The University of Sheffield

Laboratory for Verification and Validation (LVV)

Capability Directory

The Laboratory for Verification & Validation (LVV) is a unique facility enabling research into the Verification & Validation (V&V) of engineering models across test scales and in all environments.

Model validation refers to the process of building credibility in the predictions of computer models based on comparison with experimental data. The development of new validation methods and test protocols will allow significantly larger portions of the structural design and test cycle to be carried out in a virtual/computational context. The use of computer modelling gives engineering companies key benefits including:

- Faster time-to-market by reducing the need to build and test prototypes.
- The ability to design more efficient, lower cost, products.
- Tools to design bespoke products which can be tailored to different requirements, without the need for time-consuming extensive product development.
- Design capabilities to create products with a longer life span via the modelling ability to accurately predict how and when failures will occur.

The LVV, part funded by the EPSRC and by the European Regional Development Fund (ERDF), will enable programmes of testing and research that will drive advances in V&V technology in the field of structural dynamics and beyond. It will be larger and more versatile than any facility of its kind currently available for open academic and industrial use.

The centrepiece of the facility will be a series of three environmental chambers designed for dynamic testing under realistic environmental conditions. They will offer the ability to control temperature and humidity and to simulate both wind and rainfall. An integrated shake table and reconfigurable electro-dynamic shakers will enable dynamic testing across a broad frequency range within the chambers. A separate wave tank facility will enable generation of deep water wave conditions. A strong wall and floor will be available for the testing of large size components and structures.

Led by the Dynamics Research Group (DRG) in the University's Department of Mechanical Engineering, the laboratory will offer significant benefits across a range of industrial sectors including energy, aerospace, automotive, renewables and medical engineering.

The DRG is already one of the largest specialist groups in the world; the LVV will drive forward collaborative research and cement Sheffield's position as a world leader in structural dynamics.

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Technical Capability Overview

The LVV will comprise:

- Three individual climatic test rooms allowing simulation of temperature, humidity, wind and rainfall effects. One room will contain an integrated Multi Axis Shaker Table (MAST). Further electrodynamic vibration systems will allow a flexible range of testing to be conducted both within and outside the climatic test rooms.
- A precision glass-sided wave tank with double flap wave generator (12m long, 1.5m deep) enabling simulation of deep water conditions.
- A strong floor (16m long x 3.5m wide) and wall (3m tall x 3.5m wide) enabling testing of large components and structures in a range of mounting configurations.
- Flexible laboratory space suitable for a broad range of dynamic testing at ambient temperatures (approx. 12m x 12m).

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Climatic Test Rooms

The climatic test room control system allows complex simulation programs to be created and executed. Set point and actual values of environmental conditions are recorded and available for future analysis. The chambers can be operated with or without personnel inside.

Test Room Dimensions

Climatic Test Room	Internal Dimensions (h x w x d)
Room 1 (including Wind Fan)	3m x 5m x 8m
Room 2 (including Multi-Axis Shaker Table (MAST)	3m x 5m x 9m
Room 3	3m x 5m x 5m

Temperature Working Range

Total temperature range	-55°C to +50°C
Cooling and heating rates	0.6°C/min (average) [1,2]

Humidity Working Range

Temperature range for humidity control	+10°C to +50°C
Humidity range	10 to 80 % relative humidity[2]

Wind Simulation Fan

Nozzle outlet velocity	Max. 80.5 km/h (50 mph)
Maximum volumetric flow rate	Max. approx. 50,000m³/h
Temperature range for wind fan operation	-20 °C to +50 °C

Rain Simulation System

One mobile rain simulation system is available and can be used in any of the three rooms.

Flow rate	Max. 1 litre/min/m^2
Coverage area	3m x 4m
Nozzle height	1500 to 2750mm

[1]without test specimen
[2]without thermal load

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Excitation and Acquisition

The hydraulic, 6-degree of freedom MAST system is situated 50mm above floor level within climatic test room 2, enabling excitation of large structures at low frequencies. Electrodynamic shakers enable testing at higher frequency ranges both within and outside the climatic test rooms. The MAST system is MAN-rated, enabling safe operation where human subjects form part of the payload.

Multi-Axis Shaker Table (MAST) System

Table Dimensions	3.2m x 2.2m
Indicative Performance	Max. 1000kg at 3g peak acceleration
Frequency range	5-80Hz (x-axis, y-axis) 5-120Hz (z-axis)

Electrodynamic Shaker: System 1

Force (sine, peak)	Max 9.8kN
Force (random, peak)	Max 9.8kN
Force (shock, peak)	Max 19.6kN
Frequency range	DC-4000Hz
Max. Acceleration	100g (no test load)
Max. Displacement	51mm (Peak to Peak)

Electrodynamic Shaker: System 2

Force (sine, peak)	Max 100N
Force (random, peak)	Max 100N
Frequency range	DC-8000Hz
Max. Acceleration	35g (no test load)
Max. Displacement	20mm (Peak to Peak)

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Data Acquisition Equipment

A range of industry standard data acquisition equipment enables a full range of dynamic testing and analysis. The LMS SCADAS system offers industry leading signal acquisition and conditioning hardware in a rugged, IP32-rated mobile chassis. The hardware is supported by a comprehensive suite of software (Test.Lab) enabling a full range of testing from fundamental spectral and modal analysis through to Ground Vibration and Military Standard testing. The NI system offers the flexibility to perform a wide range of testing from low to high channel counts (up to 129 IEPE accelerometer inputs), with the flexibility to programme test campaigns and implement bespoke analysis through the LabVIEW software package.

Siemens LMS SCADAS Mobile Data Acquisition System

Equipment type	Quantity	Description
Analogue ICP/IEPE input channels	64	Input range: ±10 V 24-Bit analogue-to-digital conversion Simultaneous sample rate: 204.8 kHz
Analogue output channels	6	Input range: ±10 V 24-Bit analogue-to-digital conversion Excitation band width: up to 40kHz

National Instruments Data Acquisition System

Equipment type	Quantity	Description
cDAQ-9179 14-slot chassis cDAQ-9178 8-slot chassis	4 1	A selection of chasses enabling flexible testing at high and low channel counts
NI-9469 Synchronisation module	4	Enables time synchronisation across chasses for high channel count tests
NI-9260 Analogue Output module	5	2 channel AO Module ±4.24 V, 24-Bit ADC, 51.2 kS/s/ch
NI-9232 IEPE Analogue Input module	43	3 channel IEPE AI module ±30 V, 24-Bit, 102.4 kS/s/ch,
NI-9213 Thermocouple module	2	16ch thermocouple module ±78 mV, 24-bit ADC, 75 S/s
NI-9223 4ch Analogue Input module	1	4 channel high sample rate AI module ±10 V, 16-Bit, 1 MS/s,
NI-9201 8ch Analogue Input module	1	8 channel general use AI module 10 V, 12-Bit, 500 kS/s

Sensors and Transducers

Equipment type	Quantity	Description
ICP Accelerometers: PCB353B18	128	Frequency range: 1 to 10kHz Sensitivity: 10 mV/g
ICP Force transducers: PCB208C02	4	Force range: ± 100lb Sensitivity: 50 mV/lb

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Wave Tank

The LVV will contain a precision, glass-sided wave tank. The tank will feature a flap wave generator at each end enabling simulation of representative deep water waves. The tank sides will consist of 25mm toughened glass with steel side rails ensuring cross-sectional uniformity. Software will enable the simulation of sine waves, multi-spectral seas and perform demonstrations of special effect waves. The software will allow a single computer to synchronise wave generation with data collection and trigger experimental rigs.

Width of working section	0.6m
Design water depth	1.2m
Depth of working section	1.5m
Length of working section	12m
Wave height	Max 0.28m (Peak to Trough)
Flow velocity	0.4m/s

Strong Wall and Floor

The strong wall and floor will enable testing of large size components and structures. Structures may be supported by either the strong wall itself or from a substantial steel frame built at a height of 3m above the strong floor.

Strong wall dimensions	3m (h) x 3.5m (w)
Strong floor dimensions	16m (l) x 3.5m (w)
Strong wall channel layout	6 x 3m channels at 0.5m centres
Strong floor channel layout	6 x 3m channels at 0.5m centres
Channel strength per attachment point	Max 55kN (tensile) Max 70kN (shear)

Flexible Laboratory Space

In addition to the climatic test rooms, strong floor and wave tank, the facility will offer flexible laboratory space suitable for the testing of both floor-mounted and frame-mounted structures. The laboratory is serviced by an overhead crane and forklift truck.

Floor area	Approx. 12m x 12m
Crane hook height	8m
Crane safe working load	10t SWL
Fork lift capacity	Max 2t

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