

GIF Industry Forum: AI for Nuclear (TS 02)

Date & Venue: Tuesday October 4 at 10:15-12:00, Room Halton, Delta Hotel, Toronto, Canada.

Objectives

The objective of this session was to discuss how new digital technologies like the Artificial Intelligence can help development of Gen IV reactors. International experts from industry, national labs and regulators were invited to discuss the following topics:

- Understand how best to utilise AI-powered technologies to accelerate and de-risk GIF projects.
- What should be the priority for short- and long-term AI strategies?
- Can smaller subgroups be created to collaborate on different subject matters such as: AI security, AI Ethics, AI for nuclear reactor solutions, AI for asset management, etc?
- Understand current challenges (regulatory acceptance, data sharing) and capabilities.
- Share AI success stories / use cases from private and public sector.
- Identify collaboration opportunities to share data and develop, train and test AI models.

Program and Participants

The session was chaired by Prof. Nawal Prinja which had the following six presentations: -

“How AI is empowering the future of UK nuclear industry – A Position Paper” – Caroline Chibelushi, KTN, UKRI and AI for nuclear (AI4N) group, Nuclear Institute, UK

“Application of AI within data-centric engineering and autonomous systems” – Nigel Tate, Rolls Royce, UK.

“The Challenge of Autonomous Operation and Automated Reasoning as an AI Enabler” – Robert Ponciroli, ANL, USA

“AI-powered Cognitive Search for Information for Nuclear Knowledge Management” – Thomas Devraj, S & P Global (formerly I H S), USA/UK

“Development of the regulation of AI for nuclear applications in UK” – David Smeatham, Principal Nuclear Inspector, Office for Nuclear Regulation, UK

“IAEA’s role in the deployment of AI for Nuclear Power” – Aline Des Cloizeaux, IAEA.

Each speaker made a short presentation followed by Q&A session. There was general discussion moderated by the chair, Prof. Nawal Prinja.

Key messages of the presentations

Opening remarks: Prof. Prinja opened the session by introducing the SWOT analysis of AI in nuclear. In summary, the ‘Strength’ lies in the nuclear industry having years of tacit knowledge and historical data, the ‘Weakness’ is that most of the data is not labelled for ready use for AI, the ‘Opportunities’ are many particularly in the field of predictive maintenance and the ‘Threats’ are caused by the lack of AI-skilled staff and resistance to change. When compared with the other industry sectors, it is found that the nuclear sector is lagging behind others in effective application of the AI technology.

“How AI is empowering the future of UK nuclear industry”

Caroline Chibelushi representing KTN of UKRI and the AI for nuclear (AI4N) group of the Nuclear Institute from UK could not attend in person and her slides were presented by Prof. Prinja. It was reported that the ‘AI for Nuclear’ (AI4N) sub-group has been formed from the Nuclear Institute’s Digital Special Interest Group (DIGSIG) and was launched on 28 June 2022 in the UK. The AI4N will focus on the challenges in decommissioning old nuclear sites, supporting the delivery of UK government’s energy strategy and achieving Great British Nuclear’s objective of generating 25% of electricity from nuclear by 2050, reducing the costs of nuclear decommissioning by introducing innovative AI, upskilling the workforce to embrace AI and contributing to the international GEN-IV Innovation Forum (GIF). AI4N has identified AI case studies that could form the UK contribution to sharing of information at an international expert session on AI.

“Application of AI within data-centric engineering and autonomous systems”

Nigel Tate from Rolls Royce discussed how AI can help take data centric approach to solve engineering problems. He recognized the big challenge in nuclear about giving autonomy to AI tools. His proposal was to have four levels of autonomy from enhanced operability to fully autonomous system.

“The Challenge of Autonomous Operation and Automated Reasoning as an AI Enabler”

Robert Ponciroli from ANL, USA proposed that AI can help limit the O & M costs and is needed as nearly one third of the nuclear power units are not profitable. He suggested use of AI algorithms to perform repetitive tasks and warned that distinction must be made between ‘control’ (dealing with normal operation) and ‘protection’ (dealing with safety). He emphasized on reliability of sensors as AI relies on data and the data is obtained from sensors. To reduce false positives or false negatives, he proposed new automated reasoning Bayesian model.

“AI-powered Cognitive Search for Information for Nuclear Knowledge Management”

Thomas Devraj from S & P Global (formerly I H S) described the need to maintain and leverage tacit and explicit knowledge over the Life-cycle of typical nuclear projects that can exceed 100 years. This will require extraction of relevant knowledge from millions of unstructured documents in various formats. He described AI-powered ‘Goldfire’ software that can perform cognitive search that can extract underlying meaning and get back precisely relevant answers. Semantic lenses and automatic metadata extraction can display information which is helpful when looking for evidence supporting nuclear safety cases and establish relationships between causes and effects.

“Development of the regulation of AI for nuclear applications in UK”

David Smeatham, Principal Nuclear Inspector representing the Office for Nuclear Regulation, UK explained the work being done by the UK Regulator to try and establish a safe and secure way for the nuclear industry to gain the benefits from AI and maintain safety and security. The ONR sees innovation as the implementation of new ideas that generate value and described pros and cons of AI technology being considered by their Innovation Hub. They see three broad opportunities for the deployment of AI; Advisory, Supervisory and Control – in increasing order of complexity. Their key regulatory themes are: Development of AI systems, Understand performance characteristics of the AI systems, Confidence in performance of AI systems, Dealing with failure and Develop skills and experience including understanding the complexities of behaviours between humans and AI. In addition to saving time and cost, such AI-powered NLP tools can be used to leverage the expertise of the past for the solutions of the future.

“IAEA’s role in the deployment of AI for Nuclear Power”

Aline Des Cloizeaux from the IAEA reported that in Oct 2021 a technical meeting was organized with an objective to provide an international, cross-cutting forum to discuss and foster cooperation on artificial intelligence applications, methodologies, tools and enabling infrastructure that have the potential to advance nuclear technology and applications, while taking into account existing mandates and programmatic priorities. She described the following challenges facing AI for nuclear power: (i) Interpretability, confidence, and robustness measures of performance for AI, (ii) Development of AI technologies for safety critical applications could present a challenge to regulators, as many traditional V&V approaches might not be easily applicable, (iii) Limited transparency of AI/ML, (iv) Demonstration of compliance with standards which are being developed for the adoption of new technologies and (v) Security of data. She announced that two Technical Meetings are planned for 2023: The first on 16 – 19 May: TM on Artificial Intelligence and its Existing and Near-term Deployment in Operating Nuclear Power Plants and the second on 16 – 20 October: TM on the Safety Implications of the Use of Artificial Intelligence in Nuclear Power Plants.

NEA/OECD presented a view that AI is part of the digital transformation that is taking place in the industry and requires work on data management, interfaces and standards. There was a warning that not all nuclear regulators are accepting innovative AI applications and welcomed the approaches being taken by the ONR in the UK and the IAEA.

Outcomes of the discussion

There is great potential for the AI technology to help the nuclear industry. In the UK alone, over 100 organisations have joined the 'AI for Nuclear' group started by the Nuclear Institute. Other countries should take similar steps.

In the nuclear industry often, concerns are raised about autonomous control systems. It became clear that AI will start by helping to make informed decisions rather than assume autonomous control. Consensus was reached on 4 levels of autonomy (from Enhanced Operability to Fully autonomous)

It was agreed to make a distinction between 'Control' vs 'Protection'. However, in order to provide help in decision making, methods are needed to improve accuracy and reduce false positives/false negatives.

One big area where AI can help the nuclear sector is AI-powered semantic search tools that can help Nuclear Knowledge Management. Nuclear industry has to deal with project life cycle of over 100 years. They can retrieve relevant and valuable information from historic records. GIF should consider it.

Two regulators (from ONR in UK and the IAEA) offered help to industry. The ONR in the UK is willing to share research by their Innovation Hub and AI roadmap. The IAEA has taken initiatives to improve 'data availability' and are working on bridging the gaps between AI community and nuclear industry.

Overall, the delegates felt that there is great potential in using AI technology that can help accelerate and de-risk research and development for Gen IV reactors.

Actions and next steps

- Another similar event needs to be held. GIF secretariat has been given an action to plan similar event.
- SIAP should work closely with the IAEA for the initiatives being taken to industrialise the use of AI technology.

List of Attendees