

CASE STUDY

Norway

Kongsberg Defence & Aerospace Modal Analysis and Vibration Testing

Defence and Aerospace Industries

PULSE, Software, Transducers

With its headquarters in Kongsberg, Norway, Kongsberg Gruppen is an international technology corporation that focuses on two main business areas – Maritime and Defence. The group's products are based on the four core competencies of signal processing, cybernetics, software and systems integration. With a staff of 4000 employees, Kongsberg Gruppen is represented in more than 20 countries and works extensively with many leading international corporations. The major shareholder is The Norwegian State.

Within the defence industry, Kongsberg Defence & Aerospace AS is one of Norway's leading high-tech defence suppliers. It has diversified activities covering several defence and aerospace related markets and product areas.

The Naval Strike Missile Program was commenced in 1997 and is now in the final stages of development. Brüel & Kjær PULSE™ systems and transducers are used in the mechanical testing of complete missiles, components and systems.



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Kongsberg Defence & Aerospace

The history of Kongsberg Gruppen dates back to 1814 when the weapons factory, Kongsberg Våpenfabrikk, was founded. The company takes its name from the town of Kongsberg, about 50 miles (80 km) south-west of Oslo.

Today, as a part of the Kongsberg Group, Kongsberg Defence & Aerospace (KDA) shares this idyllic location with its sister company Kongsberg Maritime. KDA is Norway's largest defence equipment manufacturer and its diversified activities cover a number of markets related to the high-tech defence and aerospace industries.

KDA's main areas of activity are:

- Missiles
- Aerospace
- Dynamic systems
- Air defence
- Underwater systems
- Defence communication

The company has some 1500 employees and has a wealth of expertise and application knowledge gained over many years from managing demanding and complex projects. A commercially driven business, KDA cooperates extensively with leading global companies that work in the defence and aerospace industries.

Naval Strike Missile – NSM

Fig. 1
KDA's new Naval Strike Missile can be deployed from ships, helicopters, aircraft and from land-based launch facilities



The Naval Strike Missile (NSM) illustrates KDA's development of advanced weapon systems. Shown on the front cover during a test firing, NSM is in development for the Royal Norwegian Navy. It is an autonomous, all-weather, terrain-following, long-range, precision standoff missile. The missile is designed to destroy high-value, well-defended targets on land and at sea.

NSM's passive intelligent imaging infrared seeker is a totally new design. It includes real-time image processing for unique target recognition and classification, advanced target selection, ability to discriminate target ships from nearby landmasses or other ships, and countermeasure immunity.

The multimission NSM can be deployed from naval vessels, helicopters, aircraft and land-based trucks.

Core Expertise

KDA's specialists are its core ability to design, develop and manufacture state-of-the-art products and systems for the highly demanding defence and aerospace industries. The combined resources available within the Kongsberg group, and its 4000 employees, gives KDA enviable resources and facilities.

Fig. 2
Mitchell A. Bitney is
Head of
Mechanical Testing
for the Missiles and
Space Department



Mitchell A. Bitney is Head of Mechanical Testing for the Missile and Space Department. He has a Bachelor's Degree in Mechanical Engineering from The University of Minnesota, and a Master's Degree in Energy and Environmental Management from The International School of Management, Sandvika, Norway. Mitchell has worked at KDA for 4 years.

Mitchell says, "We have a staff of 11 people in the mechanical testing department. The people in group have specialised backgrounds and experience. Two people with structural analysis backgrounds are dedicated to test and analysis of shock and vibration including modal testing.

Three others work in the mechanical workshop and fabricate models, test fixtures and jigs, and set up test arrangements and perform testing. The rest of the group are test engineers who manage, perform and analyse tests at various levels of complexity".

"We carry out development and verification testing for many groups working within KDA. Currently, our prime responsibility is mechanical testing of the new Naval Strike Missile (NSM) system. We are also working on a number of other projects, for example, the unfolding antenna for the Mars Express mission, the separation mechanism for the Ariane 5 launch vehicle, remote weapons systems for the US Army, components for the Eurofighter, and testing advanced composite materials for use in many aerospace and defence applications."

Mechanical Testing

Fig. 3
Modal testing is
performed using
PULSE and
ME'scopeVES™.
The antenna is
excited by a TIRA
shaker



Mitchell explains, "Within my group, we carry out a variety of mechanical tests including vibration, modal analysis, shock and pyroshock testing. The test data is also used to verify mathematical modelling programmes".

The tests involve the measurement, control, monitoring and analysis of many parameters including force, acceleration, strain and stress. Voltages, temperatures, pressures, etc., are also recorded. The tests are often highly instrumented using large numbers of sensors and real-time telemetry. Quite frequently, the tests are also filmed with digital high-speed video.

"Emphasis is put in measuring local environment parameters for component and subsystems. We then design fixtures to recreate the correct boundary conditions and expose test objects to combined environments. Functional testing are often run during environment exposure", says Mitchell.

Target Tracking Program

This ship-borne defence system is a target illumination system currently in advanced development. KDA is responsible for developing the director mechanism (IDG) controlling the RF-emitting antenna. The Royal Norwegian Navy has ordered five new frigates that are currently being constructed. Two IDG units will be installed on each ship.

A variety of mechanical tests are made using PULSE. These include:

- Verification of finite element models
- Finding modal analysis parameters using PULSE and a TIRA shaker or modal hammer together with ME'scopeVES™
- Shock testing to MIL 901 standard – Time Capture
- Vibration testing according to MIL 167 standard – FFT

Mitchell says, “The TIRA shaker is driven by the generator module in PULSE. We excite the structure in as many ways as possible using different levels of random flat spectrum excitation”.

“A MIL standard suggests ways of predicting the life cycle. We can use multibuffers, store the spectra and analyse their evolution for future fatigue analysis input. Modal testing is used in development and verification of the finite element models. Non-linearity related to couplings and connections are tough tasks where modal testing has shown to be a strong tool. A secondary effect of using modal testing is better communication and understanding between test engineers and structural analysts”.

He adds, “PULSE and the modal testing software have given us good results in this area. By providing accurate test data, we can substantially increase the accuracy of the forced response predictions using mathematical models”.

PULSE

Mitchell says, “We bought the first PULSE system in 2000. Our original requirement was for 48-channels and we wanted a Windows®-based system rather than Unix. Brüel & Kjær, at that time, had a maximum of 32-channels using DSP cards. After some discussions, we visited Brüel & Kjær, Nærum who presented its ‘roadmap’ which included a system with a higher channel count in the near future. As a result of the meeting and our previous good experience with Brüel & Kjær, we purchased a 32-channel PULSE system with the option to upgrade to a higher channel-count system when it was ready”.

“Although the original PULSE system worked fine, our experience led to the need for both a larger and more flexible solution. The new portable PULSE front ends satisfied both requirements and therefore we decided to upgrade to a portable PULSE system. We currently have two PULSE front-ends – one with 29 channels and the other with 6/1-channels. If required we can stack the systems together, giving us a total of 36 channels. Or we can use them separately if less analysis capacity is needed. It's very practical and flexible having this capability. The portability of PULSE makes it very easy to take to other sites and PULSE is used very frequently.”

KDA has a variety of PULSE software applications including:

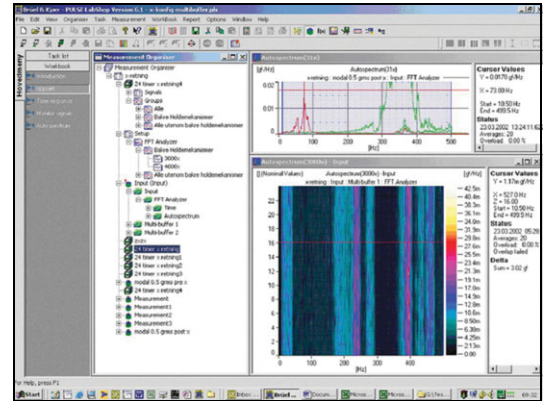
- FFT & CPB Analysis Type 7700
- ME'scopeVES™ Type 7754
- PULSE Bridge to ME'scopeVES™ Type 7755 A
- Time Capture Type 7705
- Data Recorder Type 7701

Fig. 4
A typical PULSE display – vibration testing over a 24-hour period. The structure is excited by the TIRA shaker. The test reveals any changes in the structure’s resonance caused e.g., by loose parts

Modal Test Consultant™ Type 7753 is being evaluated.

Mitchell says, “We make very few repetitive tests and therefore it’s important to have a data acquisition system that is fast and easy to set up. We send our people on advanced, dedicated courses held at Brüel & Kjær’s head office in Denmark and we are very satisfied with the training and the instructors.”

KDA has more than 100 accelerometers, many of which are from Brüel & Kjær. A Calibration Exciter Type 4294 is used for accelerometer performance validation. KDA has created an Access database in which the specifications of all transducers are entered. This is downloaded to PULSE.



The Future

Mitchell says, “Just having PULSE is opening up future opportunities for noise and vibration testing. The needs for vibration, modal and shock testing are likely to grow. We are also considering acoustic testing using PULSE. We continually work to understand more of the fundamentals of modal analysis and to develop our knowledge”.

He concludes, “With our advanced technology and expertise, we are considered as an important resource within KDA – a valuable tool”.

Key Facts

- Kongsberg Gruppen is an international technology corporation that focuses on Maritime and Defence applications
- The group has about 4000 employees and is represented in more than 20 countries
- Kongsberg Defence & Aerospace AS (KDA) is a leading defence supplier and is recognised as Norway’s leading high-tech company
- KDA’s main areas of activity are missiles and aerospace, dynamic systems, air defence, underwater systems and defence communication
- Extensive mechanical testing is carried out using PULSE, a TIRA shaker, modal hammer and accelerometers – vibration, modal analysis, shock and pyroshock
- “Brüel & Kjær’s name stands for ‘quality’ and we wanted a Windows®-based system”
- “It’s important to have a data acquisition system that is quick and easy to set up”
- “PULSE opens up future opportunities for noise and vibration testing”
- “With our advanced technology and expertise, we are considered as an important resource within KDA – a valuable tool”