PUBLIC SUBMISSION

SUNI Review Complete
Template=ADM-013
E-RIDS=ADM-03

ADD: John Lane, Mary Neely
Comment (9)
Publication Date: 4/21/2021
Citation: 86 FR 20744

As of: 5/25/21 1:20 PM
Received: May 21, 2021
Status: Pending_Post
Tracking No. koy-slx4-dxqq
Comments Due: May 21, 2021
Submission Type: Web

Docket: NRC-2021-0048
Role of Artificial Intelligence Tools in Nuclear Plant Operations

Comment On: NRC-2021-0048-0001
Role of Artificial Intelligence Tools in U.S. Commercial Nuclear Power Operations

Document: NRC-2021-0048-DRAFT-0008
Comment on FR Doc # 2021-08177

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General Comment

See attached file(s)

Attachments

AI in US Nuclear Power - Response to Questions

Response to Questions

Role of Artificial Intelligence Tools in U.S. Commercial Nuclear Power Operations

May 7, 2021

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Insight is pleased to provide the following information on the state of AI/ML usage in the U.S. commercial nuclear power industry in response questions posted:

https://www.federalregister.gov/documents/2021/04/21/2021-08177/role-of-artificial-intelligence-tools-in-us-commercial-nuclear-power-operations

1. What is status of the commercial nuclear power industry development or use of AI/ML tools to improve aspects of nuclear plant design, operations or maintenance or decommissioning? What tools are being used or developed? When are the tools currently under development expected to be put into use?

AI/ML is in the early stages of development and use in the commercial nuclear power industry. But this is poised to change quickly as third-party AI/ML tools threaten large legacy service providers and over industry and global AI/ML maturity grow.

2. What areas of commercial nuclear reactor operation and management will benefit the most, and the least, from the implementation of AI/ML? Possible examples include, but are not limited to, inspection support, incident response, power generation, cybersecurity, predictive maintenance, safety/risk assessment, system and component performance monitoring, operational/maintenance efficiency and shutdown management.

While there are many potential areas of optimization for commercial nuclear power plant operations, AI/ML will have the largest benefits to design, fuel management and outage reduction (both in number and duration). Optimized design will have small but cumulatively impressive benefits to fuel use, re-use and maintenance. Improved maintenance prediction and planning will reduce the number and length of outages, reducing generation revenue losses. And fuel operation optimization will reduce new fuel purchases, and costs from fuel maintenance operations. Other areas will have less impact either due to small ROI or long development cycles due to risk and regulation (see figure below). For example, optimizing staff productivity will of course provide benefit, but since preventing a single outage per year can be equivalent to 4 or more FTEs and reusing a single fuel additional assembly during refueling is equivalent to 8 or more FTEs the AI/ML focus should be on design, maintenance and fuel.

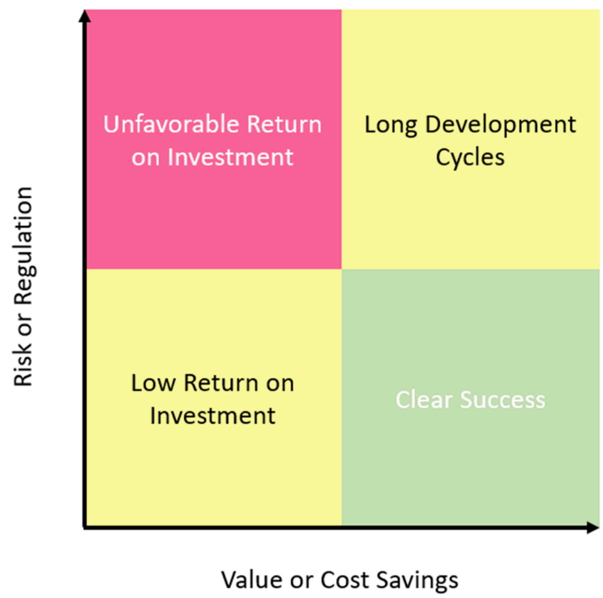

Figure 1: AI Investment by Risk and Value

3. What are the potential benefits to commercial nuclear power operations of incorporating AI/ML in terms of (a) design or operational automation, (b) preventive maintenance trending, and (c) improved reactor operations staff productivity?

Complete benefits analysis is beyond the scope of this document but the three areas out line above are poised to have significant benefit to the commercial nuclear power industry. AI/ML optimization of design and operations will have potentially massive cumulative benefits, possibly reducing overall operational costs by several cumulative percentage points for a plant's lifetime. Facility maintenance optimization also has the potential to dramatically improve plant productivity by decreasing the number and length of offline events, increasing annual power generation revenue. Staff productivity will also have an impact, but not as much. Labor costs in the commercial nuclear power industry are dwarfed by big ticket items such as fuel purchasing or outages. Saving a week of reactor engineer time will have an impact 400 times less significant than obviating the purchase of one fuel assembly.

4. What AI/ML methods are either currently being used or will be in the near future in commercial nuclear plant management and operations? Example of possible AI/ML methods include, but are not limited to, artificial neural networks, decision trees, random forests, support vector machines, clustering algorithms, dimensionality reduction algorithms, data mining and content analytics tools, gaussian processes, Bayesian methods, natural language processing, and image digitization.

A wide range of AI/ML methods are currently used in the nuclear power generation industry, including all the above. This list is representative of methods being used, but one important AI/ML area not covered in the list above that will be essential to the industry is explainable AI (XAI). XAI is a cross-cutting subset of models and approaches that make AI/ML predictions understandable to a knowledgeable human. While some areas will permit the use of black-box algorithms like neural nets, any AI/ML model that has an impact on safe reactor operation will likely require both XAI and extensive safety testing.

Figure 2: Iterative Platform Growth

5. What are the advantages or disadvantages of a high-level, top-down strategic goal for developing and implementing AI/ML across a wide spectrum of general applications versus an ad-hoc, case-by-case targeted approach?

Both a top-down strategy and a targeted-implementation approach are required for AI/ML success. The top-down approach ensures that AI/ML successes are repeatable and fundamental infrastructures and architectures are reusable. But the targeted approach allows the industry to align on immediate value delivery. The best practice is for organizations to create a Center of Excellence. That Center of Excellence then defines a minimal, high-level, cross-cutting approach to AI/ML success and aligns a series of high-value point solutions to execute on. Point solutions should be prioritized to have low complexity and short time to value. This provides a cadence of visible success while limiting technical risk. And with every project a different piece of high-level architectures is defined and built or extended to meet only the needs of the existing projects. As the organizations overall AI/ML maturity increases those skills and best practices can be transferred from the CoE to the business.

6. With respect to AI/ML, what phase of technology adoption is the commercial nuclear power industry currently experiencing and why? The current technology adoption model characterizes phases into categories such as: the innovator phase, the early adopter phase, the early majority phase, the late majority phase, and the laggard phase.

The commercial nuclear power industry is currently in the innovator phase with AI/ML. As in most industries, the large, legacy businesses have been slow to adopt new technologies like AI/ML. It is smaller third-party startups that are creating competitive pressure to force innovation in the industry. The commercial nuclear power industries cultural conservatism makes this even more profound.

7. What challenges are involved in balancing the costs associated with the development and application of AI/ML tools, against plant operational and engineering benefits when integrating AI/ML into operational decision-making and workflow management?

The high levels of risk-aversion and regulation in the commercial nuclear power industry add additional engineering and business restrictions which add to the cost of developing AI solutions in the industry. Coupled with the commercial nuclear power industries cultural conservatism this creates a general drag on innovation and AI/ML adoption in specific.

8. What is the general level of AI/ML expertise in the commercial nuclear power industry (*e.g.* expert, well-versed/skilled, or beginner)?

AI/ML expertise in the commercial nuclear power industry is overall well-versed/skilled, which is the same with other power generation sources and in most industries outside of financial services. Specifically, the AI/ML and data understanding capabilities of data scientists in the nuclear power industry are expert. But the needed adjacent skills of business analysis, MLOps and organizational change management are much less mature. This also true for other power generation sources and other industries outside of financial services. The nuclear commercial power industries cultural conservatism also permeates their data science thinking. The result of conservatism and weak data-science-adjacent skills results in lower levels of innovation and impaired ability to delivery value to the business.

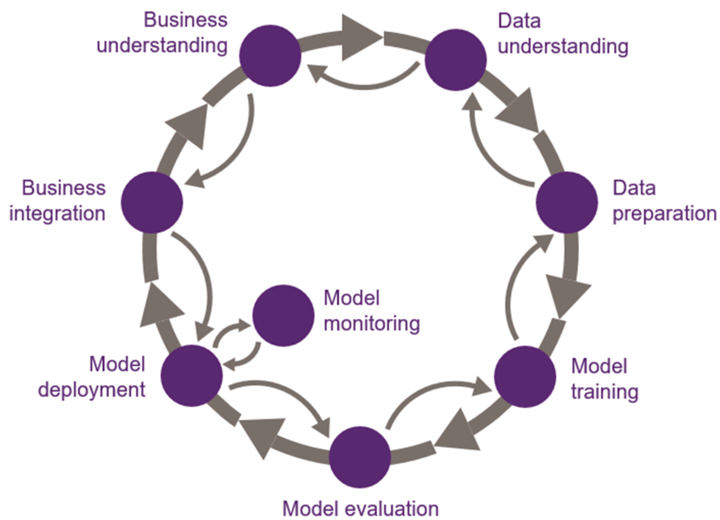

Figure 3: AI/ML Lifecycle

9. How will AI/ML effect the commercial nuclear power industry in terms of efficiency, costs, and competitive positioning in comparison to other power generation sources?

AI/ML will have a similar competitive impact on the commercial nuclear power industry compared other power generation sources. The efficiencies AI/ML around similar operational domains, such as staffing, steam generator operation, demand prediction, etc. will be identical to other power generation sources. Core operation optimization using AI/ML will provide similar benefits to other power generation sources though the pattern will be different. For other power generation sources savings is generally lower impact and more distributed across more time. In the commercial nuclear power industry, savings are more concentrated on fewer, higher impact events such as fuel optimization and crud maintenance to drive better fuel re-use and fewer fuel purchases.

10. Does AI/ML have the potential to improve the efficiency and/or effectiveness of nuclear regulatory oversight or otherwise affect regulatory costs associated with safety oversight? If so, in what ways?

While the potential exists for AI/ML to improve regulatory oversight, it is likely many years away from becoming a reality. AI/ML models are not infallible. Where safety and oversight are concerned, end-to-end AI/ML implementations must be carefully designed and implemented using Responsible AI principals. These includes everything from hardware reliability to careful data and model management to explainable AI (XAI) to human factors such as misinterpretation, automation bias or alert fatigue.

Combined with regulatory requirements and the historic conservatism of the industry it will take long, careful planning to integrate AI into effective oversight.

11. AI/ML typically necessitates the creation, transfer and evaluation of very large amounts of data. What concerns, if any, exist regarding data security in relation to proprietary nuclear plant operating experience and design information that may be stored in remote, offsite networks?

Data concerns around AI/ML development are significant and important in the nuclear power industry. Operational data, especially regarding the core, are highly sensitive and regulated. The smaller number of nuclear plants relative to other power generation methods reduces overall available data volumes which can impact the ability to generate meaningful intelligence. Attempts at data aggregation are often unfeasible due to domestic regulation, international data locality and export laws and the additional requirements of various nuclear oversight agencies. Additionally, few commercial nuclear companies have proper data sharing agreements that would allow them access to plant-specific data even if it were feasible technically or legally. The result is that AI/ML development in the nuclear power industry faces significant data management hurdles that can only be addressed with mature legal, data platform and governance capabilities. This increases the technical barrier to AI/ML success, lengthens time to value and reduces ROI of AI/ML development comparatively to other power generation sources and other industries.