Detecting acoustic emissions of ships & submarines

Italian Navy conducts tests with the “Autonomous Acoustic Measurement System” (SARA)

This application note discusses the solution used for the detection of acoustic emissions of surface and underwater vessels by means of the “Autonomous Acoustic Measurement System” (*Sistema Autonomo per Rilievi Acustici*, **SARA**). Activities were carried out by the Italian Navy at the Naval Experimentation and Support Center (*Centro di Supporto e Sperimentazione Navale*, CSSN) of La Spezia.

Examining acoustic emissions

In order to examine the “acoustic fingerprint” of surface and underwater vessels, the Italian Marine conducts acoustic analysis of the noise detected by hydrophones. All tests are performed with the “Autonomous Acoustic Measurement System” (*Sistema Autonomo per Rilievi Acustici*, **SARA**) in accordance to international standards and specific requirements of the Navy (STANAG 1136, ANSI/ASA S.12.64, etc.) in frequency bandwidths from 5 to 20,000 Hz.

The heart of the “SARA” is the imc C-SERIES measurement system, a standard solution used here to record acoustic signals, perform live processing and calculations of spectra and directly transmit the data in real time via radio link, to the naval units under test.

Acoustic buoy subsystems

The following electronic equipment necessary for testing is housed inside the watertight metallic structure:

- imc C-SERIES measurement system for acquiring and analyzing signals
- connections for hydrophones (up to 3 underwater microphones used)
- GNSS high-performance satellite receiver for geo positioning data and sync
- modem/router WiFi for data transmission/reception
- WiFi amplifier + filter
- omnidirectional WiFi antenna
- batteries for general power supply
- DC / DC converter for power supply to the subsystems
- remote on/off receiver

The batteries allow autonomy for at least 12 hours, and the main power can be switched on or off remotely via radio control.

The hydrophone sensors are submerged deep below the buoy and are connected via cabling and waterproof connectors to the imc C-SERIES data acquisition system, sampling at 50 kS/s/channel.

The imc C-SERIES system is connected to a GNSS high-performance satellite receiver from JAVAD for accurate position measurements and to synchronize data recording with GPS time.

All data recorded within the buoy, including battery voltage level, up to three hydrophones and GPS location, are stored on CompactFlash memory.

Subsets of these data are also transmitted via radio in real time to the vessel under test through the use of a WiFi modem/router which is equipped with a “booster” to increase the power of the transmitter and omnidirectional antenna.

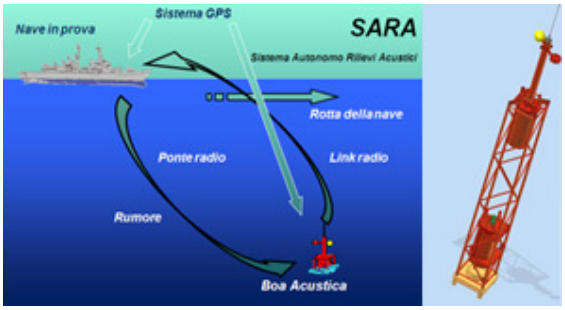
Subsystems onboard the vessel

Onboard the vessel under test, the following equipment is necessary to perform the test was installed:

- modem/router WiFi for transmitting/receiving data
- WiFi + filter amplifier
- omnidirectional WiFi antenna;
- GNSS high-performance satellite receiver
- monitoring station (PC + software)
- speakers for listening to the hydrophone signals in real time
- UPS stabilized power supply

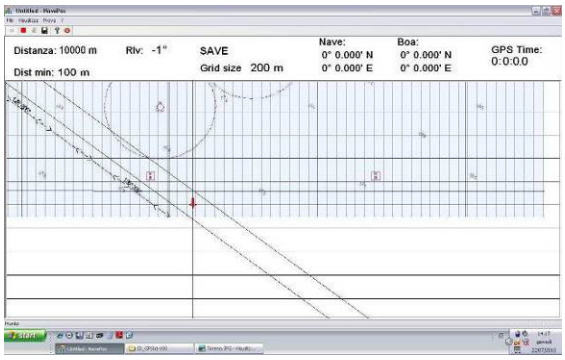
The application

In addition to data acquisition, the imc C-SERIES system, via imc Online FAMOS, supports the FFT analysis of the acoustic signals from the hydrophones in real time.



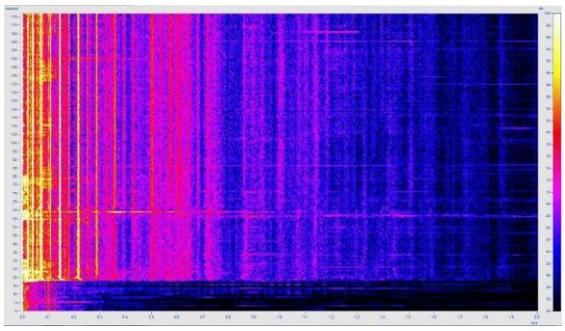
Via a bidirectional RF transmission link, data can be exchanged with the buoy, including the time-history from one of the three connected hydrophone sensors and its spectrum, battery voltage level and GPS position of the buoy.

The data-monitoring software installed on the PC within the vessel is an application developed by Instrumentation Devices / imc-Italy and allows immediate visualization of the test data. This application features a GUI and integrates the information received from the buoy with the GPS position of the vessel to obtain their exact relative positions. The display visualizes the vessel's trajectory compared to the buoy. The acoustic signals are also displayed simultaneously. The operating range extends to up to 2500 m with an accuracy of ± 1 m.



This type of real-time GPS tracking allows the verification of the ship with respect to the kinematic position of the buoy and provides an ideal cartographic representation of its current position and the route to follow. Thus, the test engineers and crew are given the opportunity to make any necessary corrections to the vessel's course of maneuver during the test itself. In the course of post-processing, provisions can be made to compensate for noise propagation losses and reflections by the test buoy to eliminate their influence on noise emission results.

During the test, the test engineer on board the ship can display the buoy data that were processed and transmitted via radio by the imc C-SERIES system directly on the PC. In particular, the FFT of the acoustic channels can be represented as color maps. Thus, it is possible for the crew to evaluate the correct signal/noise ratio.



A further feature of the data monitoring software allows listening in real time on board the

ship to the acoustic signal transmitted from the buoy in order to increase the level of confidence on the quality of the data gathered.

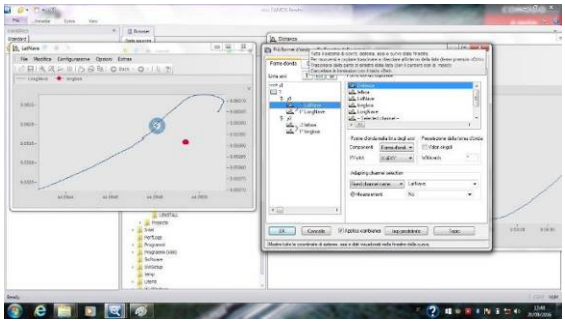
Information received by the buoy and the GPS position of the ship is also stored on the PC for their subsequent visualization and for further mathematical processing.

Post-processing

Once the buoy is recovered, a connection via LAN allows downloading of all recorded data from the imc C-SERIES system and performing all the analyses and corrections.

The recorded acoustic data are then analyzed by the imc FAMOS software and the necessary tables and reports are generated, including the diagrams of noise propagation according to the definitions of established Standards.

With the imc FAMOS software, technicians from the Naval Experimentation and Support Center can analyze the data acquired by the hydrophones. Thanks to special calculation sequences specifically implemented, the time to reach lateral proximity can be calculated (the period in which the vessel passes the point nearest to the acoustic buoy), spectra are calculated and displayed as color maps, and offset distance analyses are performed in one-third octaves and spectral lines.



Conclusion

Despite being used in a harsh environment and within a confined space, the imc measurement system provided reliable, highly flexible and easily adaptable acquisition, control and analysis operations.

Thanks to the fast and reliable data acquisition by the imc C-SERIES measurement system, the real-time processing by imc Online FAMOS and the post-analysis features of imc FAMOS, an ideal solution was realized for meeting the challenging requirements put forth by the Italian Navy. CSSN, which has revised the hardware integration with the support of Instrumentation Devices specialists, succeeded in ensuring control of the acoustic signature requirements of Italian Navy fleet and provided a suitable rapid investigation system in its favor.

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