Brüel & Kjær
BEYOND MEASURE

STREAMLINING DATA HANDLING IN NAVAL DEFENCE

Maritime defence company DCNS builds submarines, whose acoustic stealth is important. They process a huge amount of sound and vibration data, under time pressure – especially during costly sea trials. PULSE has revolutionized the speed and ease of performing tests, helping DCNS share and compare data around their organization.

CHALLENGE

Capturing, handling, sharing and comparing large data sets from diverse acceptance testing of new onboard equipment during land and sea trials

SOLUTION

- Organization-wide data acquisition platform coupled with a programmable software interface to automate application-specific GUIs
- Test database management software

RESULTS

- Significantly reduced measurement time
- Rapid recall of particular data from a huge database
- Easy comparisons across datasets

BACKGROUND

The critical stealth of submarines can be easily compromised with noise, making it vitally important to understand any problems early in the design stage rather than when at sea. New equipment such as fans, pumps, superchargers and motors must be vetted by a team of technicians and engineers. The vibration and acoustic signatures of this machinery is measured and analysed according to in-house standards, and matched up to stringent acceptance limits that ensure the repeatability of measurements, and thus reliable accept/reject criteria.

DCNS uses PULSE for acceptance testing of electro-mechanical equipment and for vibro/acoustic control of on-board systems. Sound and vibration assessment covers sound intensity, vibration, underwater acoustics, modal analysis, sound power and mobility.

These measurements are performed throughout the organisation, which totals over 13 000 employees worldwide, and at many different sites including Brest, Lorient, Nantes-Indret, Toulon and Cherbourg.

DCNS CHERBOURG

DCNS Cherbourg is the principal site for the manufacture of SNA attack and SNLE strategic submarines, where the Barracuda class programme is at work. Here, engineers have automated many of the PULSE measurement tasks using the versatile PULSE VBA/OLE 2 programming tools, and make comprehensive use of the PULSE Data Manager (PDM) in a client/server architecture to organise over 20 years' worth of data from many thousands of measurements.

DCNS PULSE LAN-XI systems:
- 1 unit at DCNS Indret with a customised front-plate for intensity measurements using two pairs of microphones at the same time
- 3 units at DCNS Brest
- 4 units at DCNS Lorient
- 1 unit at DCNS Saint-Tropez

PULSE

In an organisation like DCNS, with its diverse needs and expectations, the PULSE platform is expected to play many different roles. Different operations utilise PULSE for widely different applications such as acceptance testing, design, R&D, maintenance and troubleshooting. Measurements for sound intensity, underwater acoustics, radiated noise, vibration analysis, machine diagnostics and modal analysis are collected, processed, analysed, stored and managed by the PULSE platform.

DCNS has several PULSE systems in use at the DCNS Brest site for maintenance of SNLE (Sousmarin Nucléaire Lanceur d'Engins) strategic submarines and surface ships, and more systems are operated by the French Navy on board SNLE submarines. At the Lorient site, PULSE is in action for the design of naval systems and construction of surface ships. At Nantes-Indret, a 261-channel PULSE system played an integral role in the testing of the propulsion system of the latest SNLE strategic submarine.

PULSE front-ends are used as independent systems for machine diagnostics, modal analysis and intensity measurements. At the Cherbourg site, where submarines are constructed for the French Navy, DCNS has an extensive programme for acceptance testing and troubleshooting of all auxiliary equipment. For nuclear-powered strategic, attack, and conventional submarines, PULSE systems measure from microphones, accelerometers, hydrophones, intensity probes and force transducers.

CHALLENGES

Huge amounts of data

Measurements on equipment are made on board during harbour tests and sea trials, and in the workshop at the central office at CETEC (Centre d'Etudes Techniques et d'Evaluationde Cherbourg). The same equipment also needs to be tested on several different submarines. Coupling this with tests made for different operational conditions, different speeds and different pressures all leads to an extremely comprehensive test programme that needs significant data management. DCNS have customised and streamlined many of the measurement tasks, and now have many gigabytes of data stored on central servers from five years of tests.

LAN-XI is modular, allowing users to easily make portable units powered by a battery, or to collect modules together into large systems with hundreds of channels

"WHEN YOU CAN MANAGE THE DATA YOU CAN MAKE BETTER AND FASTER DECISIONS"

Arnaud Mesnil, Measurement Technician, Sound & Vibration Department

Under-sea testing is very expensive as it involves a lot of people and hardware – including an entire submarine – so decisions need to be taken quickly.

Strict in-house standards

Test reliability and data security are also very important as these ships rely on being undetectable, and therefore specific machine data is sensitive material. Submarine equipment suppliers are often not allowed on board, so DCNS employs strict in-house standards for the measurements, processing and handling of data that can substantiate the validity of measurements and accept/reject decisions without compromising data security.

AUTOMATING APPLICATION-SPECIFIC SETUPS

Setting up complex measurements in tight measurement time-frames is not a happy mix, so DCNS uses application-specific GUIs that confine the measurement process to just the necessary functions.

Using the versatile PULSE VBA/OLE2 programming tools they have developed intuitive, application-specific user-interfaces that automate PULSE operations for specific tasks. According to Arnaud Mesnill, "The VBA interface is an excellent tool for automating PULSE measurements, without necessitating an expert in application programming." Application-specific GUIs make the whole measurement process much easier and quicker – users just enter metadata, choose a few configuration parameters and press 'Start'. This saves valuable measurement time, especially for personnel not familiar with the standard PULSE user-interface, and removes the risk of incorrect measurement set up as it's all done for the user.

"THE VBA INTERFACE IS AN EXCELLENT TOOL FOR AUTOMATING PULSE MEASUREMENTS, WITHOUT NECESSITATING AN EXPERT IN APPLICATION PROGRAMMING"

Arnaud Mesnil

EXAMPLES

The following three application examples show how DCNS has designed time-saving solutions for its measurement programme. Each example shows how potentially complex time-consuming tasks can be turned into efficient, streamlined measurement procedures.

Automated sound power measurements

In the first example, Arnaud had the task of making a simple sound intensity measurement procedure that set up PULSE, informed the operator which faces on the object to measure, and converted and saved the intensity data in a format compatible with sound power calculation software.

To speed up measurement times, a specially built double sound intensity probe was used. The double intensity probe consisted of two pairs of microphones. One pair of ½-inch microphones spaced by 50 mm gave a frequency range of 63 to 1250 Hz, and one pair of 1/4 -inch microphones spaced by 6 mm for a frequency range of 500 – 10000 Hz. So in one sweep, they covered the whole frequency range of 63 to 10000 Hz, and the software then combined the two frequency ranges into one.

Hull measurements

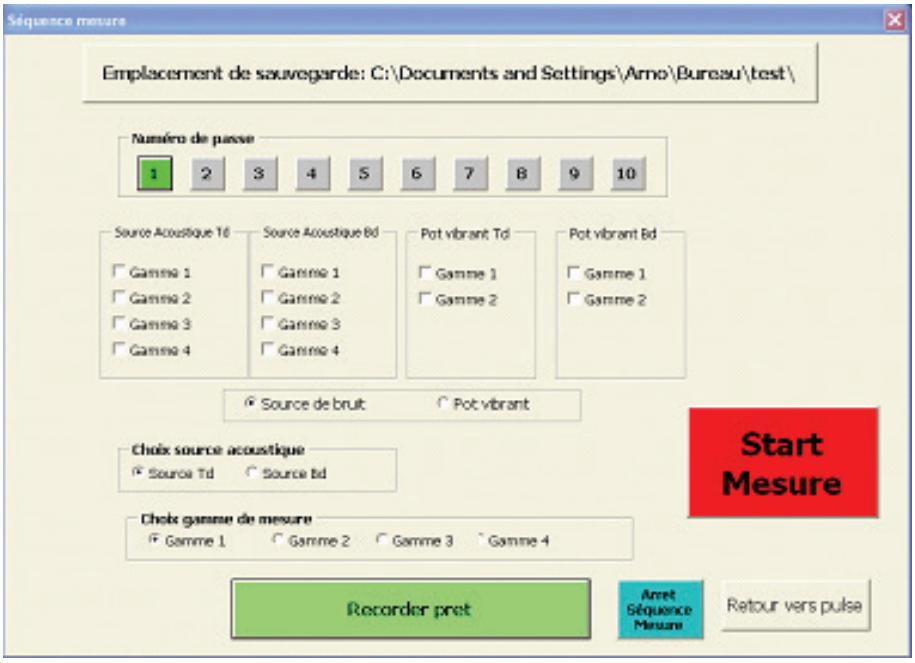
In this example, measurements had to be made at high tide to ensure uniform measurement, requiring over 400 accelerometer and hydrophone measurements on a hull – all while time is limited by the tide and number of transducers.

The test necessitated recording the signals from 16 hydrophones and 400 accelerometers, using 40 accelerometers at a time and using four sources of excitation – two acoustic sources and two shakers – over several frequency spans. Automating the data collection by PULSE meant that what had previously taken five days could be done in just two sessions.

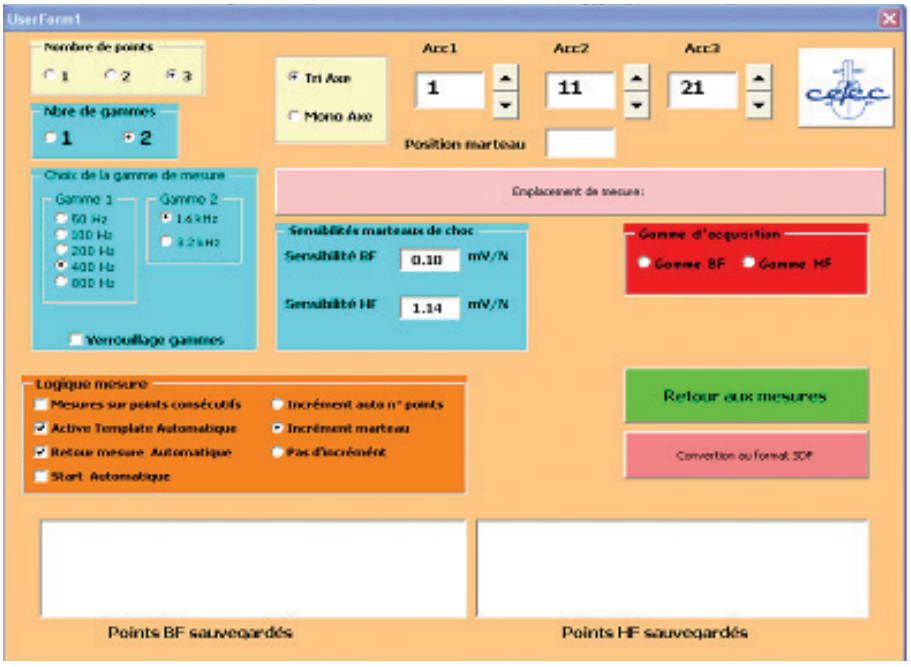
Mobility measurements

Here, the task was to carry out a large number of mobility measurements on a submarine diesel platform. The measurements had to be made under silent conditions as some measurement points were located on the submarine hull, necessitating cooperation throughout the ship, and a tight timeframe. A user-friendly measurement GUI set up the modal measurements, and saved the data using a format compatible with modal analysis calculation software. From this user-interface, the user could quickly set up and configure the following:

- Measurements in 3-axes or 1-axis
- The type of hammer – one for low frequencies and another for higher frequencies
- The number of frequency spans to be measured, and the frequency span values
- The number of measurement points – up to 3 points in 3 axes simultaneously
- The location of hammer strike and position of the accelerometers
- Changes in the number and position of accelerometers after saving a measurement
- Autoscale of the measurement display for different frequency spans

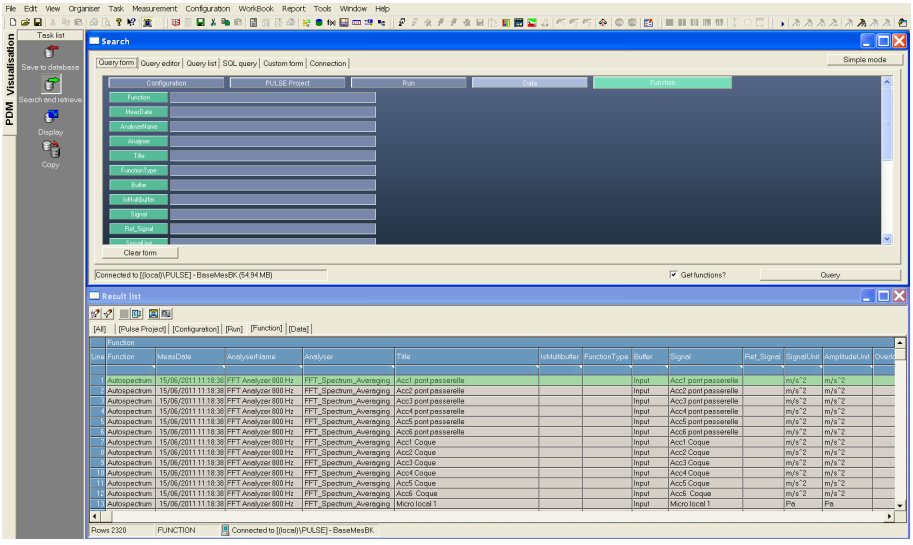


With an intelligent GUI, the whole test procedure was reduced to just selecting the measurement configuration and pressing 'Start Mesure'

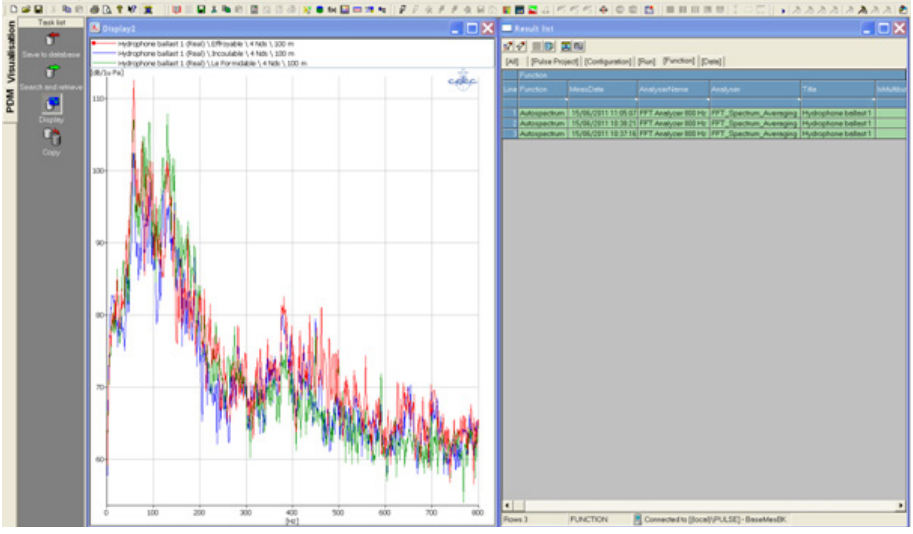


From this user-interface, the user could quickly set up and configure axes, frequency spans, measurement points, hammer strike locations and more

> "IF YOU WANT TO SEE DATA FROM A PUMP TESTED 5 YEARS AGO IT TAKES ABOUT 1 MINUTE!"
>
> *Arnaud Mesnil, Measurement Technician, Sound & Vibration Department*



At the end of the trials in this example there are 2320 functions to sort. It is easy to sort the result for one function at different speeds.



Dragging these functions into a modern display shows the results side-by-side. The same philosophy is used to easily compare the results of one sensor on three different submarines

RESULTS

Proper labelling and classifying of data becomes of paramount importance with such extensive measurement programmes. Data must be labelled with any available information on operator, location, test type, model, serial number etc.

This meta-data allows for easy search, retrieval and comparison of data. With PULSE Data Manager (PDM), all stored measurement data from PULSE and its applications are saved and labelled safely and orderly in a centralised database. This can be searched for and retrieved intuitively for display, comparison, calculation, further analysis, sorting and reporting.

During sea trials, on-board measurements can quickly be compared and correlated with those done on-shore, and conversely, factory measurements are easily correlated with on-board measurements. For example, workshop data can be easily compared with on-board measurements by searching on parameters such as machine serial numbers.

A properly organized SQL database means data retrieval in a matter of seconds, as opposed to hours in the 'old' way. Display results can be drag/dropped into live displays in Microsoft® Word reports, with active cursors and cursor values. Reports remain live, allowing one to use the cursors and change the display attributes, making reporting very easy and efficient.

Saving the data to the SQL database is a single-click operation, even with large amounts of data from many analyzers and many channels. Queries can also be initiated and defined in SQL, providing easy remote access to data. Data can also easily be exported to PDM in UFF format for easy comparison with PULSE measurements.

CONCLUSION

The ability to tailor interfaces to the specific requirements of individual tasks is now essential for efficient operation. According to Arnaud, "Measurements that took five to six hours can now be completed in less than two hours."

In addition, the easy-to-use VBA interface is an excellent tool for automating PULSE measurements, removing the need for any expertise in application programming.

As for the PULSE Data Manager itself, it has proven itself equally invaluable to DCNS, handling a huge amount of data easily and intuitively. "It gives increased productivity through easy access to data," explains Arnaud. "If you want to see data from a pump tested five years ago, it takes about 1 minute! When you can manage the data you can make better and faster decisions."

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> *Arnaud Mesnil, Measurement Technician, Sound & Vibration Department*

SNLE submarine "Le Téméraire" at Cherbourg

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