ELAC SONAR

A COHORT PLC COMPANY

SUPPORT OF SUBMARINE SEARCH AND RESCUE OPERATIONS WITH ELAC SONAR EQUIPMENT

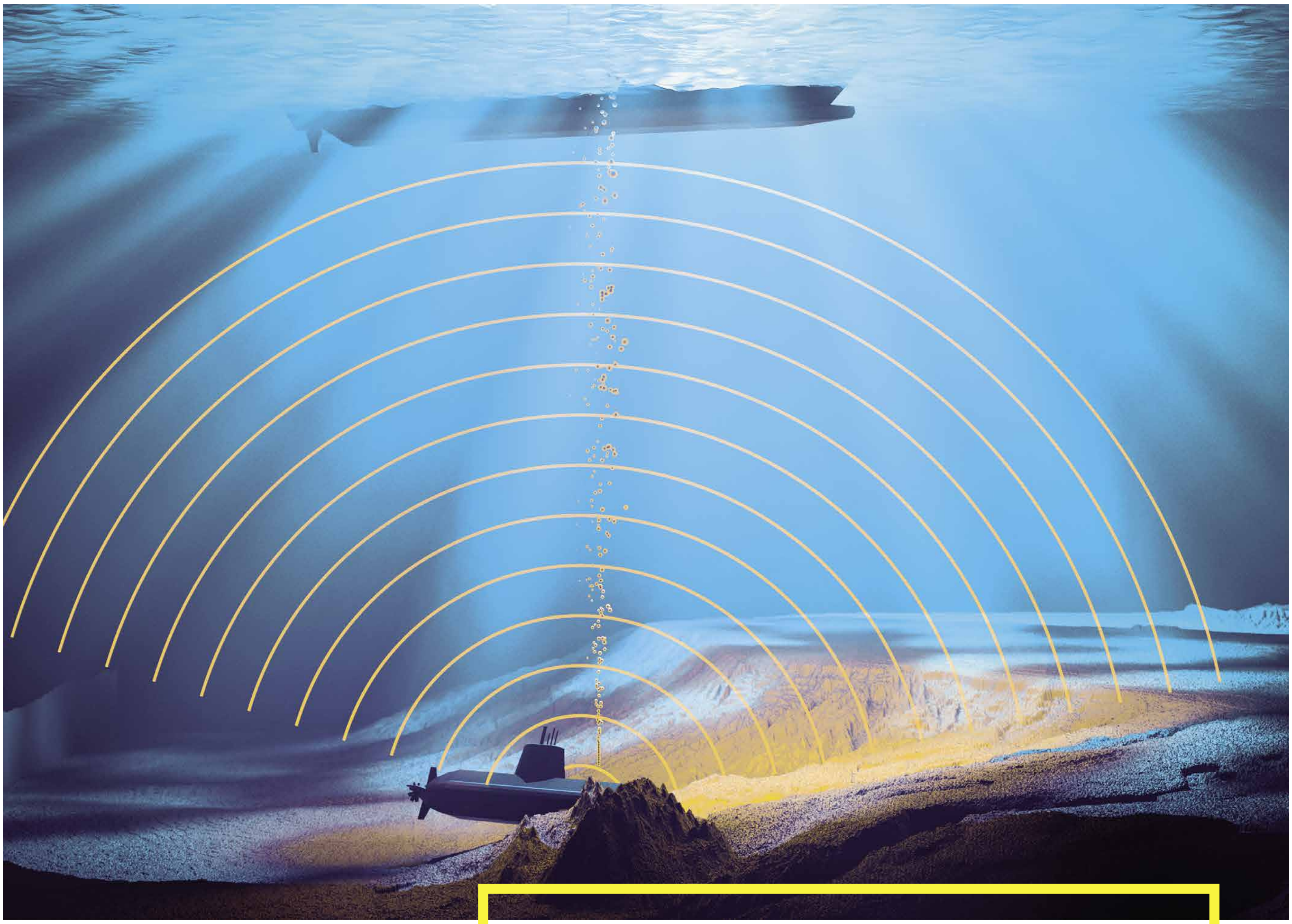
A concept basing on ATP-57(B)

Despite advanced navigation systems and the end of the cold war, incidents with submarines have not decreased. In fact, from 2000 to date nearly twenty incidents involving submarines have been reported.

Among the most notorious incidents, is the Russian Kursk explosion in mid-2000. After the explosion – that destroyed the torpedo room and triggered further detonations – the emergency systems should have been activated. Emergency buoys, intended to help rescuers locate the distressed submarine, should have been released by sudden pressure changes or fire, but unfortunately this was not the case. Under normal circumstances the emergency buoy would have been deployed which would have led the rescue vessel to the position of the distressed submarine. But what happens if the buoys are not deployed as happened with the Kursk, or if the buoys are released but drifting away?

Another tragic accident was the loss of the Argentinian submarine San Juan (S-42) in the South Atlantic on November 15, 2017. The search was initially suspended in January 2018 without success. In August 2018, the search was resumed. A diving robot located parts of the ARA San Juan at a depth of 900 meters in November 2018.

ELAC SONAR takes a complete and holistic approach to search and localisation, mission planning and communication with distressed submarines using acoustical sensors based on the Submarine Search and Rescue Manual ATP-57(B).



ELAC SONAR Equipment for Submarine Search and Rescue Operations: First Choice for Navies and Shipyards worldwide

Introduction

Submarines in distress (DISSUB) require fast and effective rescue measures to avoid personnel losses. Therefore, it is mandatory to plan the rescue missions and to operate the rescue vessels efficiently.

To define and coordinate Submarine Search and Rescue (SUBSAR) operations international accepted procedures have been established such as the Allied Tactical Procedure ATP-57(B) – Submarine Search and Rescue Manual.

ELAC SONAR develops and manufactures hydroacoustic support equipment to perform the required tasks of search, localisation, communication and planning of rescue missions.

SUBSAR PHASES

Due to the conditions on a DISSUB the aim of each SUBSAR operation is to save the lives of the submarine crew members (see ATP-57(B) Part I, Chapter 3). This requires the earliest possible localisation of the DISSUB and deployment of suitable rescue tools. Each SUBSAR operation is divided into two phases:

Search and localisation phase

Within the Search and Localisation phase it is necessary to locate the position of the DISSUB in shortest possible time and to establish the communication with the DISSUBs crew. Next, a location survey has to be carried out to initiate the Escape and Rescue Phase.

Escape and rescue phase

The Escape and Rescue Phase starts with preparatory tasks for the escape operation such as debris removal or preparation of the DISSUB for connecting the rescue vehicle. Within the rescue phase it is crucial to monitor the conditions onboard of the DISSUB and get access to the DISSUB in order to help the crew members escape.

SEARCH AND LOCALISATION PHASE

The following figure gives an overview of the water areas where rescue of the submarine crew is possible, defined by the International Submarine Escape and Rescue Liaison Office (ISMERLO).

Localisation of a lost submarine is best achieved by detecting the DISSUBs indicator or messenger buoy that provides radio or SAT COM based communication devices and position indication devices. However, there may be situations where the emergency buoy cannot be deployed, as happened with the Kursk, or where the buoys are drifting away. In this case the only possibility to locate the distressed submarine is through the use of acoustic sonar beacon equipment which starts pinging either automatically in case of water contact or can be manually started by the crew. The submarine in distress could be located by sonar systems either passively by listening to pinger signals of the emergency beacon (e.g. SBE 1 by ELAC SONAR), or actively by using active sonar and evaluating the echoes of the transmitted signals over long ranges.

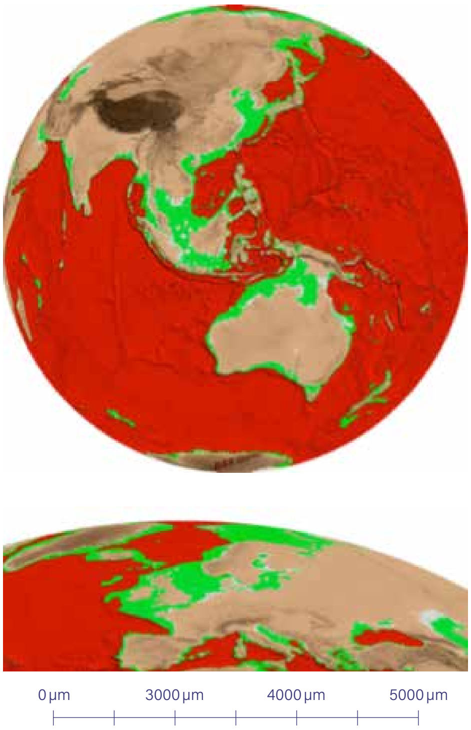


fig. 1: Rescue capable waters acc. to ISMERLO

PILOS 2.0

Pinger Localisation Sonar

The Pinger Localisation Sonar PILOS 2.0 is a versatile, modern passive sonar especially designed for surface vessels to provide the bearing of a sound's source. This can be any type of sound in a wide range of frequencies between 1 and 50 kHz. Either a pinger or beacon equipment operated in this frequency range can be detected with a high degree of accuracy of less than two degrees (≤ 2°). Therefore, the system provides the opportunity to approach the source of noise directly with the vessel having PILOS installed.

The latest technology of Sphere® is already running inside the PILOS 2.0, which therefore makes it the successor to the proven in-field PILOS system. Based on the latest receiver electronics, using multi-channel analog-digital conversion technique and an open system architecture based on open DDS middleware, PILOS 2.0 expands the functional range with transient analysis and intercept processing. These features significantly increase the opportunity to initially detect a distress pinger with a very low pulse repetition rate. Data can so be cross-referenced to known pinger characteristics by the operator to classify the pinger or noise.

Normally the passive sonar is installed on board of submarines for survey and navigation purposes as the main sensor of the sub. Similar to this sonar, PILOS 2.0 was designed as a passive sonar and makes use of a circular array, to avoid moving parts of the antenna as much as possible and to provide 360 degree coverage. For special operation on surface vessels, which may sail very fast, the array is attached to hoisting gear. If the system is not in operation, the antenna can be retracted into the ship's hull, to avoid sailing limitations to the ship and damage to the antenna.

PILOS 2.0 is able to detect emergency beacon pingers at distances of up to 70 km and airplane pingers at distances up to 5 km in ideal sonar conditions. For better or additional evaluation of the signals, the received signals are transformed into the audible frequency range between 0.3 kHz and 3 kHz, to provide the operator not just a visual, but also audible impression of the situation under water. The system provides frequency analysis functionalities to discriminate between natural and artificial hydroacoustical signals and to classify emergency beacon signals.

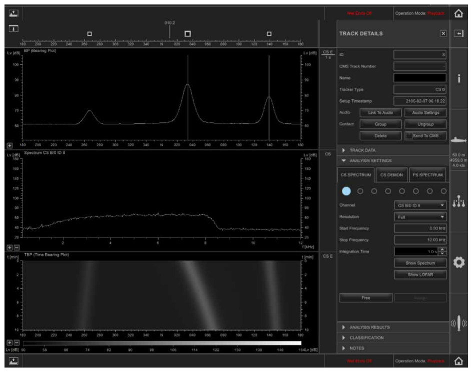


fig. 2: PILOS 2.0 HMI showing bearing, frequency and time bearing plots (night mode)

PILOS 2.0 is a compact system and can easily be integrated into the Rescue Ship.

Directly after localisation of the DISSUB, the establishment of the communication between the first ship arriving and the crew of the lost submarine (see ATP-57(B), Part I 312.2c) is necessary. Communication is essential for the rescue mission and shall not be disrupted by other acoustical systems such as sonar systems. The communication scripts to be used are defined in Annex 5B of ATP-57(B).

An additional communication standard for DISSUB situations is currently in its final definition phase using state of the art digital communication technics. The open JANUS digital communication standard defined in NATO STANAG will be the basis for a substantial improvement for under water communication in a rescue scenario.

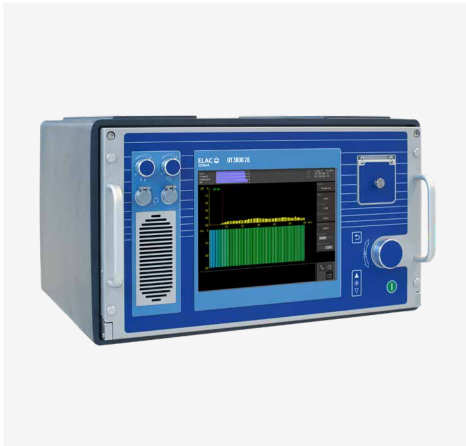
With the JANUS DISSUB application, an automated, fast and reliable information exchange between mother ship and DISSUB will be secured.

ELAC SONAR has implemented a DISSUB JANUS application and made it a standard function of every UT 3000 2G underwater communication system. Existing UT 3000 1G systems can be easily updated with the JANUS applications through a combined software and hardware update.

UT 3000 2G

Digital UW Coms System

ELAC SONAR underwater communication system UT 3000 2G provides the means to communicate with the crew of the submarine in distress by analog, manual or automated digital communication.
The UT 3000 2G underwater communication system is in operation with numerous navies around the globe. It is compatible to NATO STANAG 1475 and, due to its selectable carrier frequencies and sideband, it can be integrated with all known naval underwater communication systems in the world.



In addition to the JANUS DISSUB application, the following features of the UT 3000 2G are essential for submarine rescue scenarios:

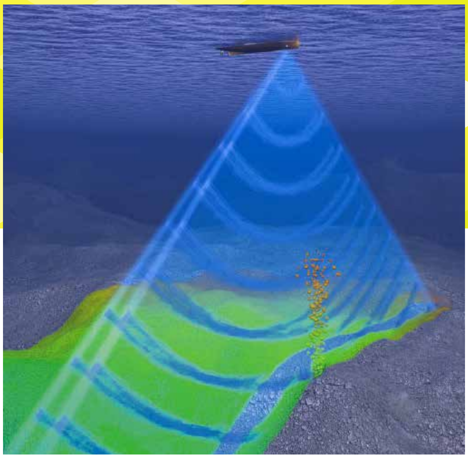
- **Communication via telephony and telegraphy using international standards**
- **Directional transducer configuration**
- **Wireless underwater communication with divers Pinger mode to provide a beacon signal for SONAR systems or underwater telephones with directional transducer capability (please refer to the description of PILOS 2.0 as well.)**
- **Digital data transmission of messages or small files using ELAC MFSK coding**

Parallel to the establishment of the communication, the mission planning for the rescue must also take place.

Once the submarine is located, the officer in command should know how the submarine is orientated to initiate appropriate rescue measures.

This can be performed with a fan beam sonar like SB 3050 2G, which is used to create two- and three-dimensional maps of the sea floor and even side scan-like images of the surveyed area. On such maps the submarine could be detected and located quite easily. Depending on the sea area the DISSUB is located the use of optical systems may deliver insufficient results.

SB 3050 2G



Multibeam echosounder

Another reliable safety and planning measure is the use of highly accurate seafloor maps. Unfortunately, electronic charts used in ECDIS systems are partially based on older surveys and may not give an accurate picture of the situation at the seafloor as required for rescue missions. With a multibeam sonar system the seafloor will be surveyed and digital, three dimensional maps are created out of the collected data. The following pictures demonstrate how such measurements can be used to visualize the sea floor.

The multibeam system also supports side scan imagery which provides a high resolution image of the situation and an overview of how the distressed submarine is positioned at the seafloor. The figure 5 shows an examples of side scan data recorded with a Klein side scan sonar. The multibeam sonar system SB 3050 2G operates with a frequency of 50 kHz which is capable of reaching down to approx. 600 meters with a very wide fan of 140 degrees for quick surveys to save time. To get down to even greater depths, the fan can be concentrated to a narrower angle, which allows measurements down to 3,000 meters. Using multi-ping fans of directed sectors during the transmission to compensate for the ship's movements, enables the system to operate at higher speeds with high accuracy during the survey phase.

It is therefore possible to create very accurate maps of the seafloor, even in areas where official surveys are not published.By post processing the collected data, the created pictures can be used to support the navigation of submarines or to plan missions remotely operated underwater vehicles (ROV) missions to a maximum extent. For the commander of a submarine rescue mission these pictures help with planning how to approach the submarine in distress in the best way. They also help survey the area where the submarine is supposed to have been operated, to search for it and to provide information relating to the orientation of the submarine and its surroundings.

It is possible to obtain geological information over the quality and physical parameters of the seafloor itself. Measuring the echo strength of the returned signals and indicating the backscatter in the drawn maps shows areas of the sea floor which are acoustically harder than others. Such information is necessary if equipment has to be lowered to and/or to be installed on the seafloor. Using the SB 3050 2G this data will be available quickly for a large area of the sea floor compared to conventional methods.

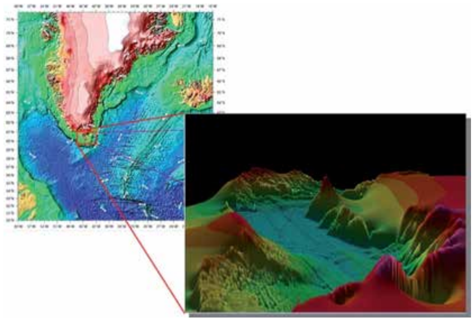


fig. 3: Multibeam 3D seafloor mapping

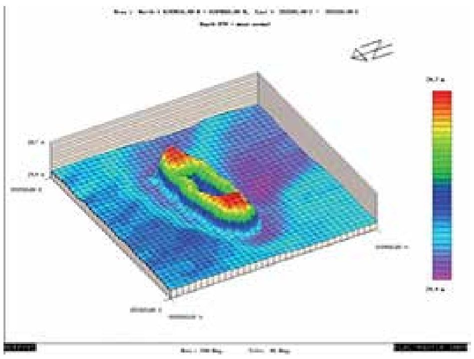


fig. 4: Wreck at seafloor (multibeam image)

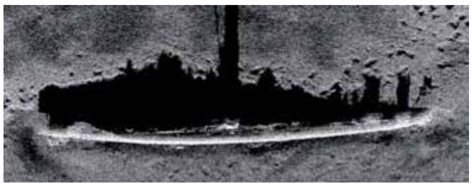


fig. 5: Side scan image of a submarine at sea floor

ESCAPE AND RESCUE PHASE

After the Search and Localisation Phase the Escape and Rescue Phase is initiated.

It begins with debris removal and the preparation of the DISSUB for connection of the rescue vehicle (DSRV). Depending on the depth the DISSUB is located, all the preparatory tasks are done either by means of ROVs or autonomous underwater vehicles (AUV). High accuracy positioning of the underwater vehicles (UVs) is crucial in the preparation phase in order to parallelize tasks and avoid collisions between the UVs. For positioning and navigation of all the UVs including the DSRV itself, acoustical positioning methods such as ultra-short baselining (USBL) systems can be used.

The rescue phase ends with the escape of the DISSUBs crew by means of the rescue vehicle.

CONCLUSION

Despite technological improvements to submarines during recent years, the number of submarine incidents has not decreased. Submarine Search and Rescue Operations (SUBSAR) are well defined in Allied Tactical Procedures such as the ATP-57(B) and coordinated by international organizations such as International Submarine Escape and Rescue Liaison Office (ISMERLO).

It has been shown that the Search and Localisation Phase of a SUBSAR operation is crucial. When radio and SAT COM units break down, well suited acoustical localisation systems are particularly vital. These allow faster localisation and identification of the acoustical emergency beacon over long ranges to help rescue DISSUBs.

Equipment and technology explained in this report is ideally suited to meeting procedures defined within the ATP-57(B).

Authors biography

Matthias Conrad served as an officer in the German Army and received his diploma degree in electrical engineering with specialization in electronics and communication technology from the University of Applied Sciences in Kiel, Germany in 2004. Since 2005 he is working as a system engineer and product manager in the system design department at ELAC SONAR in Kiel. His main field of work is the design of underwater communication systems and active sonar systems.

Markus Schäfer is a system engineer and a product manager for single and multibeam systems at ELAC SONAR. He graduated from the University of German Armed Forces in Hamburg (Germany) as an engineer. Markus Schäfer joined the German Navy in 1993 and spent 13 years as a naval officer.

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by

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