SONAR DOME Monitoring System

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THE CHALLENGE

To validate the design and the integration of the different components inside of the sonar dome of Italian Navy FREMM frigates.

THE SOLUTION

To develop a Sonar Dome Monitoring System (SDMS), based on NI LabVIEW and NI PXI Data Acquisition System, able to collect and process on board all relevant data and a shore post-processing system, based on NI DIAdem.

Products used

LabVIEW
PXI/CompactPCI
SCXI
Acquisizione dati
DIAdem

The SDMS main functions are:

- *Collecting data useful to analyze the structural and vibrational behavior of the sonar dome and the elastic response, due to hydrodynamics components during the ship's normal operations. System provides a first step of real-time elaboration, but deeper elaborations and cross-correlations will be analyzed with NI Diadem by using the recorded data set;*
- *Calculating the platform Self Noise;*
- *Evaluating the propagation of the machinery noise over the dome and its influence through recorded data and their successive analysis.*

One of the main advantages of system architecture is that using TDMS data file format (see below) you can automatically relate, both in real-time and in post processing, raw or processed data together with the vessel structure both in terms of attitude, speed ecc and in terms of propulsive attitude, RPM and propeller pitch.

The Application

The Sonar Dome Monitoring System (SDMS) has been developed following the specifications made by Orizzonte Sistemi Navali (OSN), Prime Contractor for FREMM Frigates. The whole system was developed and integrated by CETENA and the LabVIEW online software was developed by SITEM.
The SDMS architecture is described in the following scheme:

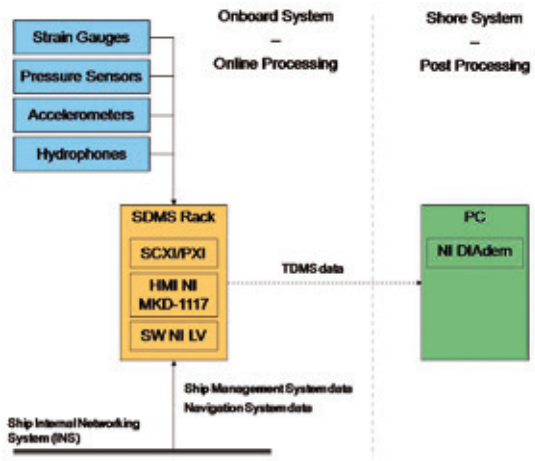

Figure 1: Sonar Dome Monitoring System architecture

The Data Acquisition System is based on a PXI/SCXI platform, and includes: 1 NI PXI 8110 controller, 1 PXI 1050 chassis, 1 PXI-6251 general purpose Data Acquisition board, 4 PXI-4462 IEPE accelerometers data acquisition boards, 2 SCXI-1520 strain gage input modules.
The SDMS is designed to record all relevant structural and acoustic parameters of the sonar dome even without a dedicated operator; the latter can occur during ship operations in order to allow a validation of the integration of the different components inside the dome, without generating too much data.
The SDMS operating modes are the following:

1. Not Assisted mode: in this operative mode the SDMS SW checks some significant incoming signals in order to detect the start/stop recording triggers depending upon the set threshold values.
2. Assisted mode: the threshold real-time evaluations for triggering are disabled. User can decide whether to start or stop manually a recording session. User can also manage recorded data.

The operating mode transaction is commanded by operator selection from the window main view depicted in the following chapters.
SDMS manages the data acquisition mainly in three ways:

1. DAQ Analog Input data acquisition: signals coming from NI Data Acquisition boards are acquired, analyzed and stored directly by the application.
1. OPC data acquisition: OPC signals are acquired through a TCP/IP connection and an Ethernet network connected to the Ship Management System (SMS). These signals are relative to some SHIPs machinery such as DGs RPM, propeller pitch or other equipment status.
1. UDP data acquisition: these signals are collected through an Ethernet network from the navigation system.

All recorded data are saved in TDMS file format. Being this an open architecture, this allows users to inspect data with many data analysis software (for example NI DIAdem). TDMS file may contain raw data, OPC, UDP and accelerometers FFT waveforms and calculated channels (called "Synthetic channels" – see below).
A brief description of SDMS main features follows.

SDMS sub-capability

The SDMS HMI provides an easy to use graphical interface to manage the acquisition and processing aimed at managing tasks foreseen by requirements. HMI consists of a set of views devoted to given tasks and grouped on the basis of homogeneous functions. The homepage ("Overview") is entered as the operator evokes the SDMS program. It is the entry point to the SDMS capabilities each one managed by its own SW module. Namely:

- Continuous data acquisition, synthetic calculations, spectral analysis.
- Data Recording.
- Data Retrieving.

The SDMS main panel appears as follows:

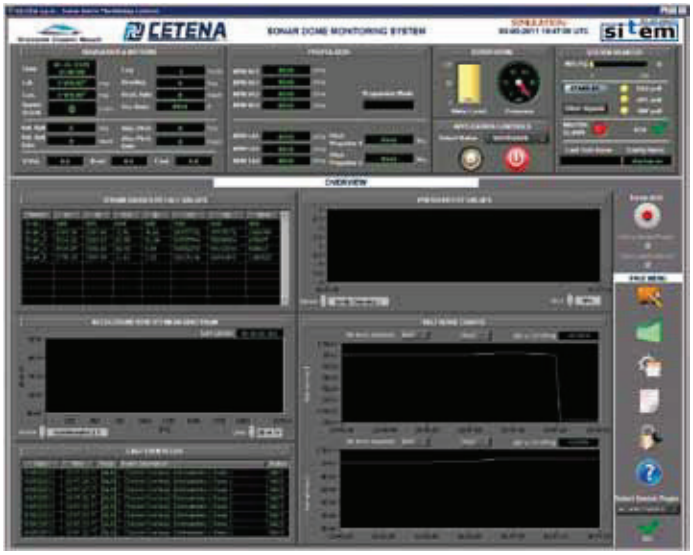

Figure 2 – Main view of SDMS HMI

The SDMS HMI provides a fixed header on the top of the screen, which also provides the real-time value of some fixed OPC and UDP signals coming from NAVigation System (NAVS) and Ship's Machinery. The center of the screen provides dynamic subpanels which will be called by the user. The default home subpanel is called "Overview" and provides the User to have access to other subpanels.
The SDMS will calculate some additional "Synthetic channels". These channels can be obtained by strain-gages, pressures, hydrophones or accelerometers signals.

SDMS channels grouping

All channels acquired by the NI acquisition system are collected into some groups. This grouping allows to record all the channels raw data inside the selected group, when just one synthetic single signal among the channels of the group will exceed its threshold.

session saves data relative to the time window before the trigger event detection as soon that a trigger event is detected.
SDMS SW provides an automatic hard disk drive saturation control tool.

Stop record – trigger hysteresis

The whole recording session will be stopped when:
1. The main speed returns below its threshold.
This event stops also any other group raw data recording.
The group raw data recording will be stopped when the relative synthetic channel will return below its threshold.
2. The "Stop Record" button (Overview Subpanel) has been pressed.

SDMS processing

SDMS provides a Fast Fourier Transform (FFT) analysis of hydrophones and accelerometers raw data.
Regarding hydrophones signals, raw data coming are subjected to the applied spectral analysis in order to achieve the real-time Self-Noise calculation, a waterfall and a third-octave graphical representations of the time-frequency spectral relationship.

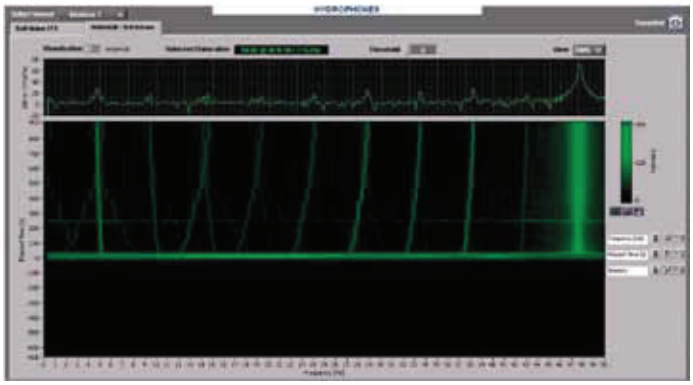

Figure 3 – Hydrophones subpanel – Waterfall visualization

Similarly, accelerometers FFT calculation will be performed continuously on each sensor.

SDMS data retrieve

The HISTORY subpanel allows the User to browse into old test session and so to navigate into recorded TDMS data file.

"NI LabVIEW and NI PXI Data Acquisition System were able to collect and process on board all relevant data and a shore post-processing system, based on NI DIAdem, to develop a Sonar Dome Monitoring System (SDMS)."

Data storage specification – record start events

The main recording event is detected when the ship's speed (UDP signal) exceeds its threshold.
When the main trigger event occurs, all OPC, UDP and Synthetic calculated channels are stored.
After that, the main recording event has been detected and the other group thresholds are continuously evaluated.
A pre-trigger buffer is also available. This means that the recording

SDMS alarm log

The LOG VISUALIZATION subpanel allows the User to see the historic list of all the alarm events and system events. A filter option provides the following features:

- Day filter.
- Start Time/Stop Time filter.
- Event Type filter.