

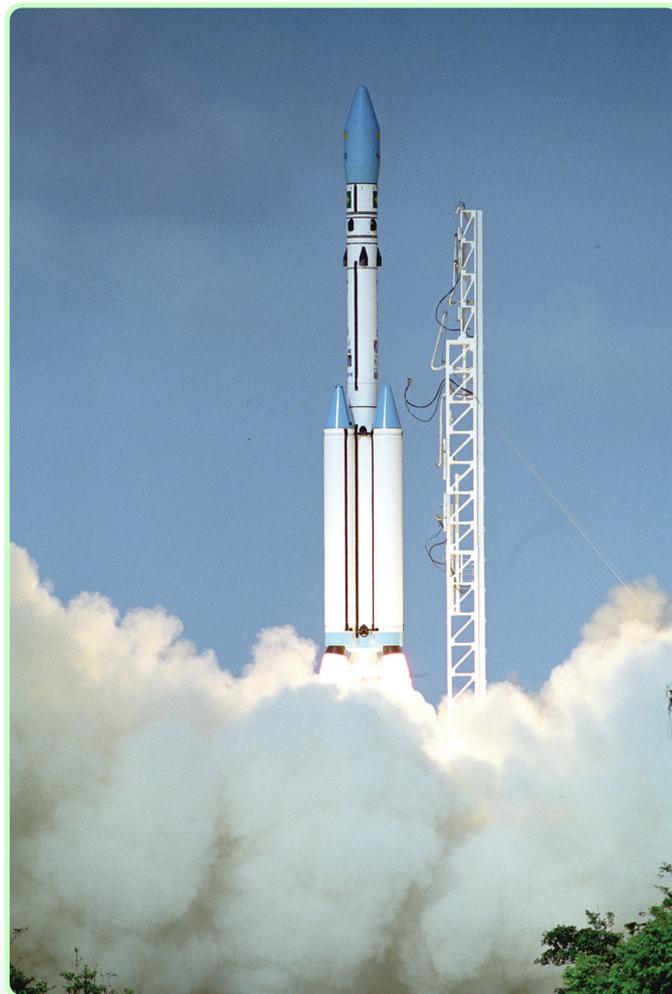
# CASE STUDY

## DCTA – The Department of Aerospace Science and Technology

Brazil  
Aerospace & Defence  
PULSE, LDS Shakers, Transducers

*The Department of Aerospace Science and Technology (DCTA) is the Brazilian national military research centre for aviation and space flight. DCTA is subordinated to the Brazilian Air Force and coordinates all technical and scientific activities related to the aerospace sector. Noise and vibration testing play a vital role in many phases of operations and DCTA benefits from Brüel & Kjær's complete measurement solutions. They have a large installed base of Brüel & Kjær products ranging from shakers for environmental and structural testing, noise and vibration sensors for a wealth of applications from rugged flight-testing to highly sophisticated laboratory use, multichannel data acquisition and analysis platforms, and an enormous range of noise, vibration and shock software application packages.*

*Photos courtesy of DCTA*



## DCTA and Brüel & Kjær – a Long and Fruitful Relationship

The Department of Aerospace Science and Technology (DCTA) is the Brazilian national military research centre for aviation and space flight. DCTA is subordinated to the Brazilian Air Force and coordinates all technical and scientific activities related to the aerospace sector in which there are interests by the Ministry of Defence.

DCTA's interests within the world of noise and vibration are multifold and they have greatly benefited from a long-term and close relationship with Brüel & Kjær. With operations covering everything from validating equipment for transport, launch and flight-path loading, high quality, efficient testing is vital.

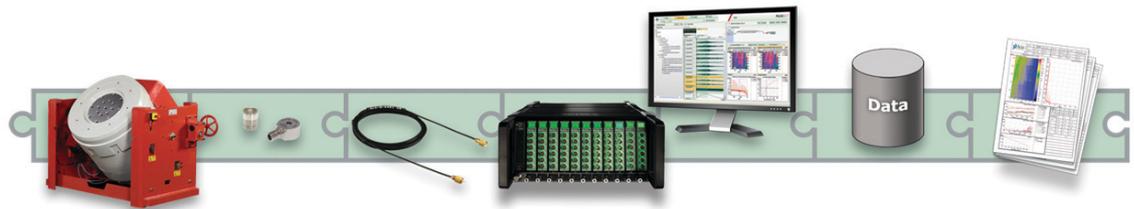
Noise and vibration testing plays a vital role in many phases of operations, and DCTA benefits from the complete measurement solutions offered by Brüel & Kjær. They have a large installed base of Brüel & Kjær products ranging from shakers for environmental- and structural testing, noise and vibration sensors for a wealth of applications from rugged flight-testing to highly sophisticated laboratory use, multichannel data acquisition and analysis platforms, and a huge range of noise, vibration and shock software application packages.

The Brüel & Kjær/DCTA relationship goes back many years and, with the LDS and Brüel & Kjær merger at the end of 2008, the relationship has become even stronger. Local Brüel & Kjær expertise, with full service and calibration facilities, further provides the fundament for a long-lasting relationship, providing CTA with high quality, goal-focused, time- and cost-efficient testing solutions.

The Institute of Aeronautics and Space (IAE) (Instituto de Aeronáutica e Espaço) is a division of DCTA and develops projects in the aeronautical, aerospace and defence sectors. IAE is co-responsible for the execution of the Brazilian Space Mission – working on projects such as the VLS-1 Launcher, which is designed to launch small satellites into low earth orbit. IAE also supports the Brazilian Air Force with, for example, flight test capabilities. They also provide launch capabilities for microgravity experiments supporting the VS-30 and VS-40 launchers.



## DCTA's Impressive Range of Brüel & Kjær Solutions



Satellite and launcher testing is a multidisciplinary operation. Environmental vibration/acoustic durability testing is paramount to ensure that structures and equipment can survive a launch; SRS analysis determines shock response properties of structures; modal testing facilitates the understanding and optimisation of dynamic properties of structures; vibration qualification testing provides system and component acceptance testing.

**Fig. 1**  
The LDS V994 shaker

The systems necessary to cover such a diversity of tests range from shakers for environmental and structural testing; flight-tested and laboratory noise and vibration sensors; high-speed, multichannel data acquisition and analysis platforms, and an enormous range of noise, vibration and shock software application packages.

DCTA has several LDS Shakers and Controllers for standard vibration testing of electronic equipment. Recently DCTA purchased the largest LDS shaker on the market, the V994. The V944 Shaker was tested in Brüel & Kjær's Royston office in the UK and shipped to Brazil, where it now awaits installation following the completion of DCTA's newest test facility.



With well over 100 channels of PULSE IDA<sup>e</sup> front-ends (in 17 frames), some 66 channels of LAN-XI modules, and a wide range and number of acoustic and vibration sensors to match, DCTA are in a position to carry out all relevant noise and vibration measurement/analysis tasks. Backed by PULSE application packages LabShop, Operational Modal Analysis (OMA), Modal Test, Reflex Shock Response Analysis and Data Manager, DCTA are in a position to carry out relevant noise and vibration testing and qualification of satellites, space launchers and their components.

## Launcher and Satellite Noise and Vibration Testing

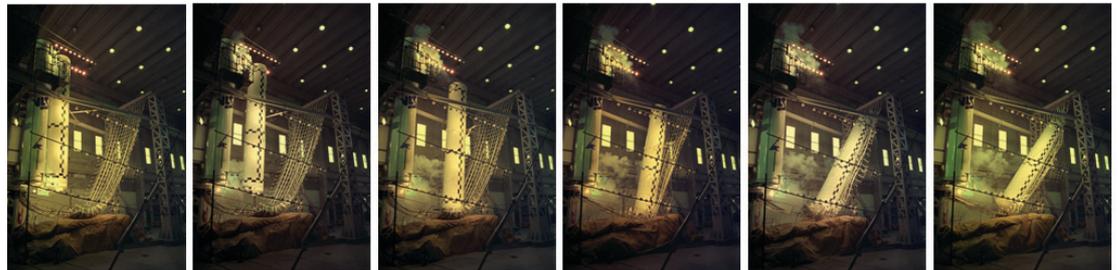
The demands placed upon a rocket and its payload are severe during rocket launch. Launchers generate extreme noise and vibration and, at separation stages, pyroshocks cause additional severe loading of the launcher.

Validating equipment for launch is, therefore, not a small task. Testing must be made at all stages of the product – during development to provide qualification of finite element models, during qualification and acceptance testing to validate the design via extensive vibration testing. DCTA provides for the complete on-board measurement and telemetry systems, and can perform dedicated launcher tests such as separation tests, firing tests and transportation tests.

### Separation Tests Using Shock Response and Modal Analysis

DCTA (IAE) is tasked with the upcoming separation test of the VGLS-1 Launcher and plans to use an 80-channel PULSE system for shock, PULSE Reflex SRS applications and 60 channels for vibration. PULSE OMA will be used to analyze the pyroshock and the response in additional detail.

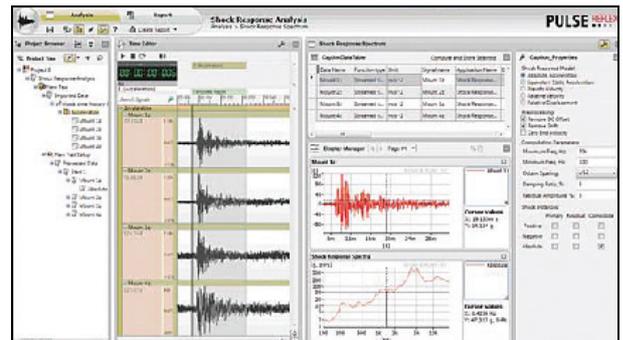
**Fig. 2**  
Separation testing



### PULSE Shock Response Spectra

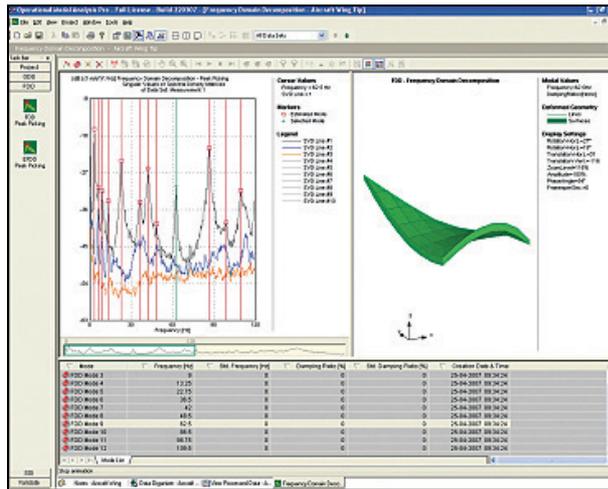
PULSE Shock Response Analysis Type 8730 computes the shock response spectrum (SRS) from transients in the time domain in order to determine the damage potential of transient events such as pyroshock.

A transient (shock) event, such as pyroshock or a structural impact, has the potential to damage components in a structural system. Just as with any motion input to a system, the response can be amplified by structural resonances, increasing the damage potential.



The aim of the SRS calculation is to convert motion input to a set of single degree of freedom (SDOF) damped oscillator responses calculated in the time domain. The response amplitudes of the oscillators are plotted as a function of SDOF frequency to produce the shock response spectrum.

## PULSE Operational Modal Analysis



PULSE Operational Modal Analysis Type 7760 is an analysis tool for effective modal identification in cases where only the output is known. The software allows you to perform accurate modal identification under operational conditions and in situations where the structure is impossible or difficult to excite using externally applied forces.

Experimental modal analysis is the process of using experimental data to determine the modal parameters (natural frequency, damping ratio, and mode shape) of a structure for the modes in the frequency range of interest. The mode shape is the deflection pattern that represents the relative displacement of all parts of the structure for that particular mode.

Modal parameters are important because they describe the inherent dynamic properties of a structure. The set of modal parameters constitutes a unique set of numbers that can be used for model validation and updating, design verification, benchmarking, troubleshooting, quality control or structural health monitoring.

In Classical Modal Analysis, the modal parameters are found by fitting a model to Frequency Response Functions (or Impulse Response Functions) relating excitation forces to vibration responses. In Operational Modal Analysis (OMA), the modal identification is based on the vibration responses only, and different identification techniques are used.

### Launcher Firing Tests Using Operational Modal Analysis

During launcher firing tests, OMA is used to validate the excited modes of the launcher during the ignition and burning phases.

Also during the firing test, noise data is obtained to validate/investigate/understand in detail the influence of noise on the thermal protection of the engine, and to correlate with the models for lift-off noise.

**Fig. 3**

Launcher in support structure before firing test (left); during the launcher firing test, Brüel & Kjær Microphones Type 4956, Preamplifiers Type 2670, and a PULSE data acquisition system are used to obtain noise data (right)



### Launcher Transportation Test Using Vibration Durability Testing and Operational Modal Analysis

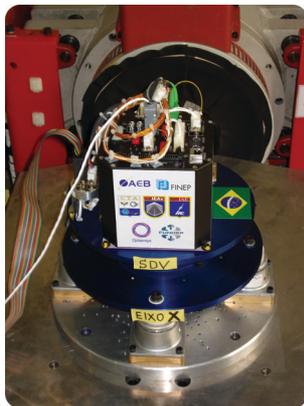
Part of the environmental test program of a launcher is the transportation tests, covering packaging, loading, flight- and road-transport.

PULSE Operational Modal Analysis is used to validate the vibration level and natural excited modes of the launcher throughout these phases.

### Component Testing Using Vibration Shakers

DCTA (IAE) performs environmental testing services for internal and external customers. Environmental testing is required to verify reliability and flight safety requirements.

DCTA has several LDS shakers and a Dactron vibration control system to answer local demands for the different space programs, aerospace and automotive applications it is involved in.



### Flight Tests Using Modal Analysis

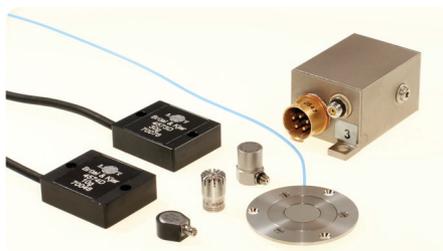
DCTA (IAE) also provides flight test services for the Brazilian Air Force, testing modifications on aircraft and helicopters and re-establishing flight envelopes.

As part of these services, Classical and Operational Modal Analysis (OMA) was carried out on a modified and unmodified helicopter during on-ground and in-flight tests.

The tests made it possible to identify any critical modes that would significantly influence the structural and aerodynamic behaviour of the helicopter, with consequential maintenance and safety issues.



### Launch Telemetry Using Acoustic and Vibration Sensors



Brüel & Kjær is working closely with DCTA to deliver a range of sensors and airborne amplifiers to provide critical flight data to their on-board telemetry system for the VLS-1 satellite launch vehicle program.

### Missile Firing Tests Using Operational Modal Analysis

DCTA (IAE) is involved in missile firing tests that are performed on the ground and validated in-flight using Operational Modal Analysis. The missile flight profiles are loaded into the shaker controller to verify all environmental conditions of the DCTA-developed missiles during flight.

These tests assist and help design the interface between the missile and the aircraft.