow cable is a torque balanced armoured cable, fitted with ribbons and hard fairings to reduce strum and drag, transmitting energy and piloting orders from the ship and sonar data from the vehicle. The maximum working load is 10000 newtons, breaking strength is better than 50000 newtons.

3.2.2 TSM 2054 side-scan sonar. The acoustic length of the array can be matched to a specific requirement. In a base line configuration the performances of the side-scan sonar read as follows:

- altitude : from 4 to 15 meters
- speed : from 4 to 15 knots
- range : 2 x 100 meters (or 2 x 50 meters with a twice better resolution)
- dynamic focusing

Signal processing ensures a signal to noise ratio better than 10 dB at maximum range. The beams are electronically stabilized against pitch and yaw movements. Beam spacing is automatically adjusted in order to provide a full coverage without any holidays according to the vehicles towing speed, yaw and pitch movements.

The sonar images are displayed on board on a high-resolution 19 inch colour screen in waterfall mode. Sonar data are recorded on high-density data tapes.

3.2.3 Computer Automatic Detection (CAD). Due to the high-operating speed capability of the vehicle and the very high information density of the pictures, it could be quite difficult for the operator to detect in real time objects lying inside the sonar field especially at the highest speed. So, CAD performs as a vital operator's aid. A specific algorithm detects the shadows whose sizes are similar to the shadow of the objects of interest, the reference size being adjustable before starting the operation:

- this process runs in real time,
- detected shadows are highlighted on the detection display,
- shadows larger than target shadows are highlighted as blind areas
- detected objects are automatically sent to the tactical system.

CAD works on all types of bottom on pictures obtained with a grazing angle less than 45°. The detection operator always has the possibility to display the CAD results on his screen or not. Nevertheless, if he decides not to display these results, the process runs on without interruption.

3.2.4 Computer Automatic Classification (CAC). This function requires a special classification console for a classifier operator. When a target has been manually or automatically detected, the operator sends this target to the classification console which appears as a frozen frame of 50 m per 50 m. At the same time, the CAC process estimates the sizes of the object and displays them directly on the screen.

3.2.5 Data Base. The data base mainly consists of a collection of objects with their history and information like coordinates, size, etc.. Its main purposes are:

- first, to supply the CAD process with previously recorded bottom data in order to enable it to outline only the new objects of interest. In this way, every new object becomes a suspicious one,
- second, to supply the classification operator with previously stored frames allowing him to perform the picture comparison.

The classifier operator processes with a slight delay the list of targets that have to be classified. After he has taken his decision on a target, he updates the data base.

Mass storage medium used for the data base is double-face optical gigadisks providing a high-storage capacity.

4. CONCLUSIONS

IBIS 43 system has now been fully evaluated at sea. Navigation trials started in early 1991 and were followed in mid 91 by sonar evaluation tests. Measured performances have shown that all the specifications are reached.

It has been demonstrated that ultra high-stability of the vehicle associated to additional electronic beam stabilization are really mandatory requirements for high-resolution sonar imagery.

IBIS 43 is already a very effective system with unequalled performances. Its qualities make it an excellent tool for route surveillance in mine warfare as well as for other applications as surveys for scientific work, applications in the oil industry, wreck searches, etc..

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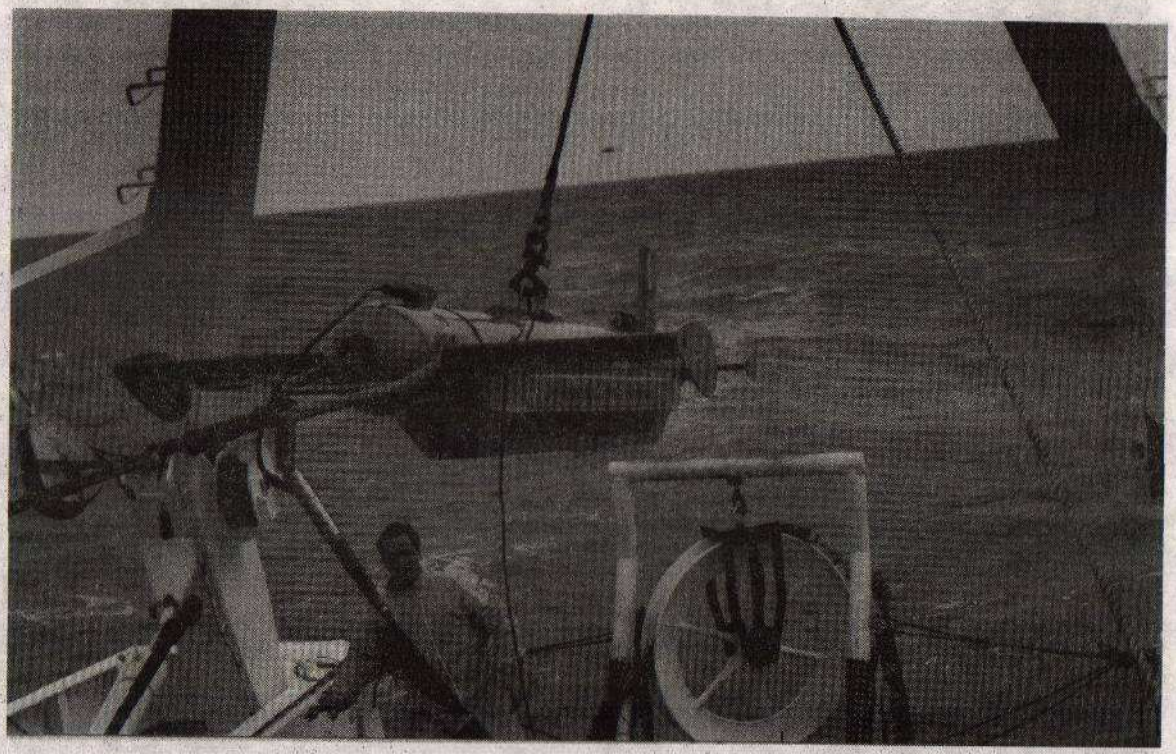

Figure 1 : IBIS 43's vehicle at sea-trials

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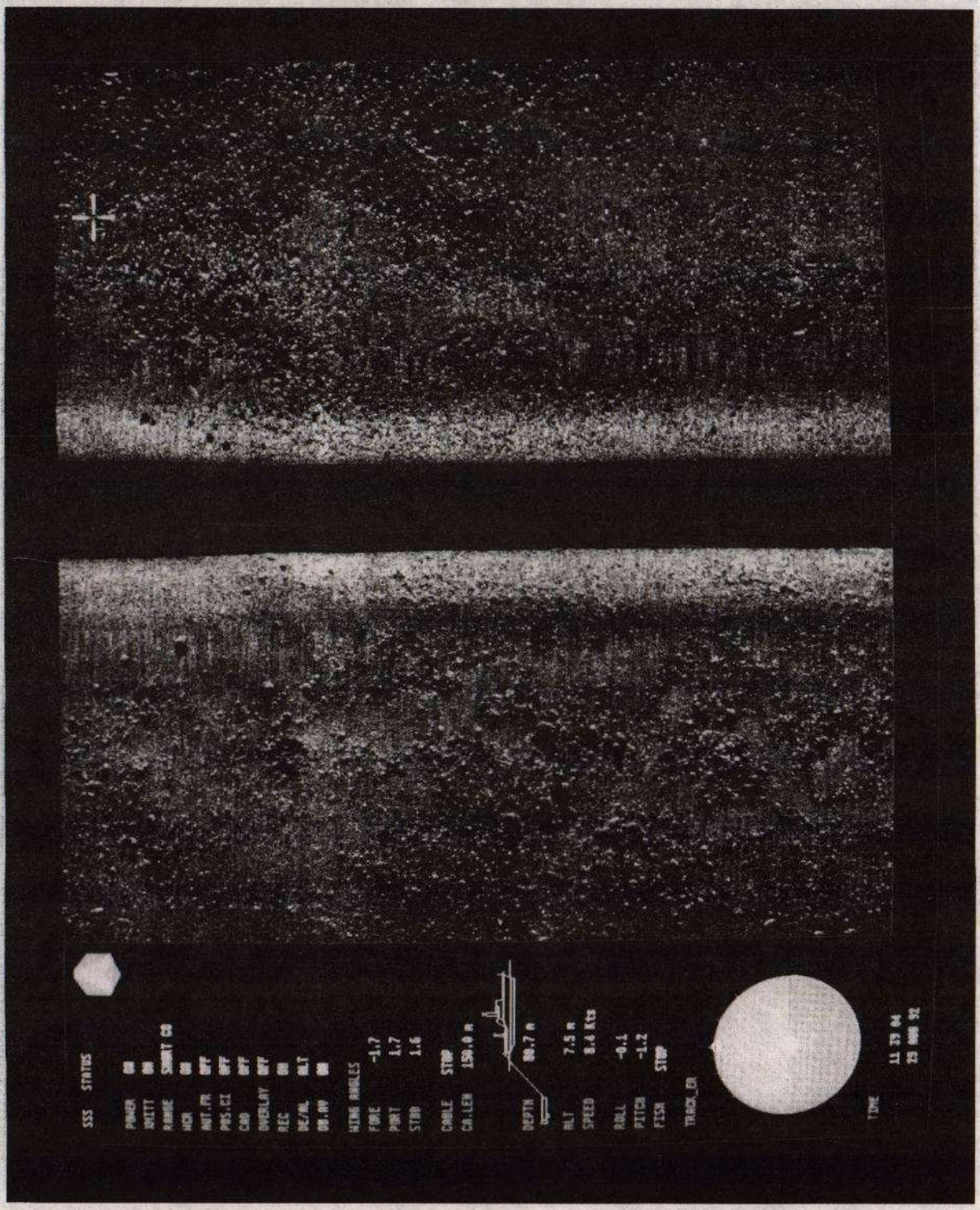

Figure 2 : Example of Rocky bottom images obtained with TSM 2054 side-scan sonar

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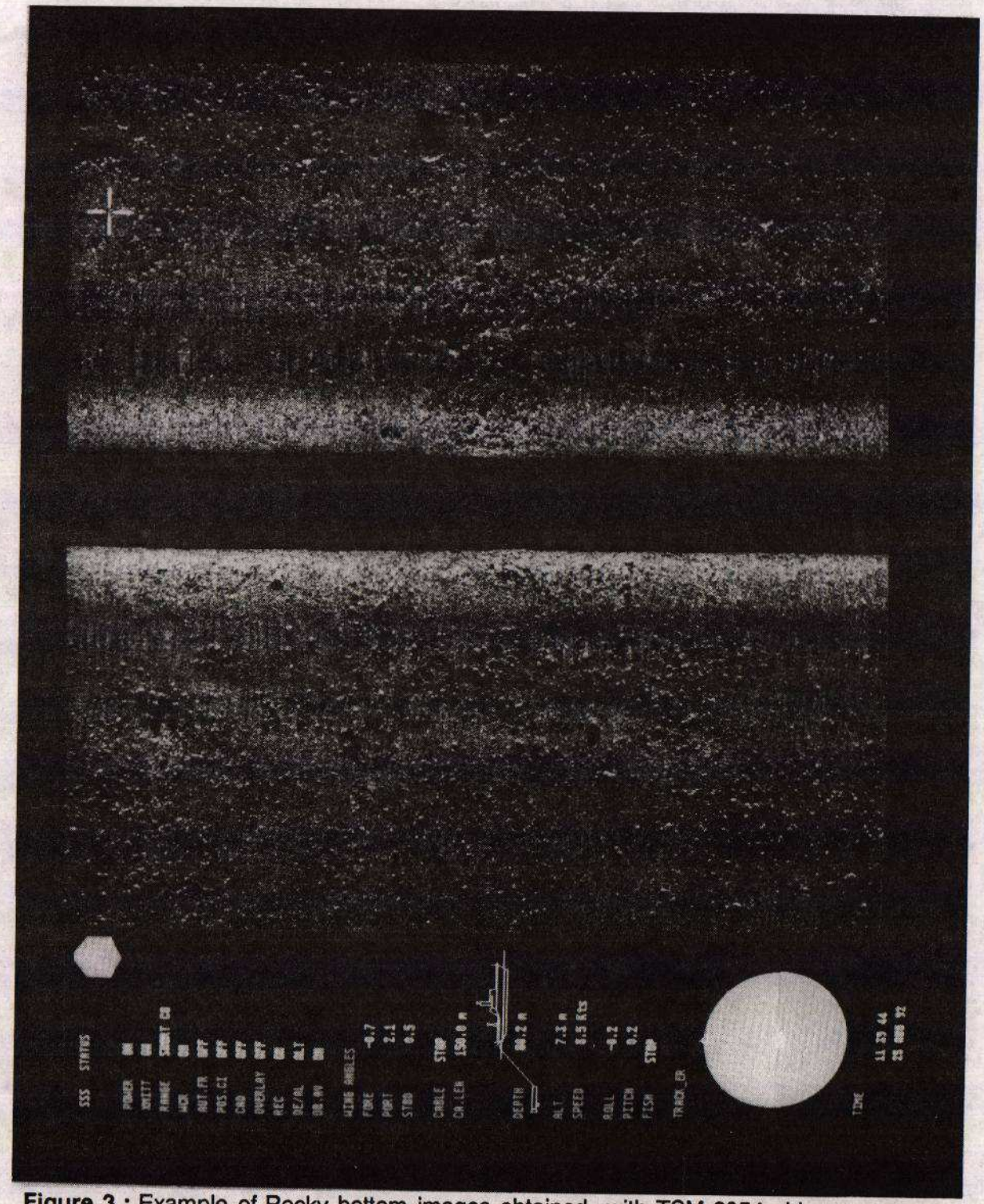

Figure 3 : Example of Rocky bottom images obtained with TSM 2054 side-scan sonar