

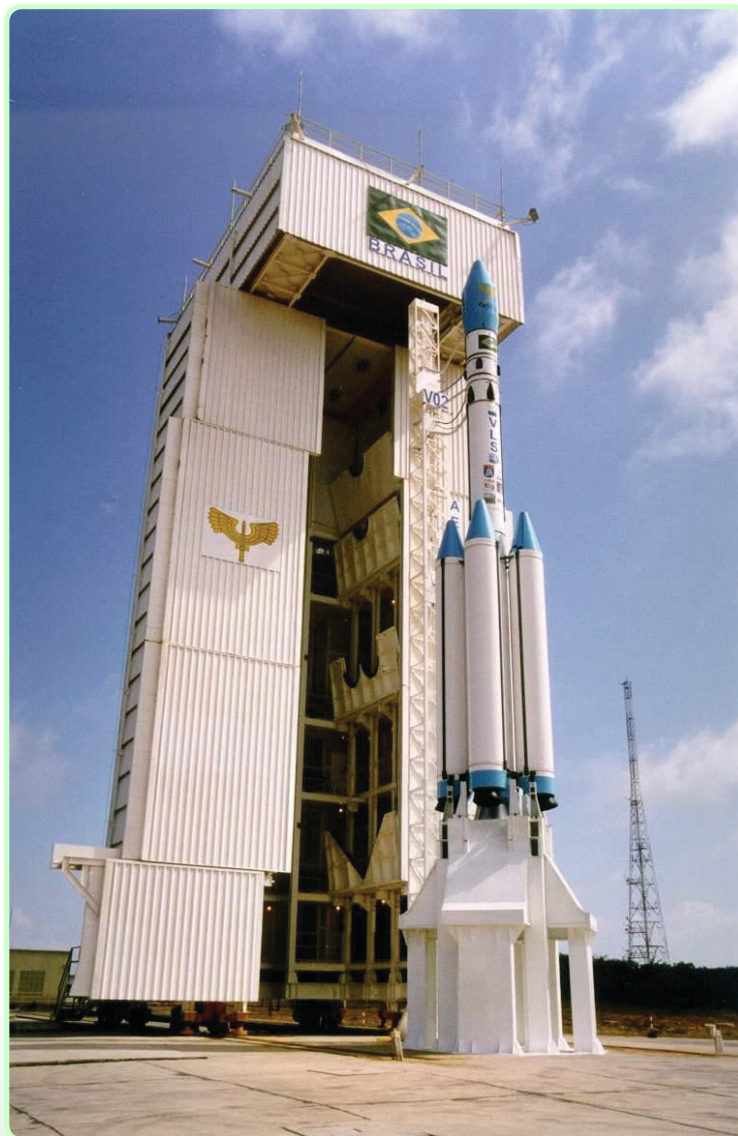
CASE STUDY

Sensors and Airborne Amplifiers help DCTA Launch the VLS-1 Rocket

Brazil
Aerospace & Defence
Charge Amplifiers, Transducers, Calibration

Brüel & Kjær is working closely with the Institute of Aeronautics and Space (Instituto de Aeronáutica e Espaço, IAE) division of Brazil's Department of Aerospace Science and Technology (DCTA) to deliver a range of sensors and airborne amplifiers to provide critical flight data for their on-board telemetry system for the VLS-1 satellite launch vehicle program. The VLS-1 rocket is designed to launch small satellites with payloads ranging from 100 – 380 kg for equatorial circular orbits and 75 – 275 kg for polar circular orbits.

Photos courtesy of DCTA



Introduction

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The demands placed upon a rocket, its payload and the launch pad are extreme during rocket launch. Launchers generate extreme noise and vibration with intense acoustic loads being experienced during launch, lift-off and the transonic climb phase. During the launch, the separation stages, pyro-shocks, cause additional shock and vibration to the launcher.

To ensure/document that the environmental parameters experienced by the payload do not exceed design criteria, on-board telemetry systems measure critical noise and vibration parameters.



About DCTA

The Department of Aerospace Science and Technology (DCTA) is the national military research centre for aviation and space flight of Brazil. It is subordinated to the Brazilian Air Force, The Ministry of Defence.

Established in 1953, DCTA coordinates all technical and scientific activities related to the aerospace sector and in which the Ministry of Defence has an interest. It currently employs several thousand civilian and military personnel.

The Institute of Aeronautics and Space (Instituto de Aeronáutica e Espaço, IAE) is a division of DCTA and develops projects in the aeronautical, aerospace and defence sectors. It is co-responsible for the execution of the Brazilian Space Mission.



The VLS-1 Programme

The VLS-1 programme is of significant importance for Brazil as it will consolidate essential technologies for launchers and satellites.

The VLS-1 four-stage rocket is designed to launch small satellites, with payloads ranging from 100 – 380 kg for equatorial circular at altitudes ranging from 200 to 1200 km, and 75 – 275 kg for polar circular orbits at altitudes ranging from 200 to 1000 km. The rocket is 19 m long, has seven motors and has a total take-off weight of 50 tons.

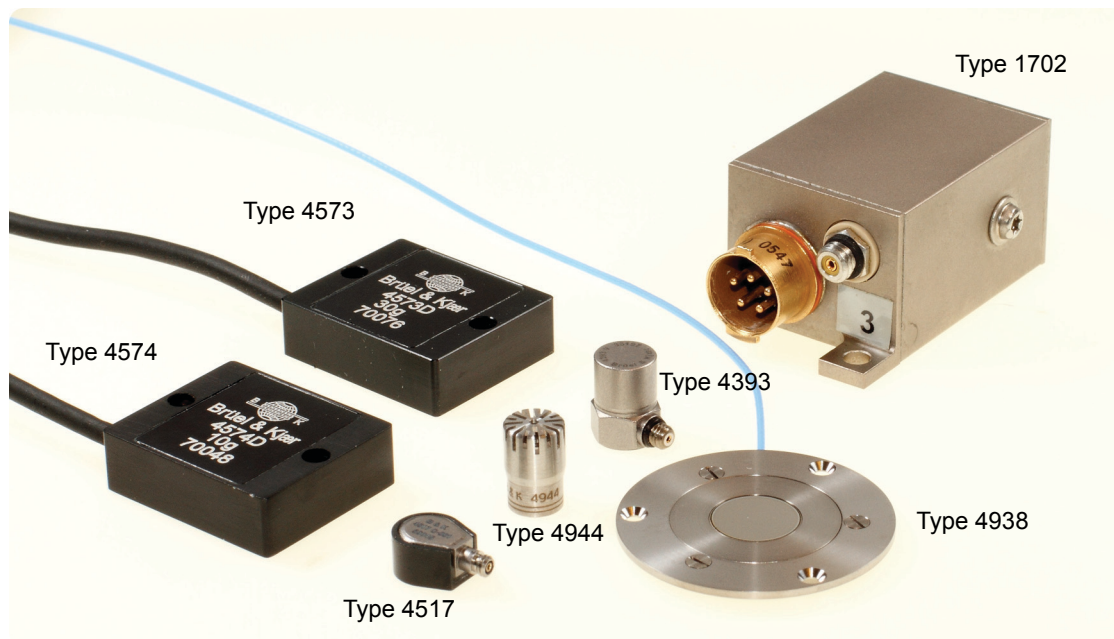
Currently, the VLS-1 programme is in the flight qualification phase, with a technology flight planned for 2012 to qualify the vehicle for commercial launch operation. Once qualified, it will put Brazil in the exclusive group of countries with satellite launching capabilities.

DCTA and Brüel & Kjær Cooperation on the VLS-1 Programme

On-board measurements on a launcher are complex and DCTA has chosen to work with Brüel & Kjær to provide state-of-the-art noise and vibration sensors and amplifiers to provide critical flight data of the launcher to its on-board telemetry system OMC (On-board Measurement Complex).

The OMC telemetry system monitors parameters for multiple conditions – structural and static vibration, and linear, shock and noise lift-off measurements. Two sets of parameters are monitored – OMC-1, which is the standard telemetry system for both the qualification and the future standard operational flight, and OMC-2, which is an additional set of parameters added for the qualification flights only.

Fig. 1
The acoustic and vibration sensors supplied to DCTA



Structural Vibration

For structural vibration measurements (5 Hz – 2000 Hz), the Brüel & Kjær piezoelectric shear accelerometer with side connector Type 4517-W-004 is used. It has an anodized case providing excellent electrical insulation and a low weight making it an excellent choice for measurements on delicate structures.

Type 4517 is used in combination with the Brüel & Kjær Charge Amplifier Type 1702-X in a number of versions with different sensitivities (see table below).

Type	Sensitivity	Frequency Range	Preset Sensitivity
1702-A	5 to 50 mV/pC	5 Hz to 1 kHz	10 mV/pC
1702-B	5 to 50 mV/pC	5 Hz to 2 kHz	10 mV/pC
1702-C	0.2 to 2 mV/pC	5 Hz to 5 kHz	1 mV/pC
1702-D	0.2 to 2 mV/pC	5 Hz to 2 kHz	1 mV/pC
1702-E	0.1 to 1 mV/pC	5 Hz to 5 kHz	0.5 mV/pC

Charge Amplifier Type 1702-X is primed for airborne applications and is designed and tested against the relevant MIL standards for Temperature, Humidity, Vibration, Shock and EMC. It is equipped with different filters to reduce the amount of data for the telemetry system. OMC-1 (5 – 2000 Hz) will need a total of 40 Types 4517 and 1702 and OMC-2 (5 – 1200 Hz) a total of 44.

Static Vibration

For static vibration measurements (DC – 50 to 60 Hz), Brüel & Kjær DC accelerometers are used to define the X,Y, Z flight positions of the launcher for comparison with GPS data. These units are used in combination with a DCTA-made amplifier to reduce the amount of data for the telemetry system. DC Accelerometers Types 4573-D and 4574-D provide high thermal stability, a wide dynamic range and very stable frequency response

Shock

For shock measurements (up to 4 kHz), a Brüel & Kjær Charge Accelerometer Type 4393-V is used in combination with Charge Amplifier Type 1702-X. Two dedicated control points are included to manage potential spikes in the measurement systems, a control point is used to distinguish between a true physical shock (up to 2000 g) and an electrical problem (up to 9000 g).

Charge Accelerometer Type 4393-V is a DeltaShear® design involving three piezoelectric elements and three masses arranged in a triangular configuration around a triangular centre post. The ring pre-stresses the piezoelectric elements to give a high degree of linearity.

	OMC-1 (5 – 2000 Hz)	OMC-2 (5 – 1200 Hz)
4393-V + WB-3456-W-003	9	1
4393-V + WB-3456-W-005	0	1
Total	9	2

Lift-off Noise

Brüel & Kjær Type 4944 is a Prepolarized, Pressure-field, ¼-inch Microphone. A number of these will be installed on the launch pad, the launch pad service structure and on the launchers themselves (on both the inside and outside) to measure lift-off noise. They are specially designed for high-level and high frequency measurements. Brüel & Kjær Surface Microphones Type 4948 are designed for measurements on surfaces during flight and will be used on the outside of the launcher.

Measured data is used in the Equipment and Control Bay to determine the relation between internal and external noise transmission and to validate the attenuation material used to reduce both acoustic and vibration noise. For the engine, data is used to investigate the relation of noise on the engine and to understand in detail the influence of noise on the thermal protection.

Calibration Systems

A rocket launch is a one-shot measurement, so calibrated sensors are of the utmost importance. DCTA uses a Brüel & Kjær calibration system for both accelerometers and microphones.

Fig. 2

The Brüel & Kjær/DCTA team from left to right: Mr. Marcos F. Piai, Sales Manger Brüel & Kjær Brazil; Dr. Edilson Camargo PhD, Leader of the Dynamic Test Group; Dr. Rogerio Pirk PhD, Leader of the Acoustic Laboratory; Dr. Everaldo Barros PhD, Leader of the Modal Laboratory; Mr. Domingos Strafacci, Technician specialising in dynamics tests; Mr. Patrick Wethly, Aerospace & Defence Global Key Account Manager Brüel & Kjær



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