University Strategic Research Group (USRG)

Monitoring of Engineered and Natural Systems Using Sensors (MENSUS)

Dr Ling Wang, Chair of MENSUS

11th October 2016

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MENSUS Team:

Co-Chairs and Theme Leaders

Ling Wang

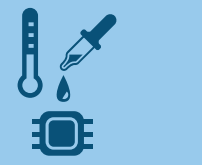
Joerg Fliege

Matt Mowlem

Roger Gardner

System Characterisation focuses on modelling and

Tim Waters



Sensors and Devices encompass a wide range of

Chris Holmes

Energy Harvesting is the process of using ambient forms of

Neil White

Big Data and Analytics deals with structuring and analysing

Honor Powrie

System Integration enables the identification of the system

Janice Barton

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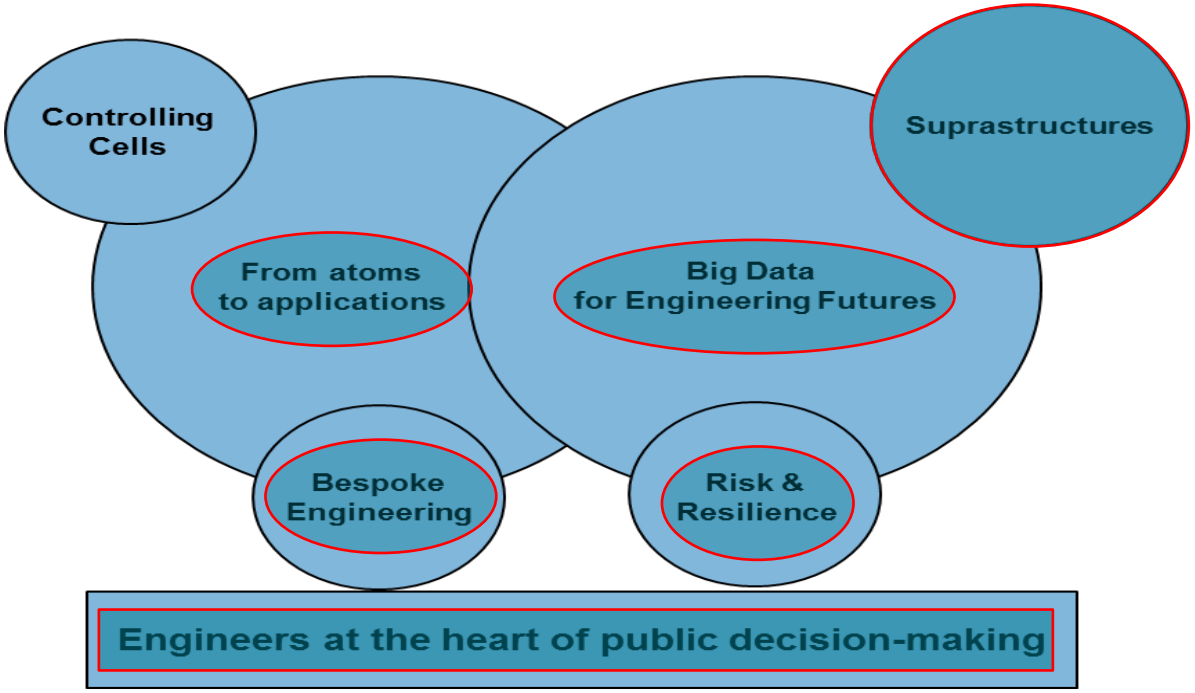
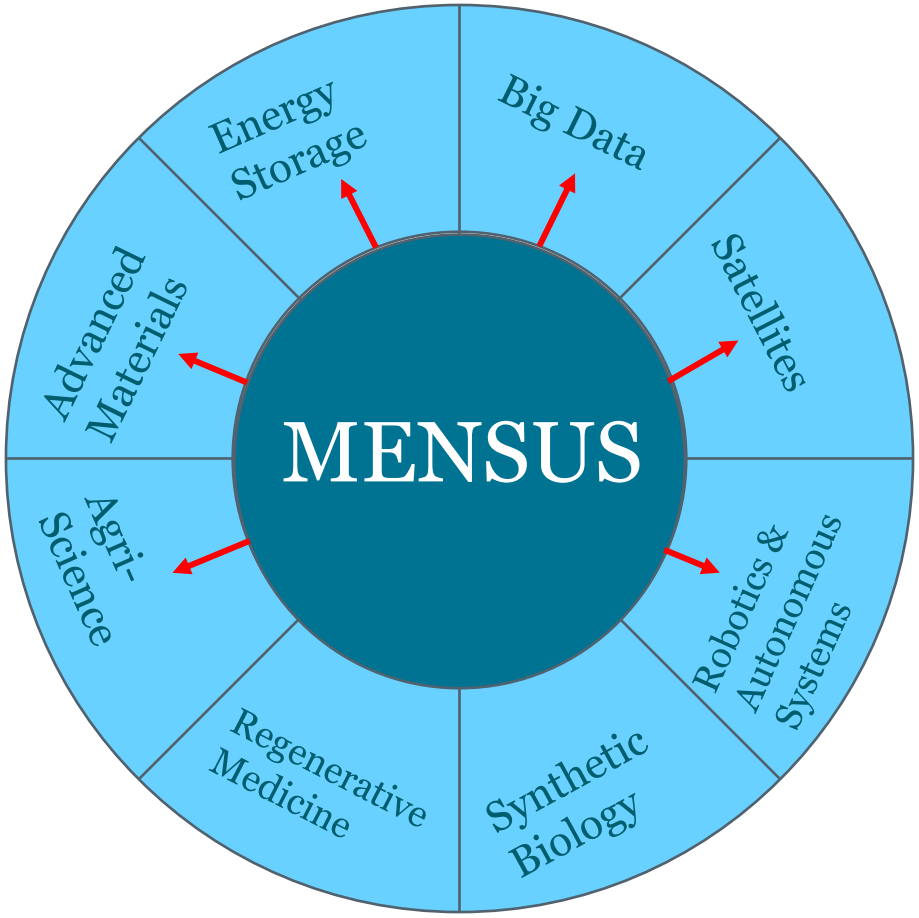
The Seven Grand Challenges (EPSRC)



MENSUS also links with data-centric engineering, smart city/factory, cyber security and risks

The Eight Great Technologies (UK Government)



MENSUS fits with the funding framework:

- Agricultural technologies;
- New advanced materials;
- Energy storage and technologies for new energy sources;
- Big data revolution and energy-efficient computing;
- Satellites especially analysing data from them;
- Robots and other autonomous systems.

MENSUS research activities:
a wide range of engineered and natural systems

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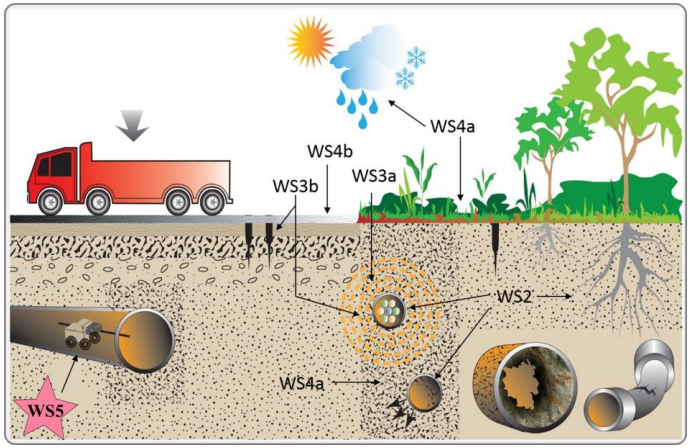

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MENSUS Five Themes

System Characterisation focuses on modelling and experimental methods for establishing the behaviour of time varying systems to controlled or naturally occurring stimuli. Observed changes to their responses can then be attributed to the existence and severity of any evolving abnormalities.

Sensors and Devices encompass a wide range of physical and chemical detection methods using both optical and electronic platforms. The theme promotes novel sensors that utilise nano and micro fabrication, smart materials and photonics to monitor harsh environments, provide energy efficient solutions and integrate into smart networks.

Energy Harvesting is the process of using ambient forms of energy (solar, thermal, vibration, wind etc.) and converting this into electrical energy, which can be used to power autonomous devices, sensor nodes and measurement systems. A key enabler is wireless sensor networks, which can be coupled with energy harvesting systems to provide low-power, wire-free solutions.

Big Data and Analytics deals with structuring and analysing high volume data, enabling extraction of insightful and actionable information. Examples include high resolution data, such as imaging or acoustic data, or data collected from multiple or numerous entities and a variety of sources, as encountered with industrial machines.

System Integration enables the identification of the system measurable characteristics and appropriate sensor selection, sensor excitation and powering, signal processing and data transfer to be treated holistically. The theme focuses on the performance of the integrated system in its operational environment. An overarching consideration is the business models for application of the integrated system, managing risk, and societal and environmental impact in a highly sensed world.

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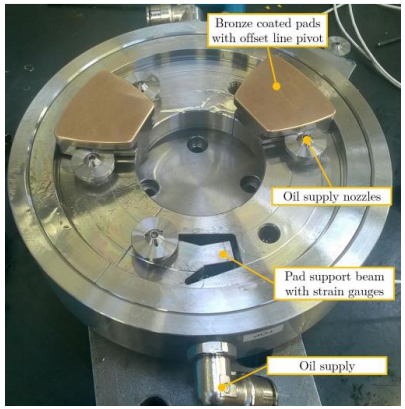
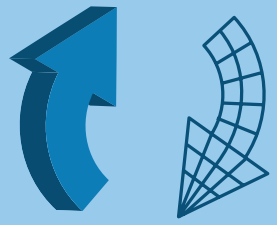
System characterisation

Inputs → SYSTEM (TIME VARYING) → Outputs

Understand system **in order that** abnormal behaviour can be recognised

Experimentation and modelling





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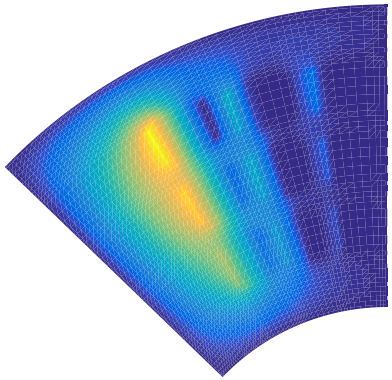

Sensors and Devices

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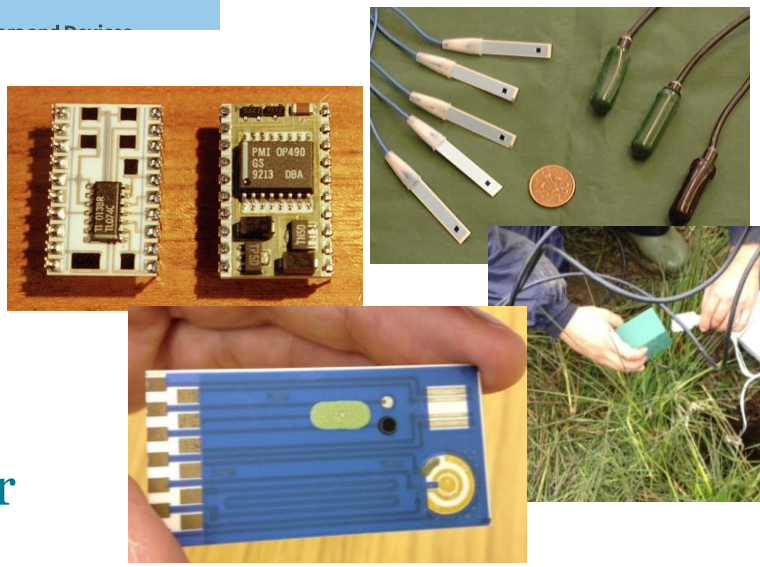
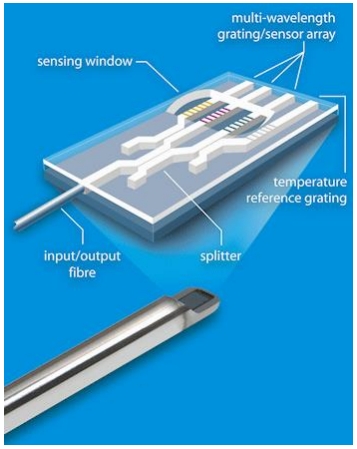
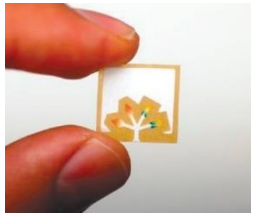
- Thick film sensors (physical sensors and chemical sensors)
- Optical fibre sensors for temperature, strain, gas; micro-sensors; biophotonics; planar devices; paper based sensors, etc.
- Microfluidic sensors: chemical analyser
- MEMS and E-textile sensors

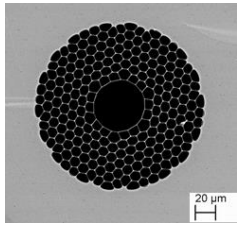




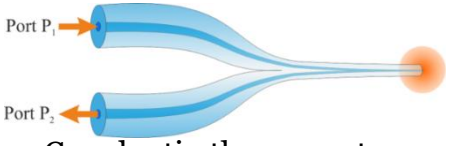
Planar devices



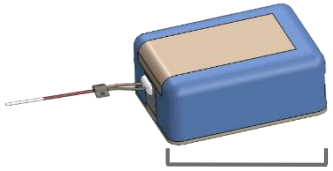
Paper based sensors



Hollow core microstructured optical fibres



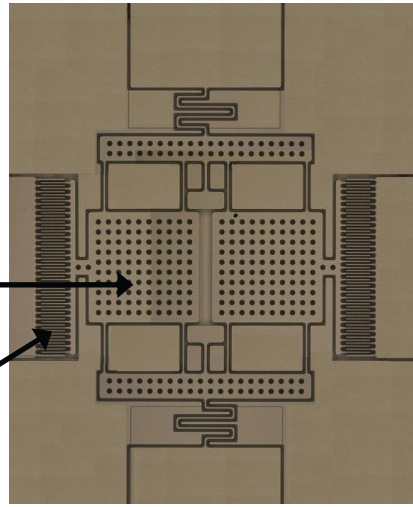
Coupler tip thermometer
Temperature ~1511 ˚C



7 cm

Microfluidic sensor

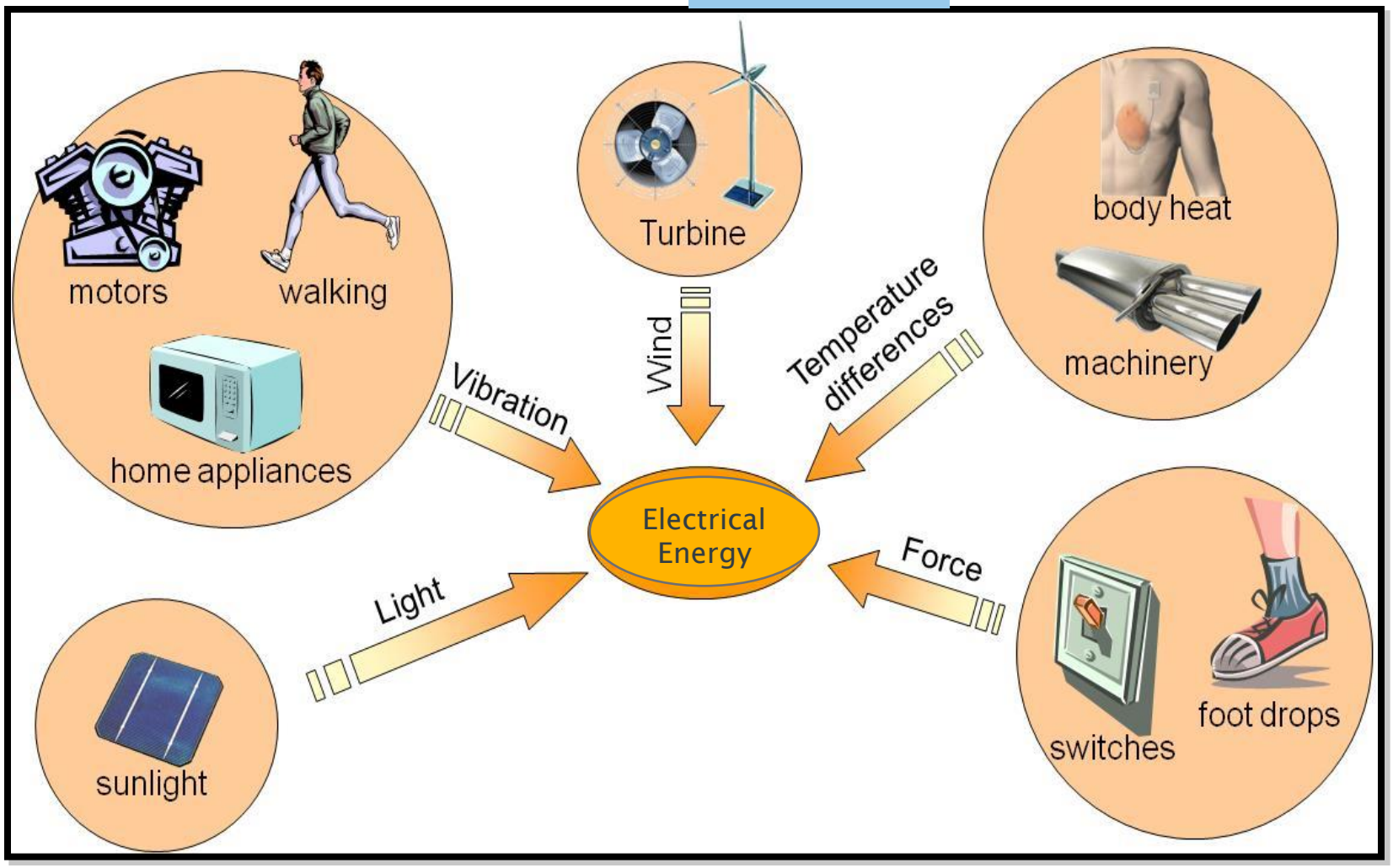
MEMS resonant sensor



Resonant structure

Electrostatic comb drive

Energy Harvesting



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Wireless Sensor Networks

Pumping station shown is Bartlett Street Pump Station, Portland, Connecticut; taken from http://www.nlja.com

Big Data & Analytics

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Big Data & Analytics

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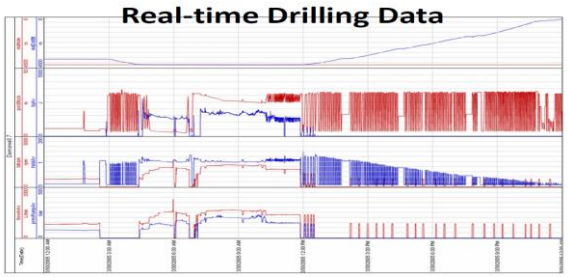
- An example: Industrial drilling big data

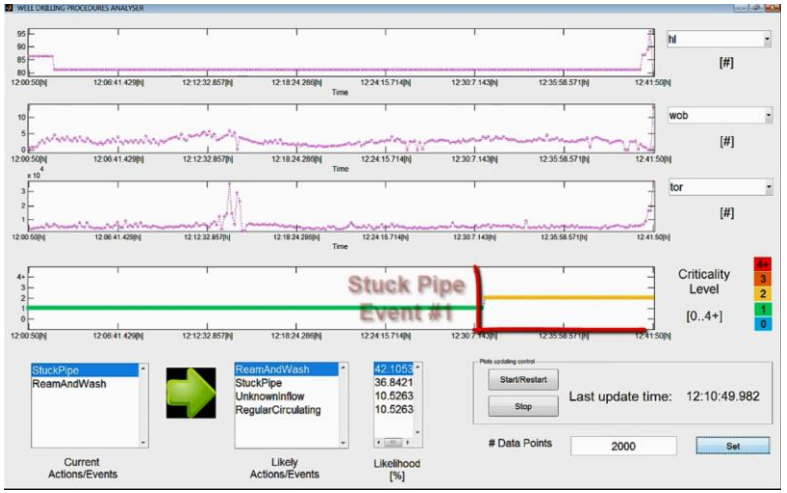
Normal operations



Disaster situations

- **Automatic detection** of "normal drilling state Operations"
- Deployment of machine learning methods for the detection of operational drilling states- i.e. **Random Forest +AdaboostM2**
- Automated forecast of abnormal operational situation, which potentially lead to critical events using an **encoded knowledge based model**.

i.e.: Stuck pipe, kicks, blowouts, etc.



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System Integration & Mission Plan

- An overarching consideration is the business models for application of the integrated system, managing risk, and societal and environmental impact in a highly sensed world.

Characterisation

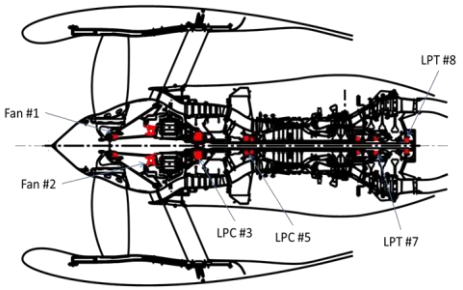
Sensors and devices

Energy harvesting Wireless comms

Data handling

→ Integration → Implementation

Smart Bearings in UHPE Ground DEMO



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Our Mission

As a diverse but complimentary research community of *sensors*, *big data*, *wireless communications*, *instrumentation* as well as *business* aspects of monitoring, MENSUS aims to develop world-class **integrated systems level solutions** for health monitoring of engineered and natural systems.