SPACE SOUNDS

The acoustic experts at d&b audiotechnik and the vibration control team at m+p international have come together to revolutionize the acoustic testing of satellites, greatly reducing time and costs

// BY HANS-JÜRGEN BORUTTA & TOBIAS WULF

When satellites are launched into space they are subjected to very high mechanical, thermal, electromagnetic and acoustic forces that may cause damage to electronic circuits, as well as to other components, thus jeopardizing their functioning. Satellites therefore undergo extensive stress tests before any space mission starts. To test their acoustic durability, satellites are often placed in a reverberant acoustic test facility (RATF), where they are subjected to extremely high sound pressure levels – the sound intensity and frequency range applied in this 'torture chamber' simulate real-world launch conditions.

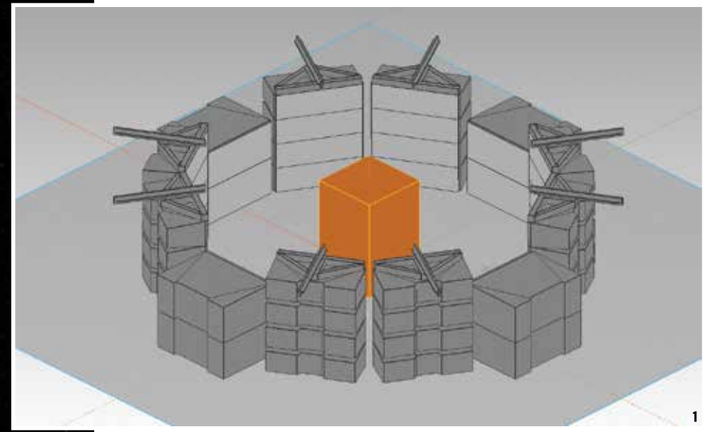
As this testing procedure is complex and very cost intensive, experts have for many years investigated alternative technologies that could produce similarly meaningful results with reduced efforts. Hence d&b audiotechnik, based in Backnang (near Stuttgart, Germany) and m+p international Mess- und Rechnertechnik, headquartered in Hannover, Germany, have decided to combine their unique expertise to present their Direct Field Acoustic Control System (DF-ACS) as an attractive alternative.

d&b audiotechnik's responsibility in this partnership includes loudspeakers, amplifiers and simulation software. The renowned manufacturer has decided to use its most powerful loudspeakers to meet the challenging requirements. The GSL8 array module is part of the SL series of loudspeakers. Its high Q factor offers a clear benefit for satellite testing: the high rear attenuation helps to avoid any unnecessary excitation of the environment.

"A challenge with satellite testing is to ensure the required homogeneity of the sound field," d&b application support specialist, Boris Rehders explains. "In the area around the test object, the field must be absolutely homogeneous even at extremely high levels. We need to reproduce frequencies in the range 18Hz to 12.8kHz – which means the bass area is extended far to the low range."

The d&b SL series also includes powerful subwoofers. As many as three loudspeakers per module emit sound to the front (2 x 21in) and rear (1 x 21in), resulting in a kidney-shaped radiation pattern.

Various aspects need to be considered to reproduce low frequencies with the required sound levels – excessive load would cause the moving coil to hit and damage the magnet. Also, the applied current needs to be monitored and limited if necessary as the moving coil could otherwise overheat and the copper wire might melt. The relevant parameters are monitored by the amplifiers, which are part of the d&b system and controlled if it is required.



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"THE SATELLITE IS SUBJECTED TO A 146DB SOUND PRESSURE FIELD"

1 // The loudspeakers are arranged in a circle around the test object to create a sound pressure field

TEST SETUP

Described by terms like 'loudspeaker-based direct field' or 'direct field acoustic excitation', the test setup is based on d&b loudspeakers that are circularly positioned around the device to be tested. The distance between the loudspeakers, the control microphones and the satellite is critical to achieve the required homogeneous sound pressure level. The test setups so far implemented by d&b and m+p international include 8 x 4 GSL8 plus 4 x 2 modified SL-SUB while 20 d&b D80 four-channel amplifiers are used to drive the output.

The test period during which the satellite is subjected to the 146dB sound pressure field is in most cases only one minute – an additional build-up time of one or two minutes is necessary for the system. The entire test preparation and setup may require a few days.

The test setup is simulated in advance by means of software. "The device to be tested is less than four meters (near field) from the loudspeakers, so it does not make sense to use simulation programs, which only calculate valid results for the far field," explains Rehders. "We are therefore constantly adapting the software to optimize the simulation processes for this special task."

NATURAL PARTNER

Headquartered in Hannover (Germany), m+p international Mess- und Rechnertechnik has decades of vital experience in the field of measurement and control technology, developing and manufacturing test and measurement systems for vibration testing, vibration analysis, data acquisition, process monitoring and test stand automation.

Products manufactured by m+p international meet the most sophisticated standards in terms of quality and reliability. The company's quality management system has been certified according to ISO 9001:2015; and it has a global coverage with subsidiaries in the USA, UK, France and China, plus representatives in another 30 countries. With its measurements systems, m+p international is considered the market leader for reverberant chamber excitation – large test rooms with high reflection characteristics that are designed for special measurement purposes.

The proven m+p VibRunner measurement hardware platform is used for satellite testing as it is an ideal tool for dynamic measurements and vibration tests where precise and efficient testing is a top priority. Each m+p VibRunner mainframe accommodates up to 24 input channels with A/D converters (24bit resolution, up to 204.8kHz sample rate). Several m+p VibRunner mainframes can be daisy-chained to implement higher channel counts. An Ethernet interface is used for communication with the controller PC.

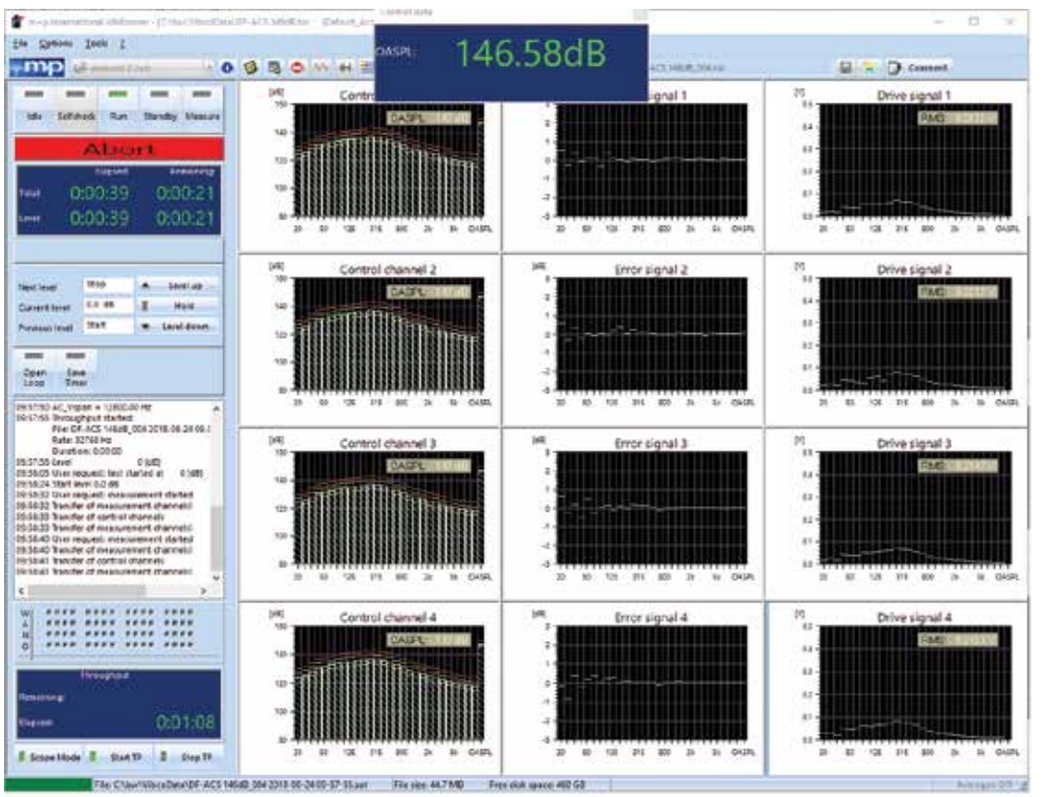
A number of incoherent closed loops are typical for this application: "The system is excited, measurements are taken, and the 1/3-octave bands are optimized while the overall level gradually increases," explains m+p international's team leader and senior development engineer, Raf Mangelschots.

"We need to make sure that all levels are correct – typically with a maximum deviation of 1dB per 1/3-octave band and 0.5dB for the overall sound pressure level."

The m+p VibRunner hardware is operated in combination with an updated version of the standard Acoustic Control System (ACS) software developed by m+p international. This software controls the complete test procedure and logs all steps of the process. Broadband random signals are used as excitation signals, with ANSI S1.11 certified octave or 1/3-octave time domain measurements used for control and analysis. This combination of m+p hardware and software, used with products supplied by d&b audiotechnik, is referred to as DF-ACS (Direct Field Acoustic Control System).

REVERBERANT CHAMBER VERSUS LOUDSPEAKER-BASED DIRECT FIELD

The installation of reverberant chambers specially designed for satellite testing is



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2 // m+p international's software controls the complete test procedure

"AN INTELLIGENT TEST SETUP MAKES TESTING INDEPENDENT OF ROOM"

very expensive and has high recurring operational costs. As a result, only a few such facilities are available on a global scale. Electro-pneumatic, high-intensity horns are typically used for sound generation, operated with either liquid nitrogen or compressed air.

The use of nitrogen is expensive and means personnel cannot enter the test chamber for considerable time after the completion of the test. Also, the horns have a maximum output frequency of 400-500Hz. Higher frequencies are generated through harmonics – the characteristics of which can only be controlled by very complex strategies.

These dedicated test chambers are therefore following an approach different from the direct field concept promoted by d&b and m+p international. Working in reverberant chambers, the reverberant (diffuse) field dominates in almost any frequency range, as provided the distance to the limiting surfaces is sufficiently large, the impact of the direct field is no longer as crucial.

The homogeneity of the field is primarily achieved by means of diffuse sound. The reverberation times of 15 or more seconds are extremely long. Standing waves can also become a problem mainly because of the use of frequencies below the Schroeder frequency; a distinct modal behavior has in many cases been observed in chambers between low and medium frequencies.

In contrast to the above issue, the satellite under test is not in the reverberant (diffuse) field when using the d&b and m+p international approach. In contrast, the amount of direct sound produced clearly prevails here while reverberant sound is negligible.

"Given an intelligent test setup, we are rather independent of the individual room acoustics, provided that there is a sufficient distance to the walls," argues Rehders, who sees this as a major benefit of DF-ACS.

"We have managed to reliably generate a homogeneous sound field according to the required specifications, without using any narrowband measurements involving inevitable errors," adds Mangelschots.

NO MORE COSTLY SHIPPING

The satellite test scenario developed by d&b and m+p international does not require any specially prepared environment or test stand. Considering certain specifications, a multitude of different rooms will instead suffice to ensure significant results that are accepted by experts. Satellites no longer need to be shipped hundreds of miles, and the costs and risks involved with such transport (including not only the material itself, but also the responsible engineers) are no longer necessary. Also saved is the rental cost for such special facilities, which may even be operated by a direct competitor.

The d&b and m+p international teams have been cooperating successfully on this new satellite test approach for three years. The contact between these two German companies, each a market leader in their special field, was initially established via the m+p international office in Verona, New Jersey. For d&b audiotechnik, the global business unit, including Ralf Köhler, Tobias Wulf and Eva Argandoña, has been the driving force for this project.

Since the first joint tests were performed in Asheville, North Carolina, in October 2016, four test campaigns have been successfully completed in cooperation.

"By now we are fully aware of the loudspeaker configuration which is the most suitable for each project, and there are only a few minor issues that we are currently optimizing," Rehders concludes with some satisfaction.

"There has been a steep learning curve over the past three years, and we have been able to exhaustively answer all questions in our test campaigns."

Mangelschots also sounds an optimistic note: "We have already sent out the first quotations. Our system is available, consistent and provides reliable results faster, better and more cost efficiently than other solutions.

"The countdown has started. We are ready with our DF-ACS!" \\

Hans-Jürgen Borutta is chief development engineer for vibration control and signal analysis with m+p international Mess- und Rechnertechnik GmbH; Tobias Wulf is global account manager with d&b audiotechnik