Our Vision

Our vision is to be a leading global provider of test services to the industries that we serve.

We will realise this vision through a relentless focus on our Priorities.
Spectris Overview

Millbrook is part of the Test and Measurement business segment of Spectris plc.
Millbrook is part of the Test and Measurement business segment of Spectris plc
Track Testing – UK
Track Testing – Finland

Mellatracks Proving Ground

Airport Proving Ground

1000m
Propulsion Testing

- Engine Strip, Rate and Build
- Variable Temperature Emissions Chamber
- LD and HD Real Driving Emissions
- Battery Testing
- Electric Machine Testing
- CEC Engine Testing
- Engine NVH Testing
- Engine and Driveline Testing
- 4WD Climatic Emissions Chassis Dynamometer
Overview of Battery Test capabilities

- Electric Machine and Inverter Testing
- Climatic Chambers
- Chassis and Hub Dynamometers
- 48V Hybrid Cells
- Full EV Durability
- Battery Cyclers
- ServoSled for Physical Crash Simulation
- Battery cycling

and a separate "outdoor" Battery abuse area
Active Safety

- Lane Departure Warning
- Lane Keeping
- Emergency Lane Keeping
- Vehicle To Pedestrian
- Vehicle To Cyclist
- Forward Collision Warning
- Autonomous Emergency Braking
CAV Testing

- Semi-Controlled Urban Environment
- Public Road Management
- Controlled Urban Environment
- Virtual Proving Ground
- 5G
- Guided Soft Targets
- Open Source Reference Vehicles
1. Your Project
   - Test services to the CAV industry
   - New test facilities
     - Improved physical infrastructure
     - Simulation suite
     - V2X capability
     - DCMS 5G Testbed
   - Already testing CAV’s

2. What’s innovative about it?
   - Clear path to on-road operation
   - Open to all players
   - Link to UK testbeds via Meridian
   - No IP threat or compromise

3. The services you can offer?
   - Development, trials, test, demonstration
   - Vehicles, components and systems
   - 80km tracks, 900 acres. Endless scenarios with and without other road users

4. The customers you seek?
   - Start up’s, SME’s, OEM’s, consortia
   - On or off road testing. Static or dynamic
   - City, urban, interurban users, virtual players
The UK’s Controlled Urban Testbed – partnership with UK Atomic Energy Authority

- Groundbreaking collaboration across the urban mobility test sector
- Access to controlled sites with urban simulation
- Initial development at Millbrook, more mature development at RACE
- Culham site has 2,000 staff and semi-controlled urban test routes
- Linkage to UK CAV Testbed Ecosystem
- Under construction Q2, 2018, complementing existing facilities

- Full connectivity to high speed wifi, mobile and 5G emulation
- Co-located simulation suite on Millbrook site
- Provision of open source reference vehicles
- Latest technology traffic management systems
- Open to all, open all hours
Open all hours

Open to all
Open now
Available to all
Available now
Not an IP threat
Trusted and independent
Impartial, safe and secure
Experienced
100% British
Ease of entry
Reducing barriers to entry
SME and start up friendly
Outward facing
Hills, valleys, curves, straights and streets
Additional ADAS equipment

To update and expand current ADAS offer into CAV’s:

- Data management equipment
- Inertial navigation and positioning (Datron)
- Additional targets (Moshon & ABD)
- Steering robot (ABD)
- Braking robot (ABD)
Further equipment in addition to previously mentioned soft targets and driving robots:

- Data acquisition software
  - Polygon visualisation tool
- OxTS RT3003 inertial & navigational measurements
- High positional accuracy;
  - Proving Ground wide Racelogic RTK corrections to 2cm
  - Local OxTS RTK Base station to 1cm
  - NTRIP mobile network corrections on public road
- Vehicle-vehicle data links
- Multiple camera views
- Additional sensors can include;
  - Microphones for acoustic feedback
  - Accelerometers for haptic feedback
  - Vehicle CANbus parameters
  - Pedal position & force
  - Brake line pressures
  - Steering wheel angle & torque
Key Partner: Streetdrone

Open source reference vehicle

Available to all customers.

Configurable vehicle characteristics

Prefit with sensors, optional LIDAR

Available Q3, 2018

Specification

- Drive-by-Wire
- CAN bus interface
- Control of vehicle ancillaries
- Auxiliary Power Additional 12V system
- Autonomous Ready
- AV Platform NVIDIA DRIVE PX2
- AV Software NVIDIA DriveWorks
- Functional Safety
- Emergency Stop Button
- Data Server FreeNAS 4TB
- Option: 4G, Bluetooth Connectivity
- Front, roof, side and rear sensor mounting
  - points
- Flat roof mounting area for LiDAR and GPS
- Flexible wiring options
- GPS
- IMU
- Wheel Speed Sensors
- Steering Angle Sensors
- Power Performance Diagnostics
- Actuator Monitoring
- Cameras 4 x GMSL FOV 60 2MP, 3 x GMSL FOV 120 2MP

Options

- GPS Bounding
- Remote Kill Switch
- LiDAR Velodyne Puck LITE™
- RADAR Continental ARS510
- 360 Camera Samsung Gear 360

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Road signage

To offer fixed and variable road signage for CAV development:
• Traffic sign recognition
• Fixed signage with covers
• Digital variable signs

Implicit Speedlimits

<table>
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<th>Highway &amp; Motorway</th>
<th>France</th>
<th>Germany</th>
<th>Netherlands</th>
<th>Sweden</th>
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<td>Dual carriageway</td>
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Proving Ground Scanning

Full 3D surface models in high resolution:

- Key partner: rFPro
- All tarmac and concrete tracks
- 1mm resolution
- Engineered surface and high graphics
- Suitable for simulation for CAV’s and dynamics
- Saleable commodity on it’s own
- Will be expanded to RACE @ Culham
Simulator Suite

Co-located at the trackside:

- Full range of simulation:
  - Software in the loop
  - Modelling in the Loop
  - Hardware in the Loop
  - System in the Loop
  - Human in the Loop
  - Vehicle in the Loop

- Complete framework being developed for CAV development and Validation
- Certification routes being explored
Local circuit modifications

Addition of real street layouts and furniture:
- Adaptation of City Circuit
- Working crossings
- To assist in testing and verification
- Flexible enough to adapt further
Autonomous Village and location

Buildings:
Five connected car and one bus garage with offices to meet the needs of CAV developers. These buildings will also attract ADAS developers and test customers.
New location, clustered working spaces:

- 5 vehicle garages
- 1 commercial garage
- Offices and meeting rooms in garages
- Located close to active tracks
- Build in 2019
- Contains simulation suite
Control systems and embedded systems are core technologies to improve automotive safety and comfort.

Electronic Stability Control (ESC)

Lane Keeping Assistance System (LKAS)
broad range of driver assistance functions already in production today

Standard features
- Hold assist
- Audi pre sense basic
- Audi pre sense city
- Park assist rear
- Adjustable speed limiter
- Cruise control system
- Break recommendation function

Tour assistance package
- Turn assist left
- Adaptive cruise control
- Audi active lane assist
- Audi pre sense front
- Obstacle avoidance assist
- Camera-based traffic sign recognition
- Predictive efficiency assistant
- Traffic jam assist

City assistance package
- Audi side assist
- Exit warning
- Audi pre sense rear
- Park assist plus
- Rear cross-traffic assist
- Reversing camera

Additional options
- Trailer assist
- Main beam assist
- MMI navigation plus with MMI touch
- Night vision assistant

Parking assistance package
- Surroundings camera
- Park assist
Autonomous?
WHAT'S MORE FORWARD THINKING?

DRIVERLESS CARS

CAR-LESS DRIVERS

EFFICIENT PUBLIC TRANSPORT
Hype Cycle for Connected Vehicles - 2018

- In-Vehicle Advanced UX and UI Digital Security
- 5G
- Digital Personalization
- Flying Autonomous Vehicles
- Mobility as a Service
- In-Vehicle Services
- Virtual Assistants
- eSIM
- Automotive Real-Time Data Analytics
- Blockchain
- Smart Transportation
- Over the Air Software Updates
- Automotive Lidar
- Autonomous Vehicles
- Vehicle Sensing and Environment Model
- Connected Car Platforms
- Continuous Software Deployment
- Electric Vehicle Charging Infrastructure
- Electric Vehicles
- Vehicle-to-Vehicle Communications
- HD Maps
- Mobile Device Integration Into Automobiles

As of July 2018

Plateau will be reached:
- less than 2 years
- 2 to 5 years
- 5 to 10 years
- more than 10 years
- obsolete before plateau

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Following distance = enhanced aerodynamics
Low fuel consumption
Better road usage efficiency
Optimised traffic flow
No overtaking
Lower Operational costs
Enhanced safety
System is always alert

Inputs:
- Radar
- Camera
- Wifi-P

Actuators:
- Driveline
- Braking system
- Steering system
THE COMING FLOOD OF DATA IN AUTONOMOUS VEHICLES

RADAR
~10-100 KB PER SECOND

SONAR
~10-100 KB PER SECOND

GPS
~50KB PER SECOND

CAMERAS
~20-40 MB PER SECOND

LIDAR
~10-70 MB PER SECOND

AUTONOMOUS VEHICLES
4,000 GB PER DAY... EACH DAY

intel
Connectivity (Fibre and Power)

Addition of high speed fibre and wireless communications (802.11p):
- Key Partner: AWTG
- Creating a base infrastructure to provide Power and Fibre connectivity to all locations across the track facility
- 3G/4G coverage assurance across the entire track site.
- Tuneable mobile network for testing 5G and CCAV

Fibre network (14kms)

Wifi network (23 points)
Cisco Grant Project: Orkney Islands
The project is named 5G Rural First and will be based mainly on the Orkney Islands and in rural Shropshire and Somerset. This project will look at smart farming, autonomous farm vehicles and remote veterinary inspections.

Sensor City Grant: Liverpool
This project is based at Liverpool and includes public sector health suppliers, the NHS, university researchers etc. The focus here will be in patient care and monitoring, loneliness in older adults and communication between hospitals and the community.

Worcestershire 5G Consortium: Malvern Hills Science Park
This project sees O2 and BT involved along with companies such as Huawei looking at ways to increase industrial productivity robotics, cyber security, big data analytics and Augmented Reality over 5G. This testbed will be located at Malvern Hills Science Park.

Quickline Communications Grant: Rural across 7 counties
This project is named the 5G Rural Integrated Testbed (5GRIT) and will be used to trial and test smart agriculture, 5G-ready AR apps for tourists and connecting poorly-served communities across the following counties: Cumbria, Northumberland, North Yorkshire, Lincolnshire, Inverness-shire, Perthshire and Monmouthshire.

Airspan Communications Ltd Grant: Bedford
This project looks at the development and validation of connected and autonomous vehicles at the vehicle proving ground at Millbrook. The main focus for this project covers complicated cell-tower handoffs, and autonomous vehicles network bandwidth issues and how 5G connectivity solutions could be transferable to both road and rail transportation.

West of England Combined Authority Grant: Bristol and Bath
This project is named 5G Smart Tourism and will have attractions in Bath roman baths and Bristol's Millennium Square. The project will focus on delivering enhanced visual experiences for tourists via Augmented Reality (AR) and Virtual Reality (VR) technology.