Workshop report

Title: Machine Learning Innovations for Structural Integrity and Net Zero Goals

Date: 15th May 2025

Workshop summary (500-700 words)

On 15th May 2025, the University of Surrey hosted a one-day workshop titled "Machine Learning Innovations for Structural Integrity and Net Zero Goals" at Wates House. Organised by Dr Tan Sui, Professor Mark Whiting, and Dr Bin Zhu, the event brought together a select group of 43 participants representing over ten different. This industrial-focused and invitation-only workshop aimed to explore how machine learning (ML) can transform materials performance evaluation for Materials 4.0 and drive sustainable engineering solutions across diverse sectors.

The day began with a warm welcome from Dr Tan Sui, Associate Professor (Reader) in the School of Engineering, who opened the event by introducing Surrey's research on advancing structural integrity assessment and digital transformation. Her talk demonstrated how material and mechanical characterisation underpins correlative data interpretation, drawing on Surrey's research work, led by Dr Sui, on nuclear fusion in-vessel similar and dissimilar joint components for nuclear fusion. This research forms the foundation for developing robust ML models.

The morning continued with three keynote presentations from Surrey's key partners, chaired by Dr Sui. Sente Software Ltd, a leader in thermodynamics and physically-based materials modelling, presented their approach for predicting a range of material properties based on composition, heat treatment history, and thermo-mechanical models. The theme of uncertainty, trustworthy ML and AI, and their potential in materials testing and analysis was central to the contribution from the Data Science department at the National Physical Laboratory (NPL). This was followed by the Advanced Engineering Materials group at NPL, who showcased the application of ML in advancing tribology assessment. A compelling presentation from the UK Atomic Energy Authority (UKAEA) outlined the real-world materials and engineering challenges of developing materials and ensuring the structural integrity of fusion reactor components operating in extreme service environments, a domain where ML tools can provide critical support.

Tony Fry chaired seven industry-led presentations, with businesses spanning SMEs, large companies, and national facilities, including Alemnis AG, Deben UK, Fidgeon-Stresstech, TESCAN, STFC-ISIS neutron and muon, and Plastometrex. Their presentations showcased advanced material characterisation and multiscale mechanical testing capabilities as enabling techniques for ML, particularly by facilitating the generation of high-quality, reliable experimental datasets. COMSOL, as a simulation software provider, further showcased how its platform is evolving through the integration of ML-driven surrogate models. These models aim to significantly improve the computational efficiency of structural integrity simulations, particularly in multiscale and multi-fidelity scenarios, paving the way for scalable, real-time design tools.

The lunchtime exhibitions fostered active engagement and informal exchanges among attendees, helping to seed ideas and facilitate deeper discussion. Following this lively mid-day session, the workshop transitioned into interactive roundtable discussions. Participants were then divided into two groups, chaired by Stefanos Giannis and Mark Whiting, to explore four core questions focused on the strengths, weaknesses, opportunities, and threats (SWOT) in adopting ML for materials performance evaluation in the context of Materials 4.0. Key takeaways included a strong interest in standardisation, enhanced cross-sector collaboration, and the development of workforce skills.

The final component of the workshop was a scheduled set of lab tours at the School of Engineering, giving all attendees the opportunity to explore Surrey's cutting-edge facilities for materials characterisation. These were followed by a series of one-on-one interviews between the organising team and each industrial delegate. The conversations provided valuable feedback on the workshop's content, reinforcing its relevance and impact. These conversations provided valuable feedback on the workshop's content, highlighted the impact of Surrey's research, and opened the door to future partnerships. Many industrial participants expressed enthusiasm for continued engagement and showed interest in building stronger connections with the University of Surrey.

In summary, the workshop successfully fostered deep technical dialogue and laid a strong foundation for future collaboration. Discussions throughout the day emphasised

that machine learning, when guided by high-quality data, physical insight, and strong partnerships, has the potential to become a powerful tool for advancing sustainable technologies and driving the digital transformation of structural integrity assessment.

Outcomes:

- Deepened strategic collaboration with UKAEA, Sente, and NPL to accelerate the industrial adoption of ML-driven approaches in structural integrity assessment.
- Attracted new industrial participants, signalling growing demand for stronger industry–academia partnerships in support of digital transformation.
- Laid foundations for a cross-sector consortium to address challenges in data quality, model validation, and real-world deployment.
- Feedback from one-on-one interviews reinforced the impact of Surrey's research, contributing to a high-quality REF 2029 case study that positions the University as a leader in structural integrity innovation.

Delegate feedback:

The collective feedback reflected a strong consensus that this was a well-organised, engaging, and highly valuable workshop. Communication before and during the event was clear and effective, and the venue was well arranged to support both presentations and networking. Overall, delegates described the experience as positive and impactful. Some specific comments included:

- *"The talks were great and pitched at the right level. We often attend research-heavy events that, while interesting, can feel disconnected if you're not directly aligned. This was a breath of fresh air, relevant and engaging."*
- *"The workshop included interactive elements, such as the roundtable discussion, which enhanced engagement."*
- *"The roundtable struck a good balance between identifying problems and proposing solutions. It helped address existing questions and sparked new lines of inquiry. I also enjoyed the lunch!"*

Acknowledgements:

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We are also deeply grateful to the PhD students, David England, Brandon Steel, Omar Mohamed, Aqsa Qambrani, Uyanga Jargalsaikhan, whose dedication and hands-on support throughout the day were essential to the smooth running of the event. Their enthusiasm and teamwork were truly appreciated.