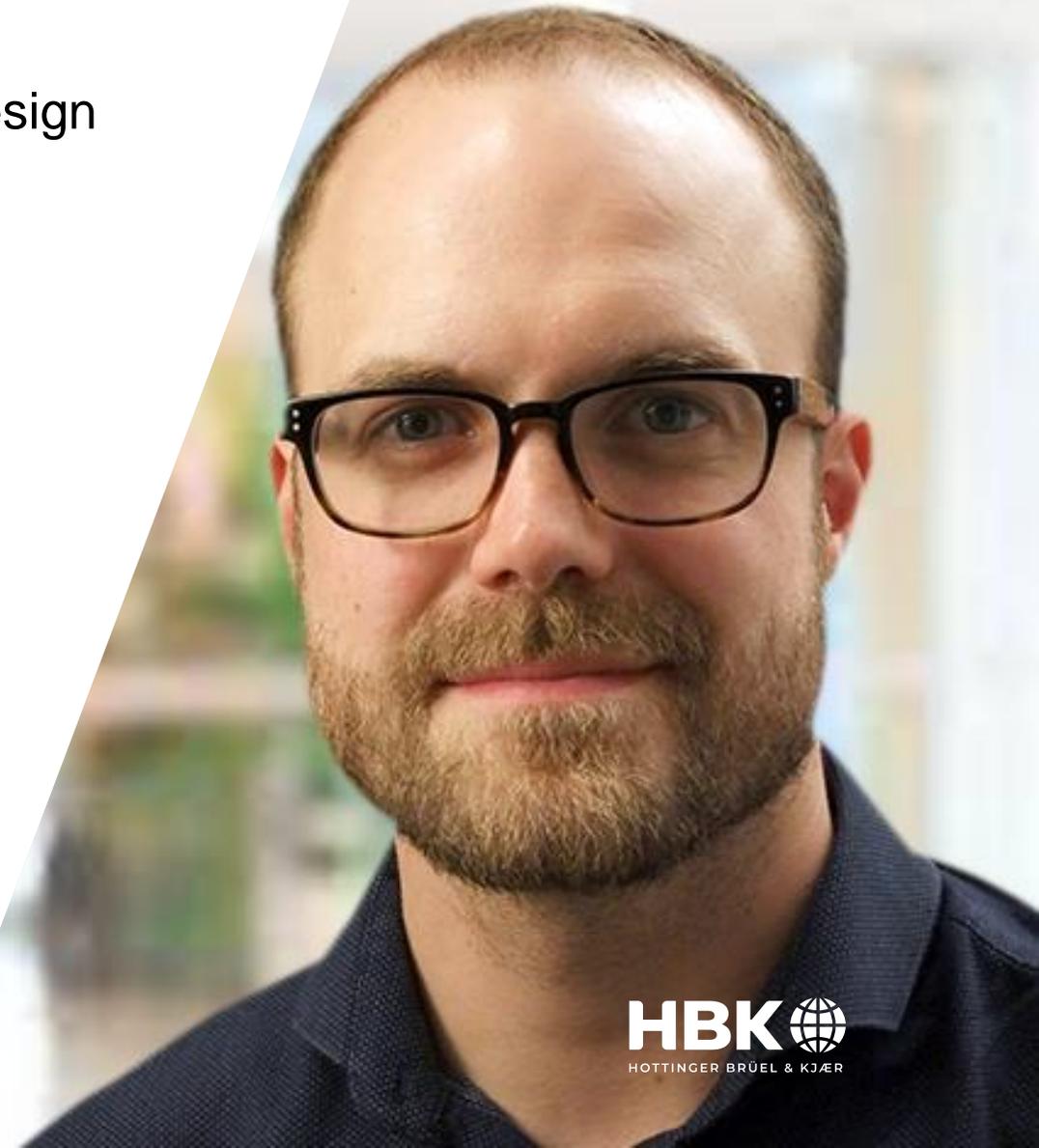


Welcome to the “An introduction into Shaker Systems” Webinar

Introductions – Brian Zielinski-Smith

- ▲ Bachelor of Sciences with Honours in Engineering Design
- ▲ Design engineer at Welding Alloys Ltd, UK
- ▲ Operations Manager at Welding Alloys Ltd, UK
- ▲ Product Manager at Welding Alloys Global
- ▲ Joined Brüel & Kjær in 2016 (based in Royston, UK)
 - Product Manager - Shakers & Amplifiers
 - Product Manager - Shaker Systems



Topics

1. A Brief History
 - How LDS Shaker Systems came to be, and core dates since
2. Shakers – The how
 - An introduction in to vibration testing and the theory behind it
3. Product Range
 - How the product range meets market demands
4. Applications
 - Typical applications across the market
5. Value Added Testing
6. Questions

A Brief History

- 1950 Original joint venture Pye-Ling moved to Royston, UK (LTV Ling Altec)
- 1970 Ling Dynamic Systems (LDS) founded from US and UK S&V businesses
- 1976 LDS began selling vibration test systems in the US market
- 1988 World's highest force 289kN water-cooled shaker (V994)
- 1988 Prince Charles opens the new building extension at the Heath Road works
- 2001 LDS acquires Dactron (vibration controller & analysis specialist)
- 2002 V9 shaker system launched
- 2003 V8 shaker system launched
- 2004 LDS changes its name to LDS Test and Measurement
- 2008 LDS Test and Measurement is acquired by Brüel & Kjær
- 2008 V875LS shaker system launched
- 2009 Supplied the V994 to NASA JPL for the testing of the Mars Rover (launched 2011)
- 2016 World's first 80 kN air-cooled shaker (V8900)
- 2019 Brüel & Kjær and HBM merge to form HBK



A Brief History

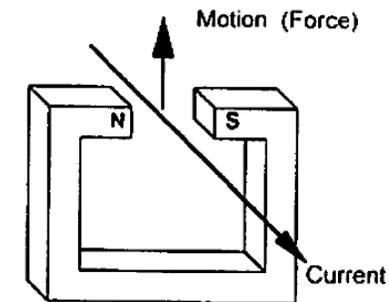
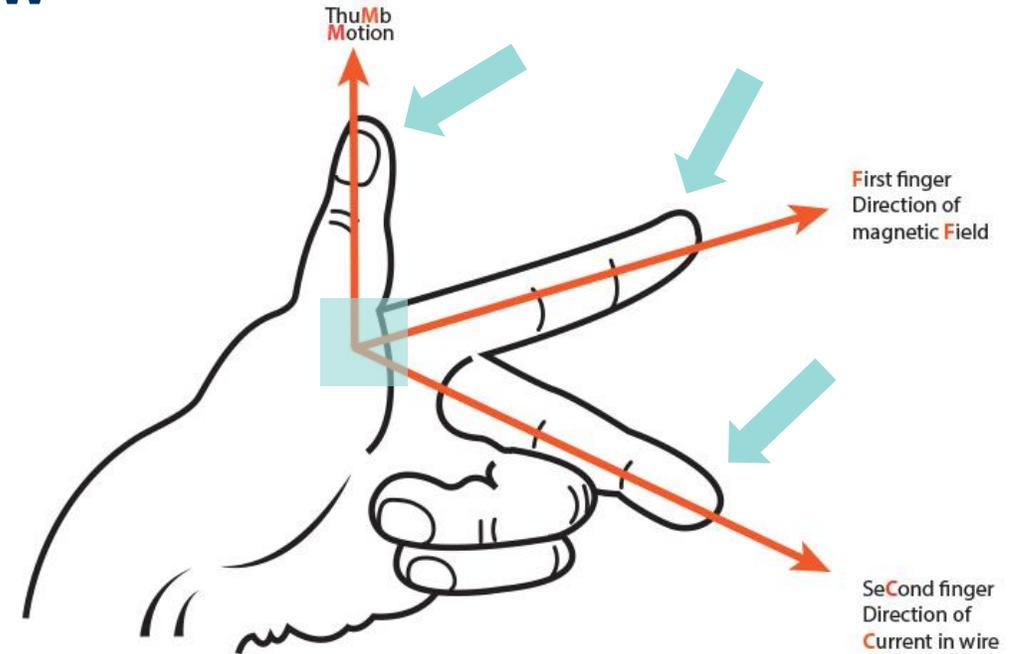
- ▲ NASA - Saturn V Apollo Shake Test
- ▲ Ensure the rocket would survive instability and not brake apart
- ▲ Now things are a little more controlled



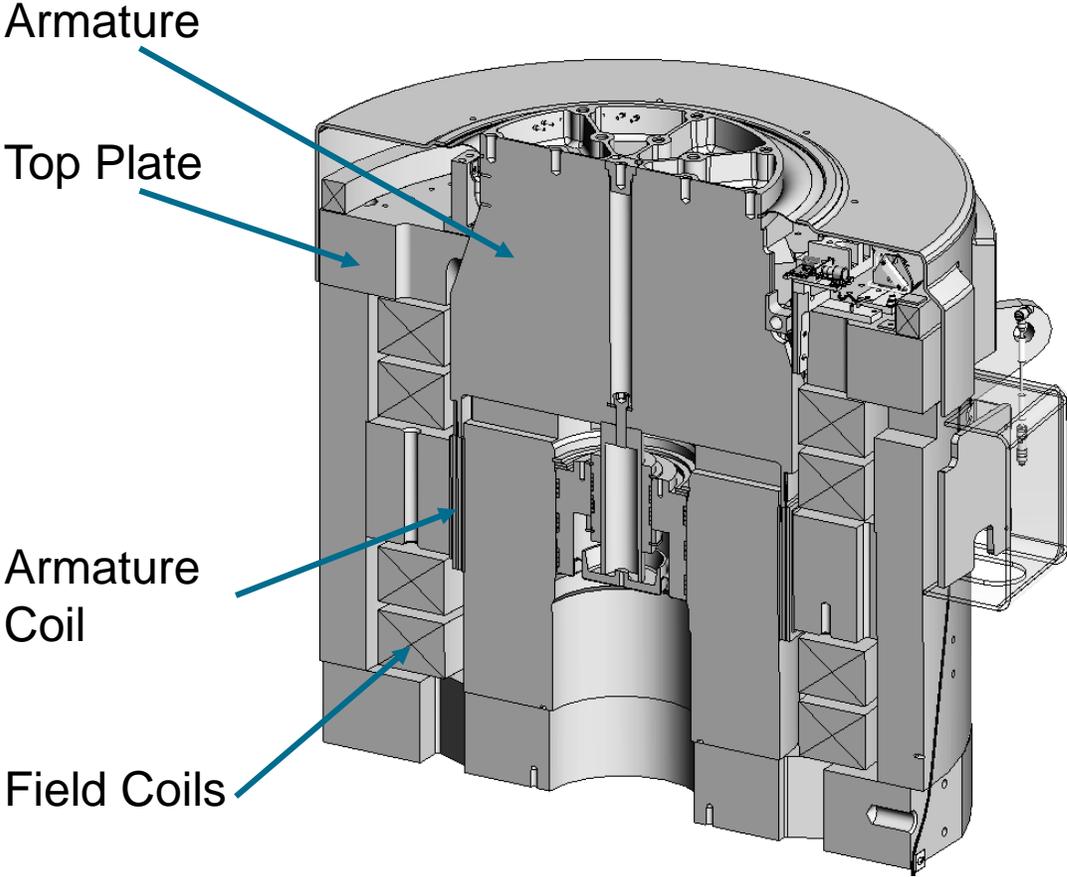
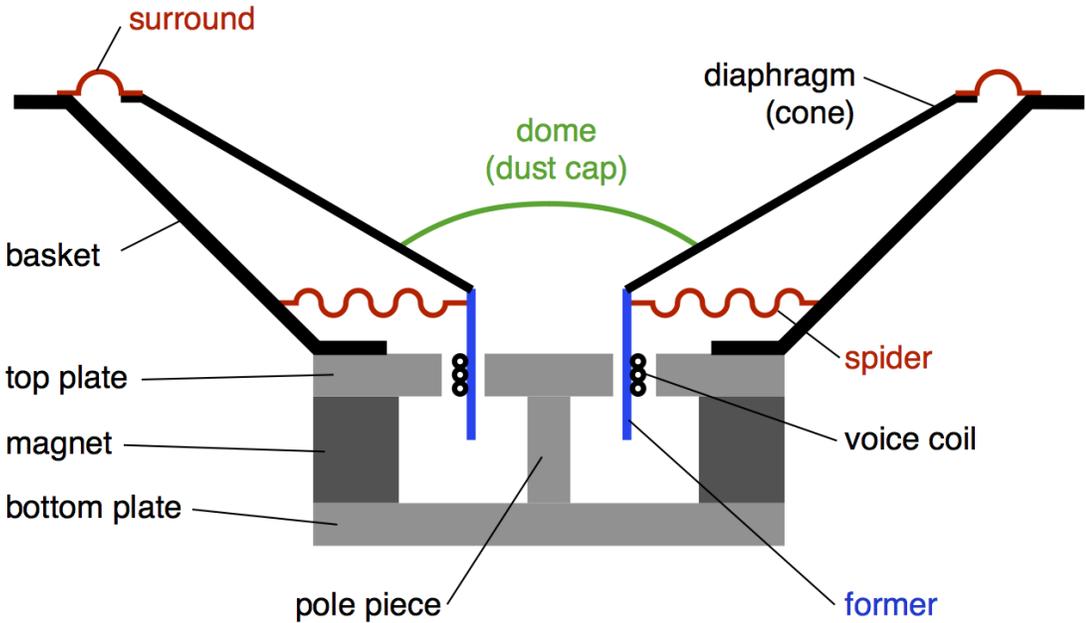
Source: Youtube (<https://youtu.be/s0UYNoTPdNs>)

Electrodynamic Shakers – The How

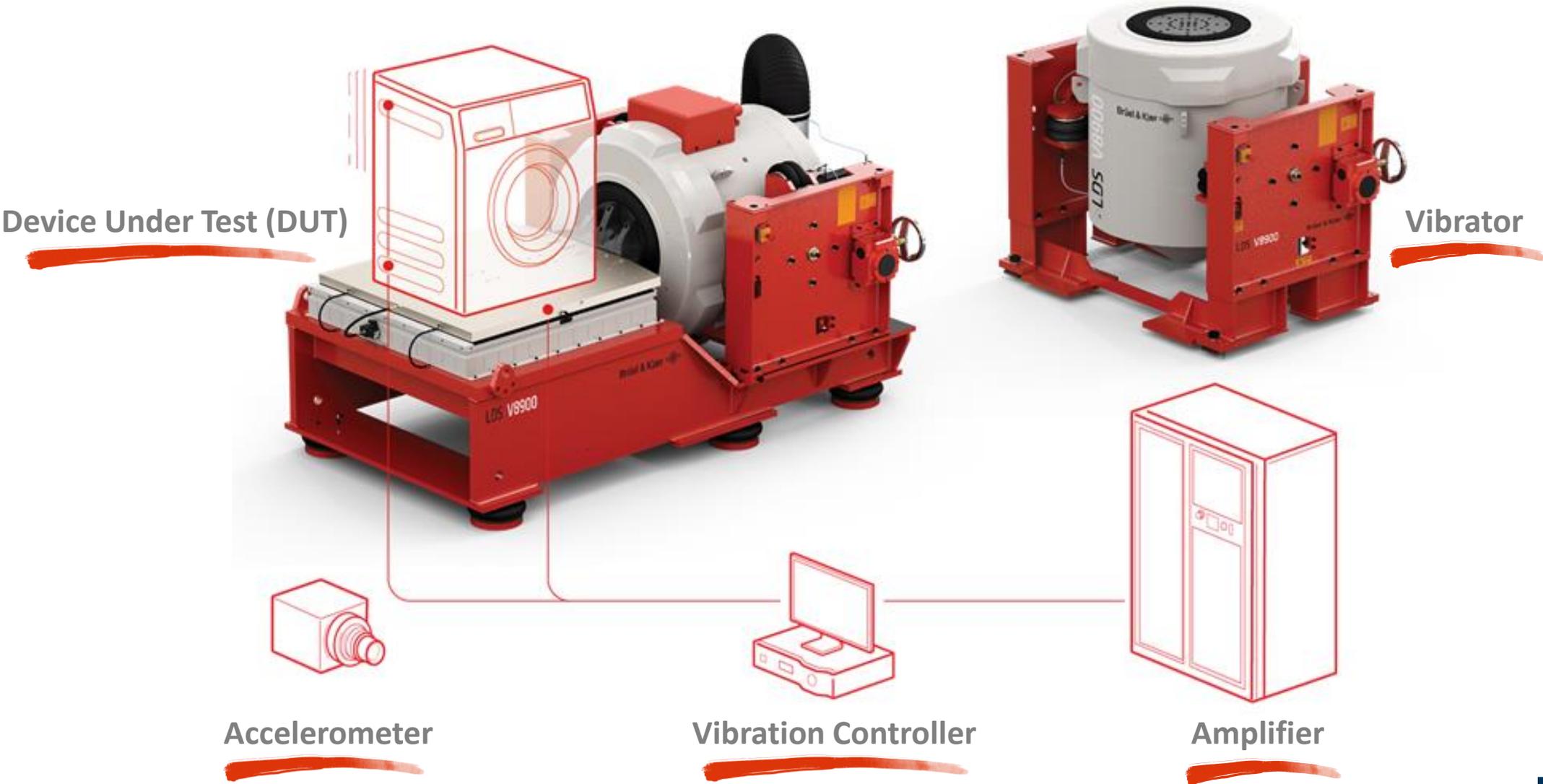
- ▲ Passing an electric current through a coil produces a magnetic field around it. This is the basic principle of **Electromagnetism**.
- ▲ **Left Hand Rule** - Recalls the relative directions of the magnetic field, current, and motion.
- ▲ All three directions are represented by the thumb (for **thrust** or **motion**), forefinger (for **field**), and second finger (for **current direction**), all held at right angles to each other.



Electrodynamic Shakers – The How



Electrodynamic Shakers – The How



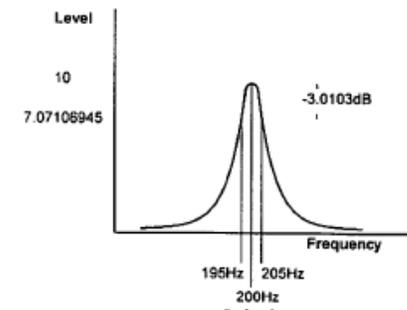
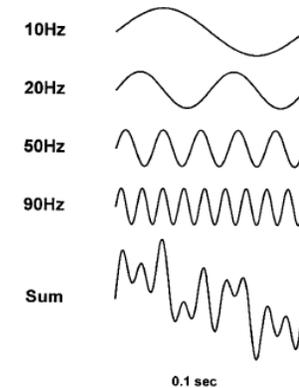
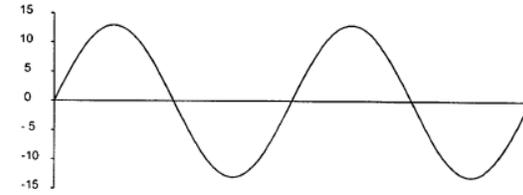


Electrodynamic Shakers – The How

- ▲ What do you want to test?
- ▲ What vibration do you want to simulate?
- ▲ What data do you wish to capture?
- ▲ What information do you want to acquire?
- ▲ What budget do you have?

Electrodynamic Shakers – The How

- ▲ **Sine Profiles**
 - Single frequency or swept over a range of frequencies.
- ▲ **Random Profiles**
 - Gaussian distribution of different level of vibration.
- ▲ **Shock Profiles**
 - Single or multiple Pulses with a given duration at specific frequencies.
- ▲ **Mixed Mode Profiles**
 - SOR, ROR, SRS etc.



Electrodynamic Shakers – The How

▲ Swept Sine Test

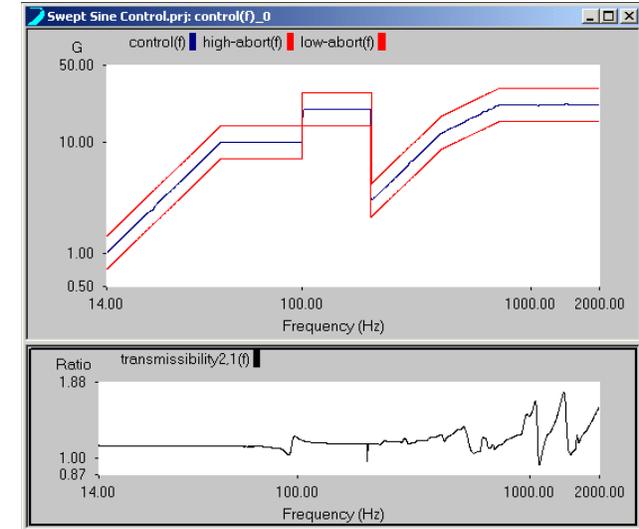
- The units used for sinusoidal vibration testing are:
 - Frequency Hz or radian/s
 - Displacement mm or inches peak-peak or peak
 - Velocity m/s or in/s peak
 - Acceleration m/s² or gn peak

$$\frac{1}{\log 2} = 3.321280$$

$$\frac{1000}{15} = 66.666666$$

$$(\log 3.321280) \times (\log 66.666666) = \underline{6.058893}$$

The classical Vibration Test
Locating structural resonances

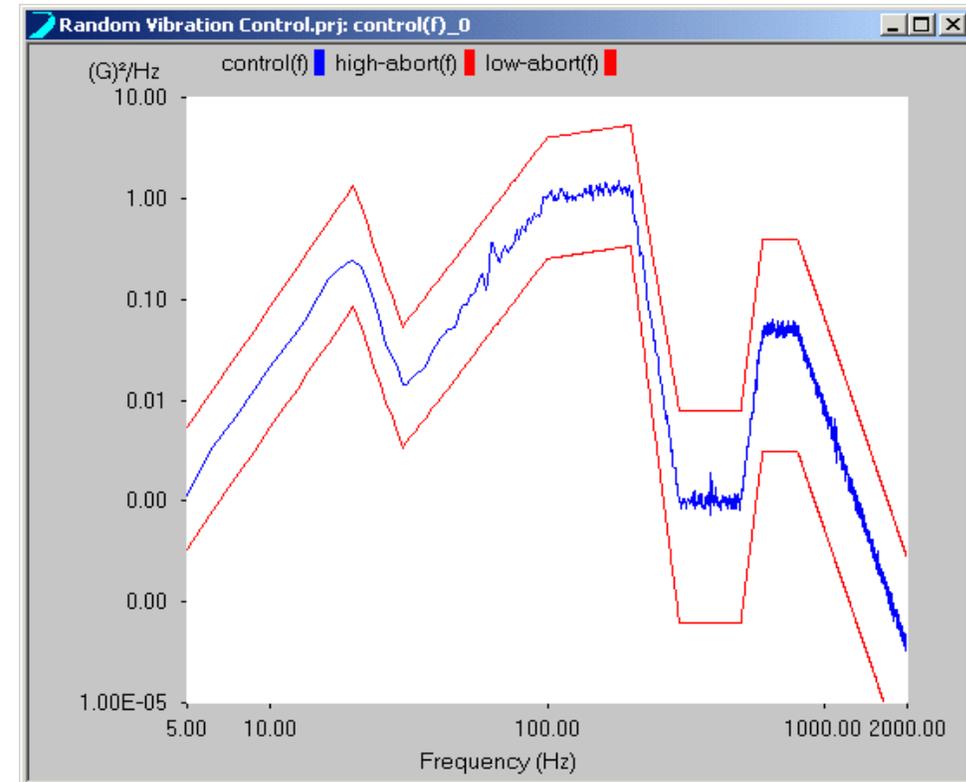


6.058893 mins @ 1 Octave/min

Electrodynamic Shakers – The How

- ▲ Random Test 
- Varying level test
- Unpredictable levels
- Has no fixed frequencies

A classical broadband test

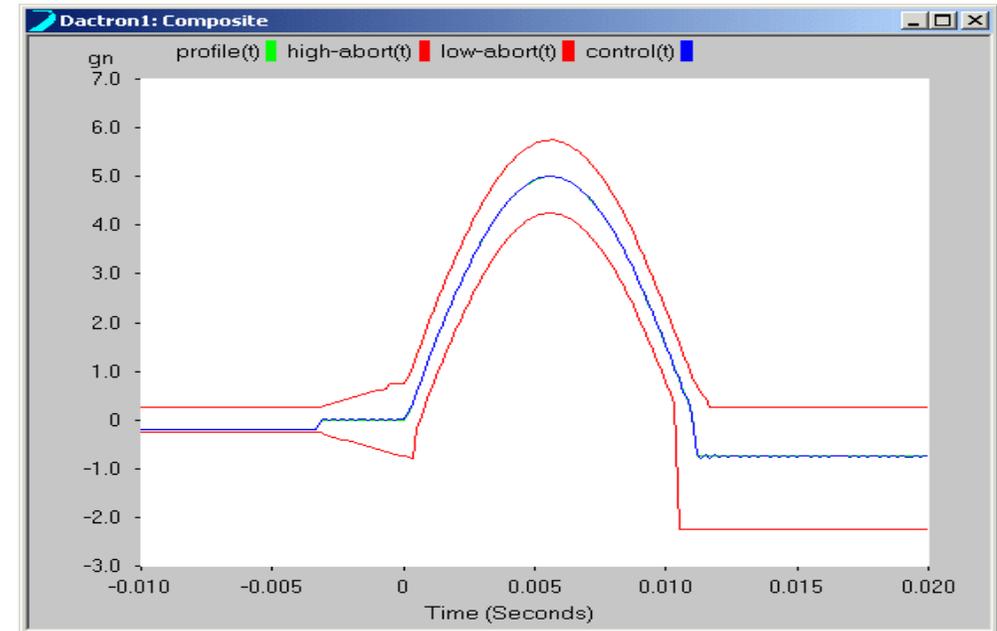


Electrodynamic Shakers – The How

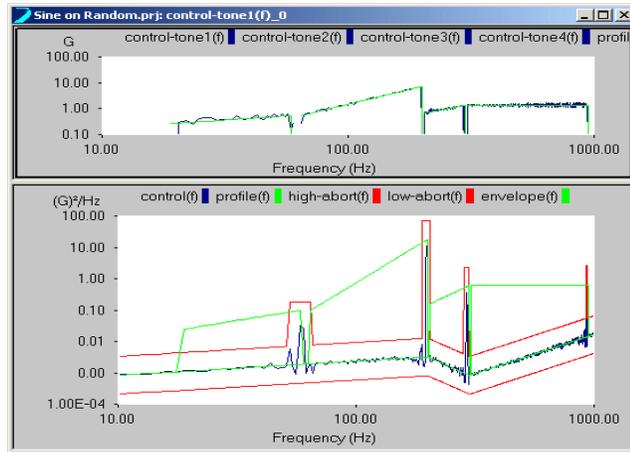
▲ Shock Test

- Transient pulse
- Duration = period of time to go from zero to maximum to zero acceleration,
- Usually defined in milliseconds.

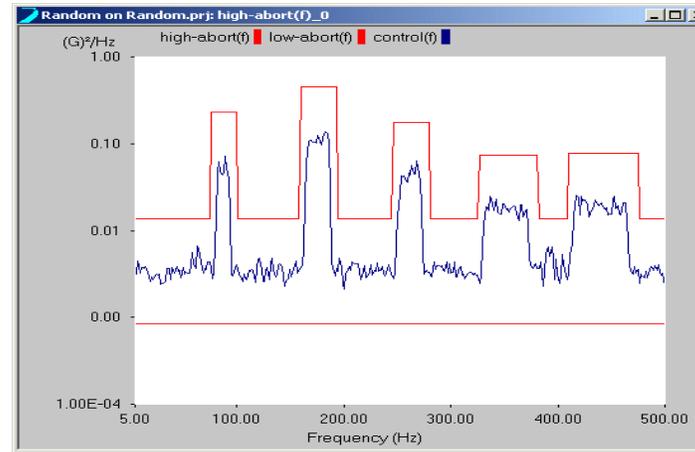
A classical drop test



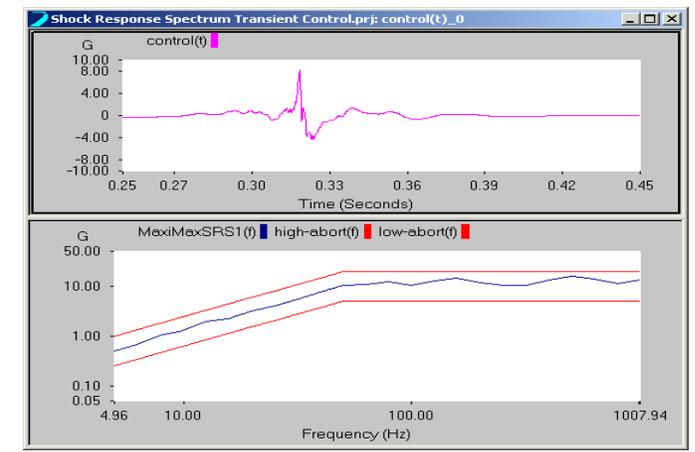
Electrodynamic Shakers – The How



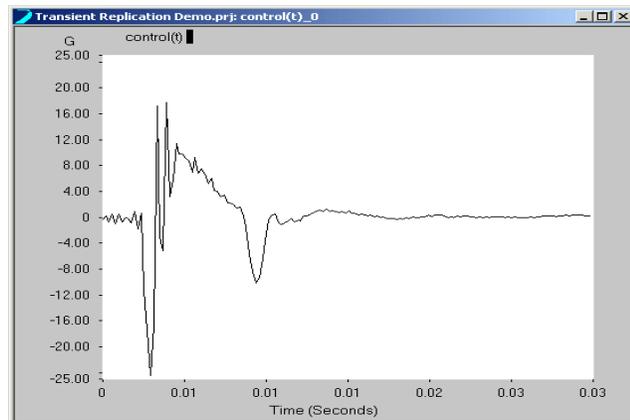
Sine on Random (SoR)



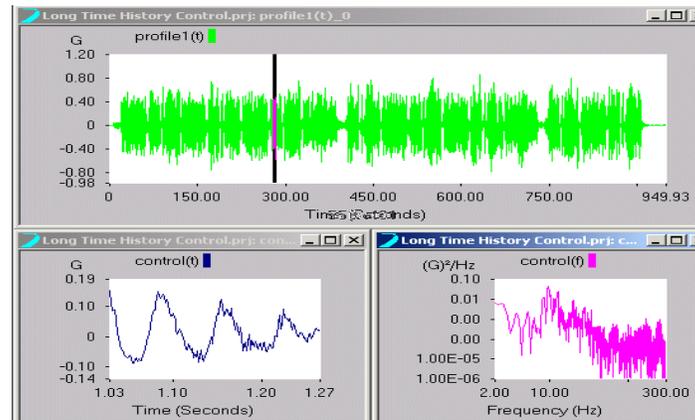
Random on Random (RoR)



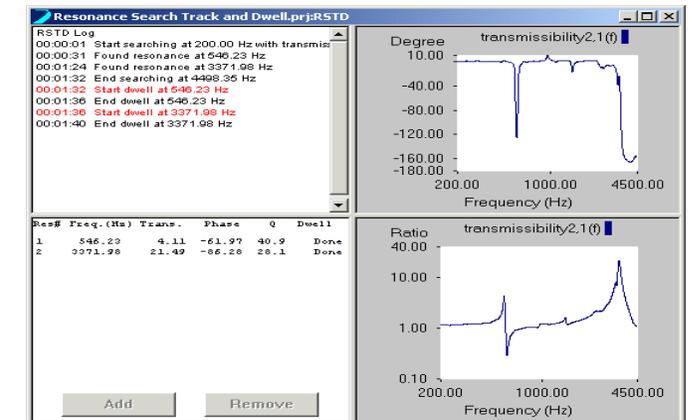
Shock Response Spectrum (SRS)



Transient Replication



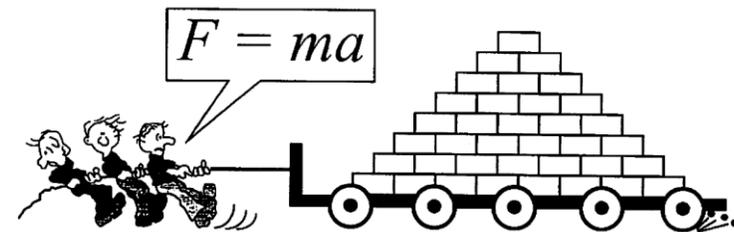
Replication of Long Time Histories



Resonance Dwell

Electrodynamic Shakers – The How

- ▲ Most fundamental rule is Newtons 2nd law of motion ($F=MA$):
 - Force (F) required to move an object is the Mass (M) multiplied by the Acceleration (A)
- ▲ However, there are other factors that need to be considered:
 - Displacement (physical distance to move)
 - Velocity (speed at which to move)
 - Frequency Range



Electrodynamic Shakers – The How

- ▲ Product has been identified
- ▲ Profile has been identified
- ▲ Which shaker?



Product Range

LDS VIBRATION TEST SYSTEMS

- ▲ 5 Permanent Magnet Shakers
- ▲ 4 Low Force Shakers
- ▲ 5 Medium Force Shakers
- ▲ 5 High Force Shakers

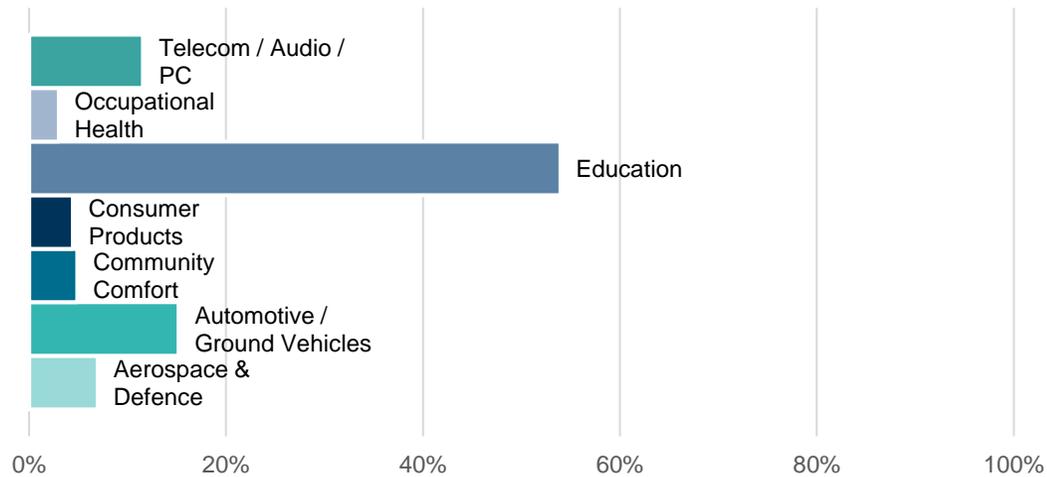


Product Range



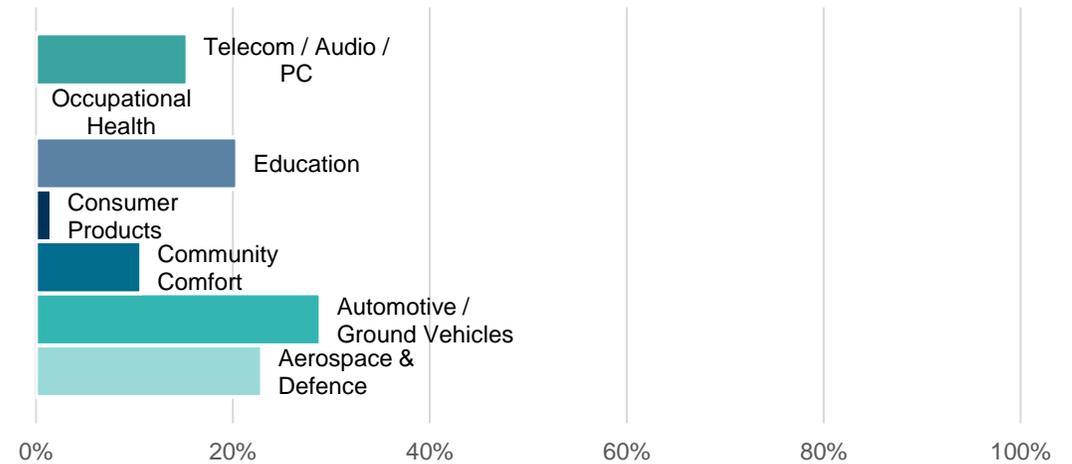
Permanent Magnet Shakers ⑤

V101 – V455



Low Force Shakers ④

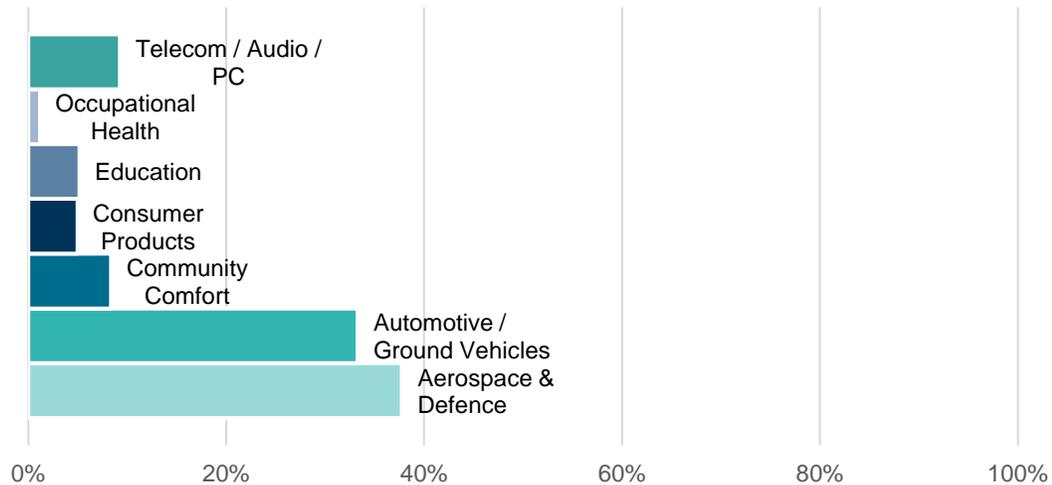
V555 – V780



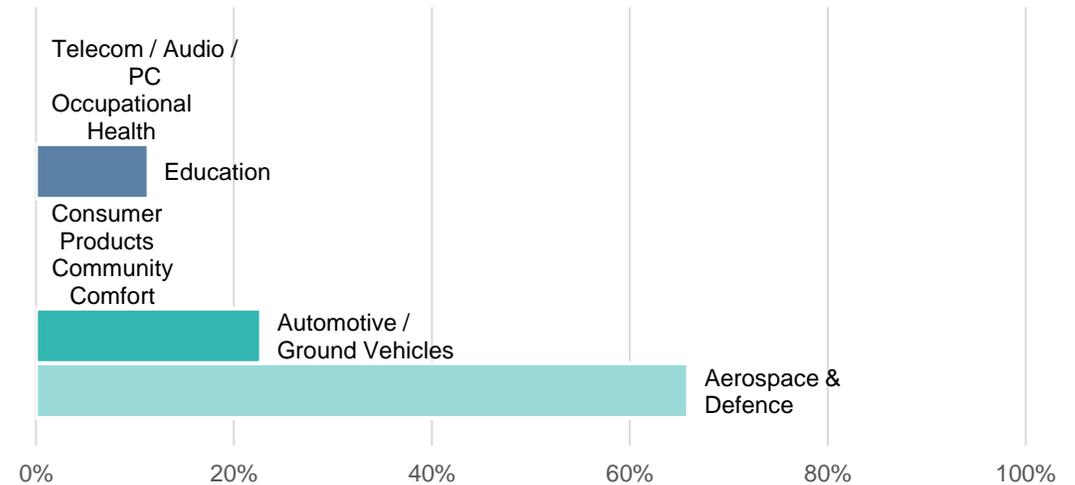
Product Range



Medium Force Shakers ⑤
V830 – V8



High Force Shakers ⑤
V8900 – V994



Product Range



LPA Series Amp



HPA-K Series Amp



SPA-K Series Amp



XPA-K Series Amp



DPA-K Series Amp

Product Range

LASER



- ▲ 4 to 16 Input Channels
- ▲ 2 Outputs
- ▲ Digital I/O (eg. chamber control)

COMET

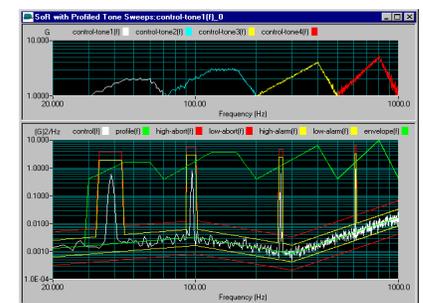
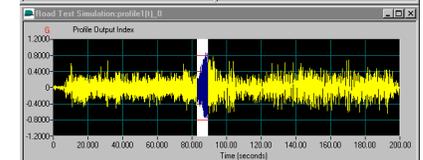
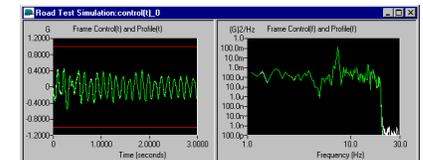
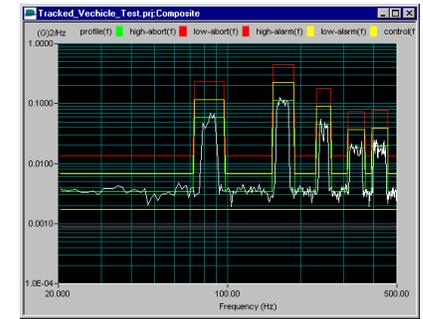
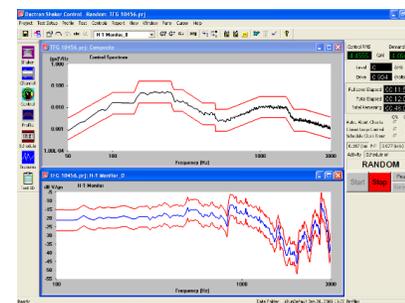
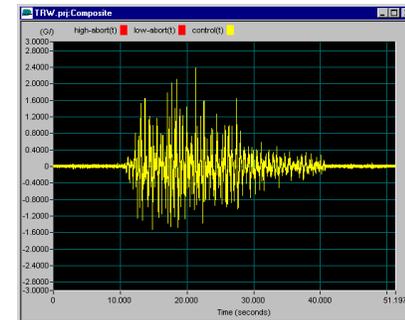
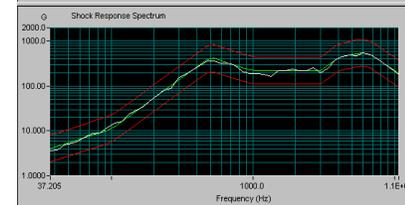
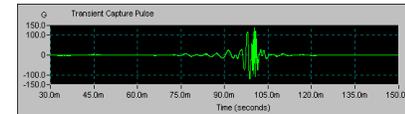


- ▲ 2 Input Channels
- ▲ 1 Drive Output

- ▲ Distributed DSPs handle control independently of PC
- ▲ Performance and safety not subject to PC latencies
- ▲ USB 2.0 connection with host PC

Product Range

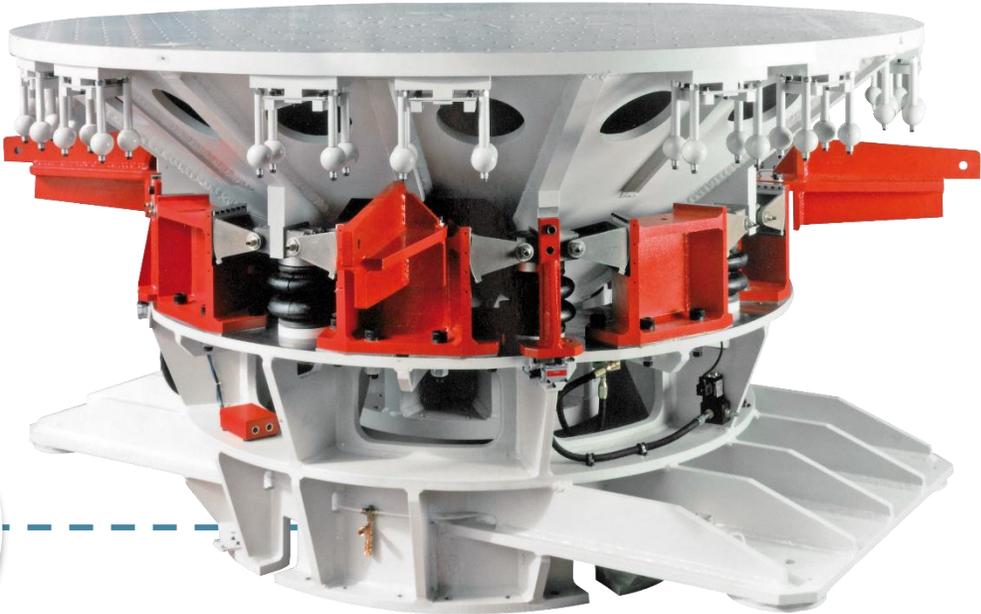
- ▲ Sine on Random
- ▲ Random on Random
- ▲ Random Fatigue Monitor
- ▲ Shock Transient Replication
- ▲ SRS Synthesis
- ▲ Simulating Real-Life Environment
- ▲ Virtual Signals
- ▲ Analyse Anywhere



Product Range



Load Bearing Platforms



Head Expanders

Slip Tables



Custom Fixturing



Applications

EVERYTHING SEES A VIBRATION IN ITS LIFE

- ▲ Aerospace/Defence
- ▲ Space
- ▲ Automotive
- ▲ Telecom Audio/PC
- ▲ Education
- ▲ Many others



Applications – Aerospace/Defence

- ▲ Overview of typical products being tested:
 - Electronics
 - Components
 - Avionics
- ▲ Purpose:
 - Product certification
 - Tests against MIL-STD's to certify the product for use
 - Research and development
 - Testing of advanced designs
 - Special environments
 - Launch/take off, atmospheric conditions, combat conditions and environments

Applications – Space

▲ R&D / Product Qualification – Vibration Testing Systems

- Overview of typical products being tested:
- Electronics
- Components
- Satellites (Nano, Small, Medium & Large)

▲ Purpose:

- Product qualification
- Tests against standards to certify the product for use
- Qualifies design against requirements
- Research and development
- Testing of advanced designs and Special environments
- Rocket launch, space conditions and environments



Applications – Automotive

- ▲ R&D / Product Qualification – Vibration Testing Systems
 - Overview of typical products being tested:
 - Electronics
 - Components
 - Quarter, Half and Full Car
- ▲ Purpose:
 - Product qualification
 - Tests against standards to certify the product for use
 - Qualifies design against requirements
 - Customer Satisfaction & testing of safety design
 - Characterise longevity of product life
 - Special environments





Value Added

- ▲ Not just a shaker manufacturer
- ▲ Offer a global service solution
- ▲ Many accessories
- ▲ Calibration
- ▲ Training
- ▲ Warranty
- ▲ Armature exchanges
- ▲ The complete solution

Questions?

Thank You

Brian Zielinski-Smith – Product Manager (Shaker Systems)
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