



Bus, Truck and Off-Highway



www.millbrook.co.uk



Introduction

At Millbrook Group, we provide a complete range of test, validation and demonstration services to manufacturers and operators of commercial and public service vehicles.

We can support the full product development process through to type approval. Our highly experienced engineers perform emissions and fuel economy testing to any test cycle, and manage vehicle validation testing either to meet customers' own requirements or to full certification test requirements.

We develop custom tests for individual markets and road conditions, including testing for passenger comfort, market-specific warranties and durability. A key focus in recent years has been on refinement and user experience; we can help optimise NVH, driveability, HMI, style and comfort.

Please do not hesitate to contact us to discuss a particular requirement.

Alex Burns

President

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Millbrook Group Overview



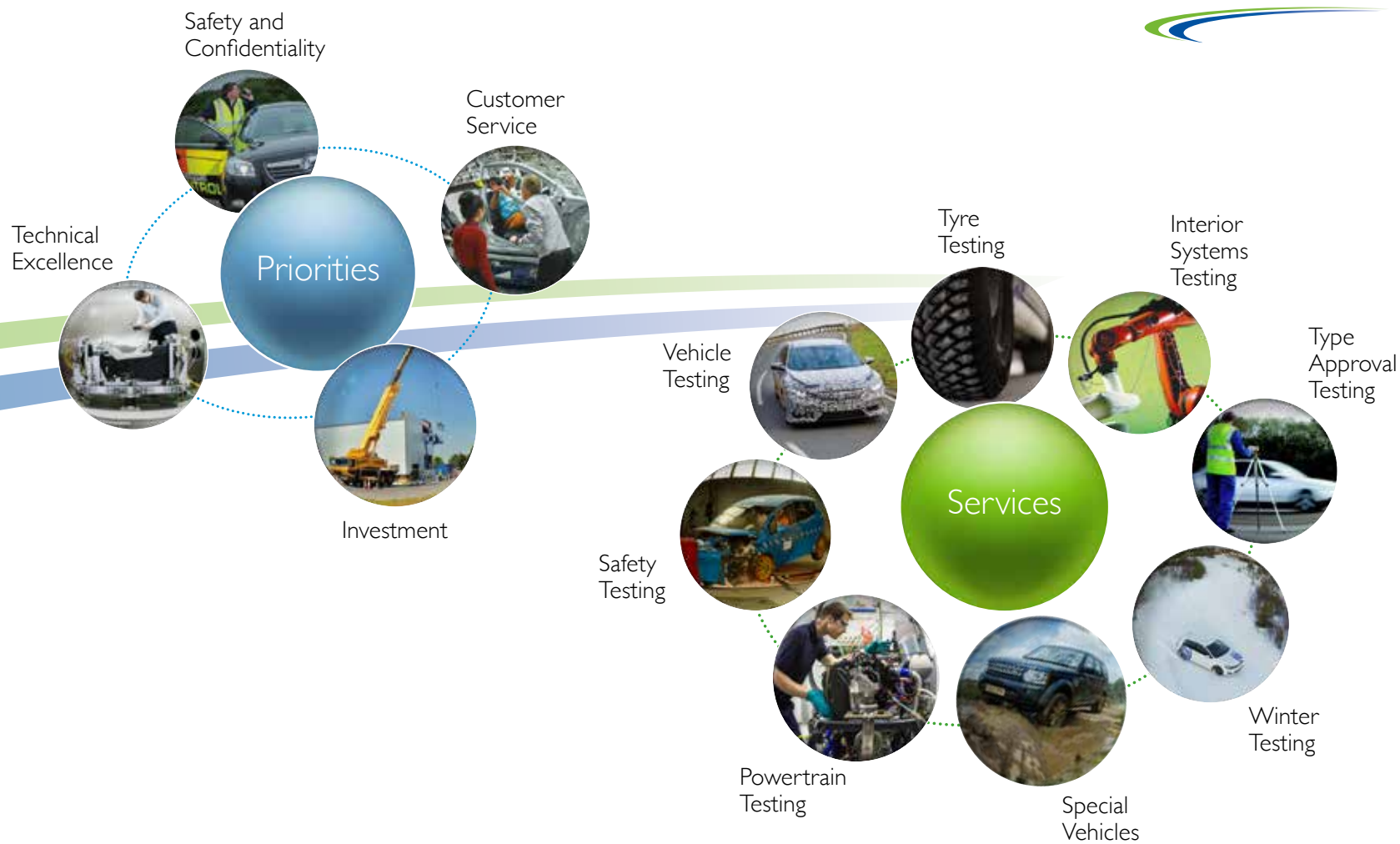
Millbrook Group is part of the Test and Measurement business segment of Spectris plc and consists of Millbrook in the UK and Test World in Finnish Lapland.

Spectris is a leading supplier of productivity-enhancing instrumentation and controls.

Millbrook is best known for its test tracks where it performs repeatable tests in a safe and secure environment. Millbrook also has a range of test facilities for full vehicles, tyres and components, including engine dynamometers, structural test laboratories, crash laboratories, interior systems laboratories, advanced emissions chassis dynamometers and innovative indoor winter test tracks.

Millbrook supports its customers with specialist vehicle conversions, workshops in its Technology Park and vehicle-related events.





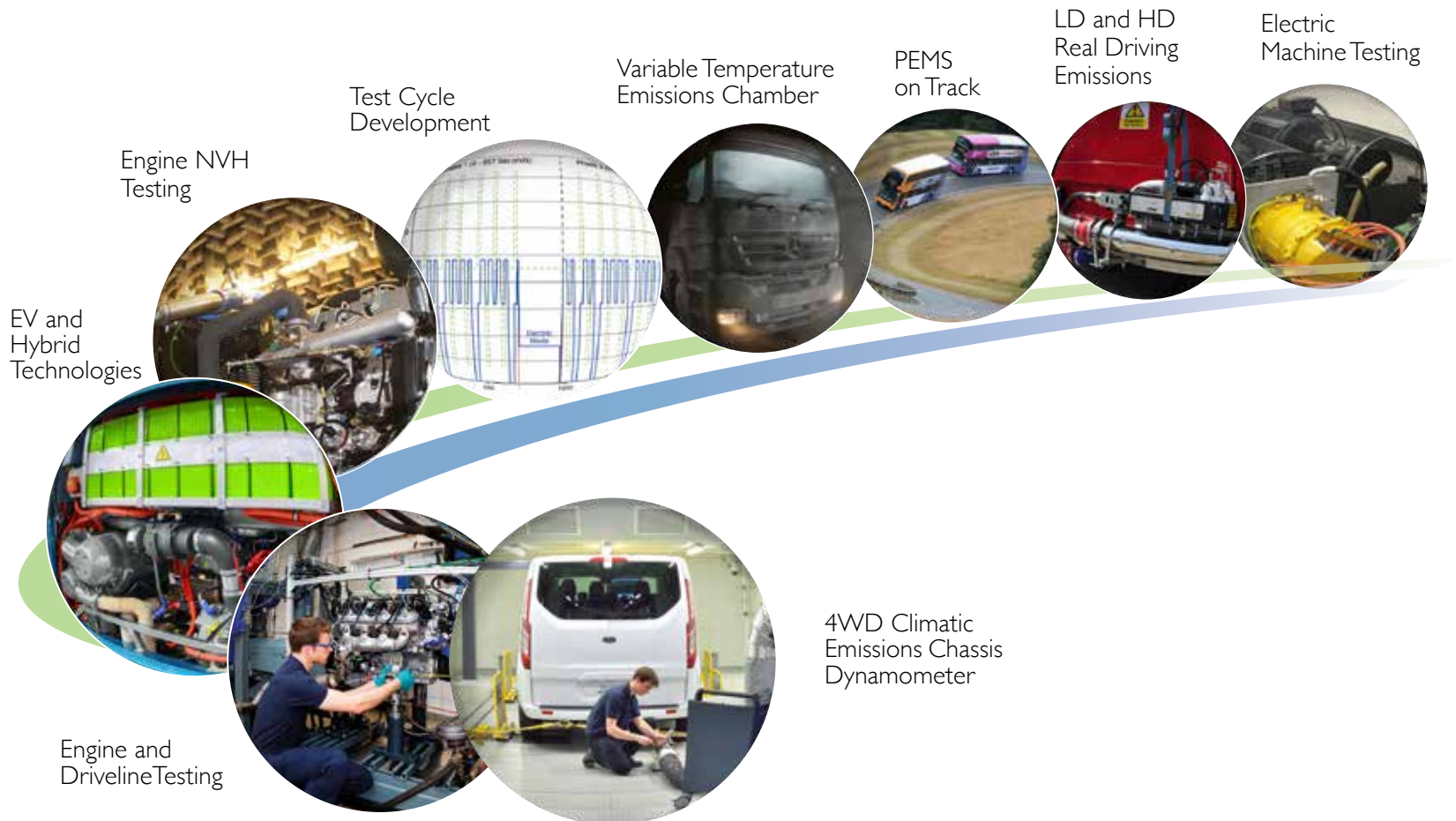
Services

From component to full vehicle, Millbrook takes care of all test and validation requirements for commercial and public service vehicles.





Powertrain Testing



Millbrook has some of the world's leading independent powertrain test facilities. With ever-increasing pressure in this area, customers can rely on Millbrook's support and expertise to develop cleaner and more efficient vehicles.

Millbrook provides full test and development support for engine and exhaust aftertreatment update programmes on existing vehicles, as well as comprehensive fuel and energy consumption, range and emissions testing on new and existing vehicles. Millbrook tests hybrid and electric powertrains.

Millbrook works with both national and local legislators, authorities and manufacturers on air quality issues. It develops individual test cycles in order to provide reliable, repeatable data, using its dynamometers and portable equipment. It provides NVH testing for engines and powertrain components.

E-machine Testing capabilities include:

- Integrated systems or individual subsystems
- Energy storage and power electronics and interconnections.



Vehicle Testing capabilities include:

- EV powertrain performance, energy consumption and range testing
- Evaluation of impact of air conditioning and heating systems on emissions, fuel economy and energy
- Representative real world drive cycle development
- Powertrain integration including engine upgrades on existing chassis
- Emissions and fuel consumption testing:
 - Real Driving Emissions (RDE)
 - 4WD climatic emissions chassis dynamometer testing
 - Heavy duty climatic emissions chassis dynamometer testing (Variable Temperature Emissions Chamber)

- Particle size distribution measurement
- Evaporative emissions
- Standard On-Road Test cycle (SORT)
- FTIRs for NO_x and other pollutant speciation
- Low carbon vehicle certification
- HGV Accreditation Scheme
- Heavy duty semi-anechoic chassis dynamometer for internal and external noise development

Engine Testing capabilities include:

- Latest cell automation software and hardware
- Up to 2.1MW dynamometers
- Cold climatic capability, down to -30°C
- Road Load Simulation
- Extensive emissions measurement capability
- Full DOE capability with real time controllers and online optimisation
- Vehicle simulation on an engine test bed
- DSPACE and CAMEO capability
- HIL and SIL capability
- NVH



Case Study: Bus Emissions



First Bus Fuel Economy Challenge identifies the cleanest buses.

Millbrook rigorously tests the latest bus technologies using a test procedure developed with First Bus.

The exercise is run as a competition called the First Bus Fuel Economy Challenge and is based on the First Bus Millbrook Fuel Economy Trial (FMFET). The results of the competition play a major part in a procurement strategy designed to ensure First Bus chooses only the cleanest most efficient vehicles for use across the UK.

Test vehicles are fitted with sophisticated equipment to monitor performance and emissions and subjected to tests which reflect a variety of rural, urban and interurban bus routes.

The process replicates the driving pattern of a bus on an average working day, the buses following a route which includes hills, junctions, roundabouts and

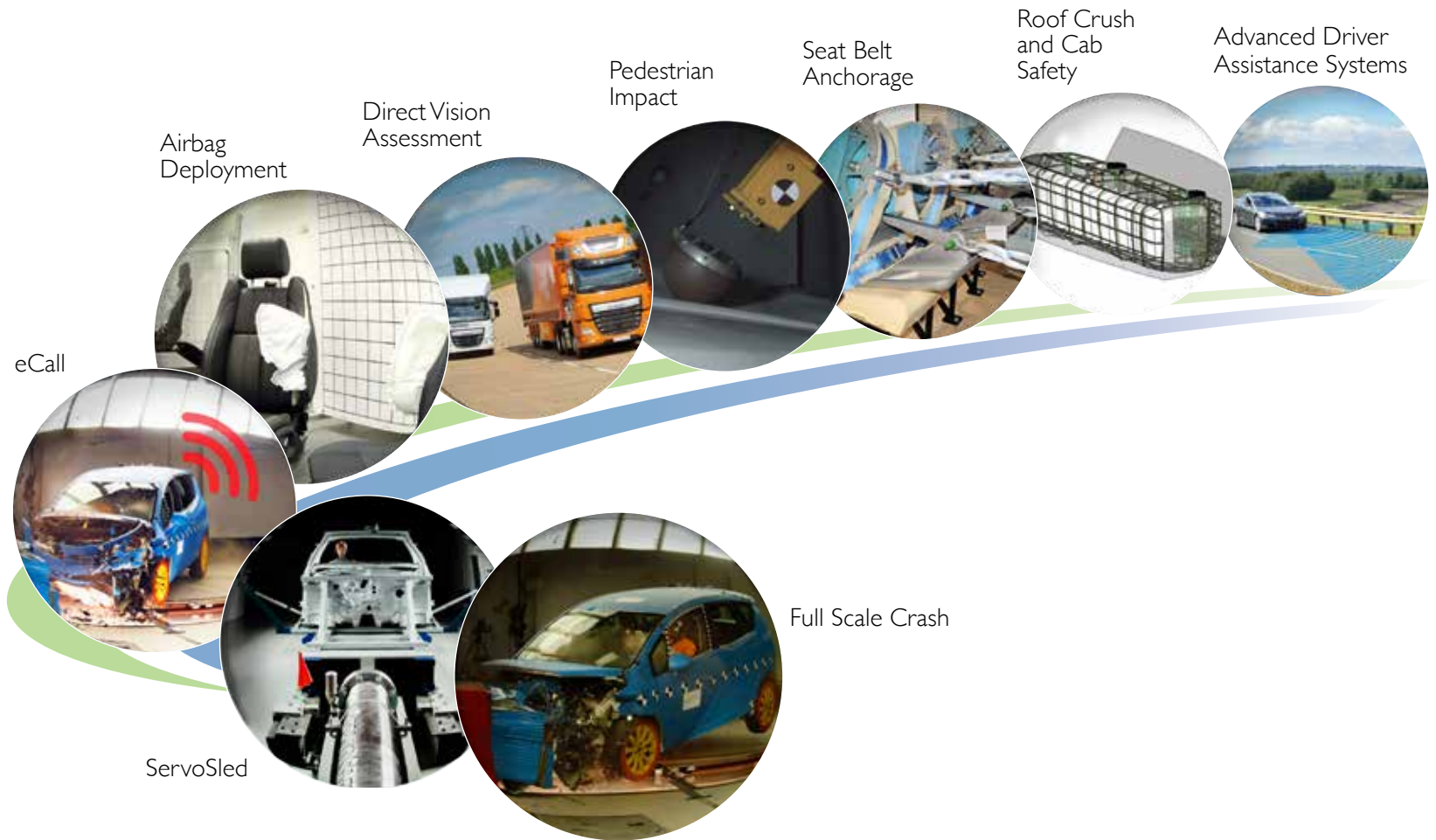
numerous bus stops. Buses travel at a range of pre-defined speeds and spend a proportion of the test idling to simulate waiting at bus stops, just as they would in service.

*Maximum speed and
acceleration tests*

*Extreme gradients up to 25%
Real Driving Emissions*



Safety Testing



Millbrook is comprehensively equipped for commercial vehicle safety testing, both in the laboratory and on the proving ground.

Millbrook offers a full suite of regulatory, consumer and customer test protocols for commercial vehicles: from ECE R66 for bus structural integrity to heavy vehicle testing to EuroNCAP. Computer simulation as well as both destructive and non-destructive test methods are employed to ensure that customers' programmes are efficient, reliable and cost-effective.

Millbrook has high voltage BEV and HEV crash test capability. It performs sophisticated Advanced Driver Assistance Systems testing on its proving ground, from automated emergency braking to full autonomous vehicles.

The facilities include indoor and outdoor crash laboratories, ServoSled, pedestrian impact rigs and component test rigs.



Vehicle Testing



Millbrook supports the design and development of buses, trucks and off-highway vehicles with full vehicle, body and chassis testing and measurement.

The next few years will usher in demanding new challenges for commercial vehicle manufacturers. In addition to providing comprehensive support for existing technologies, Millbrook is fully equipped to handle the development of EVs and Hybrids and conducts accreditation for a range of environmental tests in the UK.

Millbrook's unique proving ground, which offers gradients of up to 26% and specialist durability surfaces and features, functions as an outdoor laboratory. It is supported by indoor workshops, weighbridges and test facilities in Bedford and Leyland, enabling the provision of complete development solutions.

Accelerated life cycle, strength and fatigue testing capabilities:

- Quick assessments to full structural durability and quality testing
- Accelerated corrosion (10 years in 20 weeks)
- Custom test programmes for specific investigations
- Simulation
- Field testing
- 800m² structural test laboratory including two electro-hydraulic ring mains, a reinforced concrete floor grid and a dynamic modular beam system
- Hydraulic actuators up to 500kN
- Single and multi axis
- Road Load Simulation
- 600°C diesel burners
- Exhaust durability
- Stress and Strain Analysis

Comfort, refinement and driver experience:

- Whole body vibration ISO 2631
- Ride isolation and road load data collection
- Development and legislative noise testing
- User assessment, development and refinement

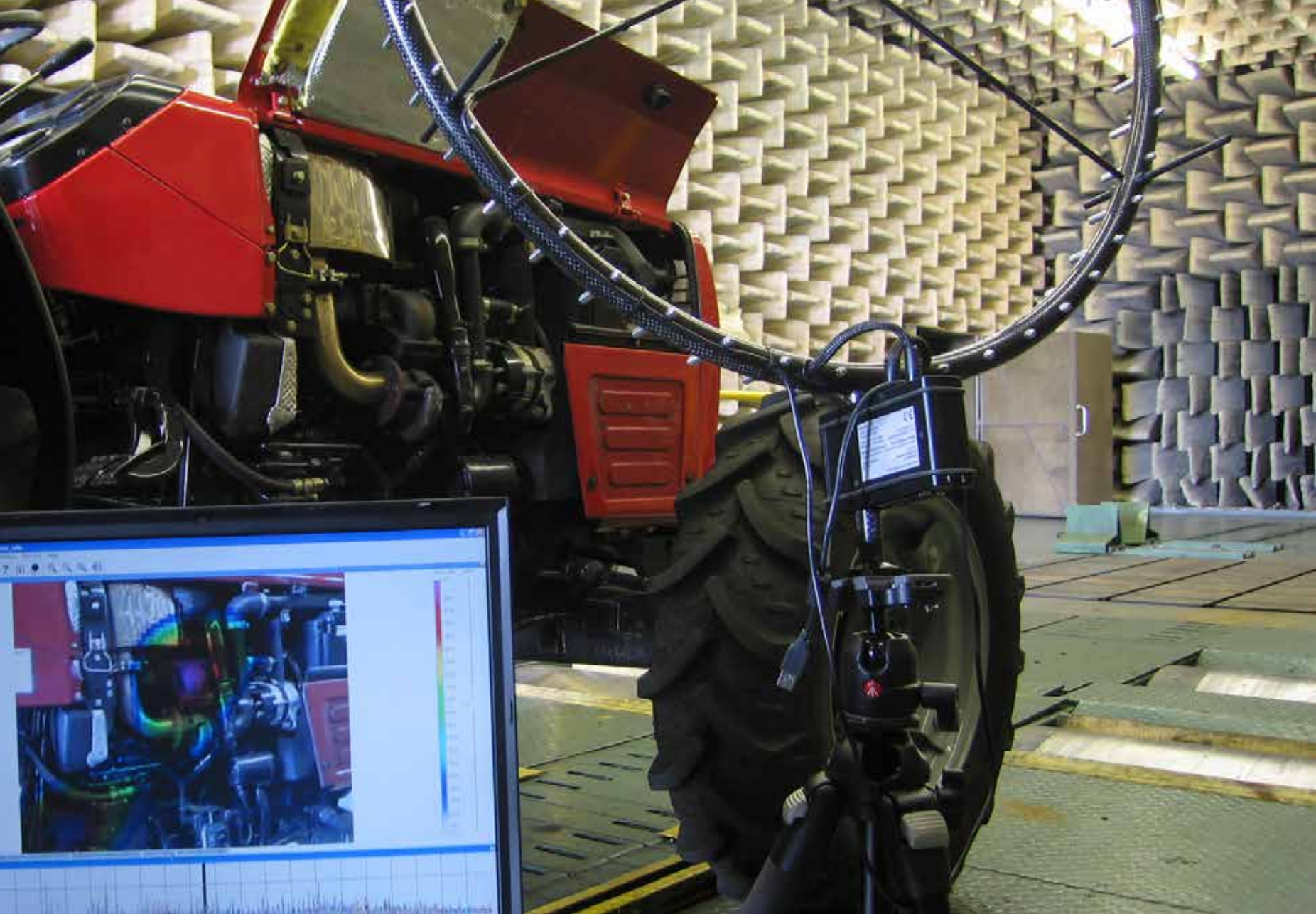
From noise source ranking to measurement of torsional vibration, Millbrook offers a full range of Noise, Vibration and Harshness (NVH) tests.

Millbrook carries out NVH tests at full vehicle and component level using a wide range of state-of-the-art equipment both in its laboratories and on the test track. Data collection is of the highest specification for fast and effective characterisation.

Typical applications include squeak and rattle, external noise, engine testing, general refinement and problem solving and sound power measurements (ISO 3744).

- Semi-anechoic chamber
- Dynamometers
- Acoustic cameras
- Laser vibrometers





Interior Systems Testing



Millbrook provides expert testing of the performance characteristics and durability of interiors, systems and components particular to buses, trucks and off-highway vehicles taking into account the environment in which these machines operate.

Millbrook helps customers to ensure that the products they produce are reliable, durable and refined. Its highly experienced teams provide support throughout test programmes on the latest technologies associated with lightweight vehicle structures, premium interiors and connected vehicles.

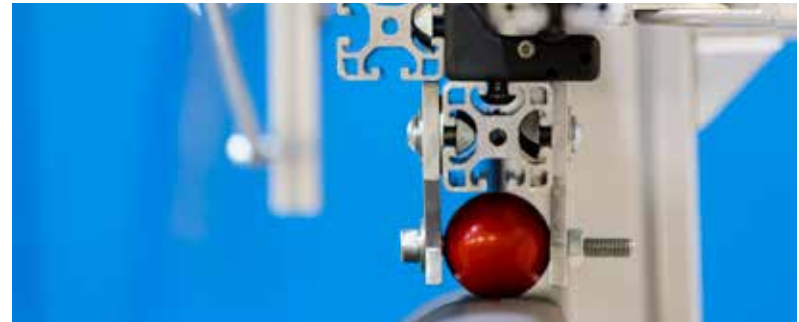
Millbrook operates UKAS accredited testing and calibration laboratories, Nos. 2498 and 10121. Its test reports are accepted globally.

Environmental Testing capabilities include:

- Climatic chambers up to 13.7m x 5.7m x 6m, -60°C to +150°C and up to 98% RH
- EM Shakers / Slip Tables (up to 32kN)
- GOM / FARO Arm measurement and analysis

Materials Testing capabilities include:

- Full suite of materials tests from flammability and odour to taber abrasion and crocking



Seat Testing capabilities include:

- Kuka robots for ingress and egress testing
- ServoSled laboratory
- Seat pressure mapping
- Chuck and deflection
- KLT (including climatic)
- MAST
- Squeak and rattle assessment
- Airbag and seatbelt testing

Vehicle Winter Testing



Millbrook's winter proving ground, Test World in Northern Finland, offers a long winter season and range of safe and secure test facilities to challenge all types of on- and off-highway vehicles.

Test World boasts 1,250 hectares of proving ground, split over two sites. Its specially-designed and maintained tracks are suitable for anything from sports cars to the biggest on-highway vehicles.

Test tracks developed specifically for vehicle testing include a high speed circuit, a vehicle dynamics area and a snow handling track. These shared access tracks, offering faster speeds with increased run off for safety, are based on compressed snow.

Their construction method avoids the negative 'polishing' effect typical of lake-based test tracks. The expertly prepared snow tracks are inherently safer, do not suffer from unwanted surface depression, and have a longer operational season.

Customers benefit from the availability of service buildings nearby, from a wide range of accommodation and hospitality options, and from Test World's legendary customer service.



At the main site and the secondary 150 hectare site there are large, steep natural hills to test and demonstrate off-highway machinery with both maintained and 'wild' areas. Ballast loads can also be provided to exercise excavating and digging machinery. Both sites also have large workshop facilities, offices and other necessary infrastructure.

Temperatures in this region typically vary between -5°C to -25°C but often go down to -35°C . There are twice-daily flights to Ivalo airport, plentiful hotel rooms and restaurants nearby, and other activities to alleviate the routine of cold environment testing.

*1,250 hectares
300km North of
the Arctic Circle
Year-round winter
testing*





Type Approval Testing

Quasi Static
Testing



Certification



Noise Testing



Tyre
Labelling



Homologation
Testing



Emissions
Testing



Crash
Testing



Vehicle and trailer system and component certification and homologation services.

Millbrook can provide all the services and administration necessary to obtain type approval on conventional, EV and Hybrid buses, trucks, trailers and off-highway vehicles.

Millbrook is a one-stop shop for negotiating the legislative complexities of type approval, negotiation with authorities, test programme development, project management and the production of technical drawings and documentation.

Millbrook is an expert in European whole vehicle type approval and provides technical services for:

- Vehicle Certification Agency
- RDW
- VSCC Authorised Laboratory for Taiwan
- RVCS Test Facility for Australia
- TRIAS Accreditation Laboratories for Japan



Special Vehicles



Millbrook's Special Vehicles team use their automotive engineering knowledge and the test facilities to produce vehicles with enhanced capabilities or major modifications.

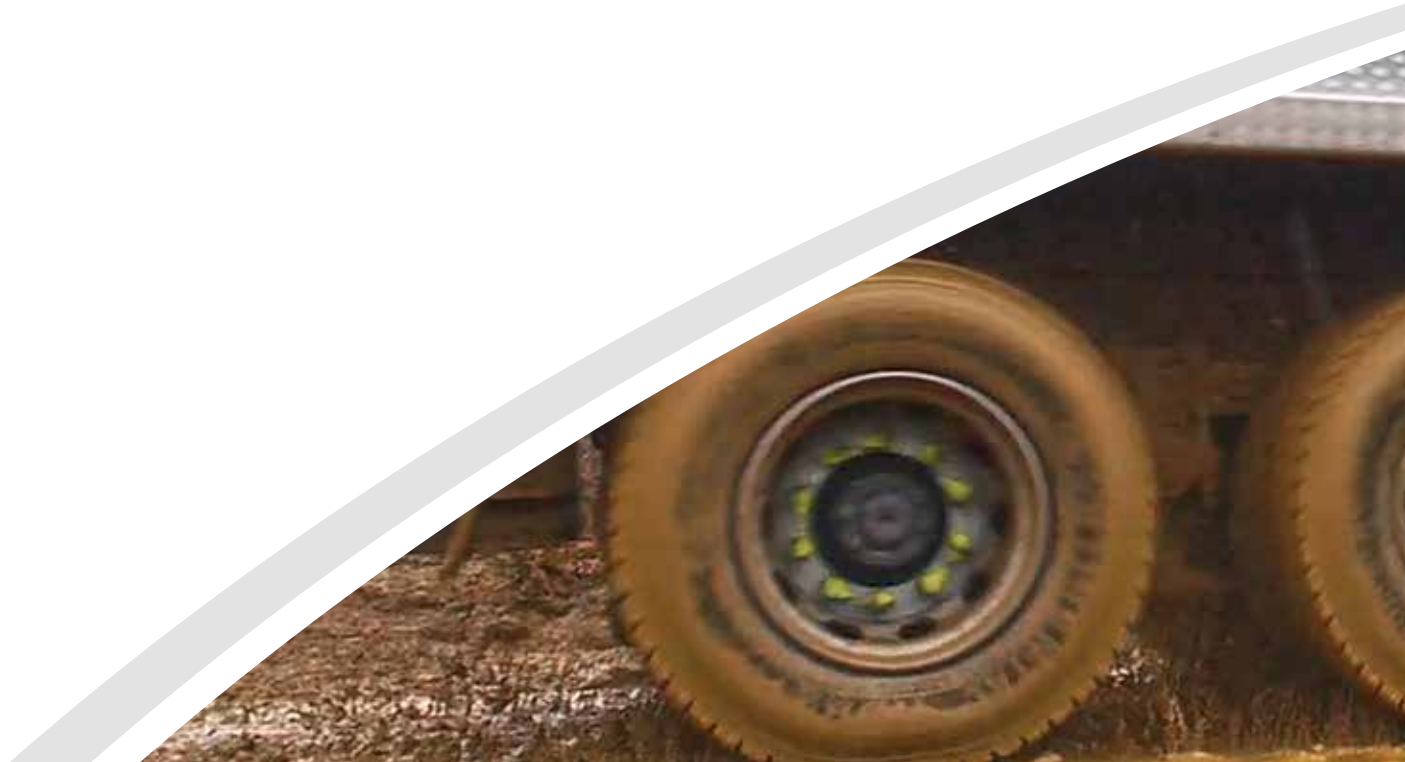
Millbrook provides independent commercial vehicle conversion services to fleet operators. These include:

- Powertrain modifications
- Emissions reduction projects
- Electronic equipment integration
- Structural modifications
- Adaptation for specialist tasks

Millbrook's deep understanding of vehicle structures and systems means that it is able to design and implement specialist conversion tasks for other vehicle converters. These may include work on powertrain installations or hydraulics systems and they can all be verified in Millbrook's laboratories.



Further Information





Venues

Millbrook has a number of event venues around its proving grounds in the UK and in Finland, each with its own atmosphere.

Millbrook's events team give customers complete flexibility for event design, with each venue being available on an exclusive basis. They are located in a secure environment, allowing for total confidentiality.

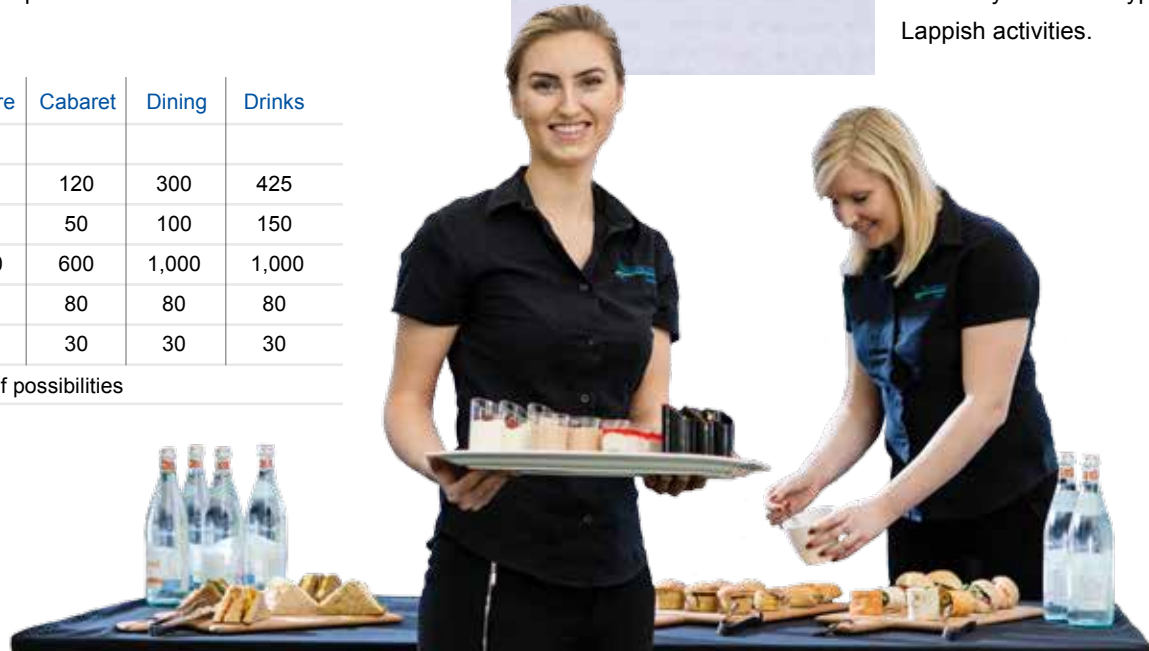
Millbrook offers customers the opportunity to combine top-grade hospitality and catering with access to private test tracks. This makes the facilities ideally suited to product launches or dealer training, with classroom sessions followed by driving experiences.



Test World

In Finland, Millbrook is able to offer tailored events, combining driving on snow and ice with skiing, husky dog sledging, Northern Lights discovery and other typical Lappish activities.

Venue	Area	Theatre	Cabaret	Dining	Drinks
Concept 1					
per wing	388m ²	350	120	300	425
per dome	160m ²	150	50	100	150
Concept 2	1,250m ²	1,000	600	1,000	1,000
Pod	375m ²	80	80	80	80
Cubo	120m ²	30	30	30	30
Test World	1,250 hectares of possibilities				





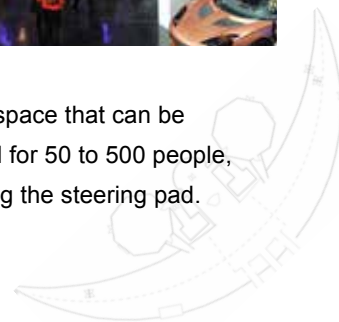
Concept 2

1,250m² of open space for large events for up to 1,000 people.



Concept 1

A flexible space that can be configured for 50 to 500 people, overlooking the steering pad.



Pod

A discreet, medium-sized venue close to the tracks with parking for vehicles.



Cubo

An intimate venue for up to 30 guests in the heart of the proving ground.



Case Study: Tailored Driving Days at Millbrook

DAF Trucks UK has been a regular visitor to Millbrook's proving ground in the UK.

Customers recognise that the fantastic facilities and adaptable approach tailoring events provide the ideal solution for ride and drive days and professional driving experiences.

Millbrook hosted the DAF Transport Efficiency Driver Challenge in 2016, in which a select group of drivers were invited to take part in a series of practical and knowledge-based assessments. The event had to

meet strict criteria for testing the drivers, and was designed to select the 'best of the best'.

The team were briefed at one of the on-site Venues and then headed out to tackle the challenges. Throughout the day the wide-ranging test tracks were used to put the drivers through their paces. The City Route was chosen for the DAF LF and an urban driving challenge, and other tasks included the attendees testing their off-road skills in a DAF CF.

Ride and drive events are used to familiarise current and potential customers with a variety of other DAF vehicles, going beyond presenting technical data and allowing people to experience the handling and broader vehicle capabilities for themselves. Millbrook provides confidentiality and safety with market-leading hospitality, making it the perfect space to showcase new vehicles.



DAF has also held customer ride and drive events at the site, notably using Millbrook to launch its Euro 6 new LF, CF and XF ranges in 2014, using the City, Alpine and Cross Country tracks and the High Speed bowl.





Track Testing – UK

Millbrook Proving Ground in the UK contains an unrivalled combination of tracks suitable for virtually every vehicle test.

Millbrook Proving Ground was purpose-built as a test facility for passenger cars and heavy duty vehicles. The on-road tracks include the famous Millbrook Hill Route, which simulates challenging European roads, the high speed circuit and numerous special surfaces.

The off-road tracks contain a large number of obstacles that test the capabilities of the finest civilian and defence vehicles.



● On-Road Tracks and Features

1. Hill Route
2. Hill Route Loop 1
3. Hill Route Loop 2
4. Hill Route Loop 3
5. High/Constant Speed Circuit
6. City/Handling Circuit
7. Outer Handling Circuit
8. Steering Pad
9. Steering Pad
10. Mile Straight/Mile Straight Apron
11. Driveway Ramps
12. Truck Slopes
13. Sine Waves
14. Random Waves
15. Noise Generating
16. Belgian Pavé
17. ABS and Traction Control
18. Drive-by External Noise
19. Twist Humps
20. Troughs
21. Rough Tracks, Kerbs and Features

● Off-Road Tracks

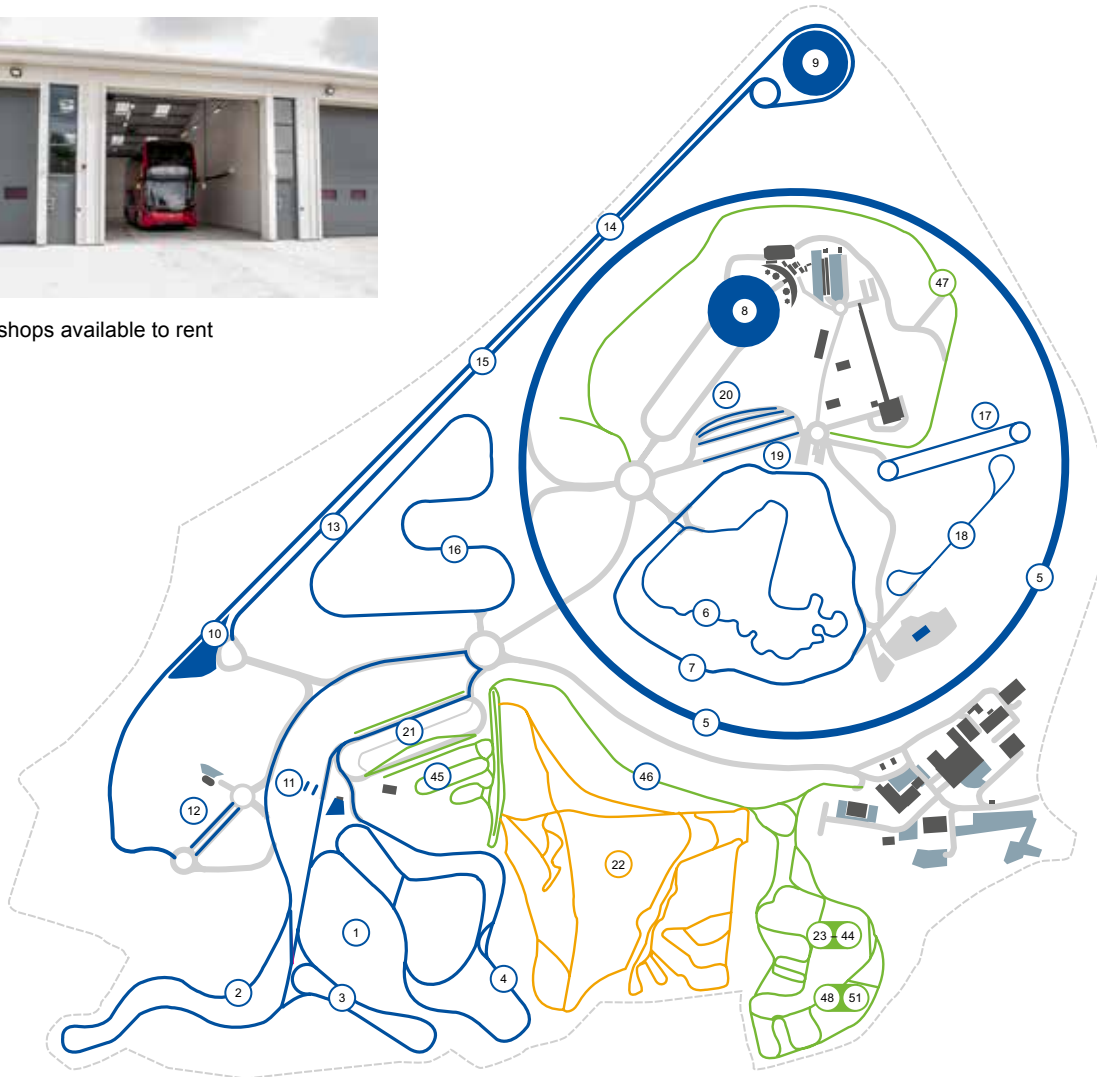
22. Off-Road and Severe Off-Road

● Off-Road Technical Features

23. Wading Pond
24. Semi Axle Bumps
25. Axle Bumps
26. Severe Vehicle Twist
27. Rock Run
28. Wading Trough
29. Concrete Ditches
30. Concrete Kerbs
31. Ditch Run
32. Mortar Holes
33. Log Roll
34. Log Run
35. Steps
36. One in One
37. 25° Traverse
38. Gravel Hills
39. 35% Gravel Hill and 155° Breakover
40. Snake Climb



Workshops available to rent



- 41. Sand Hills
- 42. Deep Ditches
- 43. Twist Climb
- 44. Offset Sinusoidals
- 45. Structural Test Features
- 46. Berm Road
- 47. Gravel Road
- 48. 60% Hill Slope
- 49. Severe Articulation/Hummer Hollows
- 50. Recovery Vehicle Winch
Anchor Points
- 51. Gravel Pits



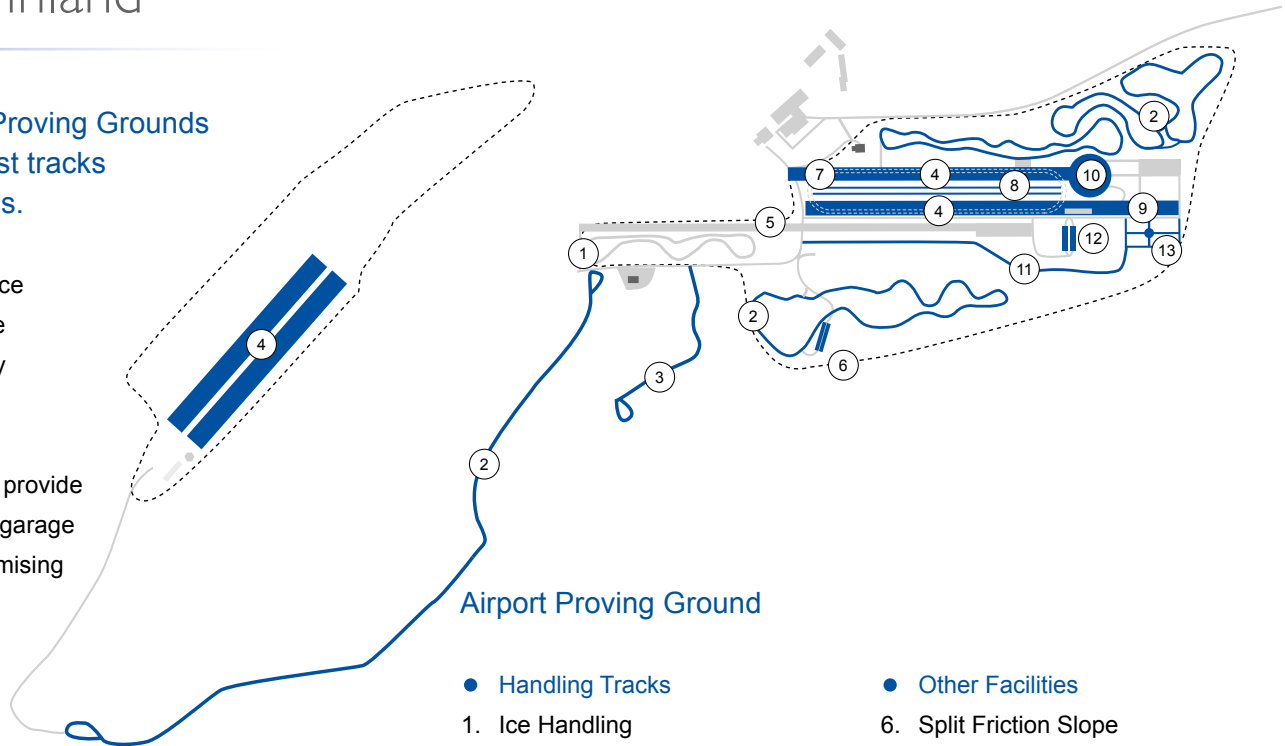
Track Testing – Finland

The Mellatracks and Airport Proving Grounds are home to superb winter test tracks and innovative Indoor facilities.

Test World prepares the snow and ice tracks to give consistent, repeatable test results that are highly valued by tyre and passenger car test teams.

The proving grounds are laid out to provide each visiting test team with its own garage and set of handling tracks, so maximising test efficiency and confidentiality.

The location 300km North of the Arctic Circle provides an exceptionally long winter test season, with outdoor tracks often open from October to April and indoor tracks open year round.



Airport Proving Ground

● Handling Tracks

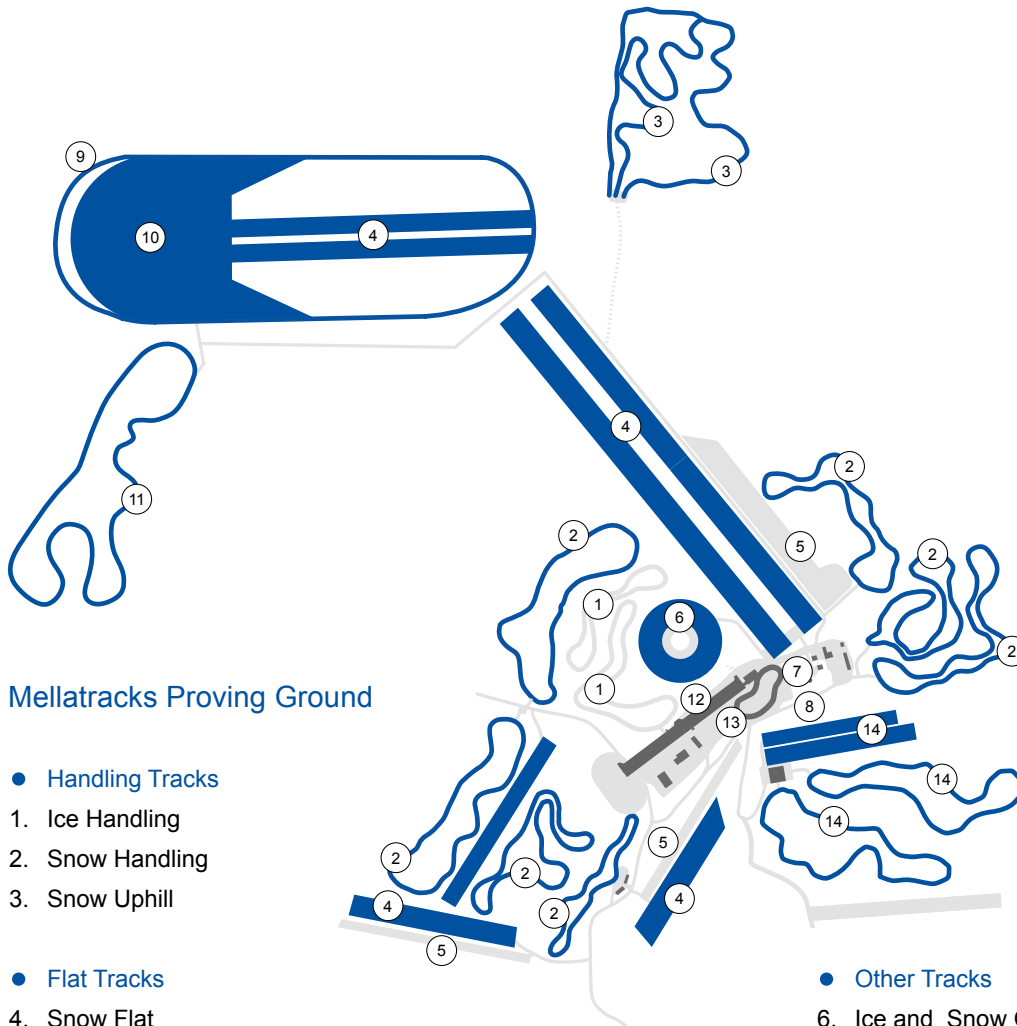
1. Ice Handling
2. Snow Handling
3. Snow Uphill

● Flat Tracks

4. Snow Flat
5. Ice Flat

● Other Facilities

6. Split Friction Slope
7. Oval Track
8. Soft Snow Tracks
9. Split Friction Track
10. Ice and Snow Circle
11. Comfort Road
12. Hill Slope
13. City Block



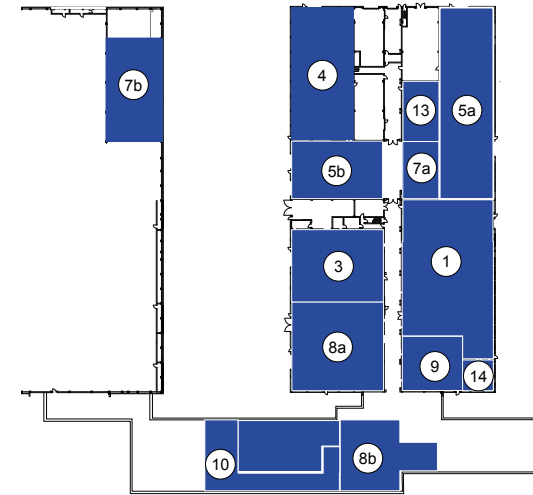
9. High Speed Snow Circuit
10. Snow Vehicle Dynamics Area
11. Snow Vehicle Handling Track
12. Indoor 1, 3, 4, 5
13. Indoor 2

Laboratory Testing

At the Leyland and Bedford test facilities, Millbrook has a wide range of laboratories suitable for testing anything from a seatbelt to a 44 ton military vehicle.

Millbrook's laboratories have been providing vehicle testing and validation for nearly 50 years and remain at the forefront of technology.

The facilities offer exceptional in-house calibration capabilities and the flexibility to design and build rigs and tests to suit customers' individual needs. They accommodate the testing of whole vehicles, systems and components, including high performance car engines and batteries.



Leyland Site Map

● Powertrain Testing

1. Engine Testing
2. Driveline Testing
3. Electric Machine Testing

● Vehicle Testing

4. Semi Anechoic Chamber
5. Structural Testing

● Interior Systems Testing

6. Vehicle Interior Environment Quality

7. Environmental Chambers

8. Seat Testing

9. Materials Testing

● Other

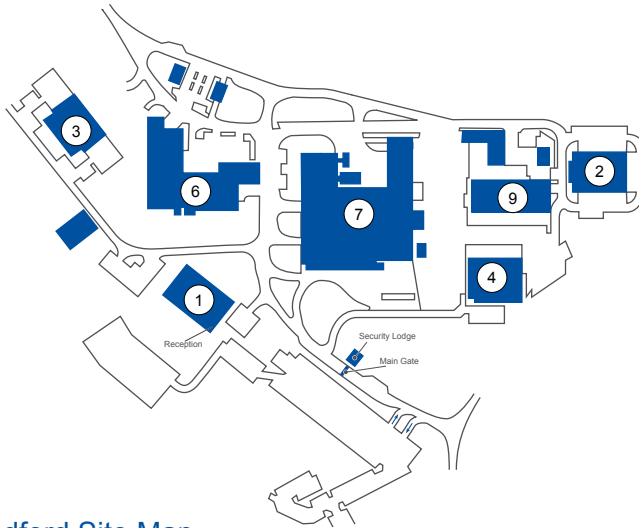
10. Offices

11. Stores

12. Fuel Stores

13. Vibration Testing

14. Instrumentation and Calibration



Bedford Site Map

- **Offices and Customer Workshops**

1. Main Reception Building
2. Workshops
3. Workshops
4. Innovation Centre
5. Commercial Vehicle Workshops

- **Powertrain Testing**

6. Dynamometer, PEMS and Engine Testing

- **Safety Testing**

7. ServoSled
8. Full-scale Crash and Safety Systems Testing

- **Vehicle and Interior Systems Testing**

7. Main Workshop Building and Instrumentation
9. Environmental Chambers and Component Testing





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