Sensors SIG Meeting, 02 July 2018

Meeting Notes

School of Civil Engineering Birmingham Centre for Railway Research and Education, University of Birmingham

Attended by:
-Prof Kirill Horoshenkov - UKAN Director - University of Sheffield
-Prof Rob Dwyer-Joyce - SIG Sensors Lead - University of Sheffield
-Dr Michele Schirru - SIG Sensors Deputy Lead - University of Sheffield
-Prof Jian Kang - UCL Institute for Environmental Design and Engineering
-Mr Chaoqing Tang (Bill) - PhD student Newcastle University
-Dr Nikhil Banda - Seiche Marine Acoustics Solutions
-Dr Nicholas Watson - University of Nottingham (Chemical Engineering)
-Mr Zhengwei Li - PhD student University of Sheffield
-Dr Sakdirat Kaewunruen - Birmingham University

Summary:

Rob opened the meeting with his introduction to the SIG.

Round of introductions by the attendees.

Rob and Michele presented the objectives for their SIG and roadmap. A nice diagram which maps acoustic frequencies and energies required for various sensors for various applications.

Individual 5-min (or so) presentations by:

- Nick Watson (Nottingham) about his sensor work for food and chemical industries, data analysis. There is a possibility for Nick to invite Michele to give a guest lecture on tribology. Nick may be a good candidate for outreach because of this experiments with food technologies. Emergence of powerful analytics for sensor data analysis may be a good topic for future research proposals – balance of mathematical methods vs data analytics?
- Nikhil Banda (Seiche) presented his work on underwater sensors for monitoring marine life population.
- Jian Kang (UCL) presented on sensors for soundscape research.
- Rob Dwyer-Joyce (Sheffield) presented on acoustic sensors applied to the field of tribology.
- Bill (Newcastle) presented on compressed sensing technologies. Jian may consider these technologies for his low-cost soundscape sensors.
- Zhengwei Li (Sheffield) robot localisation, navigation and communication.
- Kirill Horoshenkov (Sheffield) sensors for water industry.

Discussion and Actions:

Rob gave the opportunity for the attending members to discuss core objectives of this SIG. The members agreed that it is critical to listen to the industry to understand challenges and bid for better research grants. Nick suggested to link better to KTN on Sensors. Liverpool is a new sensor city [**action: Nick to contact the KTN and Liverpool**]. There are several Catapults – similar bodies which make sense to link the UKAN to. CENSIS in particular [**action: Michele to find out further details, Nick to contact Digital Catapult**].

Next meeting – invite industry people to help design research themes. We also need to get companies who manufacture sensors to attend these meetings. We need to ask them via questionnaire and/or website to tell us what they want and what will make them to attend these meetings [**action: Kirill/Rob to design this questionnaire**].

There is a possibility to develop an acoustic map of the UK: frequency, energy, research type and applications [**action: Kirill/Michele to start**].

University lab visits can be a good way to engage ECRs. Sheffield to host the first of these events in September 2018 [**action: Rob to suggest a date**]. These can be supplemented/combined with industry visit days.

The members talked about the website. It works well for the UKAN, but can be made more lively [**action: Kirill to work with Human Studio].**

Rob asked to describe the characteristics of a "dream sensor" – small one which can be put anywhere to measure anything.

Kirill suggested to run a sensor challenge prize competition similar to that run by UA SIG [**action: Rob/Kirill to work out the details and text**].

Nikhil suggested to develop a school kit for outreach which can tell students to listen ponds and rivers. 'How noisy your pond?' It also makes sense to find or to develop a suitable sound capture app to support outreach [**action: Kirill/Nikhil/Charlotte to look into these matters].**

Rob, Jian, Kirill to contract industry members of the Sensor SIG personally after we know the date for the next lab visit day. They need to find out what will make industry want to attend SIG meetings.

Special Interest Group in Acoustic Sensors (SIGSense)

Prof. Rob Dwyer-Joyce, & Dr Michele Schirru University of Sheffield

r.dwyer-joyce@sheffield.ac.uk
m.schirru@sheffield.ac.uk

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SIGSense – Purpose of first meeting

- Getting to know each other
- Create a sense of community
- Define the aims of the SIG

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Agenda for today

- 11.00-11.15 Introduction (Aims of this meeting)
- 11.30-12.30 Presentations from participants (5mins each).
- 12.30-13.30 Lunch
- 13.30-15.00 Discussion 4 x 20 minutes.
- 15.00-15.15 close & final remarks.

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SIGSense - Objectives

- Establish a membership (say 20-25 people) of academics and industrialists
- Hold meetings, webinars, and forums to exchange ideas, techniques and establish collaborations
- To identify future research needs and opportunities and where possible align these with national priorities and funding opportunities
- Compile a list of facilities, equipment, software, and infrastructure
- Get a core group of likeminded PhD students to meet, exchange and collaborate.
- Special attention to early career researchers, PhD students and RA's to get them working together and developing their careers.
- Carry out outreach activities and events

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SIGSense Roadmap

Rob Dwyer-Joyce

Michele Schirru

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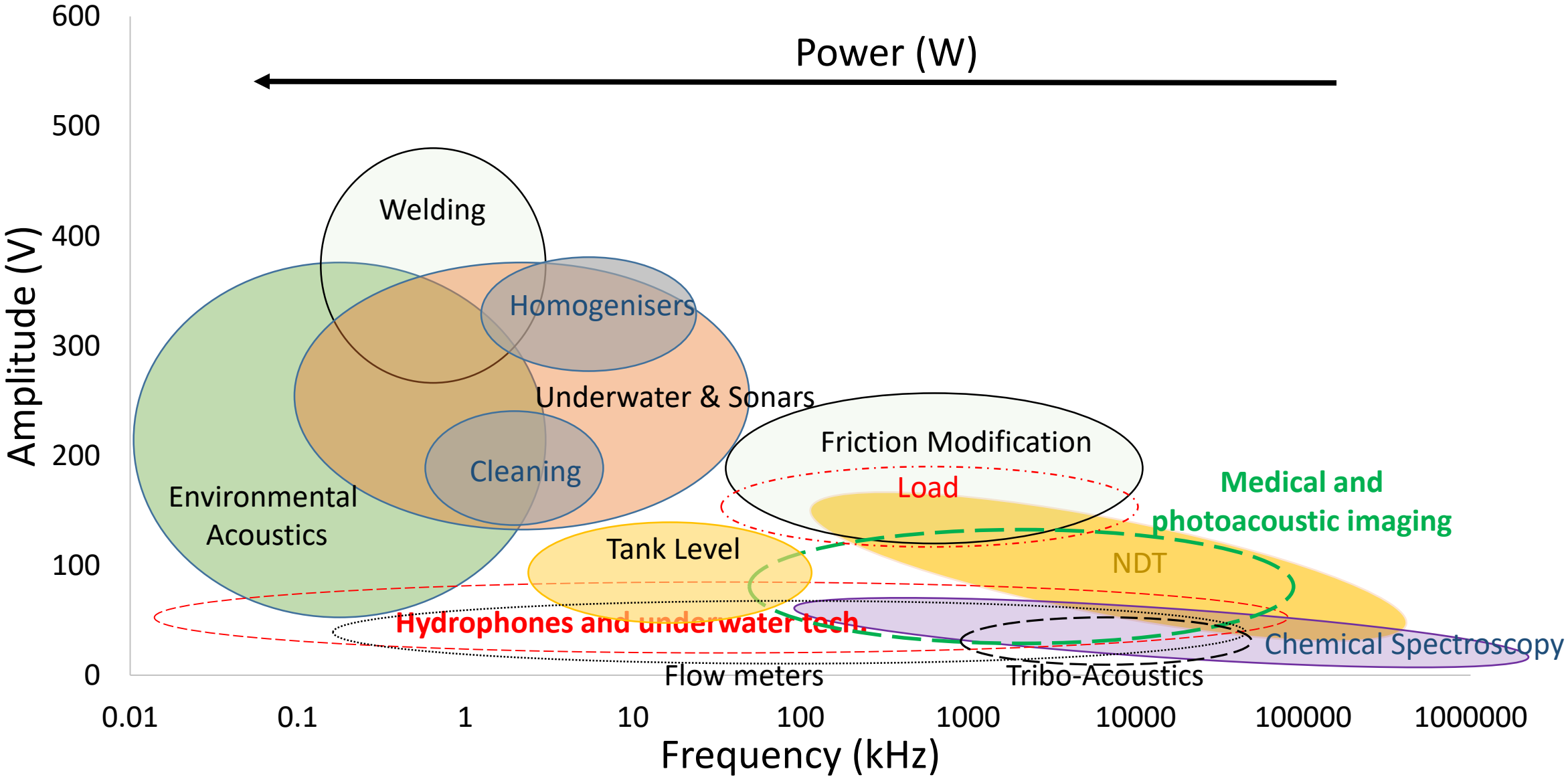
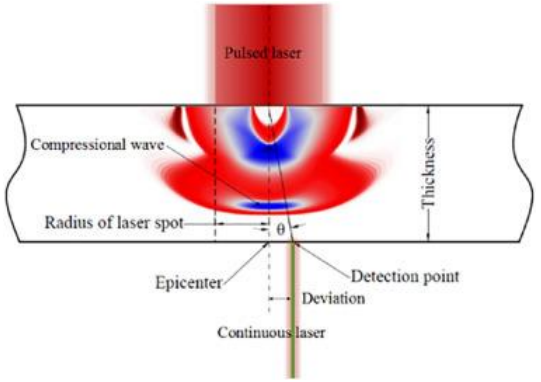
Ultrasonic applications by frequency and amplitude - overview

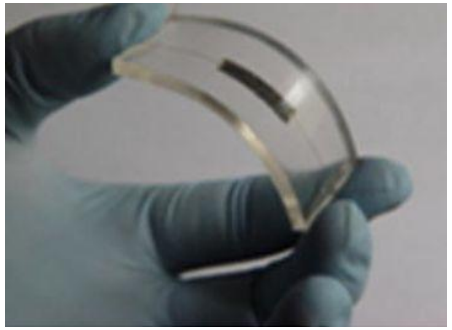
Notice: this is a live document, help us improving this acoustic sensors map! Contact: sensors@acoustics.ac.uk



Bare piezoelectric quartz

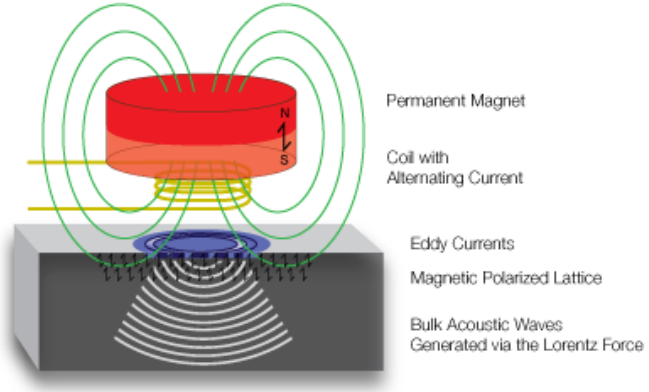


Laser ultrasonics

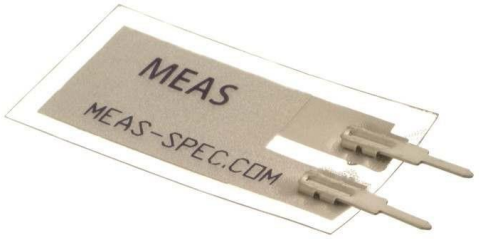


New generation graphene based sensors

Optic Fiber



Electromagnetic



Thin films

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SIGSense Discussion Topics

Rob Dwyer-Joyce

Michele Schirru

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SIGSense Flash Presentations

SIG Discussion Topics

1. Scope and Aims of the SIG - are the objectives clear/right?
2. What kinds of things do you want the SIG to do?
3. The website – what should go on here?
4. What would be your dream sensor?

SIGSense Website

Rob Dwyer-Joyce

Michele Schirru

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SIG Website

- acoustics.ac.uk

- What is it for?
- What do we want on it?

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SIGSense Aligning ourselves with UKRI (EPSRC)

Rob Dwyer-Joyce

Michele Schirru

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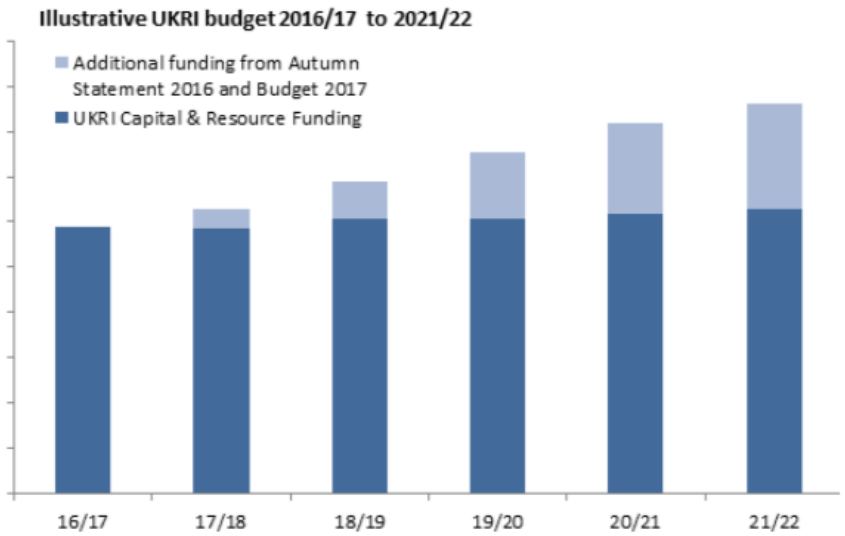
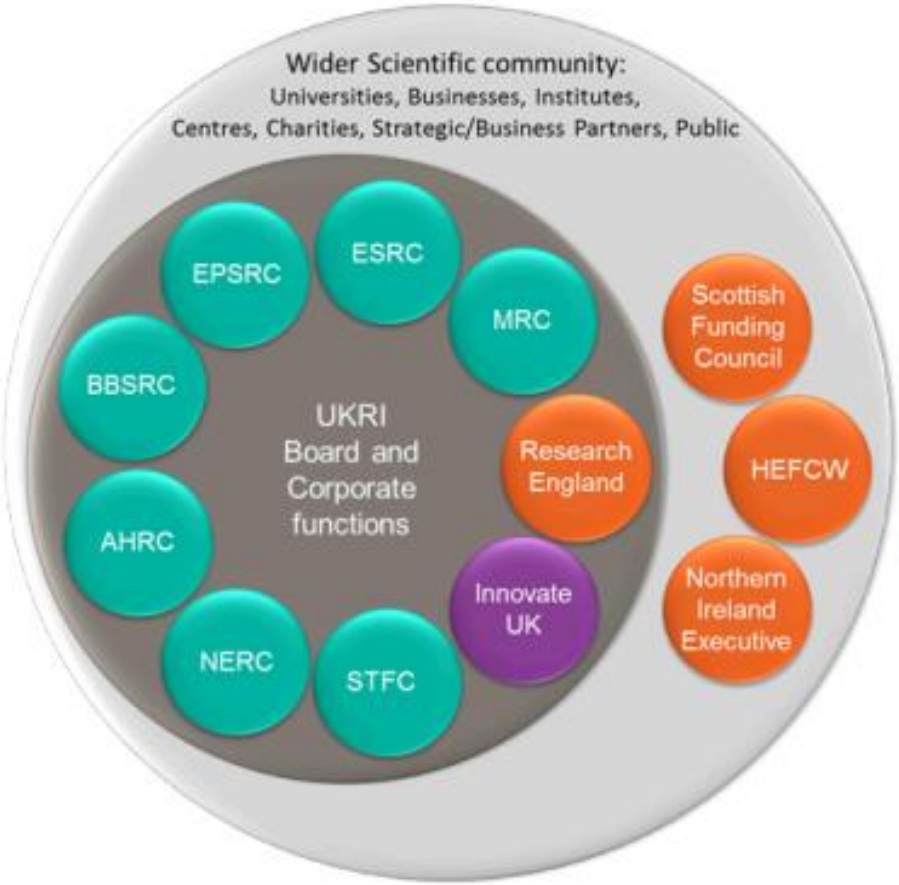
UKRI – What is it?

- From April 2018
- Grouping together of Research Councils
- EPSRC still covers EPS domain
- UKRI budget set to rise (additional £4.7bn over three years)
- Aiming to increase R&D spend from 1.7 to 2.4% of GDP





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Government White Paper 2017

- Some new funding schemes - Next three years:
  - UKRI to deliver £725M through Industrial Strategy Challenge Fund, ISCF
  - £300m developing research & innovation talent (CDTs, KTP's, fellowships etc.)
  - Working on details of Strategic Priorities Fund (common fund)
  - New £115M Strength in Places Fund
  - New 'International R&I Strategy' - £110M Fund for International Collaborations (e.g. EPSRC's C2C)

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UKRI – Industrial challenges 2018-2023

Wave One Challenges


Medicines manufacturing technologies

Robots for a safer world


Batteries for clean and flexible energy storage

Self-driving vehicles


Manufacturing and materials of the future

Satellites and space technology

INDUSTRIAL STRATEGY

Wave Two Challenges & Two Pioneers

Transforming construction: up to £170m

Prospering from the energy revolution: up to £102m

Transforming food production: up to £90m

Audience of the future: up to £33m

Data to early diagnosis and precision medicine: up to £210m

Healthy ageing: up to £98m

Next generation services: up to £20m

Quantum technologies: up to £20m

INDUSTRIAL STRATEGY

https://apply-for-innovation-funding.service.gov.uk/competition/search

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The Leonardo Tribology Centre

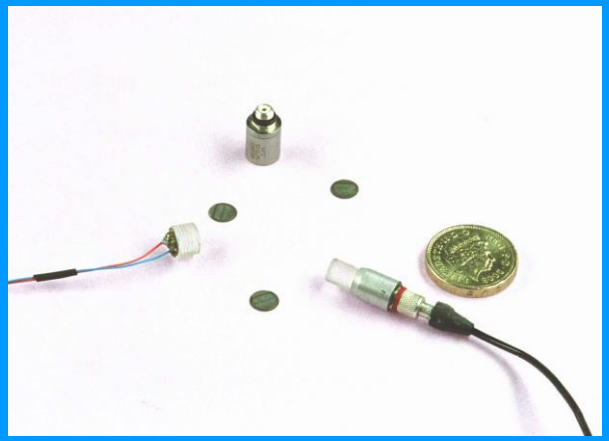
Tribo-Acoustic Sensors

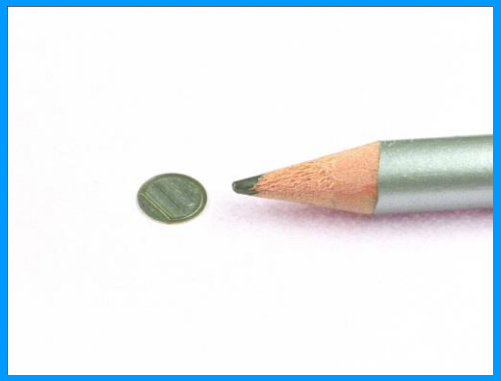
Measuring films, contact, stress, load, and viscosity inside machine element contacts

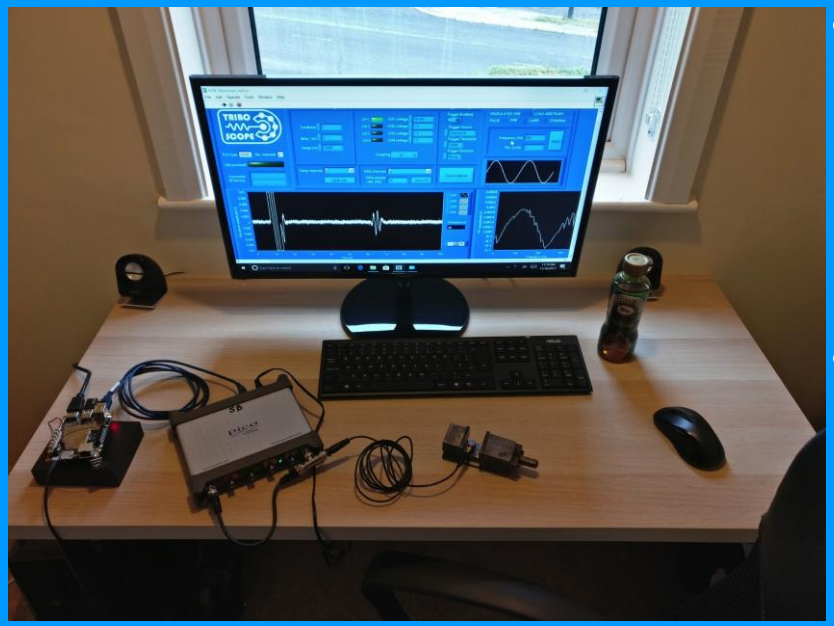
Prof Rob Dwyer-Joyce,
Leonardo Centre for Tribology,
Department of Mechanical Engineering,
University of Sheffield

The University Of Sheffield.

Piezo-Electric Transducers







- PZT Elements
  - Longitudinal or shear polarised
  - 0.5 – 20 MHz
  - 1V – 100V
  - Cut to size (down to 1mm)
- Pulsing
  - Top hat pulse
  - Short burse sine wave
  - Chirps

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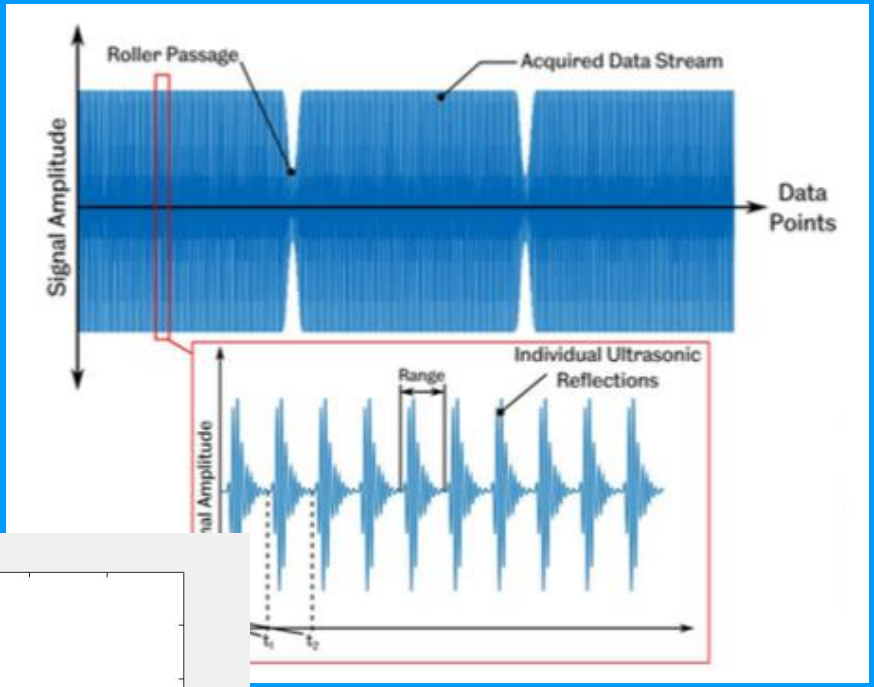
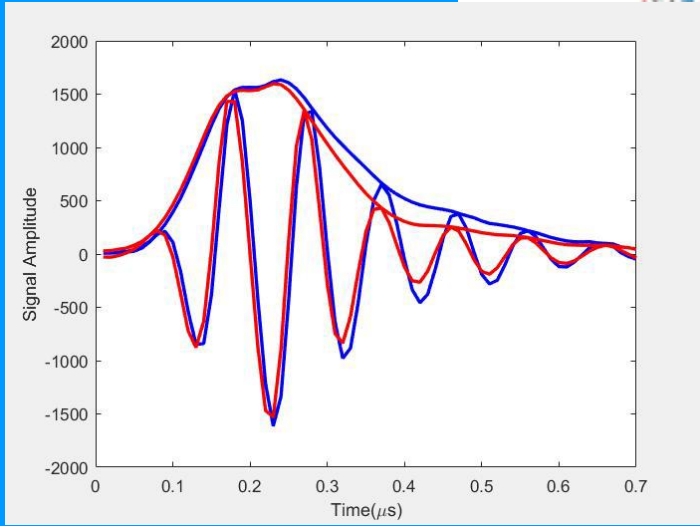
Load and Oil Film Thickness





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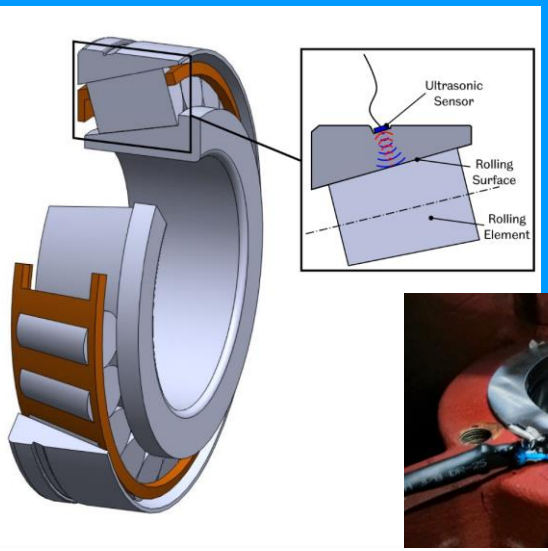
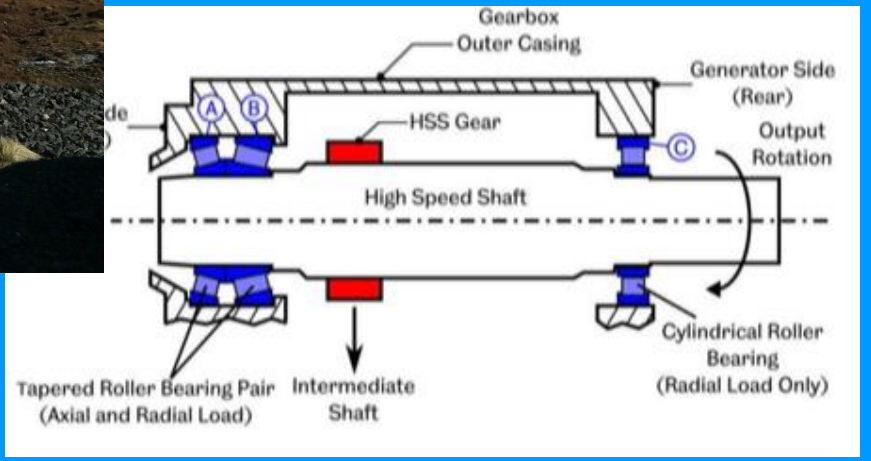
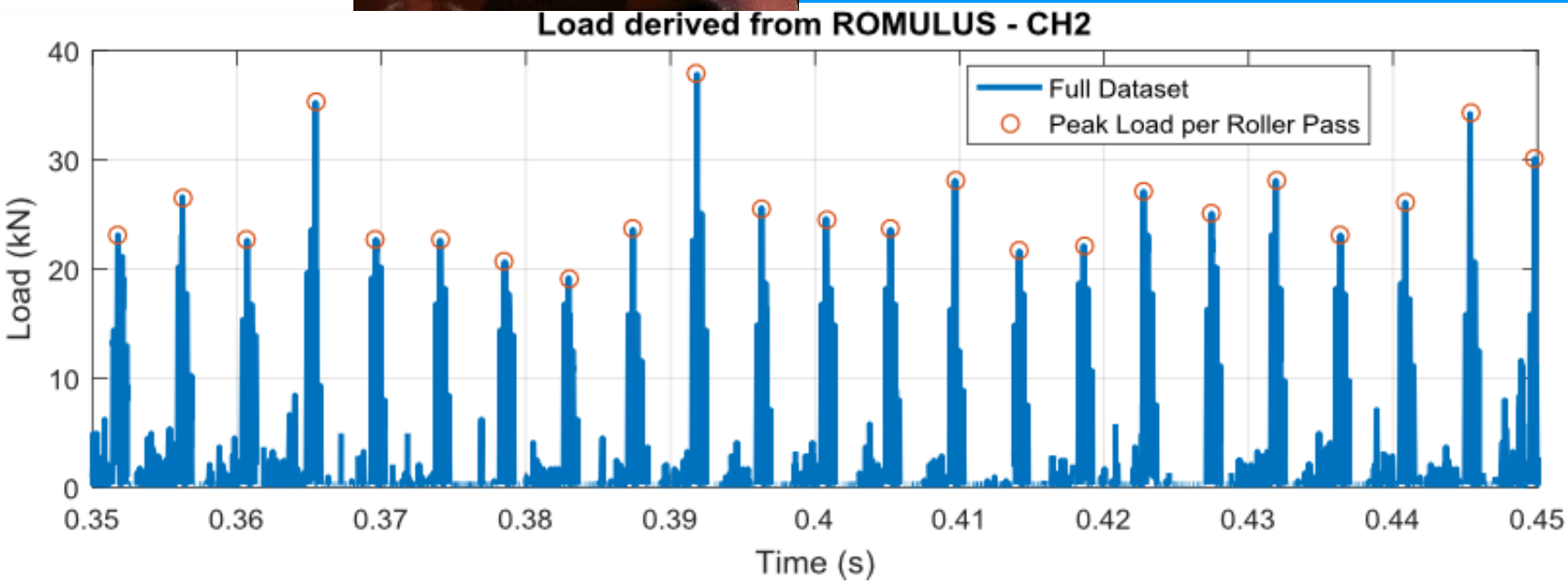
Barnesmore field
Vestas V42 600kW
32222 tapered roller bearing







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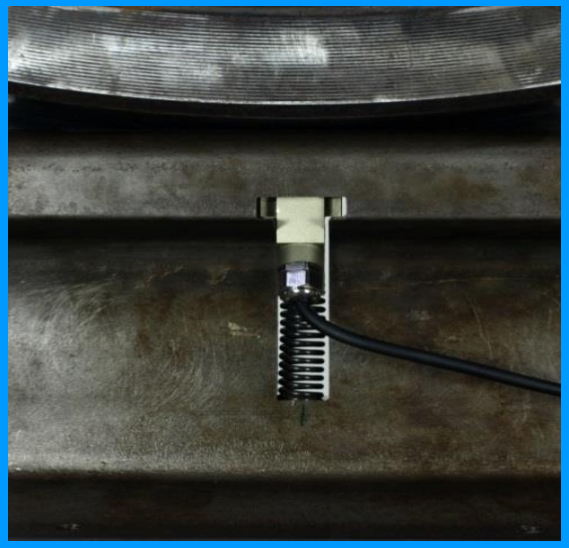
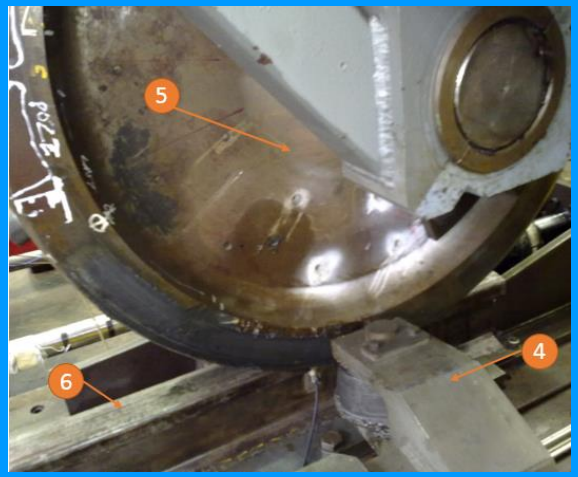
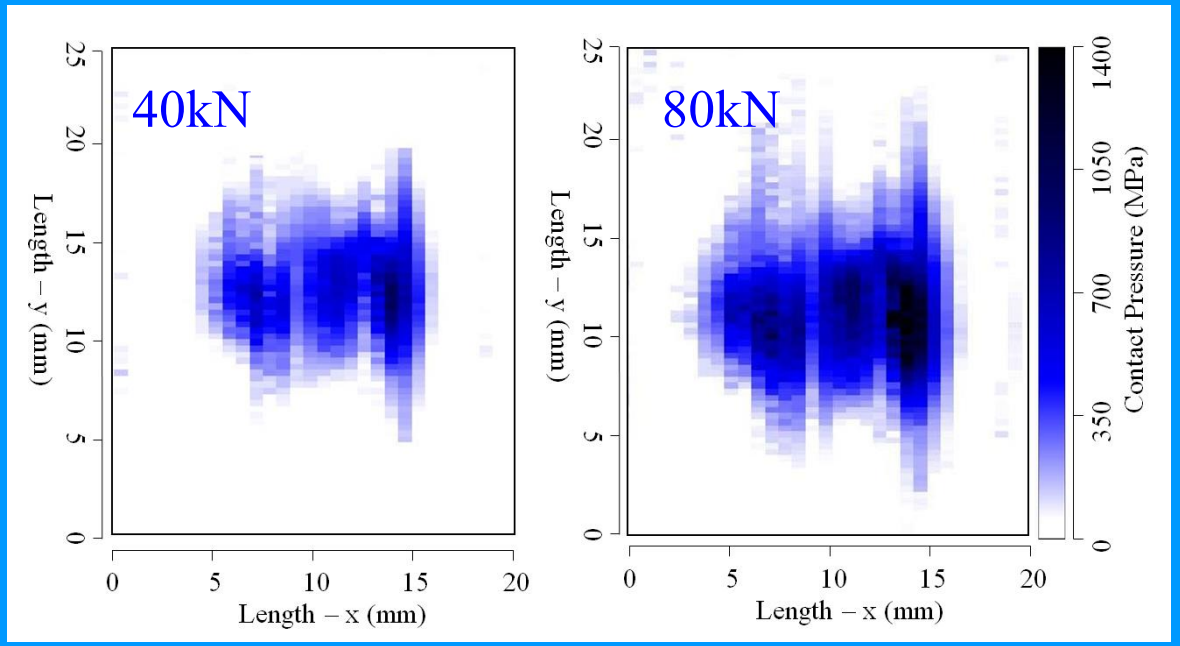
Wheel-Rail Contact Pressure







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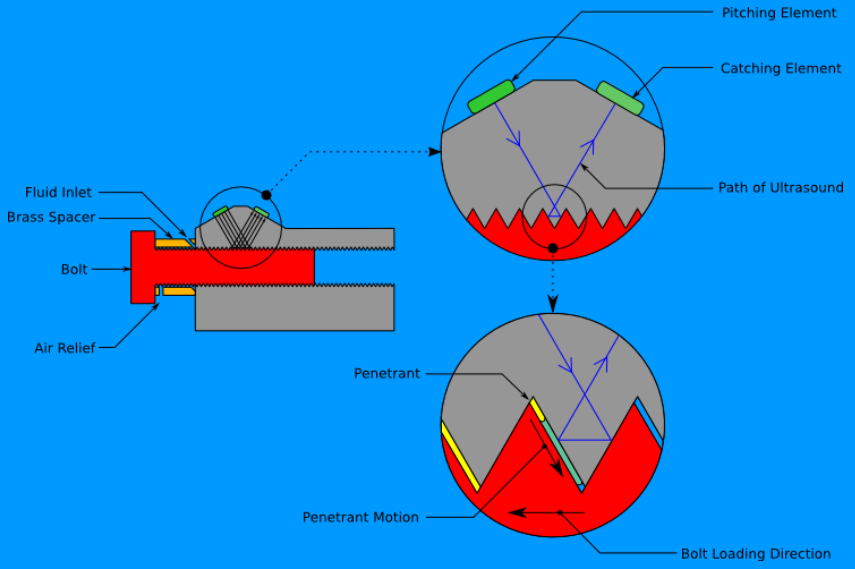
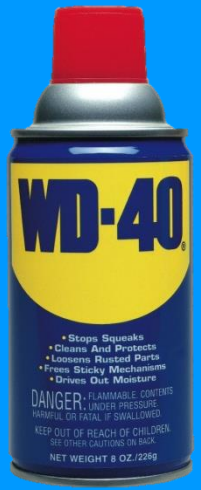
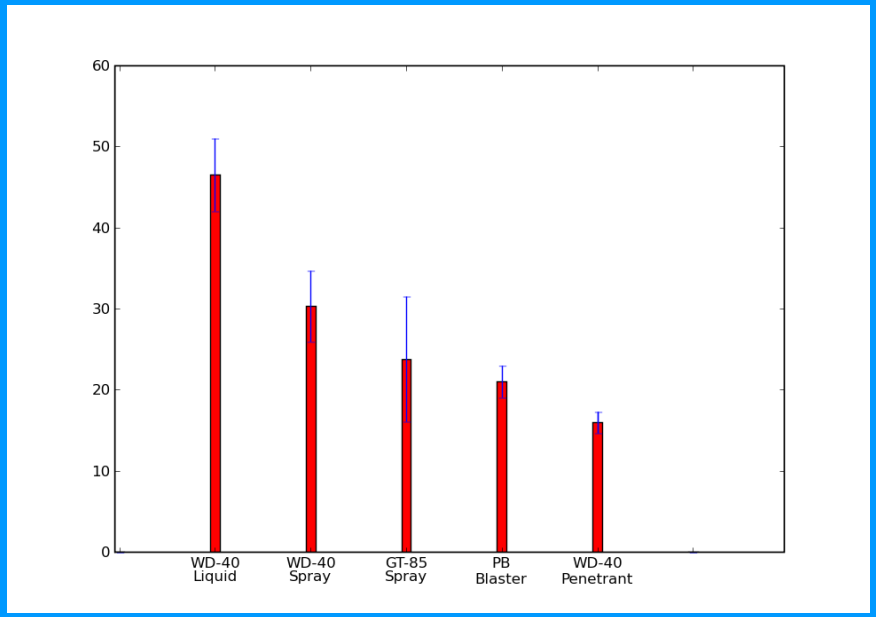
WD-40 Penetrant







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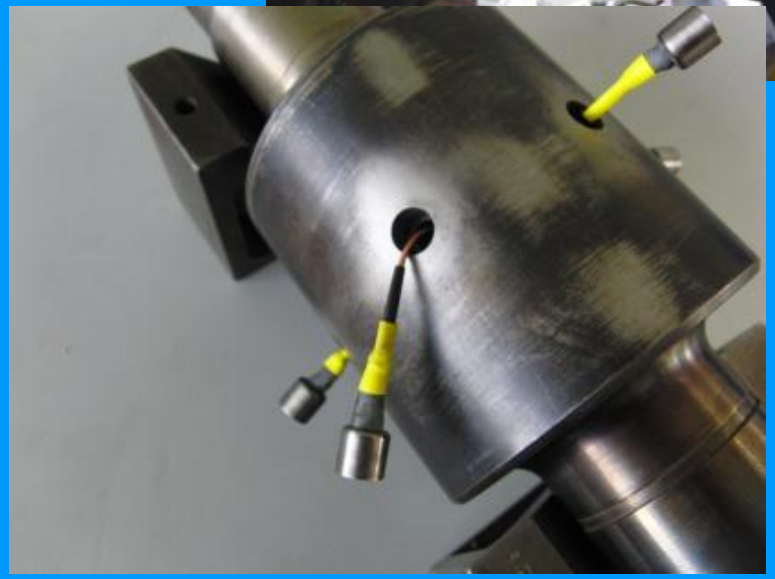
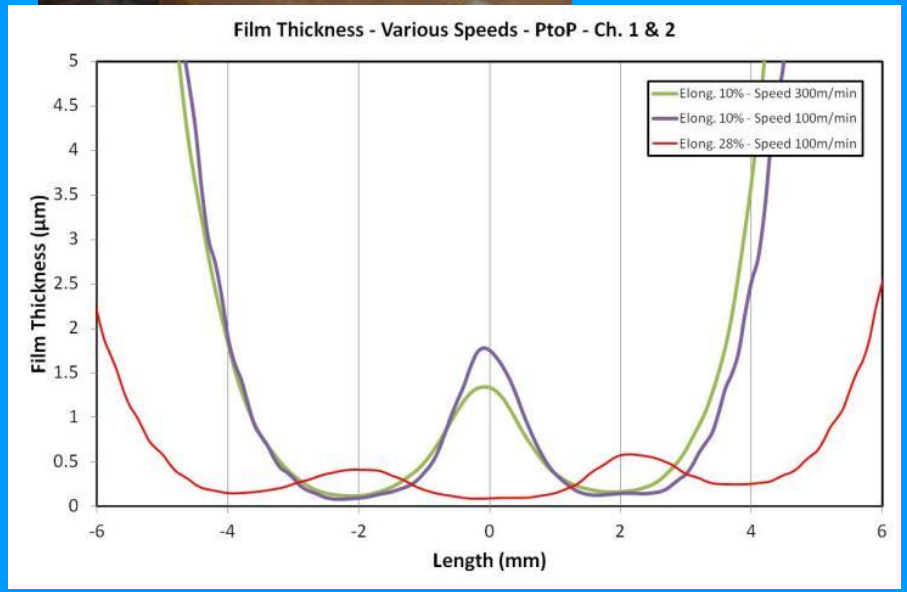
Arcelor-Mittal Pilot Mill





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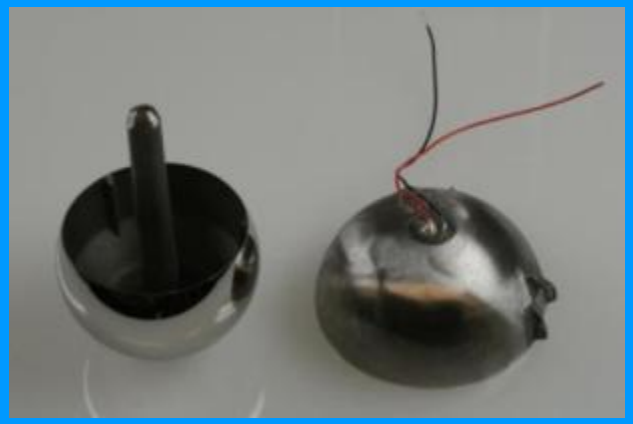
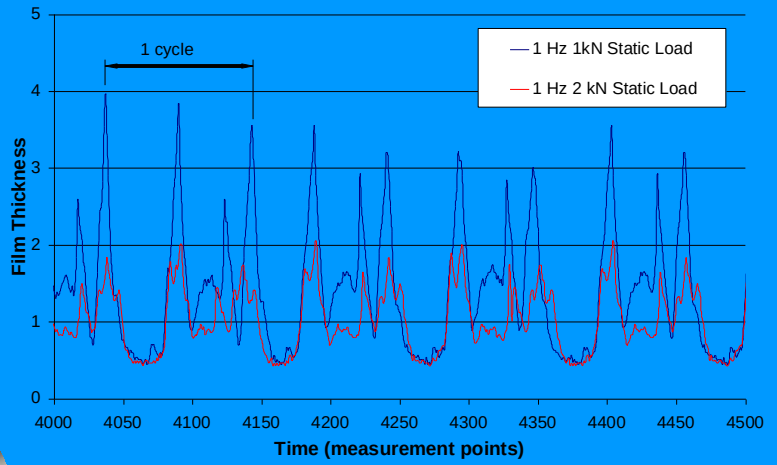
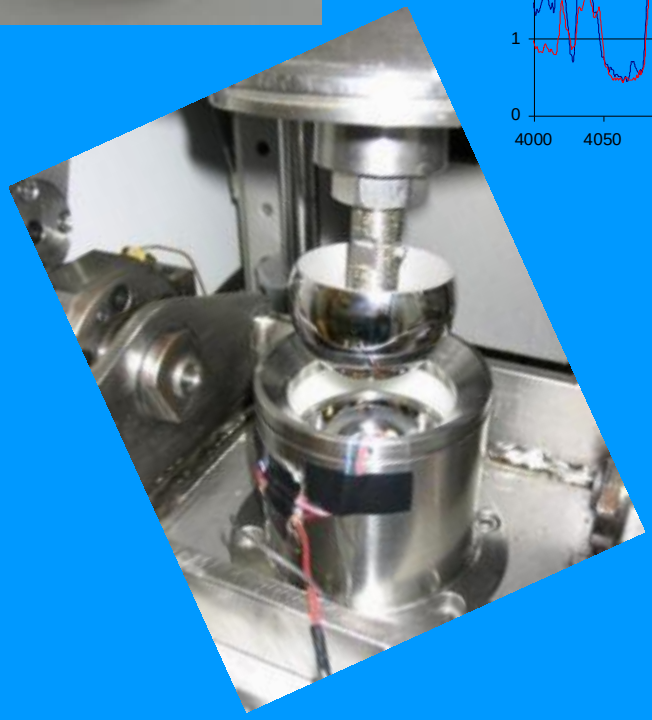
Metal-Metal Hip Joint







Acoustic Sensors for Water Industry

Kirill Horoshenkov
Department of Mechanical Engineering, University of Sheffield

k.Horoshenkov@Sheffield.ac.uk

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Research interest:

- Acoustic sensors to measure flow in open channels
- Acoustic sensors to measure conditions in pipes
- Acoustics sensors for autonomous robots for pipes

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Your expertise:

- Sound propagation in fluids
- Sound propagation in porous media
- Noise control

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Current challenges:

- Development of low cost, miniature acoustic sensors to deploy on autonomous robots.
- Development of nature-inspired acoustic sensors.
- Acoustic sensors based on non-linear effects.

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Aspirations:

- To make this Network a success: (i) through broken silos and better cooperation between separate groups; (ii) through new higher quality research bids; (iii) through closer cooperation with industry partners.

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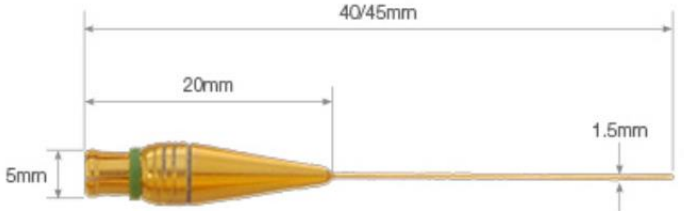
Seiche
Marine Acoustic Solutions



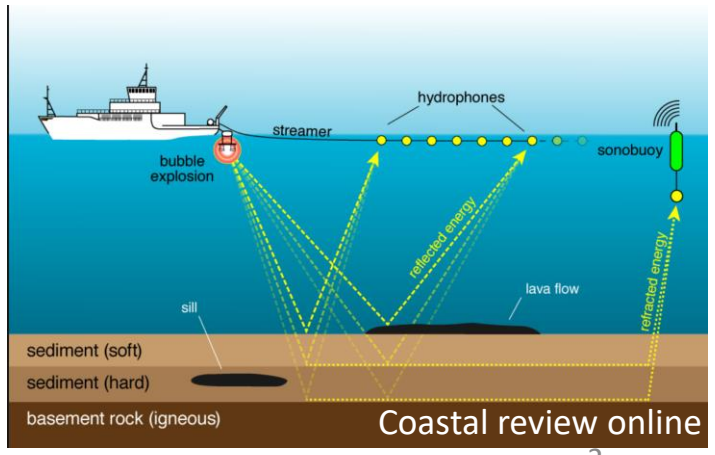
Precision acoustics

Underwater Acoustics

- Ultrasonics
  - (a) Ultrasonic cleaning
  - (b) Medical ultrasound
  - (c) Acoustic Cavitation
  - (d) Sonochemistry
- Marine acoustics

Seiche
Marine Acoustic Solutions

- Underwater Acoustics
  - Ultrasonics
  - Marine acoustics
    - Passive acoustic monitoring



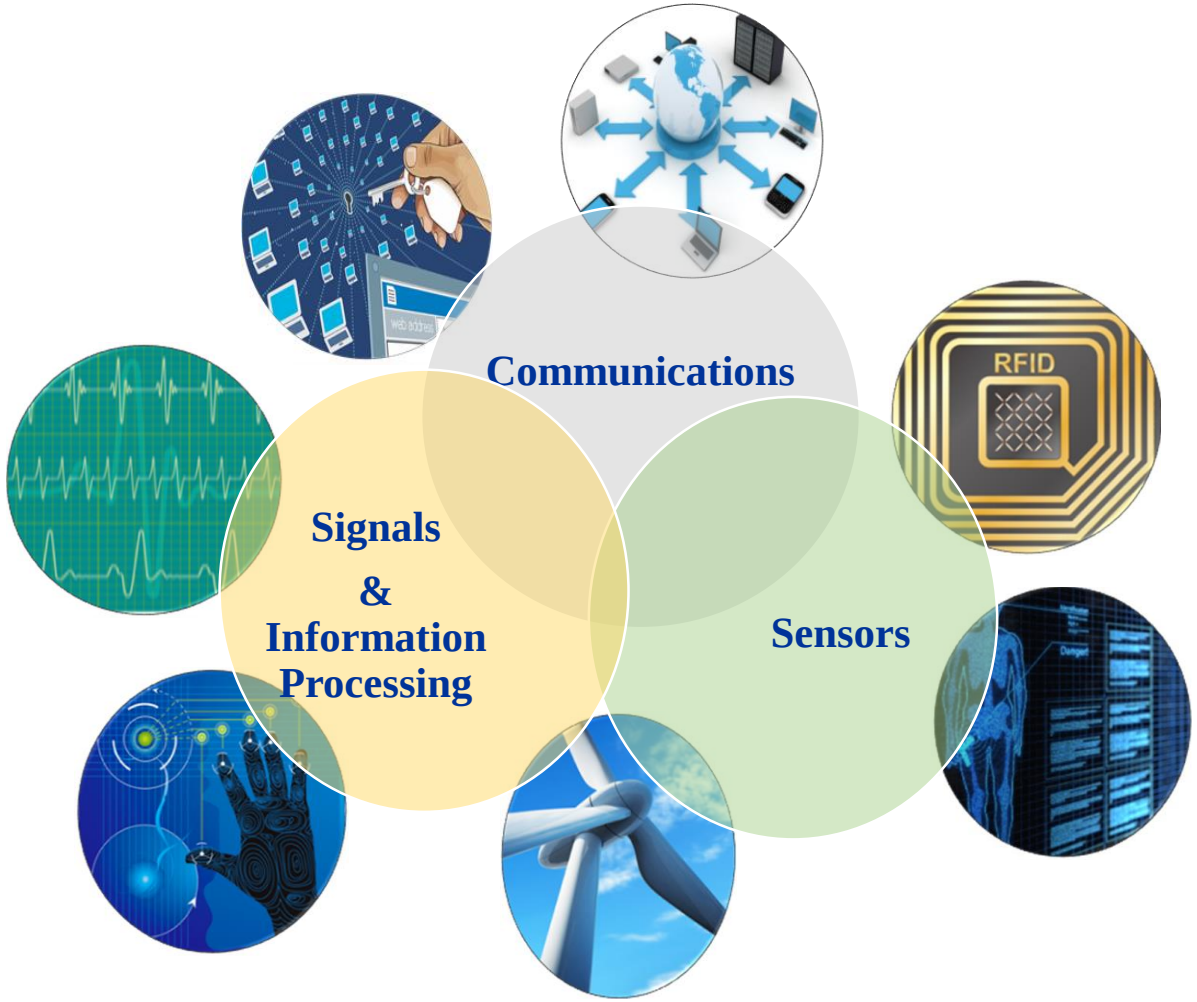
Seiche
Marine Acoustic Solutions

- Underwater Acoustics
  - Ultrasonics
  - Marine acoustics
    - Opportunist acoustics
      - Marine mammals
      - Seabed
      - Environment (speed of sound)
    - Unmanned surface vessel

Intelligent Sensing and Communications (IST) Research group

Chaoqing Tang (Bill)
Supervisor: Gui Yun Tian

Intelligent Sensing and Communications Research Group



Research themes in Prof. Tian's team

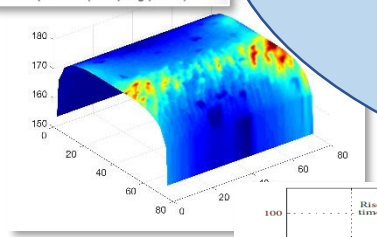
Instrumentation & Sensors for SHM
LF/UHF RFID,
UWB chipless RFID,
etc.

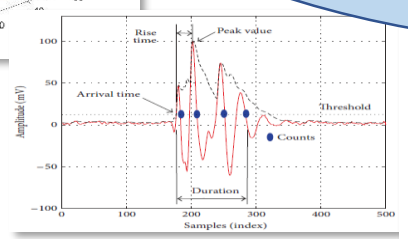
NDT&E
PEC, ECPT, Microwave,
PoD, etc.

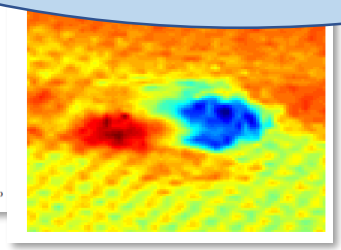
Data processing & Information management
Compressed sensing,
IoT, Security, etc.

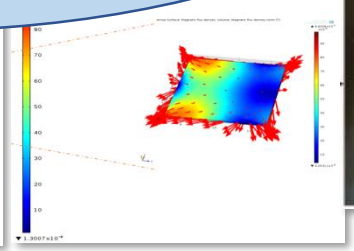
Applications

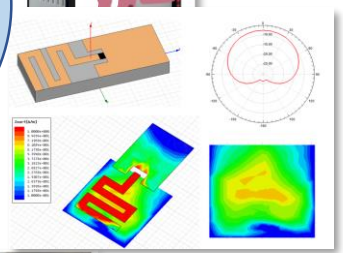
- Homeland security
- Pipelines
- Aerospace
- Renewable energy (wind, marine, Power Electronics)
- Railways
- Manufacturing





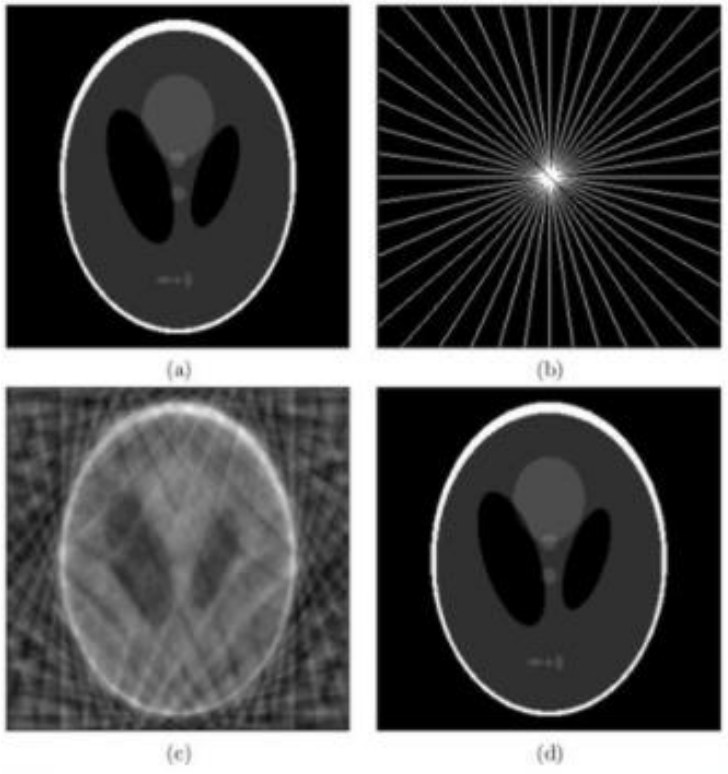




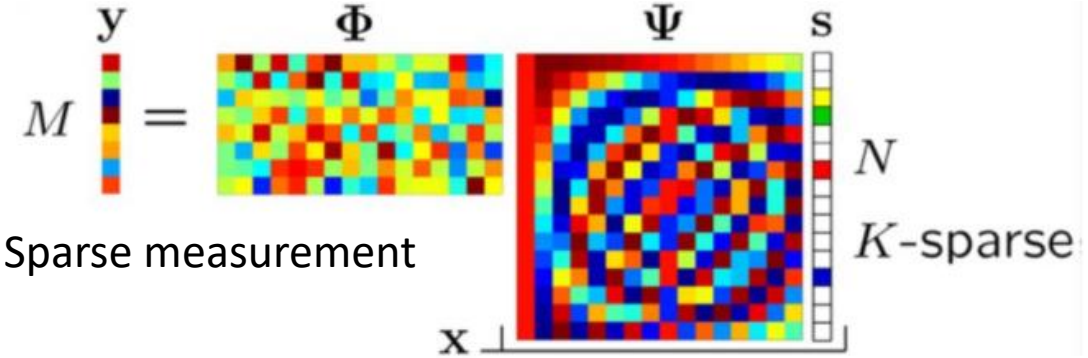


Compressed sensing—breaking the Nyquist sampling theorem

- Nyquist–Shannon sampling theorem: $f_s > 2f_{\max}$. Is it really necessary?



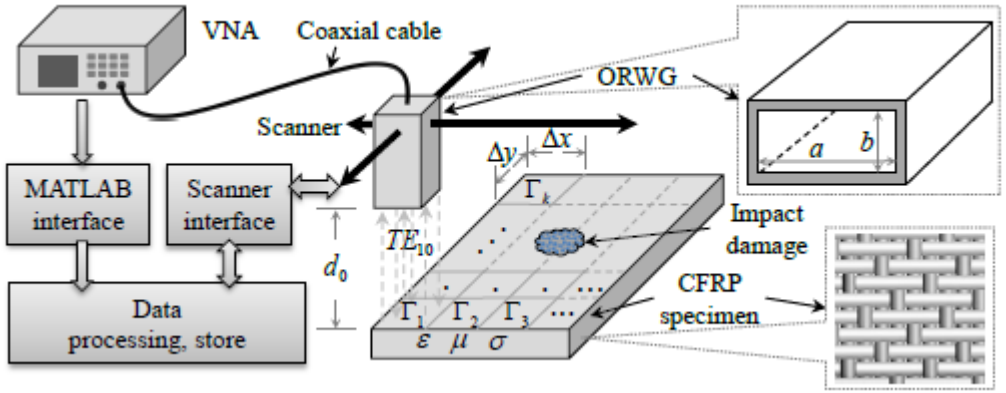
- For a simple phantom (a), it's possible to sample at only 22 radial lines (b) (equal to a sampling rate of $\pi/22$, about 50 times below the Nyquist rate of 2π) to retrieve a perfect reconstruction (d)



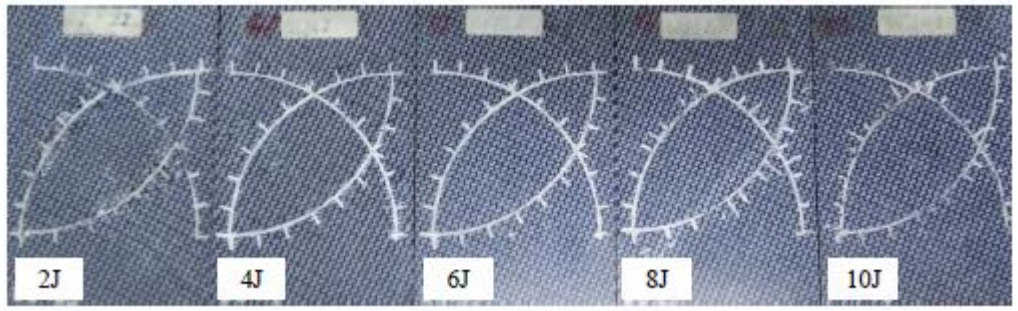
Ref: Candès, Emmanuel J., Justin Romberg, and Terence Tao. "Robust uncertainty principles: Exact signal reconstruction from highly incomplete frequency information." *IEEE Transactions on information theory* 52.2 (2006): 489-509.

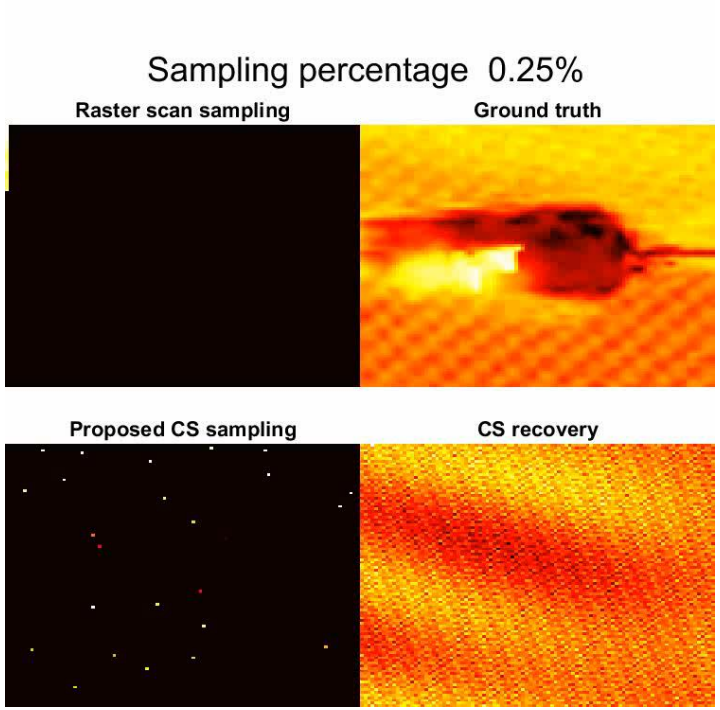
Compressed sensing in waveguide imaging for NDT

(a)



(b)

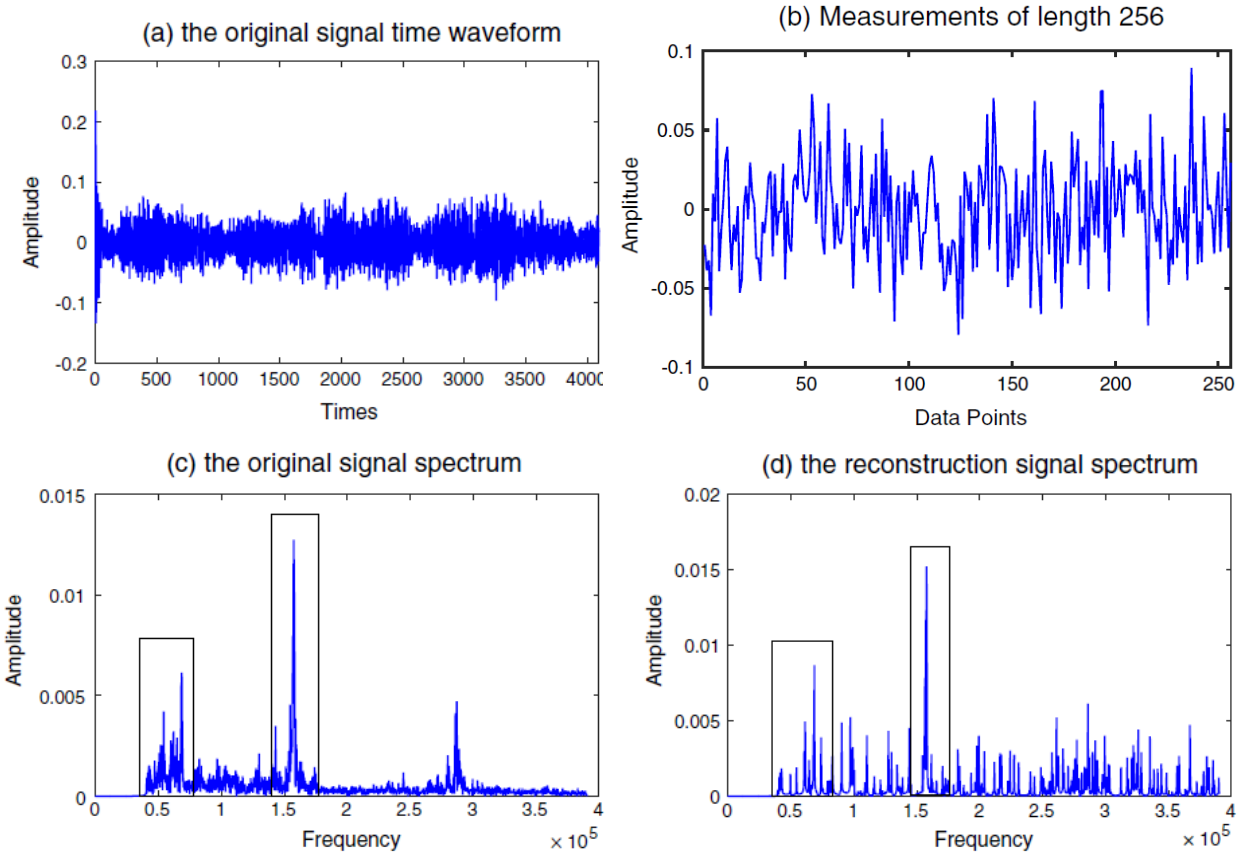


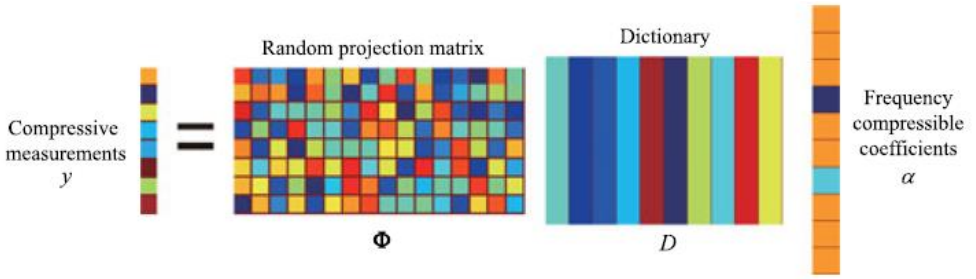


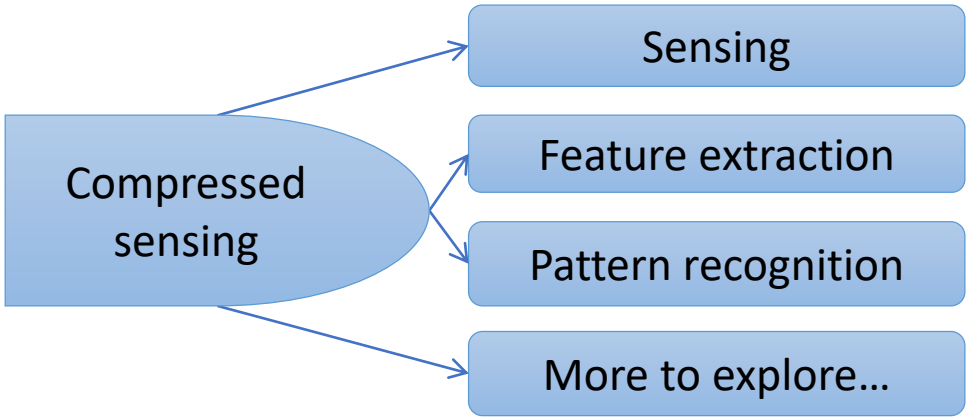
Waveguide imaging (a) system and (b) specimens for CFRP impact damage detection

Ref: Chaoqing Tang,, et al. "Smart Compressed Sensing for Online Evaluation of CFRP Structure Integrity." *IEEE Transactions on Industrial Electronics* 64.12 (2017): 9608-9617.

Compressed sensing in acoustic field







Ref: Liu, X. Wu, J. Mao, and X. Liu, "Acoustic emission signal processing for rolling bearing running state assessment using compressive sensing," *Mechanical Systems and Signal Processing,* vol. 91, pp. 395-406, 2017.

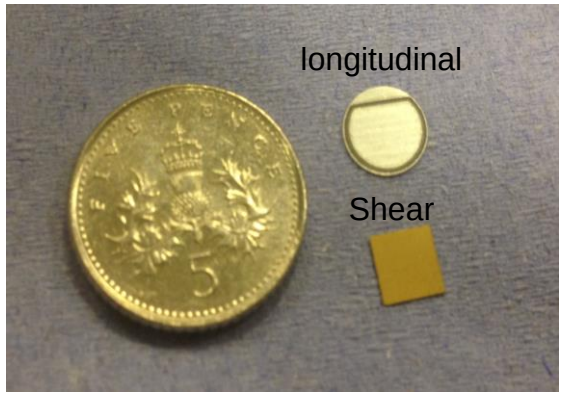
Ultrasonic Viscometer for In-Situ Industrial Applications

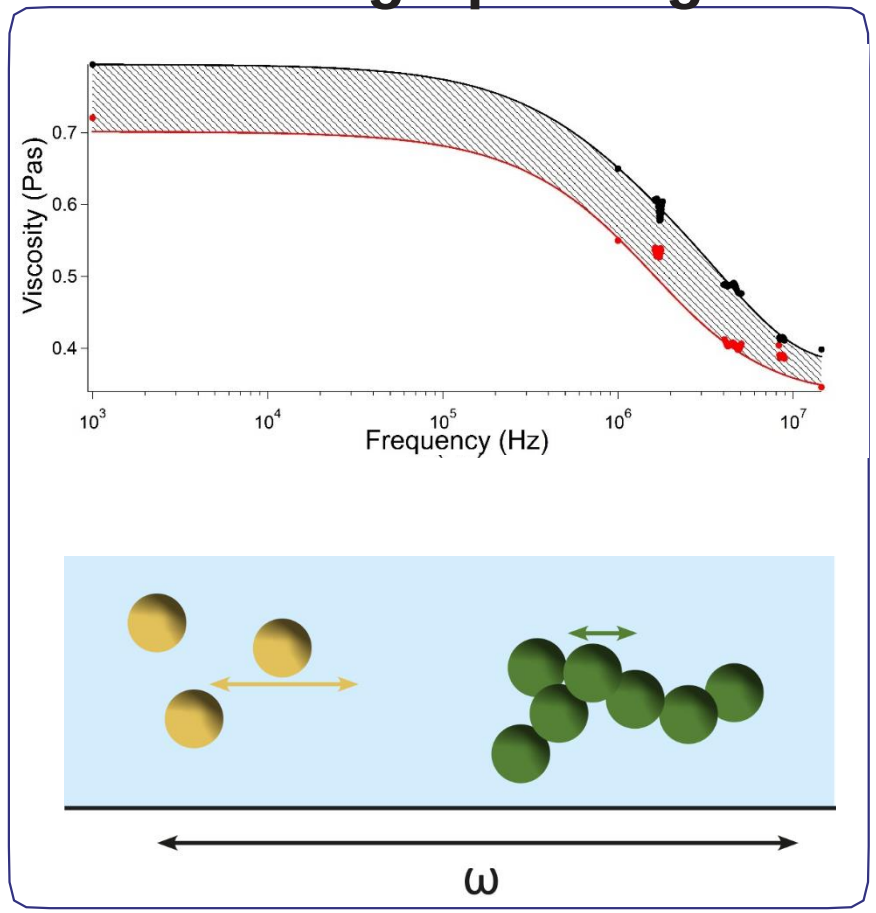
Michele Schirru

Technology

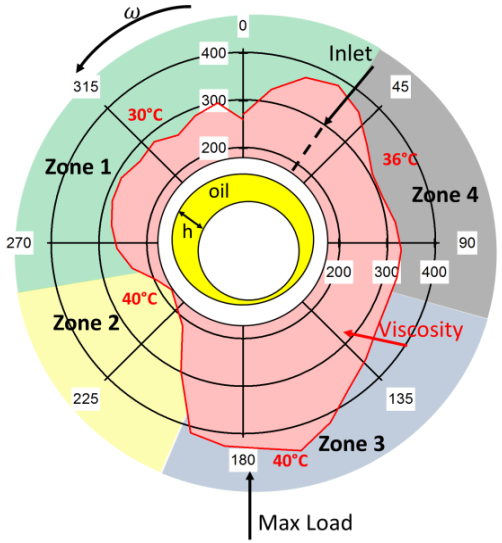
A new fluid fingerprinting method

Sensor: bare piezo





Sample result: journal bearing



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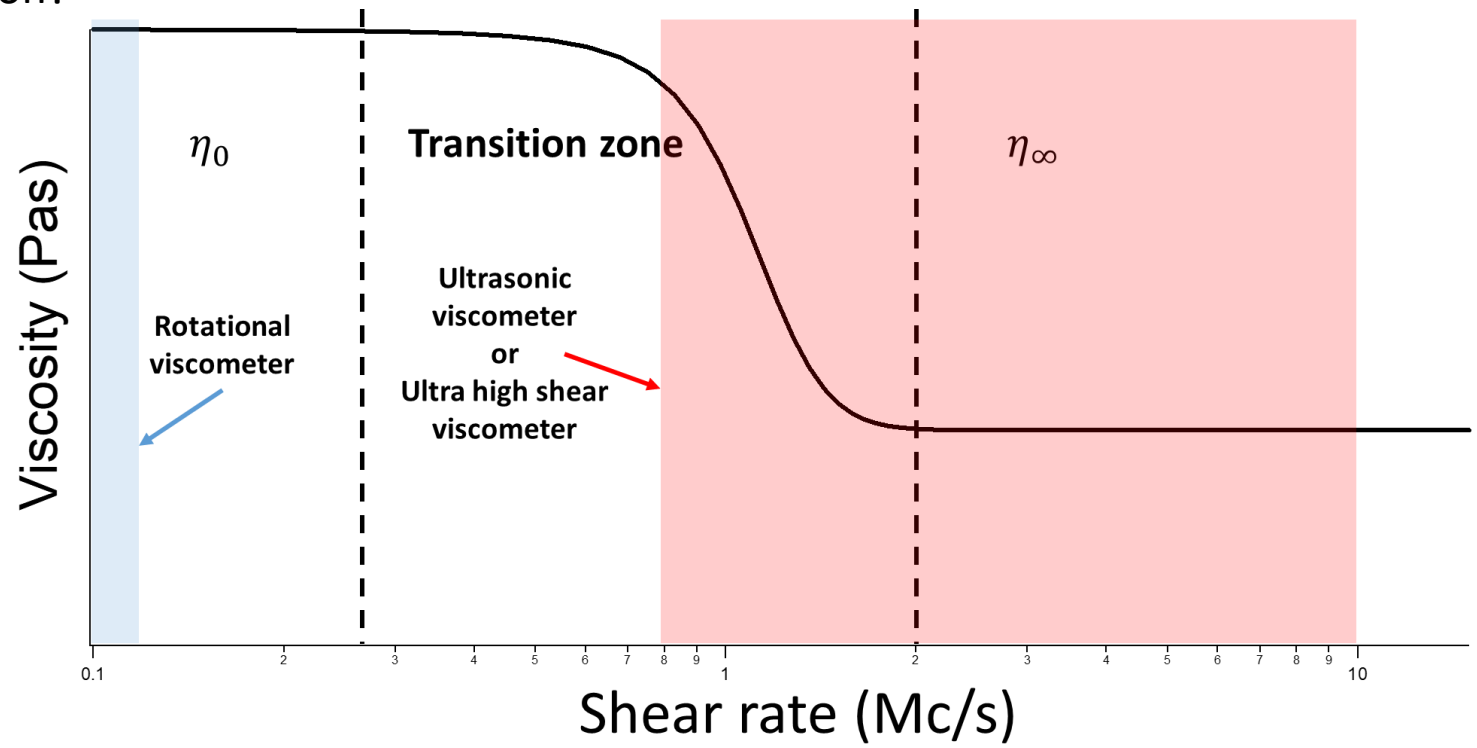
Potential and «Dream» sensor

1) Measurement dependent on front face material: best matching material? Acoustic metamaterial for optimum sound transmission?

2) Full shear rate/frequency – viscosity curve for ideal rheological characterisation



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