

# **Official Transcript of Proceedings**

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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UNITED STATES OF AMERICA  
NUCLEAR REGULATORY COMMISSION

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738TH MEETING

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

+ + + + +

THURSDAY

SEPTEMBER 3, 2026

+ + + + +

The Advisory Committee met at Two White  
Flint North, 11545 Rockville Pike, Rockville,  
Maryland, and via videoconference, at 8:30 a.m. EDT,  
Gregory H. Halnon, Chair, presiding.

COMMITTEE MEMBERS:

GREGORY H. HALNON, Chair

DAVID A. PETTI, Vice Chair

CRAIG D. HARRINGTON, Member-at-Large

ANNIE M. KAMMERER

WALTER L. KIRCHNER

ROBERT P. MARTIN

SCOTT P. PALMTAG

THOMAS E. ROBERTS

1 ACRS CONSULTANT:

2 VICKI BIER

3  
4 DESIGNATED FEDERAL OFFICIAL:

5 LAWRENCE BURKHART

6  
7 ALSO PRESENT:

8 MATTHEW ANDERSON, Idaho National Laboratory

9 NORBERT CARTE, NRR/NRC

10 STEPHEN CUMBLIDGE, NRR/NRC

11 MATT DENNIS, RES/NRC

12 BRIAN GREEN, OAR/NRC

13 NIAV HUGHES GREEN, NRR/NRC

14 JOSH KAIZER, NRR/NRC

15 JONAH LAU, Purdue University

16 AMY SHARP, RES/NRC

17 DAVID SMEATHAM, Ennuvo Limited

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P-R-O-C-E-E-D-I-N-G-S

8:30 a.m.

CHAIR HALNON: Good morning. This meeting will now come to order. This is the first day of the 738th meeting of the Advisory Committee on Reactor Safeguards.

I am Greg Halnon, Chairman of the Committee. ACRS Members in attendance in person are Dave Petti, Greg Harrington, Annie Kammerer, Walt Kirchner, Bob Martin, Scott Palmtag, and Tom Roberts. I don't believe we have any consultants online at this point. So, if I've missed anyone, please speak up.

Okay. Larry Burkhardt of the ACRS staff is the Designated Federal Officer for today's meeting. We have a quorum for today's meeting as well.

The ACRS was established by the Atomic Energy Act and is governed by the Federal Advisory Committee Act. Under the Atomic Energy Act, ACRS must advise the Nuclear Regulatory Commission on the hazards of proposed and existing reactor facilities and the adequacy of proposed safety standards.

Following issuance of Executive Order 14300, the Committee now focuses on those activities necessary to fulfill its statutory obligations. As a result, ACRS is prioritizing the review and reporting

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1 of new reactor facilities and new or revised proposed  
2 safety standards with particular attention to issues  
3 that are unique, novel, and noteworthy. The  
4 Committee will consider other nuclear safety matters  
5 at the direction of the Commission.

6 And also, please note the ACRS speaks only  
7 through its published letter reports. All member  
8 comments should be regarded as only the individual  
9 opinion of that member, not a Committee position.

10 Information about the ACRS activities such  
11 as letters, meeting rules, and transcripts are  
12 available on the NRC public website. The ACRS  
13 provides an opportunity for public input and comment  
14 on relevant technical issues during our proceedings.

15 For this full Committee meeting, we have  
16 received no written statements or requests to make  
17 verbal comments. Written statements may still be  
18 forwarded to today's designated Federal Officer. We  
19 have set aside time in the meeting for public verbal  
20 comments on the Committee technical matters.

21 A transcript of the meeting will be kept  
22 and will be posted on our website. When addressing  
23 the Committee, the participants should first identify  
24 themselves and speak with sufficient clarity and  
25 volume so that they may be readily heard.

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4 raise your hand on Teams.

5           The Teams chat feature is only for  
6 communicating IT issues or brief meeting logistics.  
7 Please do not use it for comments or questions on the  
8 topics under the Committee discussion.

9           For everyone in the room, please put all  
10 your electronic devices on silent mode. For everybody  
11 in the room, please put your devices on silent mode.  
12 Yesterday we had quite a few ringing ringtones. And  
13 please mute your laptop microphones if you're logged  
14 into Teams. In addition, please keep sidebar  
15 discussions in a room to a minimum since the ceiling  
16 microphones are live at all times.

17           For the presenters, your table microphones  
18 are unidirectional and you'll need to speak into the  
19 front of the microphone to be heard online. Finally,  
20 if you have any feedback for the ACRS about today's  
21 meeting, please fill out the public meeting feedback  
22 form on the NRC website.

23           Our first item for this full Committee  
24 meeting was scheduled to be the Proposed Rulemaking on  
25 Regulatory Enhancements for Reactor Licensing,

1 Decommissioning, and Operational Oversight, and this  
2 is related to Executive Order 14300.

3 This topic, unfortunately, cannot be  
4 discussed at this time because the proposed rule has  
5 not yet been published. It is likely that the  
6 Committee will take up this subject in October full  
7 Committee that starts on October 7.

8 For those that are logged in, I apologize  
9 that this is a late breaking news. But,  
10 unfortunately, we are constrained by Committee rules  
11 and we can't discuss that topic today.

12 Later this afternoon, at 2:00 p.m., the  
13 Committee will have an informational session with the  
14 NRC staff on the topic of artificial intelligence.  
15 This will be public. The AI topic is of interest to  
16 the Committee, because we must be familiar with  
17 current and emerging technologies that may affect  
18 operating in new advanced reactors. AI is being  
19 employed in many aspects of the nuclear arena and the  
20 Committee especially needs to understand how it's  
21 current and future uses may impact the designing,  
22 licensing and operating of advanced reactors.

23 And tomorrow the Committee will proceed  
24 with its planning and procedure session in the  
25 morning.

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1           So, as a consequence of not being able to  
2       discuss the proposed rulemaking, I'm prepared to  
3       recess this portion of the meeting of the September  
4       full Committee meeting until about 2:00 p.m., at which  
5       time we'll proceed with the AI topic.

6           Before I do that, I'll ask if any members  
7       have any comments they'd like to make in the public  
8       session?

9           (No response.)

10          CHAIR HALNON:   Okay.   I don't see any.  
11       And I would ask all of you to keep me accountable to  
12       make sure I do a public comment session after the AI  
13       informational sessions.   It's something that I may  
14       forget as we go through the day, so don't let me  
15       forget that.

16          So, with that, we will be back in session  
17       at 2:00 p.m., on this Teams channel.   And I'm going to  
18       recess the meeting until 2:00 p.m.

19          So, we are in recess.

20          (Whereupon, the above-entitled matter went  
21       off the record at 8:36 a.m. and resumed at 2:01 p.m.)

22          CHAIR HALNON:   Okay, good afternoon.   I'm  
23       going to call this meeting to order.   Just to remind  
24       people it's a 738th meeting of the Advisory Committee  
25       on Reactor Safeguards.   We do have a quorum of all

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1 members except for one.

2 I am Greg Halnon, the Chairman. And we'll  
3 continue the full Committee meeting this afternoon.

4 If you were not here for the opening  
5 remarks this morning, we could not take up the first  
6 substantive issue on the agenda, which was the  
7 Proposed Rulemaking on Regulatory Enhancements for  
8 Reactor Licensing, Decommissioning, and Operational  
9 Oversight related to Executive Order 14300, because it  
10 has not been issued yet to be made public. So, the  
11 Committee can't discuss that topic today in the public  
12 forum. It will be taken up in the October full  
13 Committee meeting, which will begin on October 7.

14 At this time, we're going to move onto the  
15 next thing on our agenda, which is an Informational  
16 Session on Artificial Intelligence. As we all know,  
17 our AI is being used more and more in the industry and  
18 in the regulatory world. And the Committee must stay  
19 up to date on emerging technologies that could be used  
20 for designing, constructing, and operating nuclear  
21 facilities with a focus on those aspects that may  
22 affect safety.

23 With that introduction, I'll turn it over  
24 to Member Roberts who will lead us through this  
25 session. Tom?

1           MEMBER ROBERTS: Yeah, thanks, Greg. Good  
2           afternoon. We're going to receive an information  
3           briefing from the NRC on the staff work they're doing  
4           on artificial intelligence. Any eventual safety-  
5           related application of this technology will likely be  
6           deemed to be unique, novel, or noteworthy, and  
7           therefore require ACRS review.

8           So, as Greg alluded to, this briefing is  
9           intended to position us to review the UNN, or unique,  
10          novel, noteworthy, aspects of applications that may  
11          present it to us in the near future. I don't expect  
12          we'll have any specific actions resulting from this  
13          information briefing, but we can discuss that at the  
14          end of this session if the members think there's some  
15          more they want to hear.

16          The briefing will consist of three parts  
17          that all focus on near term applications currently  
18          under development. The staff, along with the  
19          representative of the project's operating agent, will  
20          start with a description of an international effort to  
21          pilot a couple of different developments using a  
22          process they call sandboxing.

23          After that, the staff will describe four  
24          ongoing developments that they are currently  
25          reviewing. Finally, they along with the

1 representative from Idaho National Lab, will discuss  
2 ongoing research and developments into autonomous  
3 control, including discussion of an experiment  
4 recently conducted at the Purdue University research  
5 reactor.

6 So, again, the focus is on things that are  
7 actually happening now. So, these are, you know, real  
8 developments and not more ethereal things that might  
9 be considered. These are actually in part of those.

10 Vicki, if you're online, do you have  
11 anything you'd like to add?

12 DR. BIER: I am online. Thank you for the  
13 invitation. I just wanted to thank the staff for  
14 putting the briefings together, and look forward to  
15 hearing about what's going on.

16 MEMBER ROBERTS: Okay. Thank you, Vicki.  
17 And, with that, I'll turn this over to Amy Sharp of  
18 the NRC staff for their opening comments.

19 MS. SHARP: All right. Good afternoon,  
20 Chair and Members of the ACRS. I am Amy Sharp. I'm  
21 a Branch Chief in the Office of Nuclear Regulatory  
22 Research, Division of Systems Analysis.

23 My branch supports the Agency's regulatory  
24 readiness for industry applications of AI by  
25 supporting the development of technical bases and

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1 insights needed to evaluate these technologies as they  
2 emerge in NRC regulated activities. It's a pleasure  
3 to speak with you today.

4 So, our engagement with the ACRS on AI  
5 spans multiple briefings, subcommittee briefings over  
6 the past several years. And, during those  
7 discussions, the focus has really evolved alongside  
8 our own work from back in 2022, when we were first  
9 establishing our AI readiness strategy, and  
10 increasingly towards the practical implementations of  
11 specific use cases that we're focusing on and the  
12 unique regulatory questions that are surfaced by  
13 those.

14 In November 2022, the staff briefed you on  
15 the development of the Agency's drafts AI strategic  
16 plan and foundational regulatory considerations for AI  
17 and machine learning in nuclear applications.

18 We returned a year later in November 2023,  
19 to provide updates on the implementation of that plan,  
20 including our internal and external stakeholder  
21 engagement activities. We also brought in speakers  
22 from the Department of Energy and National Labs to  
23 share their research and insights and technical  
24 challenges of practical AI implementations.

25 And, in November of 2024, staff brought

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1 you the results of a comprehensive gap assessment of  
2 our own regulatory framework, which discussed  
3 recommendations for cost-cutting issues such as  
4 validation, verification, data quality for machine  
5 learning, and the use of AI in special computations.

6 And, while it's not November this time  
7 around, we're glad to be back in front of the ACRS to  
8 provide updates on our ongoing activities in that  
9 arena. And so, since our last meeting two years ago,  
10 we've continued to host our annual public AI workshops  
11 and symposia, which expands stakeholder awareness of  
12 our activities and provides really important input  
13 into our own readiness strategies.

14 We've also expanded our international  
15 engagements with the NEA and the IAEA through  
16 structured venues, such as one you'll hear with our  
17 first presentation today, the NEA Reg Lab Project,  
18 which allows us to evaluate hypothetical AI  
19 deployments and identify potential regulatory  
20 challenges.

21 But, most importantly, I think in that  
22 intervening time, and as Member Roberts alluded to,  
23 we're increasingly seeing licensees and applicants  
24 pilot these technologies to do things like enhance  
25 plant performance, reduce maintenance burdens, and

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1 support engineering analysis.

2 And so, I'd like to revisit some comments  
3 that were made in the same room back in 2023. Staff  
4 told you that at that time we did not have a single AI  
5 application before us in an NRC regulated activity,  
6 but that based on what we were hearing from industry,  
7 we were expecting the first regulated applications to  
8 arrive in about three to five years.

9 And the year that was named was, in fact,  
10 2026. I think that estimate was pretty spot on.  
11 Through external stakeholder engagements, including  
12 pre-submittal topical report coordination, the staff  
13 is actively preparing to evaluate a number of near-  
14 term AI use cases which have regulatory implications.

15 This includes the preparation of staff  
16 guidance documents and supporting revisions to  
17 regulatory guides that deal with these technologies.  
18 And you'll hear more about those in our second  
19 technical presentation today.

20 And, as you'll see during those  
21 presentations, so we're now faced with the need for  
22 credible evaluation frameworks, ones that address  
23 explainability, transparency, uncertainty  
24 characterization, human oversight, and data assurance.

25 So, for today's agenda, we'll be providing

1 an integrated overview of all of our activities. In  
2 addition, you'll hear from some of our colleagues on  
3 human factors research supporting preparedness for  
4 autonomous operations, including how higher levels of  
5 autonomy may affect operator roles, oversight  
6 structures, human system interaction, and  
7 accountability and advanced reactor concepts.

8 And, lastly, some commentary on progress  
9 we've made on our NRC AI Project Plan, including our  
10 soon to be published research information letter,  
11 which details the outcomes of a tabletop exercise we  
12 did with Argonne National Lab in Sandia to do a mock  
13 safety evaluation of an actual AI technology at  
14 Argonne National Labs.

15 So, in closing, I just want to express my  
16 appreciation for your continued engagement with these  
17 topics. Your feedback continues to shape how we think  
18 about our thinking and ensure that the NRC remains  
19 ready to evaluate these technologies as they emerge.

20 With that, I'll go ahead and turn it over  
21 to our first speaker. Thank you very much.

22 MR. DENNIS: All right, thanks everyone.  
23 My name is Matt Dennis. I am a member of the staff in  
24 research. I'm a Senior Data Scientist and I have had  
25 the pleasure, as Amy mentioned, of being before this

1 Committee talking about AI now for the last number of  
2 years.

3 So, thank you for having us back again,  
4 even though we didn't get to come in November. We're  
5 glad to be back here and talk about these topics in  
6 this information briefing.

7 So, I'm just going to do a quick intro to  
8 David, which I assume he is on the Teams meeting.  
9 David, can you chime in?

10 MR. SMEATHAM: I'm trying to raise my  
11 hand. I'm here, yeah.

12 MR. DENNIS: Okay. It sounds like maybe  
13 David's a little quiet. So, I don't know if we can --  
14 okay.

15 MR. SMEATHAM: Testing one, two. Can you  
16 hear me now?

17 MR. DENNIS: Is that good enough? Okay.

18 MR. SMEATHAM: Testing. Okay.

19 MR. DENNIS: Thank you. Yep, we can hear  
20 you better now, David.

21 MR. SMEATHAM: Okay.

22 MR. DENNIS: So, I'm just going to  
23 introduce this a little bit and David's going to tell  
24 you all about RegLab.

25 So, I think the last time we talked with

1 you all, we were mentioning that we were really  
2 pursuing our international activities and stakeholder  
3 engagement internationally. And one of those  
4 opportunities that came to us was participating in  
5 this International Regulatory Sandbox Initiative  
6 through NEA.

7 So, we've had the pleasure of being a  
8 supporting member of the activity, along with others  
9 like NEI, EPRI, other participants from International  
10 Regulators. David will show a slide that shows  
11 everyone who is participating.

12 But the activity was born actually of  
13 something David did at the U.K. ONR in regulatory  
14 sandboxing. And, when we were writing our CANUKUS  
15 trilateral paper, we thought this is such a great  
16 idea, we would really champion further international  
17 activities like this. And David was instrumental in  
18 getting NEA involvement, along with IAEA and the other  
19 regulators, to stand up this RegLab initiative.

20 So, with that, I'm going to turn it over  
21 to David to give you a presentation on NEA RegLab.

22 MR. SMEATHAM: Thank you, Matt. And good  
23 afternoon, everybody, and it's a pleasure to be  
24 joining you over from the U.K. That's a great  
25 introduction, Matt. Thank you. So, my name's David

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1 Smeatham. I'm the Founder and Director of a small  
2 engineering consultancy company in the U.K. We mainly  
3 focus on innovation in highly regulated sectors such  
4 as nuclear.

5 And, as Matt said, I've been doing  
6 sandboxing. I've worked at the Office of Nuclear  
7 Regulation in the U.K., where I developed the  
8 principle of regulatory sandboxing in the U.K. and in  
9 nuclear. And then it morphed later stage onto this  
10 international regulatory sandbox.

11 I'll start by crediting the other co-  
12 authors on this. RegLab is a very collaborative  
13 exercise. So, my company Ennuvo acts as the operating  
14 agent for the project, but Faiza, NEA, the Nuclear  
15 Energy Agency, was very much also a driving force, as  
16 is Kevin Lee at the Canadian Nuclear Safety  
17 Commission, who acts as a chair of a management board  
18 that we have.

19 But, we are really kind of at the top of  
20 a group of people, a big group of people, who were all  
21 collaborating in this space, including Matt and other  
22 colleagues at NRC. Okay, Matt, next slide please.

23 So, why did RegLab come about? Well,  
24 initially we could see looking at it from a nuclear  
25 regulatory perspective when I was in ONR that there

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1 were challenges ahead with nuclear.

2 There was goals around net zero carbon  
3 emissions and energy security. There was a need to  
4 reduce costs associated with nuclear.

5 So, there was a general recognition that  
6 we need to innovate within the nuclear life cycle. We  
7 also recognize that often we have preconceptions about  
8 highly regulated sectors like nuclear, that often  
9 people think, oh, there's no way you could innovate in  
10 the nuclear sector, because it's so highly regulated.

11 And ONR at the time still wanted to  
12 overcome those barriers. And so, why don't we start  
13 trying to break down those barriers and start the  
14 conversation about what is acceptable, where the  
15 challenges are associated with innovation.

16 So, I'm not talking particularly about AI  
17 here, I'm talking about innovation more generally.  
18 And, in order to take that innovation forward and do  
19 things new, then we need sound decision making around  
20 deployment of innovation.

21 We need honest discussions and take into  
22 account a diverse set of views, because we need to  
23 look at these innovations, these problems, these  
24 challenges from many directions, and we need to  
25 generate lots of ideas, lots of people's views, in

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1 order to realize the benefits and manage the risks.

2 And, in order to do that, we need to  
3 create a space where people can speak honestly about  
4 how they feel about innovation.

5 So, a lot of what RegLab was trying to do  
6 is trying to get a group of people together from  
7 diverse backgrounds, and allow them to speak honestly  
8 about how they feel about things, how we can do  
9 things, where the barriers are, how we can overcome  
10 those barriers in order to realize the innovation and  
11 also to manage the risk.

12 Where this fits into the international  
13 aspect of it, is that if we think about that  
14 internationally, we've got a chance of considering and  
15 agreeing the way things should be regulated early on  
16 in the innovation life cycle.

17 So, we're kind of banking on getting a  
18 harmonized approach right at the beginning of the  
19 innovation lifecycle that will hopefully live  
20 throughout the innovation lifecycle through to  
21 deployment.

22 By the way, I should have said at the  
23 beginning, I'm happy to take any questions at any  
24 point throughout this discussion. Okay, Matt, next  
25 please.

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1           So, what is RegLab? It's effectively a  
2     tabletop exercise, sandboxing exercise. There are a  
3     number of different derivatives of sandboxing, but  
4     this is a tabletop exercise.

5           So, it's intended to reduce regulation  
6     uncertainty, create access to regulator expertise, so  
7     licensees, technologists can get access to regulatory  
8     thinking, help identify reduction mechanisms and  
9     approaches, reduce the cost of time to entry from an  
10    innovation, which is often a barrier to its  
11    deployment. Allow regulators to test their  
12    arrangements, do they work for this particular  
13    innovation?

14          Test the technology and process innovation  
15    in a controlled environment so it's not being deployed  
16    with these are hypothetical cases we're considering,  
17    and accelerate diverse and inclusive practices within  
18    the sector, and help to develop capability.

19          One of the feedbacks we've had from doing  
20    this, is it's a great opportunity to upskill people to  
21    do, you know, it's not intended for training, but  
22    people we're finding come out of these RegLabs feeling  
23    a lot more competent about the topic matter than they  
24    were when they came in.

25          It's important to stress what it isn't as

1 well. It's not a shortcut to existing regulatory  
2 process. It's not a means of changing regulation on  
3 a permanent basis. And, importantly, it's not an  
4 endorsement from regulators for a specific technology  
5 or process, the thing that we're sandboxing.

6 So, what we do is we get industry, as in  
7 licensees, regulators, and academics, and  
8 technologists, we get them in a room. We have this  
9 thing called Chatham House Rule, which says that  
10 anything that you say will not be attributed to you  
11 unless you want it to be.

12 So, that allows people to speak freely  
13 about how they feel about things. So, we create this  
14 safe environment and we consider an innovation over  
15 two or three days.

16 So, there's quite a lot of pre-work that's  
17 done and then we consider that in a hypothetical, but  
18 representative innovation over those two or three days  
19 in a workshop type style. Okay, Matt?

20 And what value we're trying to achieve  
21 from this? Well, we're trying to reduce that  
22 regulatory uncertainty, because we have regulators,  
23 licensees, and technologists and we're looking to  
24 reduce that regulatory uncertainty from all of those  
25 stakeholders.

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1           So, regulators understand whether their  
2 regulations will work for this innovation, licensees  
3 understand what the ultimate possible is, and  
4 technologists know what they need to design into that  
5 technology, and how they can support the safe  
6 deployment.

7           We consider innovation at an international  
8 level. So, again, we bake in that harmonized thinking  
9 at an early stage.

10          We identify risk reduction mechanisms and  
11 identify where further work might be needed. So,  
12 things like research where we need more expert groups  
13 to go and consider these things. And we allow  
14 regulators and licensees to test their arrangements.  
15 And we help develop capability as I said before.  
16 Okay, Matt?

17          And, Matt's already said, it's a very  
18 collaborative process. So, we have at the moment  
19 regulators from seven countries involved in this.

20          Obviously, NRC is involved, CNSC is  
21 involved as well. The Korean regulators, the Japanese  
22 regulators, the U.K. regulators, and the French  
23 regulators, and the Spanish regulators are all  
24 involved in this.

25          In some cases, there are multiple agencies

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1 from those countries involved in the project. And  
2 it's done through NEA, the Nuclear Energy Agency, part  
3 of the OECD and Ennuvo, my company, acts as the  
4 operating agent for it.

5 But, really importantly, we get a lot of  
6 support from the IAEA through the ISOP community. So,  
7 ISOP stands for Innovation to Support Operational  
8 Power Plants. It's a network of people across the  
9 nuclear sector internationally who were considering  
10 innovation.

11 And, also really importantly, the EPRI,  
12 who have been a fantastic support in identifying these  
13 people, key people, to come and engage with these  
14 workshops.

15 So, yeah, it's very collaborative and it's  
16 intended to be so to get that diversity of views.  
17 Okay, Matt?

18 I won't go spend a lot of time on this,  
19 but it's worth stepping through the process that's  
20 evolved. So, we start off by selecting innovation  
21 topic.

22 So, we've got something like 10 or 11  
23 innovation, broad innovation topics of which  
24 artificial intelligence plays probably a key aspect of  
25 two of those. But, there's lots of other innovations

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1       that we're considering, not just artificial  
2       intelligence.

3               For that, we agree a problem opportunity  
4       statement, which is basically a short paragraph to say  
5       what we want to do, why we think it's important,  
6       what's stopping us now, and where we can get the  
7       benefits from.

8               So, it's effectively four sentences that  
9       we use. And we circulate that to try and get people's  
10      initial views on this innovation.

11              We then develop use cases with industry.  
12      It's mainly driven by the licensees, because they're  
13      the people who've got the better insights about how  
14      they see, in this case, I'm going to talk about  
15      artificial intelligence being used within the sector.

16              And then, we get the diverse group of  
17      people together. So, it's typically anything from 15  
18      to 30 people, and we do a sprint.

19              So, we consider this innovation rapidly.  
20      Where are we going to find it really difficult? Where  
21      are the really challenging areas with this  
22      application?

23              And it allows us to then focus on the main  
24      part, which is a deep dive, which is this three-day  
25      workshop that we do. We really focus in on those most

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1 important, most critical, most challenging areas of  
2 the use case and consider where are the opportunities  
3 to overcome those barriers?

4 What do we need to do for us to be able to  
5 deploy this in the future? Then we write all that up  
6 and we put it into a report that's in the public  
7 domain.

8 One of the aspects of this that's really  
9 important, is that we put everything that we do in the  
10 public domain so that we are trying to kind of engage  
11 that international community so that we can all learn  
12 about this innovation together.

13 It takes typically about 20 weeks, the  
14 cycle to do this. Okay, Matt?

15 All right, we piloted it at part of the  
16 DIET conference. So, DIET stands for Disruptive,  
17 Innovative, and Emerging Technology. It's an annual  
18 conference that's run by the Canadian Nuclear Society.

19 We piloted it, which is very much  
20 supported by EPRI, in November 2024. And Matt from  
21 NRC was there to help support this.

22 And, in that example, we looked at  
23 governance and human-in-the-loop aspects of two  
24 artificial intelligence applications. One was  
25 defining plant maintenance autonomously, and the other

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1 one was generating safety documentation.

2 So, using artificial intelligence like a  
3 large language model to generate safety documentation.  
4 That was used as a pilot, and it was considered to be  
5 successful.

6 So, what happened then was that NEA said,  
7 Oh, we'd like to do more of these. We'd like to do at  
8 least another four.

9 So, we now have a project to deliver four  
10 more of these over the space of two years. We've done  
11 two of them and we've got two more to do, which I'll  
12 talk about in a second. Okay, Matt?

13 So, the first of those two, I'm going to  
14 go into a bit more detail about what we've discussed  
15 on these two examples. So, the first of the NEA  
16 RegLab projects was again at DIET the following year,  
17 so in October '25.

18 And, there, we looked at AI to assist  
19 processes and procedures to enhance safety security  
20 safeguards and environmental protection. So, we're  
21 looking to enhance our management of those aspects and  
22 reduce costs of operations and maintenance.

23 And two things we looked at were on the  
24 use case, we looked at how could we substantiate,  
25 justify the use of the artificial intelligence, and in

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1 particular in terms of explainability. And, in  
2 considering the application, what do we need to do in  
3 terms of data assurance to give us the confidence that  
4 the data is also assured as well as the artificial  
5 intelligence model.

6 All the information around these can be  
7 found in these QR codes and in the websites below as  
8 well. So, just a bit more detail on our findings from  
9 this. Okay, Matt?

10 So, in this RegLab, participants agreed  
11 that the use case could materially improve safety,  
12 security, safeguards, and environmental protection and  
13 plant maintenance, whilst reducing operating and  
14 maintenance costs. So, it's got value.

15 Two dominant barriers to deployment were  
16 identified. Firstly, the explainability is not enough  
17 for higher consequence decisions.

18 It has to be backed up by defense-in-depth  
19 considerations. So, not just relying on the  
20 artificial intelligence kernel, but other things  
21 wrapping around that to give us confidence that the  
22 artificial intelligence is coming up with the right  
23 answers.

24 And that includes the use of deterministic  
25 physics-based models alongside the artificial

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1 intelligence, which is basically compensating for any  
2 uncertainty associated with the artificial  
3 intelligence.

4 The second main outcome with that was we  
5 need to shift our mindset around data. It's not a  
6 case when we're thinking about these models of, we  
7 have this data, what can we do with the data?

8 We have to think about it from, the data  
9 needs to be assured. We need to have confidence in  
10 its quality, its governance, and it needs to be  
11 representative of the conditions on plant. And, if it  
12 isn't, then, you know, you're just going to get  
13 rubbish in, rubbish out.

14 So, we put together a framework for data  
15 governance, as well as defense-in-depth around  
16 decision making, which included artificial  
17 intelligence and other non-artificial intelligence  
18 mechanisms. Even if we could do that, there are  
19 disbenefits that we identified.

20 So, one of them is, if the more the  
21 artificial intelligence takes over these tasks, will  
22 we run the risk of losing or increasing the amount of  
23 human complacency around it?

24 So, we trust the tools more, but that  
25 trust might be diluted. So, we need to make sure that

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1 we've got the right skills and processes around this,  
2 to make sure that we maintain proper consideration of  
3 the reliability of the artificial intelligence.

4 We'd run the risk of skills degradation,  
5 because people aren't exercising their usual skill  
6 sets that they use at the moment. So, the general  
7 skill set has a risk of reducing.

8 We do introduce new failure modes, which  
9 need to be considered due to the additional complexity  
10 of using artificial intelligence. And one of the  
11 biggest barriers, concerns, is the kind of, this  
12 concern about black-box.

13 I put that in quotations, because some  
14 artificial intelligence is more explainable than other  
15 bits of artificial intelligence. So, kind of the  
16 back-box aspect is in quotation.

17 So, we need to make sure that we  
18 understand what could go wrong with the artificial  
19 intelligence.

20 There was a number of recommendations that  
21 came out. We --

22 MEMBER HARRINGTON: David, could you --

23 MR. SMEATHAM: Oh, yes. Yes, please.

24 MEMBER HARRINGTON: Yeah, I have a  
25 question real quick. This is Craig Harrington.

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1 MR. SMEATHAM: Yes.

2 MEMBER HARRINGTON: You know, you talk  
3 about what could go wrong, and the question is, how do  
4 you know?

5 MR. SMEATHAM: Yeah. Well, here we're  
6 using these defense-in-depth, like these physics-based  
7 models alongside the artificial intelligence, which  
8 will identify where there's a deviation between what  
9 we expect and what the artificial intelligence is  
10 giving us as well.

11 So, we felt as though, you know, that's  
12 just one example. But, you'll see in the next example  
13 that we end up, spoiler alert, we end up saying that  
14 these can be considered as really useful aids, really  
15 useful tools.

16 But, we're not in a position at the moment  
17 to say that it should be led by artificial  
18 intelligence. It can help inform, but at the moment  
19 we're not saying it should be led.

20 So, we are maintaining that diversity and  
21 defense-in-depth around the AI kernel as we go through  
22 this.

23 MEMBER HARRINGTON: Okay. That makes  
24 sense. Thank you.

25 MR. SMEATHAM: Of course.

1 MEMBER PALMTAG: This is Scott Palmtag.  
2 I just had a question on maybe more of the  
3 applications. This is for the plant maintenance.

4 Does the AI come up with new kinds of  
5 maintenance, like new things to do on maintenance?  
6 Or, is this more develop maintenance schedules,  
7 existing maintenance schedules?

8 MR. SMEATHAM: The next scenario I'm going  
9 to talk about, it does, yes. So, artificial  
10 intelligence could be taking in lots of sensor data  
11 from around the plant, and could identify potential  
12 failure modes that haven't been considered before.

13 So, yes, it could do.

14 MEMBER PALMTAG: Okay. So, it actually  
15 does add a lot of or new insights into how maintenance  
16 can be done?

17 MR. SMEATHAM: Yes, it could do. The next  
18 scenario I'm going to talk about, it could do, in the  
19 sense that it could try and identify failures early.

20 Or, trying to identify the onset of  
21 failure early so that you can try and predict when you  
22 need to do maintenance, if you do need to do it,  
23 before the defined proof test interval.

24 MEMBER PALMTAG: Okay. Thank you.

25 MR. SMEATHAM: So, in terms of this

1 RegLab, then five recommendations came out. We have  
2 to remember as you're going through these, these are  
3 a load of diverse people getting together and  
4 considering these use cases.

5 We're not necessarily the world's experts  
6 on all the things that we find. And so, it's  
7 important that we try and articulate the findings for  
8 RegLab, and get other people who are the experts to  
9 consider whether they're right or not, whether we've  
10 come up with reasonable conclusions.

11 So, there was a number of areas where we  
12 thought we needed better good practice guidance,  
13 things like assurance frameworks, explainability, how  
14 do you deal with uncertainty within the artificial  
15 intelligence model?

16 How do we develop a safety envelope that  
17 we used to in nuclear safety, but we're not  
18 necessarily used to when we're thinking about  
19 artificial intelligence?

20 What does verification and validation look  
21 like for the AI model? What does graded data quality  
22 look like for this?

23 So, we feel as though there's a need for  
24 more guidance to help people make these judgements.  
25 There's a recognition that we don't necessarily have

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1 the right skills and competency at the moment in the  
2 sector, and therefore how do we start developing that?

3 In nuclear, we do human factors really,  
4 really well. But, we haven't necessarily transferred  
5 that knowledge that we've got on human factors and put  
6 it over as an overlay over the use of artificial  
7 intelligence.

8 Can we do something there that will give  
9 us human factors related to artificial intelligence  
10 guidance? And we saw that one of the problems is  
11 availability of data, and we saw that there's possibly  
12 an initiative that would be worth doing on  
13 standardizing data, metadata so that we can have a  
14 taxonomy to use with data so it allows people to have  
15 some level of assurance on the data that's available.

16 And, throughout the RegLab process  
17 project, we recognized that this is innovative in its  
18 own right, the RegLab is innovative in its own right.  
19 So, we need to be learning.

20 So, we do lots and lots of lessons  
21 learned, lots of task and review processes. But, by  
22 and large, the process was considered to work well.  
23 It was a logical process that we did, it was well  
24 structured.

25 We managed to generate that or create that

1 safe space where people felt included, the Chatham  
2 House Rule worked, and it enabled a good dialogue  
3 across the RegLab.

4 MEMBER ROBERTS: David, I have a quick  
5 question. This is Tom Roberts.

6 Recognizing in the Chatham House Rule, can  
7 you comment on whether these findings came more from  
8 regulators or from the folks who were developing the  
9 approaches?

10 I was curious whether the need for  
11 defense-in-depth was that identified by regulators?  
12 Or, was that simply not seen by the applicants as they  
13 were presenting?

14 MR. SMEATHAM: I don't think I can  
15 separate out, honestly. I think they come from  
16 everywhere.

17 So, we have stated, we generally sort of  
18 split into groups of ten, and consider this within  
19 those groups with a facilitator within that ten. And  
20 it's the dialogue that's going between the people, so  
21 from between the licensees and the regulators.

22 And we purposely ask regulators to put  
23 yourself in the shoes of a licensee, think about how  
24 you would do this and vice versa. We ask the  
25 licensees, okay, now put yourself in the shoes of the

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1 regulator.

2 If you are faced with this, what are you  
3 saying? Where are you going to identify the  
4 weaknesses? What kind of things are you going to want  
5 to give yourself the assurance that this is a good  
6 thing to do?

7 So, I think it comes from all over. I  
8 don't think it's coming from one or the other side.

9 MEMBER ROBERTS: Okay, thanks. Yeah, it  
10 sounds like putting the diverse set of people into the  
11 room and have them debate something, helps everybody  
12 see different viewpoints as Greg stated.

13 MR. SMEATHAM: Absolutely, yeah.

14 MEMBER HARRINGTON: Vicki, go ahead. We  
15 got another question from Vicki Bier.

16 DR. BIER: Yeah, Vicki Bier. A couple of  
17 comments. First of all, I think this is a fantastic  
18 initiative. I'm really glad that it's ongoing.

19 I have a couple of questions. One is, is  
20 the process kind of inherently collaborative and  
21 multi-stakeholder?

22 Or, can a specific stakeholder like a  
23 group at NRC come to RegLab and say, we want to have  
24 a workshop on some particular issue?

25 MR. SMEATHAM: Yeah, so it's funded by

1 regulators. So, it's regulators that get to choose  
2 the topics that we do the RegLabs on.

3 And we have had a case where the  
4 regulators were interested in doing a particular topic  
5 looking at particular cybersecurity. And the  
6 licensees didn't necessarily see the value in that.

7 So, we've parked that for now. But, there  
8 is obviously cybersecurity aspects when we're talking  
9 about artificial intelligence, and we've touched on  
10 that.

11 But, it's the regulators that choose a  
12 topic. But, it's got to be sufficiently engaging with  
13 the licensees, to attract them and think it's worth  
14 their while getting engaged with this.

15 Similarly for technologists. You know, if  
16 we didn't have technologists and academics around  
17 here, then we would be missing a big part of that  
18 diversity, if you like, of views.

19 Does that help answer your question?

20 DR. BIER: Yeah. I think that clarifies  
21 how the process works.

22 The other question I have, you know,  
23 again, with regard to Chatham House Rules, you know,  
24 obviously the big benefit of this, is for the  
25 participants to take away the knowledge that they get

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1 from the whole process.

2 But, are there, or are there going to be,  
3 publicly available reports where say somebody in a  
4 different industry, in aviation or whatever, could  
5 say, hey, I want to read that and learn from that?

6 MR. SMEATHAM: Yeah. So, it all goes  
7 into the public domain. All the knowledge that we  
8 gather goes into a report that goes into the public  
9 domain.

10 That's one of the ethos of this, that we  
11 need to share. We're also getting quite a lot of  
12 interest from people wanting to know what we found out  
13 as well.

14 So, I find myself, as does Kevin and  
15 Faiza, and other people in the team, talking about it  
16 quite a lot and telling people about not just the  
17 outcomes, but the process as well, because I think  
18 there's a lot of interest in the process as well, like  
19 the RegLab process that is transferable across into  
20 other sectors.

21 So, for instance, we're doing something  
22 similar in the U.K. around the broader energy network  
23 rather than just nuclear. So, there's interest in  
24 both aspects, the findings, but also the process.

25 DR. BIER: So, I'm hoping that somebody

1 after this session can disseminate a link or whatever  
2 for where people can learn more if they want to see  
3 the published findings.

4 MR. SMEATHAM: Okay, that's fine.  
5 Throughout this document, there's QR codes and  
6 websites of those links.

7 DR. BIER: Oh, sure. Okay.

8 MR. SMEATHAM: But, they're not all  
9 available at the moment. So, for instance, the next  
10 RegLab I'm going to talk about, we're on the final  
11 steps of reporting that.

12 DR. BIER: Okay. Thank you very much.

13 MR. SMEATHAM: You're welcome. Okay,  
14 Matt, I think we can go ahead. Oh yeah, sorry.

15 MR. DENNIS: Can I, I will actually, if  
16 you could indulge me for a moment, I wanted to ask or  
17 provide my perspective to Member Robert's question  
18 before we go onto the next slide about the --

19 MR. SMEATHAM: Yes, sure.

20 MR. DENNIS: As a regulator and  
21 participating in the RegLab, one observation I made,  
22 was that the industry is as much, if not more,  
23 skeptical of using AI, especially in more.

24 And I'm saying this because the next  
25 couple, two slides, Dave is going to talk about two

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1 different instantiations of an AI recommendation tool.  
2 And, in that discussion, at least at my table of, my  
3 cohort of people, which included regulators, other  
4 industry representatives, there was intense discussion  
5 about why would we ever do this for certain aspects of  
6 it?

7 So, it's definitely something that is,  
8 it's viewed as very useful, but also with a, you know,  
9 a slight amount of trepidation, and definitely a  
10 healthy dose of concern about safety, security, and  
11 all that stuff.

12 MR. SMEATHAM: I agree completely. So,  
13 the second one of the NEA projects that we did, we tie  
14 these onto conferences, because it gives us the easy  
15 access to specialists who are there already.

16 So, they tend to happen on the margins of  
17 international conferences. And we did the second one  
18 in South Korea in May this year.

19 And, in this one, we were looking at AI  
20 tech agents. They were used to analyze plant data,  
21 compare those with licensing rules, and then to  
22 automate condition-based tasks, and then make  
23 competent body level technical judgements through the  
24 AI agents, which then drove maintenance activity.

25 So, it's a very stretching example of the

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1 use of artificial intelligence. And, in here,  
2 autonomy for the purpose of the use case, it implies  
3 that these agents are operating independently.  
4 They're deciding which tools to use, how to achieve a  
5 goal after initial high level training and prompt.

6 So, the scenario interrogates the  
7 deployment of these approved coordinated set of AI  
8 agents and deterministic logic-based modules, so  
9 conventional software modules operating independently  
10 to manage the input process, which is used for work  
11 management cycle. So, it's used to determine when  
12 things need maintaining on plant.

13 In the most autonomous version of this,  
14 these agents were performing continuous monitoring and  
15 autonomous prioritization of this maintenance, and  
16 independently executing also releasing of schedules,  
17 work orders to the people, humans were picking those  
18 up and then doing the maintenance, feeding the results  
19 of that maintenance back into the system.

20 And then, it was carried on in an  
21 indefinite loop with the only human who was deciding  
22 anything, was in a governance auditing type function  
23 rather than in the loop.

24 I've got two drawings that probably  
25 describe this better. So, the first one, if you look

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1 on the left-hand side, we've got a governance layer,  
2 we've got human tasks, we've got logic-based tasks.

3 So, that's conventional software. We've  
4 got AI tasks and we've got data level, and we've got  
5 performance monitoring level.

6 So, you won't be able to see my mouse, but  
7 bottom left-hand corner, we've got plant data. That's  
8 going into an artificial intelligence equipment  
9 reliability monitoring module.

10 That's doing what I said before, that's  
11 looking at all of those, that data. It's looking for  
12 trends, it's looking for discrepancies. It's trying  
13 to identify whether things are working as anticipated  
14 or not. And its output then goes into this  
15 maintenance prioritization module.

16 There's two things that drive the  
17 maintenance. One is the regulatory approved  
18 maintenance schedule, which you see directly below it.  
19 And the other one is these kind of indications of the  
20 need for doing early or later maintenance.

21 Once you've got that prioritized list of  
22 bits of equipment, you know, so your CAT 1, Class 1E,  
23 I'm thinking in U.S. regulatory terms, your Class 1E  
24 systems for instance, would be right at the higher top  
25 end of that.

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1           If there's anything going wrong with  
2       those, that would put a flag up straight away. But,  
3       if it was non-safety-related, then it wouldn't put  
4       that flag up necessarily over something else.

5           So, it's a prioritized safety and security  
6       prioritized module. Then that goes into a planning  
7       module and plan status feeds into that.

8           Then it goes into the T-Week module. T-  
9       Week is the way of getting ready T-20, is it T-12?  
10      You start at T minus 12 and work up to T-0, which is  
11      when the work gets done.

12          When the work gets done, it sends a work  
13      order card out to either fix something or do schedule  
14      maintenance. The humans do that. They feed it back  
15      into the loop.

16          And, over the whole of this, in that  
17      purple long stripe on the human tasks, you've got a  
18      human supervising this all the way through in this  
19      scenario.

20          Any long-term planning and any long-term  
21      maintenance gets pushed out to the middle right-hand  
22      side, which is the long-term planning module. So,  
23      that's looking at, we might want to do this  
24      maintenance, not the next outage, but the outage after  
25      that.

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1           And that feeds into a human aging and  
2           obsolescence planning group. And then, over the top  
3           of this is a governance board. So, you can see in  
4           this scenario, there's a person who is actually  
5           overseeing all this.

6           So, that was what we've considered first.  
7           And then, we moved on to the next scenario, Matt, if  
8           you could put that up?

9           And you'll notice that person's gone on  
10          this. And they've now been replaced by this  
11          performance monitoring, which is a logic-based  
12          conventional safety, sorry, conventional software-  
13          based module, which is looking at compliance.

14          It's checking whether, is this maintenance  
15          happening before its scheduled maintenance is due, its  
16          approved maintenance schedule is due?

17          So, it's looking for that compliance. And  
18          if it sees anything that isn't compliant, it passes  
19          that up to the governance board and as a flag says,  
20          hang on, something's going wrong. We're no longer  
21          compliant with the regulation.

22          So, they were the two scenarios we  
23          considered. The reason why we broke it down like  
24          that, is that if you imagine replacing all of that by  
25          one block of AI, then I think everybody would say no.

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1 But, by modularizing this and thinking,  
2 okay, where do we need the benefits of AI, and where  
3 is conventional software better place to make these  
4 decisions, we are able to avoid people just saying no  
5 straight off, and at least engaging with the exercise.

6 So, what did you find out?

7 MEMBER HARRINGTON: So, David?

8 MR. SMEATHAM: Oh yeah, please.

9 MEMBER HARRINGTON: A real quick question.  
10 This is Craig Harrington. Can you help me understand  
11 to what extent the, you know, when I hear the word  
12 sandbox in, you know, computer kind of realms, I'm  
13 thinking of some kind of a separate computer system  
14 area that you can go do things in.

15 MR. SMEATHAM: Right.

16 MEMBER HARRINGTON: But, a lot of this is  
17 very much people in a collaborative environment,  
18 tabletop exercise kind of thing. But, I get the sense  
19 from these examples you just went through that maybe  
20 you're exercising AI tools as part of the scenario as  
21 well.

22 So, can you help clarify for me that  
23 balance? Or, is it one or the other?

24 MR. SMEATHAM: Yeah. So, in developing  
25 these use cases, it's all human thought that's gone

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1       into this.

2                   So, in developing this process, for  
3 instance, this is me and a colleague sitting down  
4 thinking, how can we avoid just people saying no to  
5 this?

6                   We've got to make it such that we've got  
7 the uncertainty associated with the AI modules, but we  
8 are bounding that by having conventional software  
9 decision making as well. And that allows us to kind  
10 of explore the more subtlety of what is acceptable  
11 with the AI and what isn't.

12                   But, it's all human thought. It's not --

13                   MEMBER HARRINGTON: Okay.

14                   MR. SMEATHAM: These scenarios aren't AI  
15 driven or aren't AI derived.

16                   MEMBER HARRINGTON: Okay. So, a next step  
17 then would be to try to actually implement this using  
18 AI tools with real world data sets and things like  
19 that --

20                   MR. SMEATHAM: Yes.

21                   MEMBER HARRINGTON: To build it out  
22 further.

23                   MR. SMEATHAM: Yeah, absolutely. Yep.

24                   MEMBER HARRINGTON: Okay. That helps.

25       Thank you.

1 MR. SMEATHAM: Okay. You're welcome.

2 MR. DENNIS: David, if I can also chime in  
3 real quick.

4 MR. SMEATHAM: Um-hum. Go ahead.

5 MR. DENNIS: Also, David was being pretty  
6 modest, but the management board for NEA, and David  
7 and his team at Ennuvo, craft these scenarios based on  
8 feedback from the regulators and industry.

9 And that's what's very key, is these  
10 scenarios, while they are not specific to any software  
11 service provider, are as realistic as I think we can  
12 probably get to something that is being potentially  
13 used, used, researched, or some version.

14 And at this particular RegLab in Jeju, I  
15 know there was at least discussion of, you know,  
16 Koreans having some version of this from their work  
17 order management. There's private industry in the  
18 U.S. that has some version of this.

19 So, again, I was trying to, without  
20 focusing on one tool or implementation, it was also  
21 looking at, here's the general flow of it. There are  
22 things that are AI tools that are in the work order.

23 MEMBER HARRINGTON: Yeah. Knowing that  
24 there are a lot of those kinds of commercial pieces of  
25 software that do a lot of the basic work here, maybe

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1 not the AI parts yet, but yeah, that's a complicated  
2 landscape.

3 So, that was part of the question. So,  
4 thank you.

5 MR. SMEATHAM: Okay, Matt, go on to the  
6 next slide.

7 So, the draft conclusions, because the  
8 report is quite mature, but it's still going through  
9 the kind of governance process. So, please treat  
10 these as draft, they may change.

11 So, the failure modes sit in the whole  
12 system, not just artificial intelligence modules here.  
13 So, we considered, we did a failure modes and effects  
14 analysis effectively on this.

15 But, the risk lives in data feeding the  
16 AI, interaction between the AIs, the interaction of  
17 the operators and the wider plants. So, any of those  
18 aspects can introduce a failure mode here.

19 We were trying to keep the human  
20 supervision as independent of the artificial  
21 intelligence as possible. So, when we say that we've  
22 got human in the loop or we've got to say human on the  
23 loop, we took the view that a human is going to make  
24 decisions.

25 Those decisions should be made

1 independently. They shouldn't be fed the AI  
2 information and make a judgment just on that. They  
3 need to form their own opinion given all the  
4 information around them.

5 So, that independent information, the  
6 structured decision making on that, the contextual  
7 plant knowledge and sustaining that competency, it  
8 becomes a really important part of that human  
9 supervision.

10 Because, if left unmanaged, the feeling  
11 was that the supervision just becomes a tick box  
12 exercise. Oh, it's never gone wrong, so why, I'm not  
13 going to challenge it. I'm just going to keep ticking  
14 the box, say it's fine. Which ultimately could erode  
15 the competency of the staff and a failure to actually  
16 find real faults with the system.

17 On the fully autonomous version of this,  
18 so the fact that it's fully autonomous doesn't shift  
19 the safety, security, safeguards, and environmental  
20 protection duties away from the licensee. That should  
21 remain at all points.

22 However, it does change how we might  
23 consider it. So, because other people, or sorry,  
24 yeah, this is the last bit on that.

25 Because it's going to take people from the

1 supply chain in order to make this work, there's a  
2 slight kind of gap, if you like, in the regulatory  
3 process that the licensee might, would be calling on  
4 other people to do this. They ultimately need the  
5 confidence in the tool, but how far does the supply  
6 chain take some form of responsibility again for that?  
7 And I know certainly in the U.K., the law isn't  
8 necessarily geared up for that shared responsibility.

9 And, sorry, going back to the previous  
10 bullet, I went off to the final bullet there. So,  
11 this is bullet three.

12 So, if it's autonomous, it changes the way  
13 we think about it. We need to be thinking about what  
14 guardrails we design into this system in order to  
15 maintain confidence that it's doing its right thing.

16 So, rather than a person doing those  
17 safeguards, it's another system doing it, another  
18 automated system. So, how do we verify, validate  
19 that? What's the governance that we need over that  
20 from the start?

21 So, we're designing this with AI in mind,  
22 we're not just trying to retrofit AI into something  
23 without considering those broader guardrails. Okay,  
24 Matt.

25 So, that's the two that we've done. The

1 third one is going to be virtual, which is a challenge  
2 in itself. And we are considering remote operations  
3 of nuclear reactors.

4 So, this isn't AI, it's not AI. So, we're  
5 going to be evaluating human factors, communication  
6 latency, and to ensure robust, safe oversight of two  
7 sites that are about 500 kilometers away from a  
8 central operating room. And there is a workforce that  
9 can be deployed to those sites. But, they're not  
10 there all the time.

11 And so, we're looking at the  
12 communication, the human factors associated with that.  
13 And we're also going to be subjecting that to a cyber-  
14 attack, which basically takes out that main  
15 communications link.

16 So, how do you then operate those  
17 reactors? What's the expectation of those reactors  
18 given the fact that you haven't got anyone onsite?

19 So, that's what we're doing in RegLab  
20 three. Early days on RegLab four, but we think it  
21 might be on quantum computers. Okay, Matt, next  
22 slide.

23 So, how can you get involved? So, as I've  
24 said a number of times, this is all about bringing  
25 this diverse group of people together to consider the

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1 innovation in this safe space.

2 We're always looking for people with  
3 relevant experience who are prepared to share that,  
4 and so we can all learn from that. And we are  
5 particularly interested in increasing participation  
6 for non-represented groups.

7 So far, a lot of the people engaged  
8 because of the topic matters have been male. So,  
9 we're particularly interested in more women getting  
10 involved in this and more indigenous groups getting  
11 involved. And we're also seeking how do we do that?

12 And any views on the reports, if you get  
13 a chance to read the reports, I'd be really interested  
14 in your views about the process, but also about the  
15 findings as well.

16 And, Matt, I think other than saying thank  
17 you, that might be it. Yeah, just another shout out  
18 to Faiza and Kevin. They are instrumental in making  
19 this happen, as are all of the broader community that  
20 we've got around here, including Matt, who's a great  
21 value asset to us throughout the process. Thank you.

22 MEMBER ROBERTS: Yes. I'd like to thank  
23 David for giving up part of his evening to make this  
24 presentation here, in the U.K., because it's plus four  
25 or plus five hours, but it's still evening.

1 So, thank you.

2 MR. SMEATHAM: You're welcome. It's  
3 interesting.

4 MEMBER ROBERTS: Okay. Matt, let's  
5 continue. I think we're good to go.

6 MR. DENNIS: All right. We will move onto  
7 our next part of the agenda, which will be on Near  
8 Term Industry AI Use Cases, at least from the staff's  
9 perspective of those activities.

10 And, while everyone who is a presenter in  
11 the next session is coming up, I'm going to switch  
12 computer slides here for a second.

13 So, I'll rejoin and we'll get started.  
14 All right. I should apologize at the outset. My  
15 tardiness was because the loaner laptop Wi-Fi did not  
16 work, so I had to take it back. They had to give me  
17 a new one. It didn't work. It now showed up, so.

18 MEMBER ROBERTS: And you're talking to us  
19 about AI?

20 MR. DENNIS: It was a perfect failure mode  
21 of epic proportions. As I was rushing down in the  
22 elevator, I thought how instructive this is about --

23 MEMBER ROBERTS: Obviously infallible. Go  
24 ahead, Matt.

25 MR. DENNIS: So, I think today, Amy

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1 already sort of introduced this already, but we'll be  
2 talking about three particular use cases. Let me go  
3 to the next slide here.

4 So, these three particular use cases are  
5 going to be covered by staff from NRR, Stephen  
6 Cumblidge, Norbert Carte, and Josh Kaizer, who are  
7 going to talk about, well, we have four, four use  
8 cases, three people.

9 And these are what we see as industry AI  
10 use cases that, like Amy mentioned at the outset,  
11 these are the ones that when we talked to you a couple  
12 years ago, they were kind of, yeah, this is probably  
13 it. But, now we know that this is definitely  
14 something that is near term and very soon.

15 So, Steven will be giving a presentation  
16 on non-destructive evaluation. And we've actually, in  
17 previous meetings, talked a little bit about this.

18 EPRI did come and talk about this at one  
19 of our meetings before. So, he's going to mention  
20 some more about that, and neutron emrittlement.

21 Norbert is going to talk about online  
22 monitoring, which is very front and center right now.  
23 And then, Josh is going to talk about critical heat  
24 flux and other considerations for special computations  
25 where AI would be used in place of something we

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1 traditionally have been used to.

2 So, with that, I will turn it over to  
3 Stephen.

4 MR. CUMBLIDGE: I'm Stephen Cumblidge,  
5 it's not the first time I've been here to talk about  
6 AI and machine learning of NDE. But, I will start off  
7 with that, but then I'm also a Materials Engineer in  
8 the Materials Branch II in NRR.

9 So, AI and NDE data analysis, they've been  
10 working on this for quite a while. What happened was,  
11 some open source image analysis tools were generated.

12 And Google and a bunch of other people  
13 came up with, these are image analysis, AI/ML tools,  
14 not language models or anything like that, looking at  
15 images. And a lot of groups took those and ran with  
16 them to try and figure out, okay, using these tools,  
17 how do we look at NDE data and find flaws?

18 And so, when we saw people doing that, we  
19 thought we better have a program in-house to evaluate  
20 how well that's working, the theory, the practice, so  
21 that we're not caught flatfooted or be a barrier to  
22 these being implemented if they work.

23 And, as we've been doing during the  
24 reviews, we say these algorithms really do have a  
25 potential for really improving the analysis of NDE

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1 data in the field.

2 And, also, as we're going along, we're  
3 seeing that if you use them improperly, you could wind  
4 up with a lot of common cause failure where you have  
5 a flawed algorithm that goes out there, cannot see  
6 things. Or, if people take them and get too excited  
7 with them, they might misuse them.

8 So, we're working on ways to prevent that  
9 from happening. Next slide please. That's two  
10 slides.

11 Okay. So, we look at the possible  
12 benefits of this. I've been following the NDE for a  
13 couple decades. I'll say in the '90s and early 2000s,  
14 certainly the '80s and '90s, the big problem with NDE  
15 was the procedures couldn't find the flaws. The  
16 technology wasn't really there.

17 And the problem we've been seeing lately  
18 is that whenever a flaw is missed, or we have a leak  
19 or an issue, it's because, you know, you can go back  
20 and look at the recorded data, you go back, it was  
21 there. The flaw was in the data, the person just  
22 missed it.

23 So, then we did a lot of work on human  
24 factors at the NRC and really, I think, looking at the  
25 AI tools, they have a really good possibility of

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1 improving NDE performance today, because the computer  
2 can remain vigilant in cases where humans are not  
3 vigilant.

4 There's a lot of NDE problems where you  
5 have miles of data, where you have people scanning,  
6 you can even put a camera on a pole and put it in a  
7 vessel and you're scanning around the camera.

8 That's very challenging to maintain  
9 vigilance. I've watched hours of videotapes of people  
10 looking for cracks. I tell you that's hard to do.

11 So, the increased vigilance of the  
12 computers we've leveraged to really improve human  
13 factors of examinations. Also, humans and computers  
14 make different types of mistakes.

15 As I've looked at AI analysis of things  
16 where the AI is not doing a very good job, a lot of  
17 the mistakes they make, you can note, okay, that's  
18 wrong and focus on the areas of interest.

19 And so, humans make some types of  
20 mistakes, machines make other mistakes. If you have  
21 a really good qualified human analyst using a good AI  
22 tool, you can really get the best of both worlds. And  
23 so, there's potential for, you know, good use.

24 Also, another thing which is interesting  
25 is that they're working on this, a lot of this work to

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1 date has been on encoded examinations. That's where  
2 you've recorded the data, and you're looking at, you  
3 know, image analysis of an image.

4 They're working on, the various places are  
5 to look at real time data analysis. Essentially you  
6 take a phased array ultrasonic probe and it starts  
7 highlighting areas that it thinks are cracked or  
8 thinks they're not, or ignores places that are not  
9 cracked.

10 And, if that works, that could be very  
11 useful in, you know, reducing those to inspectors in  
12 the field, because some of the inspections in the  
13 field can be pretty awkward to perform. And, if this  
14 makes that easier, that would be great. Next slide  
15 please.

16 So, the devil's in the details. Okay,  
17 there are possibilities of it being used well,  
18 possibilities being used badly. But, how is industry  
19 currently talking about using automated data analysis  
20 and using machine learning?

21 And the current method is to use it as a  
22 screening tool. I mentioned miles of data you might  
23 have to look at. What we'll do, is with the current  
24 technologies are, you know, trying out in the field,  
25 or you take that miles of data, run it through an

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1 algorithm and it flags areas of interest. And then,  
2 the inspector focuses on those areas of interest.

3 So, they have access to the entire data  
4 set, but they'll focus on the areas of interest and  
5 they can look at the places the AI is flagged.

6 And what this lets you do, is it lets you  
7 make the algorithm more paranoid. Like, it will flag  
8 more things than allegedly what would be false calls  
9 that does on its own.

10 But, you have an analyst go through and  
11 sift through it and say, okay, this is false, this is  
12 false, oh, this is real, and write that down. So, it  
13 really reduces the load on the inspector. But,  
14 ultimately it's a human being using the AI assistant  
15 who will be making the final calls.

16 And so, this looks, and then, also this  
17 fits well with the performance demonstration methods  
18 we have set up for, you know, ultrasonic testing. We  
19 can use that, like essentially someone would use that  
20 method today legally as long as they didn't change any  
21 variables going from the qualified exam.

22 And they're modifying Section XI, the ASME  
23 Code Section XI, to allow its use more easily and  
24 retraining of data if they have to.

25 And we're working with EPRI and other

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1 industry groups who are closely watching the  
2 development as these tools go forward. And, you know,  
3 one of the more recent publications that we have up  
4 here is an Oak Ridge technical letter report on  
5 assessing how this is coming along.

6 In 2027, we had a PNNL report which will  
7 be out. I believe right now we have, industry is  
8 doing field trials of upper head examinations, which  
9 generate a great deal of data.

10 They're doing field trials of in-vessel  
11 visual inspections. And they're working on, hopefully  
12 they're working on the manual examinations of  
13 ultrasound that is not yet deployable or not even  
14 doing field trials.

15 So, are there any questions on AI or NDE  
16 analysis of AI/ML?

17 MEMBER HARRINGTON: This is Greg. I'll  
18 ask the first one. I hope my NDE specialist will help  
19 me out.

20 How do you, okay, human nature, you know,  
21 we're lazy vehicles, right? We usually take the path  
22 of least resistance.

23 How do you guard against, you know, when  
24 you're doing this miles of data and you're having an  
25 NDE specialist look at something, how do you guard

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1       against this lulling of, it's okay, I don't have to do  
2       a really hard job, because I know I got a backstop  
3       with AI?

4                   Or, even worse, I'll just use their  
5       results and go home early?

6                   MR. CUMBLIDGE: The way it works right now  
7       is that it will flag more areas than are flawed, like  
8       essentially. And you have to review every area that  
9       it chooses.

10                   Now, if it chooses nowhere, you'd have to  
11       go back and probably look at the whole data set. But,  
12       hopefully, yeah, in the future, like, if you were  
13       doing a visual inspection and you're waving, you're  
14       using the camera and it's not highlighting there  
15       anywhere, would that possibly cause someone to not do  
16       as strong an inspection? I don't know.

17                   Maybe we'll have to train people and it'd  
18       be up to essentially the licensee, and it would be up  
19       to whoever's doing the inspection to prevent that from  
20       happening.

21                   And I'd say a larger danger would be if  
22       you have a test like that and you give the person one  
23       quarter of the time they used to have to do the exam,  
24       with the expectation that the AI will be good.

25                   MEMBER HARRINGTON: Yeah, you're still

1 saying you hope, you sound like you're hoping that  
2 they continue to do a great job. And I realize that  
3 people who care, I mean there's going to be those.

4 But, I've also seen NDE specialists that  
5 do a liquid penetrant exam and, eh, that's close  
6 enough, and move on. Based on, typically they would  
7 say, well, even if it fails, it's not a big deal.  
8 It's just really a small steam leak.

9 And then, you're also hoping that there's  
10 nothing, no faults or lack of calls on something that  
11 a human would pick up. And, if you're hoping on that,  
12 then why even have a human look at it in the first  
13 place?

14 MR. CUMBLIDGE: Well, the qualification  
15 programs that are being developed, where the AI has to  
16 call all flaws that are in the test set. So, if it  
17 misses any flaws, it fails.

18 MEMBER HARRINGTON: Okay. So, AI is just  
19 like a NDE specialist qualification then. You're  
20 qualifying it like a high performing person.

21 MR. CUMBLIDGE: Well, it has to find, but,  
22 in the process of making all the calls, it can make  
23 several over calls. Like, enough over calls that  
24 would, you know, disqualify it.

25 If a human being made that many over

1 calls, they'd fail the test.

2 MEMBER HARRINGTON: Okay.

3 MR. CUMBLIDGE: The machine has to find  
4 all the flaws and it can find as many extras as it  
5 wants. If it finds too many, then it becomes kind of  
6 useless.

7 And so, if it's finding all of the flaws  
8 in the test specimen or in the test set and you're  
9 confident it should find most flaws in the field, and  
10 the person's reviewing the areas that it flags, then  
11 you have reasonable assurance. Again you have  
12 perfectly reasonable assurance that it's going to  
13 provide a good test.

14 And also people miss things today.

15 MEMBER HARRINGTON: Right. Will it get  
16 better over time? I mean, from the machine learning  
17 aspect of it, you know, there's a feedback loop. Or,  
18 is that in the data input side?

19 MR. CUMBLIDGE: On the data input side, in  
20 theory, if you do a very good job of training it and  
21 keep doing a good job of training it, it should in  
22 theory keep getting better.

23 Now, the one problem they're running into  
24 in some areas, there haven't been that many flaws. I  
25 mean, from a safety standpoint, that's great. Right,

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1 don't want there to be more flaws.

2 From a training the AIs, that's  
3 problematic. They can spend hours on these, they're  
4 making virtual flaws or synthetic flaws. There are a  
5 variety of ways they're taking flaws and changing  
6 their shape and moving them around to try and train  
7 the AIs with, because there's a dearth of data.

8 In the upper head, there's plenty. That's  
9 why it's working out as well. There were plenty of  
10 cracks in the upper head and a lot of data taken and  
11 also a small variation in how you take the data.

12 But, like, for the visual tests, you know,  
13 that's, you know, they scan around looking and could,  
14 you know, is that a danger? Yes.

15 So, they going to work on that. Or, are  
16 they evaluating that as they come out with it? Yeah.  
17 They are we evaluating it to look for dangers like  
18 that.

19 MEMBER HARRINGTON: Yeah. Like, you know,  
20 an UT or an RT, some people have said it's an art to  
21 really identify stuff. And I was just concerned that  
22 the art we're getting, which is a brain drain, giving  
23 it to a machine.

24 And, although it may do a great job, I  
25 guess, I don't know. I guess that's for you all to

1 help us understand.

2 It just seems that the human over time  
3 could lose. It's just like, I mean, you probably all  
4 remember the phone number that you first grew up with  
5 in your home, but can you remember your wife's or your  
6 spouse's phone number now?

7 No, because the brain gets trained too to  
8 go a certain direction. I'm just wondering if we have  
9 safeguards or if we're watching that piece of it.

10 You know, right now we know that the  
11 machine's getting better, but are the people getting  
12 worse?

13 MR. CUMBLIDGE: Okay. We should probably  
14 have a presentation just on this at some point. This,  
15 I could be here --

16 MEMBER HARRINGTON: Yeah. It's not just  
17 NDE. It's going forward --

18 MR. CUMBLIDGE: Yeah. That's all, yeah.  
19 And the quick answer is, yes, they are thinking about  
20 that, absolutely.

21 You mentioned that you have to pass a  
22 qualification test without an AI before you can use an  
23 AI. Like, ideas like that have been thrown around.

24 MEMBER HARRINGTON: Yeah.

25 MR. CUMBLIDGE: Like, make sure you

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1 actually are good at finding, you know, doing the job  
2 before you're allowed to have an assistant.

3 So, all right, we'll see what they  
4 actually come up with. But, those are there. We're  
5 thinking of a lot of things, more things that we can  
6 cover in ten minutes.

7 MEMBER HARRINGTON: Yeah. But, the  
8 industry is, I mean, when they're talking about  
9 implementing these things, those are on their minds,  
10 right?

11 MR. CUMBLIDGE: If you watch a bunch of  
12 inspection vendors get spooked, mention that. Like,  
13 oh, we don't want completely useless people, because,  
14 you know, they want good people.

15 MEMBER HARRINGTON: Yeah.

16 MR. CUMBLIDGE: And I think I've watched  
17 a bunch of vendors jumping over that idea came with.  
18 But, you could just have a bunch of people who are  
19 basically, you know, human encoders walking around and  
20 scanning, and the AI does all the work, like, you  
21 know.

22 MEMBER HARRINGTON: Yeah. When I came out  
23 of the industry seven, eight, 12 years ago, there was  
24 a real shortage of level threes, and given that you  
25 could see a propensity to want to cover that with

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1 technology instead.

2 MR. CUMBLIDGE: Yeah. I think it has a  
3 potential of being really helpful, because it'll  
4 really improve the human factors. But, if used poorly  
5 could be a mess. And we're working to keep it out of  
6 the mess.

7 MEMBER HARRINGTON: So, whatever  
8 regulatory realm we put around this needs to be a  
9 safeguard there to do some kind of check or auditors.

10 MR. CUMBLIDGE: As much as we can, yes.

11 MEMBER HARRINGTON: Okay, thanks. Thanks  
12 for entertaining this.

13 DR. BIER: Wait. If I can expand briefly.  
14 Not really a question, but just a perspective. For  
15 the last several years, I've been following a little  
16 bit of what's happening on AI in the medical area,  
17 like reading x-rays, or mammograms, or whatever.

18 And, in the early years, what they found  
19 was what was said earlier in this presentation, that  
20 humans and AI found different types of problems. So,  
21 you really ideally wanted both in the loop.

22 And then, you have to worry a lot about  
23 what happens if the human just becomes complacent and  
24 accepts whatever the AI says. Then you don't get the  
25 benefit from having both.

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1 Over time, there were some areas where the  
2 AI is now better than AI plus a human. So, yes, they  
3 do continue to improve over time.

4 And, one of the problems in the health  
5 domain is just changing environment. Like, if there's  
6 a new disease like COVID, or you take the AI from, you  
7 know, the U.S. to India, or from a white collar  
8 neighborhood to a blue collar neighborhood, and then  
9 it's seeing a different mix of problems.

10 And so, that's a problem in the human  
11 world, maybe less of a problem, I would hope, in NDE.  
12 But, that gives just a little perspective of how this  
13 has evolved in another area.

14 MR. CUMBLIDGE: I'll say very briefly, one  
15 concern is if you have an AI that's trained on the  
16 light water reactor fleet and then you apply it to a  
17 new reactor design or new materials, would that work?

18 And, if you have lost the workforce that  
19 knows how to look for new things, you know, that's  
20 absolutely a concern that we have.

21 DR. BIER: And so, that's an excellent  
22 point. Thank you for raising that comparison.

23 MEMBER PALMTAG: Yeah, this is Scott  
24 Palmtag. In the nuclear industry, we always kind of  
25 have this invented here kind of syndrome.

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1 I mean, this has to be a problem  
2 everywhere, airplane inspections, if you're looking,  
3 I know in fuel manufacturing, they're looking at AI.  
4 And are you working with other industries to see how  
5 they're doing things like this?

6 MR. CUMBLIDGE: We're working with, you  
7 know, we're working with AI experts who are working  
8 with that. And we're working with Oak Ridge National  
9 Lab and Pacific Northwest National Laboratory and kind  
10 of getting that.

11 And there were certainly, other industries  
12 are involved in this as well, yeah.

13 MEMBER PALMTAG: Yeah. You've got  
14 airplane jack construction, welds, welding  
15 inspections. I mean, this seems to be like a, it  
16 could be a very big issue with lots of industries  
17 involved.

18 I just wondered if you're leveraging any  
19 of that or if it's more focusing just on the nuclear?

20 MR. CUMBLIDGE: It's been mostly focused  
21 on the nuclear, because it's a, we're focusing again,  
22 on what the nuclear vendors are doing, what the people  
23 are coming up with.

24 There are a small number of companies  
25 working on a small number of problems that are nuclear

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1 focused, like upper head inspections. You use upper  
2 head inspection data. You don't use aircraft data to  
3 train it.

4 Or, dissimilar metal weld inspections, if  
5 they're trying to use dissimilar metal weld data, it's  
6 then, each AI is going to be very specialized to one  
7 task.

8 MEMBER PALMTAG: Yeah.

9 MR. CUMBLIDGE: And I think an aircraft  
10 inspection would be a very different training data set  
11 for the aircraft that would may not translate well to  
12 an upper head or, you know, the other inspections.

13 MEMBER PALMTAG: Yeah. That brings up  
14 something that Vicki said. You know, if a new disease  
15 comes in, right, you're going to find different  
16 defects.

17 If you train this AI to only find one kind  
18 of defect, and then all of a sudden now there's  
19 another kind of defect, is the AI going to catch that  
20 or not?

21 MR. CUMBLIDGE: But, this is why you only  
22 have a qualified person using it. With that said,  
23 qualified people can have a problem with that as well.

24 But, you can even have, you need human  
25 beings who can read ultrasound, and can read these

1 different NDE methods in the loop, or else you're  
2 going to wind up with somewhat of a useless system.

3 DR. BIER: And I think it is true,  
4 following up on Scott's question, that currently  
5 humans are better than AI at like, holy cow, this is  
6 something new and different. And I don't know what  
7 I'm seeing, or I know that what I'm seeing doesn't  
8 match my past experience and history.

9 And I think AI, you know, from the first  
10 presentation, there was a very brief mention of  
11 treatment of uncertainties.

12 But, I think AI often has a predilection  
13 to say, well, I'll do the best I can, right. And, you  
14 know, I may only have, you know, 5 percent confidence  
15 that this is a correct judgment, but I'm going to give  
16 you this judgment anyway.

17 Where a human would say, like, whoa, this  
18 makes no sense. I'm really going to have to dig into  
19 this deeper before I render an opinion.

20 So, that is a good point about the, you  
21 know, unfamiliar situations. And, you know,  
22 engineering is pretty well constrained, right.

23 I don't think we're going to find a lot of  
24 new material failure modes that we don't know about  
25 yet. But, we can certainly find new materials that

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1 then have new failure modes.

2 And so, that could be an issue.

3 MEMBER HARRINGTON: Stephen, go ahead and  
4 finish up. And we'll, you know, quit dragging you  
5 through the dirt here.

6 MR. CUMBLIDGE: Oh, no. I think the main  
7 hazard is I could go on until it's dark out. So, I'll  
8 stop.

9 But, you know, we're working with Pacific  
10 Northwest National Laboratory and Oak Ridge to kind of  
11 watch the commercially available, you know, there's  
12 actually kind of, it's qualified in Sweden and it will  
13 be coming to the U.S. pretty soon, for the upper head  
14 examinations. And they're working on in-vessel visual  
15 examinations.

16 So, I guess, we're looking, what are  
17 people doing now? I don't know how do we make sure  
18 that we stay on the side of the angels when it comes  
19 to doing things right and preventing some of the  
20 problems that we were talking about earlier.

21 But, yeah, it's been, it's an ongoing  
22 work. And I think, like I said, it will be ongoing as  
23 this develops.

24 Now, the second thing we've been looking  
25 at, and this is again, this is data analysis, this is

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1 less image analysis and more.

2 So, neutron embrittlement, and it's a  
3 computationally interesting problem, because there's  
4 so many variables that change. You know, the  
5 chemistry, temperature, fluence, you know, how fast  
6 the influence rate can be.

7 So, kind of picking out all of that is  
8 hard to do. And, as someone said, what happens if  
9 someone doesn't use an AI/ML tool to do this?

10 You can dump a ton of data, and there is  
11 a lot of data, you know, how do you do this? How do  
12 we evaluate it if someone does it?

13 So, kicking off, actually we have the  
14 kickoff on October 1. We're working with Oak Ridge  
15 National Lab and we're going to look at a, really how  
16 would you do an AI/ML analysis of neutral  
17 embrittlement?

18 And we wanted to have a list of what are  
19 the most important things we should look at. Like, if  
20 someone does this and we want to evaluate it, what do  
21 we want to see?

22 Like, you know, essentially I said what  
23 are the most important parameters? And also, how do  
24 we test to make this working?

25 Like, what are some performance-based

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1 metrics we can use to look at the model they're using,  
2 look at the results and really see does it work?

3 So, we have a lot of work ahead of us to  
4 kind of piece together, you know. And I think this  
5 would be very useful for any type of AI/ML analysis of  
6 large complex data sets. You know, get some of the  
7 tools that we need to be able to evaluate those in the  
8 future.

9 So, you know, they started with pure iron  
10 in a reactor, and working with up to model alloys and  
11 steels. You know, I think an AI is going to be a good  
12 tool for doing this.

13 So, yeah, that work will be kicking off in  
14 October and going for about two years. Any questions?

15 (No response.)

16 MR. DENNIS: We're going to change gears  
17 to, I think the next topic is online monitoring. So,  
18 if there's anything else for Stephen now?

19 (No response.)

20 MR. DENNIS: All right. So, next up is  
21 Norbert. And we're going to talk about online  
22 monitoring, another very, very important use case.

23 MR. CARTE: So, right now we have a  
24 topical report in-house for a pre-application  
25 readiness assessment review. We've already had one

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1 meeting to discuss internal comments.

2 So, we're well on our way to providing a  
3 readiness assessment on that. But, this application  
4 is probably the first that is going to go through and  
5 it's probably the simplest that you can have.

6 So, online monitoring was first proposed  
7 20 years ago. There was an EPRI topical report, an  
8 application, but then too many questions were asked  
9 and the application was withdrawn, and nothing pursued  
10 after that.

11 It's widely used in other industries on  
12 non-safety-related instrumentation and people have  
13 confidence that it works in those domains. It has not  
14 yet been in the ML based form proposed for safety-  
15 related instrumentation.

16 There is already an OLM topical report  
17 that uses an averaging based technique and deviation  
18 from the average that is currently being used. It's  
19 an approved topical report. Several licensees are  
20 implementing that.

21 The difference is that is simply looking  
22 at averages and deviations from an average considering  
23 the uncertainties involved. This new approach is  
24 using machine learning to characterize instrument  
25 behavior between two valid calibration intervals.

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1           And then, in the future, see if the  
2           instrument behavior deviates from past behavior. And  
3           that deviation is a flag to determine where, for it to  
4           be further evaluated to determine if the drift has  
5           exceeded.

6           So, essentially instrument accuracy and  
7           uncertainties are determined by the set point  
8           uncertainty calculations. The limits of acceptable  
9           calibration tolerances at the beginning, at the end of  
10          a fuel cycle, are determined by those, are first  
11          fundamentally determined by those uncertainty  
12          calculations.

13          Those ranges are then reduced by the  
14          amount of uncertainty associated with the modeling.  
15          And if you exceed that reduced uncertainty band, then  
16          you'll be flagged for human evaluation and possibly  
17          calibration.

18          Accuracy to industry standards is  
19          determined at time of calibration. All this  
20          application is doing is looking for deviations from  
21          past behavior.

22          So, it's calibrated, it works. Does it  
23          behave differently in the same situation in the  
24          future?

25          There's two aspects of that model that are

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1 looked at. One aspect is the steady state behavior,  
2 and the other aspect is the dynamic behavior.

3 So, when you look at, say, instrument tool  
4 fouling, response time degradation effectively acts as  
5 a low pass filter. The claim is they have to  
6 demonstrate that.

7 That you can identify the effects of that  
8 low fast filter when you do the frequency analysis,  
9 even if you don't sample at a high frequency rate,  
10 because it essentially damps the peaks and valleys of  
11 your signal.

12 We've been talking with the owners group  
13 for several years on this. They think it's very  
14 ready.

15 We have several comments and we'll see how  
16 those discussions go when we have those comments.

17 MEMBER HARRINGTON: Norbert, this is Greg.  
18 You mentioned that it looks at deviations. Is there  
19 a calculation of expected value based on other  
20 instrumentation that it would compare itself to?

21 Is that the deviation you're talking  
22 about? Or, deviation from redundant instrumentation?

23 MR. CARTE: Right.

24 MEMBER HARRINGTON: All of that.

25 MR. CARTE: So, yeah, okay, I'll get to

1       that.    So, what happens is on the average system  
2       that's currently approved, they look just at redundant  
3       systems.   And it's one model for all redundant  
4       sensors.

5               The machine-based learning constructs a  
6       different model for each sensor.   And that different  
7       model could be constructed from only redundant  
8       sensors, which makes it vulnerable to common mode  
9       drift.

10              And there might be a periodic calibration  
11       backstop associated with that.   But, there can also be  
12       diverse sensors that are highly correlated.

13              And that diverse highly correlated sensor  
14       provides you some protection against common mode  
15       drift.   Because if all sensors drifted, but you would  
16       not expect the diverse sensor to drift, that diverse  
17       sensor would go, look out, you would go to calibrate  
18       that diverse sensor, it's perfectly fine.

19              You would then further investigate and  
20       determine that no, all our redundant sensors have  
21       drifted.

22              MEMBER HARRINGTON:   Okay.   Because both of  
23       those, as operators, are trained to look at both  
24       redundant sensors and an expected value based on  
25       diverse sensors.

1 So, that sounds like that, it's picked up.

2 MR. CARTE: Yeah. But, the fundamental  
3 difference, one of the fundamental differences is  
4 you're creating a model for each sensor. And you're  
5 predicting that sensor's behavior based on the context  
6 and this context is defined by the other sensors in  
7 that model.

8 MEMBER HARRINGTON: Okay. Thanks.

9 MR. CARTE: And again, it's not making an  
10 absolute decision. It's flagging things for human  
11 evaluation, both in terms of degraded response time  
12 and in terms of drift.

13 Is there another slide? I didn't actually  
14 go over the material on the slide. So, in a sense,  
15 this is the sort of problem that you're looking for.

16 You're looking for when one sensor  
17 deviates. And this is one of their demonstrations  
18 that's showing that it's caught this deviation.

19 MEMBER HARRINGTON: Can you point to where  
20 it caught it? Because that, I mean, an operator  
21 looking at this would catch it easily.

22 MR. CARTE: Right. That's what this  
23 purple line is.

24 MEMBER HARRINGTON: Okay.

25 MR. CARTE: That's where it first made the

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1 decision. And so, it's making the decision actually  
2 before it becomes very obvious.

3 MEMBER HARRINGTON: Okay. Plus, it's  
4 continuously looking at it.

5 MR. CARTE: Right. So, one of the things  
6 that's a little bit uncertain on how this stuff works,  
7 is right now we calibrate say every fuel cycle.

8 You don't actually know what the  
9 individual instrument readings are doing in the  
10 meantime. And now we have all this information  
11 continuously available.

12 And what happens if it drifts out for a  
13 little while and it drifts back? That's an  
14 interesting questions as well. For a month there it  
15 looked bad, but now it looks good. So, what do we do?

16 So, you know, the topical report needs to  
17 include clear criteria about when a human does an  
18 evaluation as well as criteria for the human to do  
19 that evaluation.

20 And so, the idea is to replace the  
21 periodic calibration requirements in the technical  
22 specifications with an online monitoring program. And  
23 use that program to assess the condition of the  
24 instrumentation and calibrate when the condition  
25 requires.

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1           And part of that program will need to  
2           include an evaluation of the sensors to make sure that  
3           they are suitable for this type of application. So,  
4           some sensors, for instance, containment pressure don't  
5           vary a lot over their normal operating range.

6           So, how do you know that they're properly  
7           calibrated at the high end of the range? That gets a  
8           little difficult.

9           Other sensors aren't very noisy. So, how  
10          do you use the frequency response spectra to determine  
11          if you have a response time degradation?

12          So, there are various issues associated  
13          with this. But, those issues basically require an  
14          evaluation for each sensor that's included in the  
15          program, to determine its acceptability for that  
16          program.

17          And the nice thing is, if there's an  
18          error, the model makes a bad prediction, you have a  
19          deviation between the model and behavior, you require  
20          calibration. Then that would be a false negative.

21          So, what's up? What's wrong? It said to  
22          calibrate it works. They have said they have no  
23          evidence of false negatives. So, I get false  
24          negatives with false positives.

25          So, they're going to have false positives.

1 That's what we want to have. And it's conservative.  
2 They have economic incentive to reduce the number of  
3 false positives.

4 We kind of don't care, because that just  
5 needs to calibrate. What we're really worried about  
6 is false negatives, and they say that they haven't  
7 found any.

8 And so, they are applying this in sensors  
9 today or there is at least one utility. There are 14  
10 utilities that are using this stuff.

11 This application, they're tracking how it  
12 works. They just can't use it or credit it for  
13 meeting tech spec surveillance requirements. And  
14 that's what this topical report will help them do.

15 MR. DENNIS: I think that wraps up the OLM  
16 portion. If there were any other questions for  
17 Norbert?

18 (No response.)

19 MR. DENNIS: We'll move onto Josh, yea,  
20 who will be discussing critical heat flux, and  
21 broadly, this topic of AI/ML for special computations  
22 where we have used it for something.

23 We have done something for a long time  
24 using like, a regression technique or, you know, other  
25 statistical methodology. And now we have AI/ML to

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1 solve all the world's problems and provide a different  
2 alternative method.

3 MR. KAIZER: So, I was at a Texas A&M  
4 conference two weeks ago, it was an AI summit. And I  
5 talked to a couple of professors there and they had  
6 people from DOE was there, and they had people from  
7 NVIDIA who were selling to universities.

8 And I was talking to a couple people from  
9 the labs, and I think a question came up, are you  
10 going to have this type of summit every year?

11 And the answer was probably not after  
12 about three years, because it's just become so  
13 pervasive. It's like we'd have like, a conference  
14 today on how are you using the internet? It's  
15 everywhere.

16 And I think that's what is true for  
17 reality. And I think what is interesting to me is,  
18 where does AI/ML first come into licensing?

19 I do still think it's probably going to  
20 come the first true potential neural network that  
21 we're going to see that's actually licensed as likely  
22 a critical heat flux model.

23 So, this kind of goes through some of the  
24 background of this. And this was something I'm  
25 actually extremely proud of, because it was a number

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1 of years ago, I went to the Office of Research and I  
2 said, hey, there's this guy named Groeneveld, and he  
3 has a whole bunch of critical heat flux data and  
4 that's just going to go away.

5 And Research is like, hey, we should pay  
6 for that and get it. So, we did it before anybody  
7 knew it was going to be used. And it sat there for  
8 three or four years.

9 And then, NEA reached out to us and said,  
10 hey, you've got all this Groeneveld CHF data. Can we  
11 use it to train our ML models?

12 And so, this is a benchmark that we ran  
13 that was part of our contribution to that benchmark  
14 series. But, that benchmark to me, was really  
15 interesting, not only because they're training ML  
16 models on critical heat flux, it's a really nice thing  
17 to start with.

18 You've got about four or five dimensions.  
19 You've got probably 25,000 data points, if not more.  
20 But, the people involved were, I mean, these are the  
21 same people I deal with when they deal with critical  
22 heat flux for their correlations they submit to the  
23 NRC. A lot of really good people at the universities.

24 And they were taking this out and taking  
25 it for a spin. And they've gotten, I think they're on

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1 stage two of the benchmark now. So, you can go and  
2 read all about that.

3 But, it's interesting, because they're  
4 trying to decide, okay, is this going to be useful?  
5 How do you make this useful? All that kind of stuff.

6 So, that's what this first slide is just  
7 talking about. It's still probably going to be in  
8 this area.

9 We're seeing people actively involved,  
10 especially people in the industry actively involved.  
11 I think right now everybody's just trying to figure  
12 out, is it worth it to build the AI model or not?

13 I think, and I saw this at the A&M Summit,  
14 people are just obsessed with using neural networks.  
15 And neural networks are a great mathematical model,  
16 but like, why don't I just give that Groeneveld data  
17 to my AI system and say, hey, tell me what  
18 mathematical model I should use.

19 Is the form of the neural network the best  
20 thing to use? Or, is it going to give me some screwy  
21 model type?

22 I mean, I don't know if you've seen the  
23 old critical heat flux correlations look horrible.  
24 There's values to the 0.3 power dividing this by that.  
25 And if that form of the correlation works well, you

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1 don't need a neural network. And if you don't use a  
2 neural network, you use a lot less data to train your  
3 model.

4 So, I think right now there's still  
5 everybody loves AI, and so we want to make everything  
6 AI. And my favorite is when I see simple control  
7 systems done with AI, and I think, why don't you just  
8 use a control system?

9 And the answer is, because people are  
10 paying for us to use AI. So, okay, cool. Learn how  
11 to use it.

12 But, I think you're kind of seeing that  
13 honeymoon phase. And then, you're also kind of  
14 getting to the reality of do I actually have the data?

15 And we're still here, I think with  
16 artificial intelligence and machine learning for  
17 critical heat flux. Next slide, please? Thanks.

18 And so, I just, I have this kind of  
19 checked off. These are the technology readiness  
20 levels. Give me a second, Matt.

21 And I wanted to kind of walk through this  
22 with where I think we are in terms of AI/ML for not  
23 just critical heat flux, but I'd say for any safety  
24 use case.

25 So, safety use case, I would put it's not

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1 just a helper tool, it's this is the thing you're  
2 using to make it a safety decision.

3 So, I forgot who came up with TRL levels.  
4 I don't -- NASA? Yeah. And the most recent document  
5 was from like, some OPM, it was weird. It was some  
6 federal Agency that I did not expect to find it at.

7 So, I use the standard nine table. So,  
8 are we at level one? Absolutely for basic principles  
9 observed. Next Matt.

10 You're clearly at level two. Go next.  
11 Proof of concept is demonstrated? Yeah. And have we  
12 validated this in a laboratory? Yeah.

13 Have we proven that you can use it in  
14 operation? No. And I just mean AI for, and mainly a  
15 machine learn model, so not like a large language  
16 model, but like a machine learn model, neural network  
17 usually for something that you're going to trust a  
18 lot, not really, not at level nine. Go to the next  
19 one.

20 System complete and quantified or  
21 qualified? No, not at level eight. And then, go to  
22 the next one. Not at level seven.

23 So, I think that's helpful to say, okay,  
24 where are we? Well, and go to the next one. We're  
25 probably in somewhere between five and six.

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1           Why does that matter? Because I think  
2           this is where, to me, the rubber meets the road.  
3           Westinghouse has stated that they are looking into  
4           this.

5           They said it publicly. They've given  
6           really good presentations on it. I'm sure one of the  
7           things that they're looking at is, can we do this?  
8           And does it make sense? Can we prove to ourselves  
9           that we can trust these models?

10          But, then the second question is, why do  
11          we do this? Why should I use a neural network to  
12          predict critical heat flux? Is this really the best  
13          mathematical form as opposed to using AI or anything  
14          else to develop that correlation?

15          And I'm sure, to me, the answer is  
16          probably with the complexity of the model and the  
17          amount of data you have.

18          And so, we have the Westinghouse Fuels  
19          meeting next week. So, I kind of wish I was there  
20          first so I could hear any updates from them and  
21          provide them to you.

22          But, this is an open session, so there's  
23          a good chance even if I did hear something cool, I  
24          wouldn't be able to pass it along. But, I think, this  
25          is where we're really, I don't want to say stuck right

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1 now, but this is where we are right now.

2 I'm convinced that machine learning will  
3 be used for something. I mean, obviously, Norbert was  
4 talking about the online monitoring.

5 I'm involved with that. It's really cool.  
6 It reminds me a lot of DVR in some instance. But,  
7 here's also an area where I'm also really happy.

8 So, we have the new proposed regulation.  
9 Part of that is 10 CFR 5221, which talks about VVUQ  
10 Programs. And one of the reasons that I really wanted  
11 to get something in the regulation talking about those  
12 programs, is because I do not think when the NRC  
13 reviews machine learning model, we will review a  
14 single model and say, yes, go forth and do good works  
15 with this single model.

16 I think we're going to be running a fleet  
17 of models. We're going to say, okay, you're going to  
18 create this model. And personally, I've never cared  
19 how the model was generated.

20 I always kind of imagine in my head, if  
21 you have someone who sits in a room with no windows  
22 and they write equations on pieces of paper and pass  
23 those under the door and you pick it up and say, hey,  
24 wow, this does a great job.

25 Can you use that model? Sure, provided

1       you can prove that the model is trustworthy. And this  
2       is all that VVUQ stuff.

3               So, I think for AI/ML, anything, you're  
4       going to be so focused not on the creation of the  
5       model and that. But, how do you know you can trust  
6       it? What is the validation you have? What is the  
7       uncertainty quantification?

8               So, getting that into the regulation, I  
9       think, is really vital if you are going to start  
10      seeing these models used in industry. So, that's  
11      pretty much what I have to say for AI/ML.

12              The other interesting challenge I would  
13      say to the ACRS, because this is something that I  
14      think is interesting, a couple years ago before, back  
15      when NVIDIA was cheap and you could invest very little  
16      money and then still be incredibly wealthy today,  
17      there were really awesome videos on YouTube about how  
18      good AI has to be.

19              So, this is before anybody knew what it  
20      was. And it brought up a philosophical question back  
21      then, which was philosophical, but today it's real.  
22      What are you going to do when you're going to put the  
23      human in a loop and know that human in the loop means  
24      less safe?

25              Because I feel like with AI, I use it a

1 ton for coding. The amount of things it does to  
2 verify that the code is real, is way more than I ever  
3 knew people actually did.

4 And I can easily see it getting to the  
5 point, and I think Dr. Bier even mentioned it, where  
6 it is clearly better than what a human can do. But,  
7 we still don't want to give up the control.

8 And I have no --

9 VICE CHAIR PETTI: So, hold on. I have to  
10 challenge you here.

11 MR. KAIZER: Go ahead.

12 VICE CHAIR PETTI: Yeah, because my son's  
13 a software engineer, and what he calls his group that  
14 writes code, he calls it AI slop. And that he  
15 constantly has to send it back.

16 So, either they're not good at telling AI  
17 what to do and how to write it, but he's not a big  
18 fan. He thinks that AI doesn't --

19 MR. KAIZER: And I think, I don't want to,  
20 I can't, I don't use a lot of code. I have a friend  
21 who works at Google. I know he's using it  
22 exclusively, and to me, he's one of the smartest  
23 people I know, also probably one of the most highly  
24 paid.

25 But, I am so impressed with how quickly

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1 it's gotten better. And I will say, do I believe you  
2 should listen to AI? No.

3 I actually have a paper submitted to the  
4 Journal of VVUQ on exactly how AI should be treated.  
5 I call it an invalidatable model.

6 So, I'm very, very concerned with how  
7 people think of it. But, because it's not subject to  
8 a lot of issues that humans are, especially as a  
9 regulator, it gets in this interesting space where, do  
10 you allow things that you know are going to be safer  
11 when people don't necessarily feel comfortable with  
12 it?

13 I have no good answer to that. I have no  
14 point. But, I can definitely see that problem coming.  
15 I mean, probably with self-driving cars will be one of  
16 the first big tests.

17 Do you think it'll be safer than a human  
18 driver? And then, you'll have the statistics to show  
19 you, well.

20 MR. CARTE: There's a following on, on  
21 that coding example. So, I also know a guy who quit  
22 his company, who's now doing a startup and they're  
23 looking at AI coding.

24 But, one of their approaches is to embed  
25 formal methods. So, if you can actually get the AI to

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1 code the formal methods, then you can  
2 deterministically prove the code works or meets its  
3 requirements.

4 And, although if your requirements are  
5 easy, it's not a problem. So, there are, you can make  
6 things more complex, but yet more verifiable.

7 And so, it does offer other interesting  
8 aspects.

9 MEMBER KAMMERER: Yeah. I do think that  
10 you have to be careful saying that it's better. And  
11 using the example of, oh, there's this smart person  
12 and they're using it all the time, because we all know  
13 it is being shoved on all of us all the time, right.

14 And there's a lot of companies that are  
15 forcing employees to learn or at least pretend like  
16 they're using it, because their supervisor loves it,  
17 right.

18 And, I mean, all of us even, you know,  
19 there's all these, oh, this is the thing of the  
20 future, because its adoption rate is higher than  
21 anything ever.

22 But, we don't have an option. If you want  
23 to use a Google search, you are then using AI, right.  
24 So, of course the adoption is higher because so many  
25 people weren't given a choice.

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1           And so, I do think we need to be very  
2 careful about saying when that point is for any  
3 particular usage about when the AI gets better than  
4 the human. And certainly adoption for me is not a  
5 compelling argument, because I'm a user, but half the  
6 time I don't want to be using it. I would like my old  
7 Google search back, thank you. When I could actually  
8 just click on things and look.

9           So, I personally think that there's a lot  
10 of great uses that we'll see coming up. And something  
11 I'm really interested in is cybersecurity and seeing  
12 an anomalous behavior that AI is going to be able to  
13 pick up a lot faster than humans will for sure.

14           But, yeah, I think there's a lot of  
15 challenges in understanding exactly where that break  
16 point is. And I don't think, I would say I'm  
17 skeptical and dubious about when folks that are  
18 working in AI are telling us.

19           And I'm not saying you all, but when folks  
20 in AI are telling us that it's further along than it  
21 is. I mean, we've seen rogue models now, right.

22           We saw some bad behavior by some rogue  
23 models. And so, you know.

24           MR. KAISER: I just want to say 100  
25 percent agree. I think the biggest problem that AI

1 has with acceptance, is I have never seen more  
2 engineers that I consider smart.

3 I will even give them the ultimate  
4 compliment. And, in my mind, I think of them as smart  
5 as me. And they do not like it. And, normally, like  
6 nothing that I can figure out tracks with AI  
7 acceptance. It doesn't track with intelligence. It  
8 doesn't track with how good you are at work.

9 There are some people that just embrace  
10 it. And it's very interesting when you find those  
11 people that I feel like it's been proven to them and  
12 they're like, this is amazing. And you have other  
13 people that are just holding out.

14 And it's interesting. And I think that  
15 other thing, is I've seen a lot of holdouts more in  
16 industry than in academia.

17 When I was at Texas A&M, I feel like a lot  
18 of the students and grad students have pretty much, I  
19 feel like they're not really as skeptical as people  
20 I've seen in the industry, because exactly what you  
21 said, I feel like a lot of us feel like it's been  
22 shoved down our throats.

23 And if you're going to tell us to force us  
24 to go one way, we're going to try to go the other.

25 MEMBER PALMTAG: My concern is not the

1 smart engineer, it's the average engineer.

2 MR. KAIZER: Yeah.

3 MEMBER PALMTAG: Because, you know, it's  
4 like the story about the doctor, you know, some  
5 doctors got As, some doctors came out of med school  
6 with Cs. You know, I mean, not everybody's the same.

7 And we're talking about an adoption  
8 across, you know, a broad industry. That's my view.

9 MEMBER HARRINGTON: So, Let me ask my  
10 question, then we'll get to Vicki. As a regulator,  
11 it's like, not all engineers are alike, not all AI  
12 models are alike.

13 And I can foresee, and it may just be my  
14 imagination, but an AI model arguing with an AI model,  
15 with a human watching it like a ping pong game, and  
16 just becoming dizzy, you know, not being able to keep  
17 up with it.

18 And is that a concern or a discussion in  
19 the regulatory world about, you know, an AI generated  
20 licensing application and an AI generated licensing  
21 application review arguing with each other, and just  
22 going to let it play out?

23 MR. KAIZER: I think the thing that we're  
24 very concerned, I mean, we're always asking the  
25 industry, how are you going to use this? And if

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1 someone in the industry says, well, I want to use AI  
2 to write my application, I think you probably should.

3  
4 I mean, I think it's been about three  
5 years now since I've switched almost all my writing  
6 over to AI. It's faster than me. It has less  
7 spelling mistakes. It doesn't drop the words. But,  
8 it's not AI doing the writing. I'm reading every  
9 paragraph if that's what I mean to say.

10 And so, I think that you're going to start  
11 seeing that more in the industry. We certainly saw it  
12 in the public comments. You can go for the public  
13 comments on the rule and a lot of them were written  
14 with AI, and they were pretty good.

15 I think how we actually use it internally  
16 to do reviews, I just got my first safety evaluation  
17 written a lot with AI, because we have Copilot, and  
18 it's helpful to get the ideas down. But, in terms of  
19 actually doing the review, I did a couple test runs.

20 And these were AIs like six months ago.  
21 Six months ago is like, decades ago in AI space. It  
22 didn't really do a good job.

23 It will be very interesting when we do  
24 have those decent models. One model says one thing,  
25 one model says another, and they conflict.

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1           One of the things I think is really  
2           interesting with AI, is when it doesn't argue the way  
3           humans do. And usually it is much more impartial.

4           So, like, I would be interested if two AIs  
5           start conflicting, would they just end up agreeing  
6           that there's a conflict there? Or, would they just  
7           reach some kind of settlement or what?

8           MEMBER HARRINGTON: Yeah. Okay.

9           MR. DENNIS: To answer your question about  
10          the dueling agents, this is later in our presentation  
11          when I talk about, when I update on the tabletop  
12          exercise.

13          But, one of the authors who's a  
14          contributor to that is from Argonne National Lab and  
15          they have done, under DOE sponsorship, done a pre-  
16          print, and there is a journal article that they were  
17          proposing that exact thing for regulator context  
18          protocol.

19          I forget the name of it, but it was  
20          basically dueling agents with an intermediary where  
21          you would have a license application submitted by an  
22          agent, and a regulatory agent review, and the two  
23          would come to some negotiation. And you would go  
24          through the typical process and it would be observed  
25          by the, you know, human licensee and human regulator.

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1 And it's an interesting concept in this  
2 particular paper that --

3 MEMBER HARRINGTON: To be determined.

4 MR. CARTE: Well, one final point. I  
5 mean, currently we live in the old-fashioned era where  
6 people sign under oath, an affirmation that this is  
7 correct, right.

8 So, I think we'll always expect a person  
9 to read and sign. And I would hope that we would hold  
10 them accountable if they just print and send.

11 But, --

12 MEMBER HARRINGTON: Someday I'll let you  
13 know how that actually works at the CNO level. So,  
14 Vicki, you had a question? Go ahead.

15 DR. BIER: Not a question, really just a  
16 comment following up on the comment about, like well,  
17 if we start having, you know, self-driving cars, we  
18 will get statistics on how the fatality rate or  
19 accident rate compares.

20 I just wanted to comment that assessing  
21 accuracy is a difficult challenge. It's not  
22 automatic.

23 For example, in places like San Francisco,  
24 some of the earliest adopters of self-driving cars are  
25 probably people wanting a ride home from the bars at

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1 1:00 in the morning. And, if those are the people  
2 that you're taking off the road, then yes, the human  
3 driven accident rate is going to be much higher than  
4 what you're replacing it with.

5 But, if you're, you know, starting to get  
6 adoption by, you know, whatever mom's driving their  
7 kids to school in the morning, the accident rate that  
8 you're replacing may be much lower.

9 And so, you know, I haven't thought  
10 through how that applies to these kinds of  
11 applications. But, I just wanted to comment that, you  
12 know, assessing accuracy can be a complicated question  
13 and is it accuracy in normal situations, in off-normal  
14 situations like bad weather, and for self-driving  
15 cars, et cetera.

16 So, it's not entirely obvious how to  
17 assess accuracy.

18 CHAIR HALNON: Okay, thanks.

19 MEMBER ROBERTS: So, I suggest we take our  
20 break now.

21 CHAIR HALNON: Well, Annie wanted to say  
22 something then.

23 MEMBER KAMMERER: Yeah. I was going to  
24 say the thing that I was recently attempting to use AI  
25 for, there was a temporal aspect to it. In other

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1 words, laws had changed over time and it wasn't  
2 capturing that.

3 When I'd ask a question, I'd get an answer  
4 that I knew was outdated because the law changed, you  
5 know, a couple years ago. And I'd say, I think that  
6 the law changed it.

7 And it'd say, you know, you're so clever,  
8 whatever it says, you know, to make you feel good  
9 about it. And then, it would correct itself. But,  
10 only because I knew more than the data it was pulling.

11 So, how would you address that, the fact  
12 that some of the data upon which it gets trained, is  
13 superseded over time and untraining it?

14 MR. KAIZER: I think this goes to how to  
15 use the tool. And I think that's what a lot of people  
16 are really struggling with.

17 I mean, you have this really cool tool,  
18 and when I thought of AI initially, it was Star Trek  
19 the Next Generation, Data, he knew everything, that's  
20 the way I should be. No.

21 It's really good if you can constrain its  
22 world, and it's amazing with mathematics, because it's  
23 a constrained world and it understands mathematics.

24 So, if you give it something that is, to  
25 me, even a remotely mathematical, as complex as it is,

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1 it can walk you through that process. Okay, great.  
2 Here's an area where I can trust it.

3 So, for example, I'm helping Norbert do  
4 the machine learning thing for PWROG. I gave AI the  
5 three NUREGs which are publicly available, and I said,  
6 hey, tell me what AAKR is. And, in about 15 minutes,  
7 it was able to explain things to me to the point  
8 where, okay, now I think I understand this. Now,  
9 could I be wrong? Sure. But everything kind of falls  
10 into place and I can do the simple little experiments  
11 and that kind of thing.

12 And I think this is where it's incredibly  
13 powerful. Where it's really, to me, bad and it goes  
14 back to that, what can you validate it to do, is if  
15 you ask it like a question about like law or  
16 something, where it's not, I'd say more formal based,  
17 if I can't just put it in a document.

18 Like, if I give it a really big law  
19 document, it can probably, it's better than an ALT-F  
20 search, because it's going to find not only just your  
21 word, but other concepts there.

22 But, I think those general questions are  
23 where it's going always, going to be misleading. And  
24 I think it's just a while for us to get used to, how  
25 do we use it well?

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1                   Because, I mean, there's going to be ways  
2                   to use it well, and there's really going to be ways to  
3                   use it poorly. And we will certainly find ways to use  
4                   it poorly.

5                   I've seen some submitted where you can  
6                   tell AI wrote it and the person didn't read it  
7                   afterwards. And you're like, this is horrible.

8                   CHAIR HALNON: Okay. Thank you. We're  
9                   going to take our first break here. It's essentially  
10                  4:00, 3:55.

11                  So, we'll come back out of recess at 4:15.  
12                  And then, we'll move on with this. So, the presenters  
13                  get ready before 4:15.

14                  So, but we'll come back into session at  
15                  4:15.

16                  (Whereupon, the above-entitled matter went  
17                  off the record at 3:55 p.m. and resumed at 4:15 p.m.)

18                  CHAIR HALNON: Okay. This is Greg Halnon,  
19                  Chairman. We are going to be back in session. It's  
20                  4:15. And Tom, did you have any opening?

21                  Okay. Matt, you go ahead.

22                  MR. DENNIS: All right. Thanks. For the  
23                  second half of the discussion, we're going to wrap it  
24                  up with AI and autonomous operations.

25                  So, Niav Hughes Green of the NRC staff is

1 going to talk about the human factors aspects. And  
2 then, Matt Anderson from Idaho National Lab will brief  
3 you all on a recent research project that involved a  
4 number of collaborators principally focused on  
5 autonomous operation at the Purdue reactor.

6 So, first up, Niav.

7 DR. HUGHES GREEN: So, thank you --

8 CHAIR HALNON: Get the microphone, bring  
9 it close to you. It's very unidirectional, so you got  
10 to talk right into it.

11 DR. HUGHES GREEN: Great, thank you.

12 MR. DENNIS: So, your mouth has to be very  
13 close.

14 DR. HUGHES GREEN: Is that good?

15 CHAIR HALNON: Yep.

16 DR. HUGHES GREEN: Okay. Okay. Thanks.  
17 Thanks for that. Good afternoon, Chair and Members of  
18 the ACRS. I'm Niav Hughes Green from the Office of  
19 Nuclear Regulatory Research's Division of Engineering  
20 and Risk Analysis in the Integrated Systems  
21 Engineering Branch.

22 That's a mouthful. It's our new branch,  
23 so apologies there. I stumbled over it. I was here  
24 just about two years ago actually talking about the  
25 NRC's human factors research portfolio a little bit

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1 more broadly.

2 And today I'm happy to be here to share  
3 the progress that we've made in our human factors  
4 research supporting regulatory preparedness for  
5 greater levels of autonomy and advanced reactor  
6 concepts. So, next slide please, Matt.

7 So, let me start by outlining the scope of  
8 this segment so the Committee has a clear  
9 understanding of what I will be focusing on. This  
10 portion of the briefing provides an overview of the  
11 NRC's human factors research that supports regulatory  
12 preparedness for licensing reviews that may include  
13 autonomous operations.

14 Throughout the next several slides, I'll  
15 describe the current research activities underway in  
16 human factors that examine autonomy and advanced  
17 reactor concepts, what forms of autonomy we  
18 anticipate, and how human system interaction changes  
19 as autonomy increases.

20 I'll be highlighting three main areas.  
21 First, the scope of our human factors research on  
22 autonomy and autonomous operations, how autonomy is  
23 expected to emerge in advanced nuclear designs, and  
24 which aspects of operator performance and supervisory  
25 control are most affected.

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1           Second, how higher levels of autonomy  
2           influence operator roles and responsibilities. And,  
3           third, I'll touch on how human factors research  
4           supports consideration of AI supported autonomy.

5           I also want to be clear about what this  
6           segment does not address. This presentation does not  
7           cover Part 53 or Part 57 requirements or policy  
8           decisions, it does not cover Agency-wide AI governance  
9           or Agency AI use, and the presentation will not be  
10          getting into technical areas outside the human factors  
11          domain such as instrumentation and control design or  
12          cybersecurity.

13          But, we do have some staff who specialize  
14          in those disciplines in the meeting today. With that  
15          scope in mind, I'm pleased to tell you about the human  
16          factors research that we've been doing. Next slide  
17          please.

18          So, our research on human factors  
19          considerations for autonomous operations was initiated  
20          in partnership with Idaho National Laboratory. The  
21          focus was on the types of autonomy anticipated in  
22          advanced reactor concepts, so not necessarily for  
23          large light water reactors.

24          The research was designed to understand  
25          the range of autonomous concepts anticipated in

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1 advanced reactors, identify human factors  
2 considerations and implications through an in-depth  
3 characterization of that range, gather research  
4 findings and lessons learned from other high risk  
5 domains including oil and gas, maritime, aviation, and  
6 aerospace, develop a taxonomy of human factors  
7 considerations important to ensuring safe operation,  
8 and finally, document the technical basis and develop  
9 recommendations for guidance.

10 By taking this systematic approach, we're  
11 ensuring that our guidance development is grounded in  
12 evidence, informed by cross-industry experience, and  
13 tailored to the unique characteristics of advanced  
14 reactor designs.

15 And this brings me to the methodology  
16 that's depicted in the figure on this slide. The  
17 approach we're using follows NRC's structured human  
18 factors guidance development process.

19 The orange sections show the work that  
20 we've completed so far. The blue sections show the  
21 steps that are still underway.

22 And this is very much a work in progress  
23 and the work that's already been completed in those  
24 orange section leads me directly to the two reports  
25 that I'm going to discuss next. This work is ongoing.

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1           We're actively building out the technical  
2 basis and the guidance recommendations right now. And  
3 the completed reports that I'll discuss next are  
4 foundational to that process. Next slide, please.

5           So, this slide shows the two completed  
6 human factors research products that anchor the  
7 autonomy work that I've been discussing. The INL  
8 technical letter report provided our initial view of  
9 anticipated uses of autonomy in advanced reactors.

10          In the report, we refer to this as our  
11 landscape analysis. What we learned from that  
12 analysis is that autonomous operations are expected to  
13 emerge in diverse ways, often through passive safety  
14 features, inherent safety characteristics, and  
15 deterministic logic, rather than necessarily AI.

16          To understand how developers were  
17 anticipating these features, we examined available  
18 design information to characterize how autonomy was  
19 expected to be implemented, looking at what functions  
20 become autonomous, when autonomy applies across normal  
21 and off-normal conditions, how different design  
22 attributes achieve autonomous behavior, and where  
23 human oversight is expected to occur.

24          This gave us our first systematic  
25 understanding of how autonomy may be implemented. The

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1 second product, the NRC research information letter,  
2 RIL 2026-02, builds on that landscape analysis.

3 It characterizes the human factors  
4 considerations associated with higher levels of  
5 autonomy, implications for operator roles, supervisory  
6 responsibilities, oversight strategies, and broader  
7 human system interaction. It also identifies the  
8 areas where additional human factors guidance will be  
9 needed as autonomy begins to appear in licensing  
10 reviews.

11 Together, these reports form the technical  
12 basis feeding into our guidance development pipeline.  
13 In the next few slides, I'll unpack some of the  
14 definitions, the analytical framing, and the human  
15 factors learnings that emerge from this work. Next  
16 slide.

17 To give us a shared foundation for the  
18 rest of the discussion, these are the working  
19 definitions from RIL 2026-02.

20 Autonomy refers to a system's ability to  
21 operate independently of human control. Importantly,  
22 autonomy is a characteristic or a capability. It  
23 describes what functions a system can perform on its  
24 own, not the mechanism that's used to achieve them.

25 Automation is defined as a device or

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1 system that accomplishes a function or task, either  
2 partially or fully. Automation can be deterministic,  
3 rule-based, adaptive, or AI enabled.

4 An important distinction in these  
5 definitions is that automation is an artifact, a  
6 system or a device, whereas autonomy is a capability  
7 that a system or device may possess.

8 In real world systems, the degree of  
9 autonomy lies on a spectrum. In nuclear designs,  
10 higher levels of autonomy may be achieved through  
11 passive safety features, inherent design  
12 characteristics, automated systems that use  
13 deterministic logic, or autonomous systems using  
14 adaptive algorithms such as AI.

15 We also distinguish types of automation in  
16 the RIL. An automated system is one that can perform  
17 functions independently, but only within fixed  
18 parameters, set points, or predefined scripts.

19 An autonomous system goes further, capable  
20 of extended independent operation and able to adapt to  
21 changing conditions, uncertainties, or constraints.  
22 An autonomous system may employ AI as part of its  
23 mechanism, but AI is not required for autonomy and  
24 autonomy does not inherently imply AI.

25 Across advanced reactor concepts, we

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1 expect to see higher levels of autonomy based  
2 primarily on inherent design characteristics and  
3 passive features. Automated systems and AI supported  
4 autonomous systems are a potential, but not as an  
5 assumed implementation pathway.

6 And, finally, there is not yet sector-wide  
7 consensus on these definitions. These working  
8 definitions and our human factors terminology continue  
9 to evolve as new information emerges. Next slide,  
10 please.

11 So, autonomous operation can also exist on  
12 a spectrum. Our working definition is that autonomous  
13 operation is the use of design features that enable a  
14 defined scope of operational and safety functions to  
15 be performed without reliance on human intervention,  
16 external command, or active control system input.

17 Autonomous operation can be enabled by a  
18 variety of design features. Some functions may be  
19 passive or highly deterministic. Others may  
20 incorporate AI.

21 It can occur on a small or a large scale  
22 at the component, system, or plant level. It may  
23 apply to a limited scope of operations such as only  
24 during normal operations, or it may extend across  
25 abnormal and accident conditions.

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1           It's important to emphasize that  
2 autonomous operations is not the same as unmanned  
3 operation. Even systems with high levels of autonomy  
4 still require human oversight and human  
5 accountability. Humans remain responsible for  
6 supervising, monitoring, diagnosing, and intervening  
7 when needed.

8           Understanding autonomy and autonomous  
9 operations as a spectrum, varying by function,  
10 mechanism, and operating condition, sets up the key  
11 questions that we use to understand the human role in  
12 a particular advanced reactor design and the potential  
13 effects on human performance. Next slide, please.

14           MEMBER KIRCHNER: Can I ask you a  
15 question? Could you stop there?

16           I want to probe your autonomous operation  
17 means the following. So, you have an autonomous  
18 vehicle driving around, those have active control  
19 systems.

20           DR. HUGHES GREEN: Yes.

21           MEMBER KIRCHNER: Without reliance on  
22 active control system input. And I'm a little bit  
23 confused about the definition.

24           I mean, these are systems that are  
25 operating autonomously, but they do have active

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1 control systems.

2 DR. HUGHES GREEN: Yep. So, active  
3 control system input. I'm thinking that the active  
4 control system input piece of this discussion is a  
5 little bit outside of the realm of my expertise in  
6 terms of this definition where we're kind of --

7 MEMBER KIRCHNER: Well, you could have a  
8 reactor, for example, that's operating remotely, maybe  
9 autonomously. We'll see if we can get there.

10 You've got a reactor protection system  
11 that's an active control system that you rely on that  
12 it safely shuts down.

13 So, I'm just, I get the meaning, yeah,  
14 your definition without human intervention and  
15 external control. But, usually this autonomous system  
16 has a built-in active control system to keep it within  
17 on the road or whatever.

18 So, I was just trying to test your  
19 definition here.

20 DR. HUGHES GREEN: Yeah, I'm going to go  
21 ahead and defer to my colleague over in OAR to maybe  
22 help me respond to this.

23 MR. GREEN: Yeah. Brian Green, Senior  
24 Technical Advisor for human factors. I think what's  
25 intended by that sentence is not to say that there are

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1 no active controls.

2 The idea is that the human doesn't have to  
3 input during the course of the, I think it's the  
4 defined scope, within the defined scope of operation.

5 MEMBER KIRCHNER: Yeah.

6 MR. GREEN: The human won't push a button  
7 to start that active control within that scope.

8 MEMBER KIRCHNER: Yeah, maybe it needs  
9 active human. Well, you have external command or  
10 active human input, but clearly these autonomous  
11 systems --

12 MR. GREEN: Yeah, they will control  
13 something actively.

14 MEMBER KIRCHNER: They will require the  
15 control systems.

16 DR. HUGHES GREEN: Yeah.

17 MR. GREEN: That's correct.

18 MEMBER KIRCHNER: Okay. Just testing.

19 DR. HUGHES GREEN: Yeah, I can appreciate  
20 your point of view there.

21 MR. GREEN: Yeah. So, Dr. Hughes  
22 mentioned that these are our definitions that we're  
23 putting forth.

24 There are many perspectives on this and  
25 there is definitely some tweakability that can and

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1 will happen as these go. But, we found it very  
2 helpful to have some operational definitions.

3 You know, I can back --

4 MEMBER KIRCHNER: Really? I'm with you on  
5 definitions.

6 MR. GREEN: Yeah. The term automation is  
7 so fraught to begin with. So, when we start to expand  
8 into autonomy, it just gets that much more  
9 complicated.

10 I once had a supervisor who thought  
11 anytime I talked about automation meant a turnkey  
12 plant. And that might have been when I was talking  
13 about an automatic reactor trip where a certain  
14 function was automatic.

15 So, we're trying to, you know, develop  
16 that language in a way where we can come to an  
17 agreement and all make sure we're talking about the  
18 same thing at the same time.

19 MEMBER KIRCHNER: Okay.

20 MEMBER ROBERTS: Yes, Tom Roberts. You  
21 said this is a work in progress. I would just  
22 observed that there are other places that use  
23 different definitions. I'm sure you're aware of that.

24 Is there any effort to try to commonalize  
25 across the NRC staff the definition of these terms?

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1 Put them in one place and use them the same way  
2 throughout?

3 DR. HUGHES GREEN: So, over the course of  
4 the human factors research, we have been engaging in  
5 a working group that is across the Office of Research,  
6 now OAR, CNRI, on the topic of remote and autonomous  
7 operations to do just that, to align on these  
8 definitions.

9 And so, as you mentioned, work in  
10 progress. So, they continue to evolve. But, we are  
11 engaging in a working group effort towards aligning.

12 MEMBER ROBERTS: Okay, thanks. I think  
13 that would be helpful.

14 DR. HUGHES GREEN: Okay. So, some of the  
15 key questions that we're exploring focus on the  
16 fundamentals.

17 So, what, when, how, and where. What is  
18 autonomous, what functions or systems operate without  
19 human intervention?

20 When is it autonomous under normal,  
21 abnormal or accident conditions? How is autonomy  
22 achieved through deterministic logic, passive  
23 features, inherent design characteristics or adaptive  
24 capabilities?

25 Where is it monitored or controlled? So,

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1 from a main control room, a local station or a remote  
2 control center, this ties to a related concept of  
3 remote operations.

4 And these questions clarify both how  
5 autonomous operation may apply in a design and what is  
6 expected from the operator under different conditions.  
7 Next slide.

8 So, there's a common misconception that  
9 automation simply replaces humans. In human factors,  
10 we refer to this as a substitution myth.

11 The assumption is that when automation  
12 takes over a task, the human role disappears. But,  
13 research and operating experience across many high  
14 risk domains shows that that's not what actually  
15 happens.

16 Automation doesn't remove the human, it  
17 reshapes the human role. As autonomy increases,  
18 operators often shift from hands-on control to  
19 supervising and monitoring automated functions.

20 Their involvement may be minimal during  
21 routine conditions, but they remain fully responsible  
22 for detecting when automation isn't performing as  
23 intended, diagnosing unexpected situations, and  
24 intervening quickly when needed.

25 In many cases, the human role becomes most

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1 demanding precisely when something abnormal or  
2 unexpected occurs. The operator may be out of the  
3 loop until an anomaly appears and then must rapidly  
4 regain awareness, understand system status and take  
5 corrective action.

6 If designs don't adequately support these  
7 supervisory roles, the operator's job becomes  
8 unnecessarily difficult. When incidents occur, they  
9 are often labeled as human error, but the root cause  
10 may actually be clumsy automation or poor allocation  
11 of functions.

12 Understanding this substitution myth is  
13 fundamental to evaluating autonomous operations. It  
14 highlights why human factors considerations must be  
15 addressed directly in the design.

16 Greater autonomy can change rather than  
17 eliminate the human role. And if these new  
18 responsibilities aren't well supported, safety and  
19 performance suffer. Next slide please.

20 So, remember that AI is a type of  
21 automation. Key human factors considerations that  
22 apply to any form of automation remain equally  
23 important and often become more pronounced when the  
24 automation is driven by AI.

25 These considerations shape how humans

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1 interact with both automated and autonomous systems.  
2 So, situational awareness becomes more challenging  
3 when operators supervise rather than directly control  
4 systems.

5 With AI driven systems, operators may also  
6 need to interpret why the system is acting a certain  
7 way or producing certain outputs, making recovery  
8 during time critical events more complex.

9 Trust calibration must match real system  
10 capability. Over trust can lead operator to rely too  
11 heavily on AI outputs, under trust can lead to  
12 workarounds that bypass intended automation benefits.

13 AI can complicate trust because its  
14 behavior may appear variable or opaque. Workload  
15 shifts as autonomy increases.

16 Routine automation may reduce workload,  
17 but anomalies can create steep spikes, especially if  
18 operators must quickly make sense of AI generated  
19 information. Very low workload can also weaken  
20 vigilance, making it harder to notice system drift or  
21 unexpected behaviors.

22 Teaming and coordination evolve with  
23 automation. Operators coordinate not just with other  
24 humans, but with increasingly capable systems. And  
25 when AI is involved, it becomes important to

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1 understand system intent, constraints, and how the  
2 system may adapt.

3 Training needs can increase rather than  
4 decrease as automation becomes more sophisticated.  
5 For AI supported systems, personnel may need training  
6 on system limitations, conditions where AI performance  
7 may degrade, and how to interpret AI outputs with the  
8 broader operational context.

9 Skill and knowledge degradation can occur  
10 when operators rarely perform tasks themselves. This  
11 becomes particularly important if operators must  
12 suddenly intervene when an AI supported autonomous  
13 system encounters a situation it cannot resolve.

14 These considerations guide how we prepare  
15 for cases where autonomous operations may involve AI.  
16 Next slide please.

17 So, to support safe AI use in autonomous  
18 operations, human factors research draws on lessons  
19 from other safety critical industries. In 2023, the  
20 Human Factors and Ergonomic Society published a set of  
21 AI guardrails for safety critical applications, and  
22 these guardrails closely align with the human factors  
23 themes that we've been discussing.

24 They emphasize explainability and  
25 transparency, ensuring operators understand system

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1 behavior and outputs. They call for human testing,  
2 salient safety alerts so personnel can detect when AI  
3 or automation is drifting or performing unexpectedly.

4 They highlight the need for fail-safe  
5 behavior and clear fallback paths, preserving operator  
6 authority when automation degrades or encounters  
7 conditions outside of its domain of validity. And  
8 they reinforce the importance of robust training and  
9 rigorous validation, especially when AI supports  
10 autonomous functions.

11 And these themes directly support the  
12 human factors principles we've covered throughout this  
13 briefing, maintaining situation awareness, calibrating  
14 trust, managing workload, ensuring human authority and  
15 designing clear intervention paths.

16 They show how AI related human factors  
17 considerations build on established automation  
18 principles, while introducing additional requirements  
19 when AI is involved. Next slide please.

20 So, building on the AI guardrails, safe  
21 AI, human AI collaboration depends on several key  
22 design expectations.

23 AI should be explainable so operators  
24 understand why the system produce a particular output  
25 or recommendation. Explainability supports situation

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1 awareness and trust calibration, especially when AI  
2 behavior differs across operating conditions.

3 Second, human in the loop decision making  
4 remains essential. Even when AI supports autonomous  
5 functions, operators must retain authority over  
6 critical decisions and intervention paths need to be  
7 clear and accessible.

8 Third, interface design plays a central  
9 role. Displays, alerts, mode indicators, and feedback  
10 should be intuitive, support transparency, and help  
11 operators track what the AI is doing and how  
12 automation interacts with plant conditions.

13 Finally, training and simulation ensure  
14 operators gain experience with AI behavior across  
15 normal, off normal, and degraded scenarios. This  
16 helps personnel develop accurate mental models of AI  
17 capabilities as well as limitations.

18 Together, these design elements ensure  
19 that AI augments human capability rather than  
20 diminishing it. Next slide, please.

21 So, as we close, a few key ideas stand  
22 out. First, AI should be treated as a support tool,  
23 not as a replacement for human judgment. Even in  
24 concepts where autonomy is high or AI supported,  
25 humans should remain responsible for oversight,

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1 interpretation, and critical decision making.

2 Second, clear guidelines for human AI  
3 collaboration in nuclear context is needed. The HFES  
4 guardrails provides an early foundation and continued  
5 human factors work will help refine how those types of  
6 guidelines should be applied for nuclear operations.

7 Third, human factors evaluations should  
8 occur early and often during the AI deployment. Human  
9 factors helps to identify where human roles shift,  
10 where the workload and trust issues might arise, and  
11 how the system can best support safe and efficient  
12 human performance.

13 Fourth, designs that incorporate AI need  
14 to be explainable and transparent to the user.  
15 Personnel must be able to understand the system's  
16 behavior, challenge its outputs, and intervene when  
17 needed. Transparency supports accurate mental models,  
18 situation awareness, and well calibrated trust.

19 So, this is ongoing work for us that  
20 continues to evolve. Human factors is often forgotten  
21 until late in the design or until something goes  
22 wrong.

23 Our work provides a foundation based on  
24 human factors principles to ensure that the NRC is  
25 ready to review designs that apply greater autonomy

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1 regardless of how it's applied, including designs that  
2 may be supported by AI.

3 Thank you for attention.

4 CHAIR HALNON: So, Niav, this is Greg.  
5 I'm thinking, you know, as an operator and a licensing  
6 guy trying to license some level of autonomy in the  
7 control room, let me see if I can formulate my  
8 question.

9 When we do licensing reviews, right for,  
10 for lack of better terms, license amendment  
11 applications that contain some credit for autonomy,  
12 will you be looking for the applicant to just simply  
13 understand the fact that you need to have a human  
14 making the judgments?

15 Or, will you be looking for hard stops to  
16 make sure that that's occurring? And let me just put  
17 some context.

18 Just like what Dave said, all engineers  
19 aren't created alike. You have the A plus ones and  
20 the Cs. You know, I've seen anywhere from an F plus  
21 operator who can barely pass the exam, all the way to  
22 the ones that can diagram and explain the integrated  
23 control system for a Babcock and Wilcox plant.

24 And, clearly, the ladder is a much better  
25 operator when it comes to a transient response. But,

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1 everything's hot, straight normal, both of them are  
2 equal, because they're just sitting there with their  
3 feet up on the desk and watching the indications and  
4 waiting for an alarm.

5 So, it's not the normal operation I'm  
6 worried about. It's when it gets into very quick  
7 happening transients, and just like we've seen in a  
8 lot of the past accidents, you know, TMI and others,  
9 there's information overload going to the operator who  
10 can't make a judgment.

11 At that point, don't you have to rely on,  
12 if AI is there, don't you think the human's going to  
13 rely on that, just because I'm so confused, I don't  
14 know what's going on, so I have to rely on that?

15 It becomes not a support tool anymore. It  
16 becomes the primary source of information. And maybe  
17 that's part of the research that you have to do when  
18 you look at simulator reviews of 30 alarms coming in  
19 at the same time.

20 We try to fix that with first in alarms,  
21 you know, top row, red, things like that. But, you  
22 know, personally, I've been in some transients that my  
23 head almost split open because I couldn't figure it  
24 out real quick what's going on.

25 And if AI is much quicker, then you're

1 going to look at the answer and go with it. So, how's  
2 research working through that aspect of it in  
3 simulation and other types of research?

4 DR. HUGHES GREEN: So, I think that I can  
5 address, I think that maybe the answer comes in two  
6 different places.

7 I mean, in terms of our human factors  
8 reviews, licensing reviews, I have confidence that the  
9 guidelines that we have in place right now that are  
10 being used for, as you mentioned, modifications, LARs,  
11 the guidelines that we have in place are based in  
12 sound human factors principles, so NUREG 0711 and  
13 0700, which are our primary human factors guidelines  
14 that are in use today.

15 And that they are there to ensure that the  
16 human factors program that is used in the design  
17 that's being reviewed, is using human factors  
18 principles to ensure that human capabilities and  
19 vulnerabilities are considered.

20 So, I really have no concerns that those  
21 principles are still going to, you know, it's just how  
22 they're going to be applied. So, we're --

23 CHAIR HALNON: Will you use the same kind  
24 of construct then for when the autonomies comes in, is  
25 that you'll be looking for those principles rather

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1 than, you know, hard, fast, we're going to put the  
2 operator through X number of simulator exams or  
3 scenarios with this many alarms coming in?

4 And that may be too prescriptive too.

5 DR. HUGHES GREEN: I think that that's,  
6 that that's exactly. So, when you have novel, so you  
7 kind of brought up, you know, some things that are  
8 going to be novel and unique in terms of the autonomy  
9 aspect.

10 So, those are the areas that the human  
11 factors reviewer is going to then focus on and apply  
12 the guidelines that are relevant to that particular,  
13 the scope of that particular operational space.

14 And so, the guidelines that we already  
15 have in place, once they're applied to that particular  
16 defined scope, will support that safety decision.

17 CHAIR HALNON: Okay.

18 MR. GREEN: If I could, I'd love to just  
19 add, this is Brian again. The NUREG 0711 that Dr.  
20 Hughes had mentioned, has a process in it called the  
21 function allocation process.

22 And this is a part of the design process  
23 where the designers intentionally consider what is  
24 needed under various operational conditions, and  
25 assign whether it should be a human or a machine to

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1 perform a function.

2 CHAIR HALNON: Is that based on timing?

3 MR. GREEN: Timing would be one of the  
4 considerations.

5 CHAIR HALNON: It would be, okay.

6 MR. GREEN: Right, because if we need an  
7 action to happen very quickly, quicker than an  
8 operator can do, it would make sense to have the  
9 machine do it.

10 And we have that. We've got automatic  
11 trips that happen in a fraction of a second once we  
12 have power extrusions.

13 CHAIR HALNON: Right.

14 MR. GREEN: So, to some extent we have  
15 that. The process that we have in place, is they have  
16 to consider that and make an intentional decision  
17 about what is the correct agent to do this? Is that  
18 agent a good choice for that?

19 And that needs to become validated later  
20 into the design. So, we can leverage that process and  
21 that process is not a new process, it's been around  
22 for quite some time, but there is a RIL, and I believe  
23 it was just published, --

24 DR. HUGHES GREEN: Um-hum.

25 MR. GREEN: Updating it to look at, to

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1 consider AI in that.

2 CHAIR HALNON: Okay. Is that a task by  
3 task review?

4 MR. GREEN: So, it feeds into a task by  
5 task review.

6 CHAIR HALNON: Okay.

7 MR. GREEN: So, this would typically,  
8 well, I guess in theory we thought it would happen,  
9 the functionality would happen before the task. And  
10 then, if the task, quick feedback, it's an iterative  
11 process.

12 So, in reality, I think it all kind of  
13 happens at the same time. So, it gets iterated on a  
14 few times and that gets validated later in the design  
15 with the simulation.

16 CHAIR HALNON: Okay. I assume that  
17 there's also, for lack of a better term, a scenario  
18 review, like a reactor trip or something like that.

19 MR. GREEN: Yeah. That would come in a  
20 little bit later. But, that would, we would expect  
21 that.

22 CHAIR HALNON: Okay. Okay, thanks.

23 DR. HUGHES GREEN: And the report that  
24 Brian was mentioning is RIL 2026-05 on function  
25 allocation.

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1 CHAIR HALNON: That's the one you  
2 mentioned earlier?

3 MR. GREEN: I think it's referenced in  
4 here, is it?

5 DR. HUGHES GREEN: No.

6 MR. GREEN: That you had led up to, or?

7 DR. HUGHES GREEN: The one in the  
8 presentation is RIL 2026-02.

9 MR. GREEN: Yeah, okay.

10 DR. HUGHES GREEN: Yeah. But, we've been  
11 doing a lot of publishing. So, you're going to notice  
12 some commonalities in those numbers is 2026.

13 There's -01 on remote operations, -02 on  
14 autonomous operations, and -05 on function allocation,  
15 human factors considerations for function allocation.

16 CHAIR HALNON: Just so you can utilize  
17 that, all those four.

18 MR. GREEN: Yeah, copy all that.

19 CHAIR HALNON: Thank you. Vicki, you had  
20 a question?

21 DR. BIER: Yeah. Again, more of a comment  
22 than a question. I think it's not just a matter of  
23 function allocation, but also of task design.

24 That if you want humans to be in the loop  
25 on certain tasks, the task has to be designed in a way

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1 that humans can stay on top of it. And, you know,  
2 there's a couple of examples from other domains.

3 I mean, you can imagine, for instance,  
4 that AI in air traffic control might be able to handle  
5 more planes than human air traffic operators. But,  
6 then if the computer system ever cuts out, the humans  
7 suddenly have way too many planes that they can never  
8 possibly handle.

9 And there was an example of that many,  
10 many years ago. I haven't kept track of it. I'm sure  
11 it's changed a lot since then.

12 But, you know, before internet and AI and  
13 everything else on air carriers, air carriers used to  
14 maintain the list of, you know, which planes were due  
15 to take off and land with like, a grease pencil on a  
16 clipboard.

17 And when they had automation first come in  
18 and the ship had a computer that kept track of it all,  
19 at least initially they still required that a sailor  
20 maintain the grease pencil and clipboard system in  
21 parallel, because if the ship took a hit or whatever  
22 and the computer system cut out, you didn't want to  
23 end up in a situation where the human couldn't pick up  
24 the job.

25 So, that's kind of a general consideration

1 that it goes beyond allocation to also task design.

2 MEMBER KAMMERER: I have a question. I  
3 feel like a few times that AI and autonomous  
4 operations were sort of treated interchangeably, or at  
5 least I didn't understand the subtleties in terms of  
6 what the separation was.

7 And, you know, the plants are engineered  
8 systems, engineered facilities, physics is physics.  
9 So, theoretically you should be able to automate if  
10 you had fast enough computing, you know, an ability to  
11 incorporate all aspects that we would see of the  
12 systems and the physics without AI, right?

13 Because we should understand this entire  
14 working environment, and it should be following a very  
15 specific set of mathematical and physics principles.

16 So, yeah, deterministic because these are  
17 engineered. Like, I mean, I also have a degree in  
18 seismology, you know, that's something we couldn't  
19 ever fully, you know, write software for.

20 But, so at what point are you talking  
21 about using AI? Because the way I was thinking of it,  
22 I guess, was that it would be a tool to help the  
23 operator bring together a whole bunch of information  
24 to make sense of it in a way that their brain works,  
25 versus having it somehow to be controlling the

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1 systems.

2 Because the systems shouldn't need  
3 anything generative, because it's all, it all should  
4 be a known quantity. I guess my question is, at what  
5 point do you go from just having enough computational  
6 power and automation in these known systems to where  
7 you're actually using AI per se, and what does that  
8 actually mean in the context that you're talking  
9 about?

10 DR. HUGHES GREEN: Yeah. So, I think that  
11 in the context of nuclear, I think you hit it right on  
12 the money, in that we're not talking about generative  
13 AI in the context of sort of operations.

14 And I think this kind of goes to a little  
15 bit of Vicki's point, I guess, is that, you know,  
16 we've also been talking about this with our  
17 counterparts, our human factors counterparts at FAA,  
18 for example, and how they're thinking about AI in  
19 aviation, commercial aviation, right.

20 So, I think it's a similar problem that  
21 you're kind of getting at. And so, they start with  
22 also their automation framework that they already have  
23 in place.

24 So, similar to what I was saying about  
25 that we already have a lot of human factors on

1 automation. And then, they apply it to the structure  
2 in AI.

3 And so, but one of the things that they're  
4 very strong on, is that AI may learn during  
5 development, but once it's actually in the cockpit, it  
6 must be fixed and validated. No continuous learning  
7 in an operational space.

8 And so, you know, I think this is a very  
9 strong point that we also need to bring into the  
10 nuclear space. And so, just to give you comments on  
11 that, I guess.

12 MEMBER KAMMERER: Yeah. So, you're  
13 talking about using, let's say, machine learning to  
14 develop the autonomous systems up to a point.

15 And then, after that point, we should  
16 always have deterministic outcomes and control of the  
17 space in which it's allowed to operate. As soon as it  
18 gets out of that space, it goes back to a sandbox.

19 Okay. Okay. I wanted to understand,  
20 because when I kept -- I was hearing AI talked about,  
21 when I was thinking more like maybe machine learning,  
22 but it should all be deterministic.

23 So, and again, theoretically, we should  
24 understand the full set of principles under which all  
25 the outcomes could be determined.

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1 DR. HUGHES GREEN: Right.

2 MEMBER KAMMERER: Okay.

3 CHAIR HALNON: Okay. Thank you.

4 MR. DENNIS: All right. So, if there's no  
5 more questions on this topic, we'll pivot to our next  
6 speaker, Matt Anderson.

7 And I do believe he has a colleague who's  
8 joining him from Idaho National Lab on some DOE,  
9 remote and autonomous operation research. Matt, are  
10 you on the Teams meeting?

11 MR. ANDERSON: Yes. Can you hear me okay?

12 MR. DENNIS: Yep. We can hear you good.

13 MR. ANDERSON: Okay.

14 MR. DENNIS: I think we're pulling up your  
15 video right now. And you just tell me next and we'll  
16 go through your slides.

17 MR. ANDERSON: Okay. Go ahead and go  
18 next. This presentation covers research funded by  
19 Idaho National Laboratory for the laboratory directed  
20 research and development program.

21 LDRD is internally directed R&D funding  
22 used to pursue strategically important innovative  
23 research. It's often early stage work intended to  
24 build capabilities and lead to later Department of  
25 Energy program funding or external sponsorship.

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1           This work is currently ongoing and the  
2 team consists of a collaboration between Idaho  
3 National Laboratory, the University of Illinois  
4 Urbana-Champaign, and Purdue University. Jonah Lau  
5 from Purdue University will be co-presenting this work  
6 with me. Next slide.

7           This research explores dynamically  
8 matching the power demand from artificial intelligence  
9 workflows, such as machine learning training and large  
10 language model inference, to the power supply from a  
11 test reactor through deliberate modulation of plant  
12 output.

13           In these experiments, the control,  
14 communication, and reactor assets are geographically  
15 distributed, not co-located. This was done as a  
16 matter of necessity given the distribution of the  
17 research collaborators and the computing assets.

18           However, it also covers a use case of  
19 interest to our team where remote operations may  
20 provide an economic benefit.

21           The principle goal of this ongoing  
22 research is to explore autonomous execution of a  
23 tightly defined reactor power tracking task within  
24 prescribed operating limits. The main mechanism for  
25 testing load following so far in this research has

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1       been reinforcement learning, and we anticipate using  
2       large language models also for the same purpose.

3               We have also explored deterministic  
4       controllers as a comparison baseline for the same  
5       experiments. Next slide.

6               A data catalog hosted on a cloud server in  
7       Virginia, facilitates the transfer of key control  
8       variables out of additional information between Idaho  
9       and Indiana, reactivity demand, power supply shown in  
10      these figures.

11              These experiments were conducted during  
12      eight science runs that occurred in late June and  
13      early July 2026, forming a partial scale demonstration  
14      with prototypic artificial intelligence workloads and  
15      reactor kinetics, which progressed geographically  
16      distributed reactor operations to technical readiness  
17      level five. Next slide.

18              The power demand from the data center  
19      originates from a Lambda Hyperplane deep learning  
20      distributed memory system called Hoodoo, consisting of  
21      44 Nvidia A100 tensor core GPUs. Co-located with this  
22      deep learning system are the servers managing the  
23      autonomous controller, namely the reinforcement  
24      learning models, and the low autonomy, to a degree, of  
25      freedom controllers.

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1           The workflow running on the deep learning  
2           system was the MNIST training benchmark, where the  
3           batch size was adjusted to run the GPUs at 100 percent  
4           capacity.

5           And, in a separate experiment, the  
6           workflow was running the Google Gemma model for large  
7           language model inference, reflecting a typical power  
8           profile from a hyperscaler type operation. Next  
9           slide.

10          Next slide.

11          MR. DENNIS: Just a second. Maybe. There  
12          we go.

13          MR. LAU: All right. Thank you, Matt.  
14          So, here for the prototypical reactor kinetics for  
15          geographically distributed remote operations, these  
16          were achieved using the Purdue University reactor  
17          number one dubbed PUR-1, which is a 10 kilowatt  
18          thermal rated open pool test research and training  
19          reactor, exhibiting plate type materials testing  
20          reactor, HALEU, high assay, low enriched uranium fuel.

21  
22          So, the U-235 fissile content is enriched  
23          to 19.75 percent. It has a fully digital  
24          instrumentations and controls reactor safety system  
25          that only permits one way remote monitoring.

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1           So, there is also a fully separate  
2           instrumentations and controls INC system that is fully  
3           independent from the reactor safety system. And this  
4           supports communication with a co-located digital twin.

5           So, this co-located digital twin, which is  
6           also located at the PUR-1 facility, supports the  
7           receiving of reactivity demand or commands from the  
8           Idaho based controllers, and then converts these  
9           demand or commands to a rod position and sends those  
10          rod positions to a cyber-physical testbed through that  
11          separate instrumentations and control system  
12          independent from the reactor safety system.

13          And so, the cyber-physical testbed has  
14          what we call an auxiliary moderator displacement rod.  
15          We dub it as an AMDR, which is fully separate from the  
16          main control rod drives or the reactor safety system.

17          This AMDR is not a neutron absorber, but  
18          it induces power transients just by displacing water  
19          right next to core with up to 42 percent mil of  
20          absolute reactivity.

21          And I just want to note here that 42  
22          percent mil is not enough to start up the PUR-1  
23          reactor. So, let me bring your attention to the next  
24          slide please.

25          Yeah. So, on the top row of this slide

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1 from left to right, you can see the experimental setup  
2 at the PUR-1 facility. Especially on the left figure,  
3 you can see that there's a distinction between the  
4 PUR-1 rods, the main control rods and the cyber-  
5 physical testbeds INC system.

6 So, this testbed's INC system receives rod  
7 position commands from a co-located digital twin at  
8 the facility, and then moves the AMDR, which is  
9 located inside a guide tube next to the core via an  
10 industrial grade PLC and a servo motor on that  
11 separate INC system.

12 But, before any of the power transients  
13 can occur based on this AMDR, the main control rod  
14 drives through the reactor safety system would have to  
15 be, the main control rods will have to be extracted  
16 manually by licensed RO operators via a standard  
17 startup procedure.

18 Only then started up to a predetermined  
19 steady state power level would the remote controllers  
20 be able to communicate and actuate what we call this  
21 AMDR.

22 So, a couple of science runs were  
23 performed, but two experiments of note are shown on  
24 the bottom row. On the left-hand plot, you can see  
25 power transients from PUR-1 that were induced by a

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reinforcement learning controller located here at INL.

This reinforcement learning controller was stochastically optimized on the point kinetic system of equations describing PUR-1 dynamics. Specifically, this reinforcement learning was tasked with providing a string of command actions within the predefined seconds of window as well as a holding period for the last command in that string.

It was also tasked to perform transits within the 300 and 800 watt range before bringing it down to stable conditions.

This was a key experimental benchmark study for us, because it allowed us to analyze and also observe some sort of complex behavior associated with such higher levels of autonomic controls like reinforcement and learning controllers, and also allowed us to take those insights and develop more adaptive controllers of the same kind.

However, this was not a real-time experiment, as we call it, because we still received a string of commands. However, on the right, that was a real-time direct power modulation of PUR-1 from the deterministic two-degree of freedom controller based here at INL, with a set point demand that was directly measured from the Hoodoo super compute nodes here

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1 running AI training.

2 And, specifically, this was convolutional  
3 neural network training on the endless data set. And,  
4 it was really neat to observe and see how the power  
5 trajectory actually reflected the dips in the set  
6 point demand. And those dips are actually associated  
7 with what we call typically the end of a training  
8 epoch in AI literature. Next slide, please.

9 MEMBER ROBERTS: Yeah, quick question.

10 MR. LAU: Yes?

11 MEMBER ROBERTS: The power seems to be  
12 hunting. Is that, was the goal of the experiment not  
13 to get to a stable power level?

14 MR. LAU: Oh, yes. So, this plot was cut  
15 short. But, yes.

16 What we're trying to show here is that  
17 based on AI workloads and workflows, these  
18 experimental results actually showed us how to better  
19 fine tune some of the controllers, deterministic  
20 controllers that we have that ultimately served as a  
21 baseline comparison for the higher levels of autonomy  
22 controllers that we're currently developing.

23 MEMBER ROBERTS: Okay, thanks. And I  
24 assume a person would've gotten to a steady broad  
25 position for that auxiliary rod and a stable power

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1 level.

2 So, okay, so that's future work to get a  
3 better control algorithm. Thanks.

4 MR. LAU: Absolutely. Yep. Yep. So,  
5 operational transferability is something that we're  
6 deeply, deeply looking into. So, thank you. Next  
7 slide, please.

8 Yeah, so throughout these experiments, the  
9 two that were shown and multiple more throughout our  
10 science runs, we have gathered some takeaways. First  
11 of all, are the potentials for autonomous control.

12 In this sense, adaptive ML controllers,  
13 machine learning controllers when coupled with data  
14 assimilation from digital twins we think could help  
15 these controllers observe more and achieve higher  
16 levels of autonomy or automation.

17 Digital twins or high fidelity digital  
18 twins as we're describing here will not only provide  
19 us with the observable state of the reactor from your  
20 detectors or sensors in and around the core  
21 containment, but also provide us with latent states.

22 So, these are typically unobservable  
23 states, but can be estimated such as neutral flux  
24 distributions, your fuel or cladding temperature, and  
25 et cetera.

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1           So, when these are fed to adaptive machine  
2     learn controllers, we can enable what's called spatial  
3     temporal anticipatory state of wear control. And, in  
4     that sense, it can use these latent state or  
5     observable states to essentially anticipate and look  
6     forward and evaluate their action consequences before  
7     prescribing an action.

8           And this is especially crucial for  
9     flexible power modulation, especially controlling from  
10    a distance, because the controller needs to be aware  
11    of, you know, safe limits or state constraints before  
12    prescribing that actions.

13          So, those limits could be your power  
14    peaking factors, hotspots, or potential structural  
15    degradation. It will also need to consider reactivity  
16    effects such as accounting for Doppler and moderator  
17    effects, fission product FP poisoning, or potential  
18    power distribution changes that can alter your reactor  
19    dynamics. It should also be cognizant of long-term  
20    state effects such as field burnup and et cetera.

21          I'd like to mention that for digital  
22    twins, digital twins are not only limited to state  
23    estimation, but should also be able to provide you  
24    with diagnostics, descriptive prognostics, predictive  
25    and prescriptive capabilities as well.

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1           So, I believe that when these are coupled  
2           with adaptive machine learning controllers or data-  
3           driven controllers, we could really achieve higher  
4           levels of autonomy. Next slide please.

5           Another key takeaway would be the  
6           prospects of remote operation. So, with physically  
7           and geographically distributed computing and energy  
8           assets, computing, for example, the digital twin  
9           aspect of it where you're provided not only the  
10          observable state, but lane state and data analytics  
11          capabilities, you'll encounter what we call a big data  
12          problem.

13          And so, this was evaluated at one hertz  
14          and 10 hertz control loop frequencies. And so, how we  
15          handled this big data problem was through a data  
16          cataloging service that was hosted at a cloud server  
17          in the state of Virginia.

18          Essentially, this data cataloging service  
19          allowed our assets to append their state information  
20          on a record through API endpoints. And this data  
21          cataloging service called DeepLink, allowed us to  
22          build knowledge ontologies and graphs from the state  
23          appended information.

24          We know that these appended information or  
25          states will continuously evolve as the control loop

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1 progresses, and this evolution is not independent.  
2 This evolution of each state is actually related and  
3 closely coupled, tightly coupled with the other assets  
4 state.

5 So, such causal and direct relationships  
6 between all of the assets, the computing and energy  
7 assets, and even sensing assets really served as the  
8 backbone of our centralized operations.

9 And so, with such distributed information  
10 and operational technology services at a one hertz  
11 control loop frequency, we actually observed an end-  
12 to-end round trip latency of a minimum to maximum of  
13 one to three seconds that was within the 2.5 percent  
14 asymptotic period of the auxiliary moderator  
15 displacement rod, which itself has 5.24 cents of the  
16 bulk reactivity of the PUR-1 system.

17 So, all of these operations were done  
18 within safe operating limits, allowing us to control  
19 PUR-1 transients.

20 VICE CHAIR PETTI: This is Dave. Just a  
21 question in terms of latency. Did you have a  
22 preconceived requirement you were hoping to achieve?

23 MR. LAU: Yes, we did. And that was  
24 allowing for essentially control of the reactor,  
25 making sure that the packet delays variations were

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1 within safe limits, you know, packet drop fractions  
2 were within safe limits.

3 But, with any of these communication  
4 scenarios, we had contingency plans. Right now the  
5 contingency plan is for the PLC through that separate  
6 ion system connected to the AMDR, if communication  
7 dropouts occurred, it would just essentially keep the  
8 route position in place with a zero order hold.

9 But, we're also evaluating common filters  
10 or even just using the digital twin to prescribe  
11 actions to bring the reactor back to a stable state.  
12 So, these are all currently actively investigated.

13 VICE CHAIR PETTI: I'm just trying to  
14 extrapolate to a real reactor with a heck of a lot  
15 more reactivity. And thinking how much latency can I  
16 have on a reactivity movement, I would think you'd  
17 want a really short latency depending on exactly what  
18 control route movements you're thinking about.

19 MR. LAU: Absolutely. Um-hum.

20 MR. ANDERSON: The data catalog we used  
21 is, you know, the latencies that we experienced for a  
22 couple seconds at most were sufficient for the test.

23 However, if latency is a concern, latency  
24 can be addressed as needed down to significantly less  
25 than a second in those cases where latency is,

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1 something is a critical component for the establishing  
2 a safe operation of the reactor.

3 VICE CHAIR PETTI: Well, I mean reactivity  
4 stuff, it's milliseconds that you want to make sure as  
5 a time constant. Just something to think about how  
6 this all extrapolates, you know, longer term.

7 MEMBER ROBERTS: Yeah. So, Tom, I think  
8 that load filing is a lot more complex in a rod  
9 reactor than this rod.

10 You can't just shim a control rod and make  
11 the reactor power change. You got to change, you  
12 know, steam flow or some sort of power conversion  
13 parameter. And that's going to feed back into the  
14 reactor system, which will eventually feed back into  
15 the rod control system. But there's a lot more to it.

16 VICE CHAIR PETTI: Yeah, yeah, good point.

17 MEMBER ROBERTS: So, I think that's just  
18 a more complex control algorithm than their digital  
19 twin, which might be doable. But, the question of  
20 latency is maybe a bigger question.

21 CHAIR HALNON: And, typically -- this is  
22 Greg -- when you load follow, you will change a  
23 secondary parameter first, and the control system will  
24 follow the reactor. So, that feedback loop is pretty  
25 well established with the present control systems that

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1 we have. You know, typically, it's a feed water flow  
2 or something else that would require a power change.

3 MEMBER ROBERTS: And, for these advanced  
4 reactors, it might be more complicated.

5 CHAIR HALNON: Yeah. It's kind of out  
6 there actually, it could be very well initiated in the  
7 reactor itself.

8 MR. LAU: Okay. Yeah. So, moving on to  
9 the next slide, please. Yeah, so even though this was  
10 a simple case in operations, like obviously mentioned,  
11 we did not model any balance of plant, you know, for  
12 any type of reactor.

13 But we do believe that, you know, remote  
14 control operations possibly with higher levels of  
15 autonomy might be the future, but should be achieved  
16 as safely as possible. And those type of safeguards,  
17 we're currently investigating achieving those  
18 safeguards with natural language per se. In this  
19 sense, using auto-regressive models pre-trained at web  
20 scale or large scale, like large language models, can  
21 help us map control inputs and outputs in a pseudo-  
22 human-like manner.

23 So, why are we evaluating or studying  
24 this? As we know that any type of reactor operation,  
25 let alone control operations, it's purview to a broad

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1 range of context, either fine or coarse grained.

2 For example, these could be the facility  
3 specifications, it's tech specs, cybersecurity state  
4 or awareness, levels of regulation under at the  
5 federal state or facility level, the current state of  
6 the reactor, operating limits of the reactor, but most  
7 importantly, the operator's context.

8 What does the operator want to achieve  
9 here? Do they want to achieve a simple experiment,  
10 radiation experiment at this test facility?

11 What type of radiation experiment? A  
12 materials radiation experiment, using what power  
13 levels to achieve what type of flux levels or flux  
14 distribution?

15 These are all what we call semantics and  
16 such an architecture can help us essentially take all  
17 these contextual chunks that I've mentioned and map it  
18 in a high-dimensional semantic space where such  
19 contexts are geometrically related to each other.

20 So, we're currently evaluating agentic AI  
21 models and interfaces with tool calling and pseudo-  
22 reasoning in the loop capabilities to achieve what we  
23 call context aware control. In this sense, an optimal  
24 control policy could take in contextualized inputs  
25 with categorized three of them, state demand,

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1 anticipatory operational, or objective constraints  
2 concatenated with state estimation or observed states  
3 from a digital twin.

4 And, using that, a natural language model  
5 can take these contextualized inputs and perform a  
6 vector search in that high dimensional semantic space  
7 to provide you with the optimal action vector, which  
8 is then prescribed at the AMDR as a control input,  
9 making sure that any of the observed or latent states  
10 and the action vector are within the acceptable action  
11 set across all time of the predefined operation  
12 envelope.

13 So, with that, I believe that our work  
14 that we're doing here, we're actively researching  
15 these controllers to achieve higher levels of  
16 autonomy.

17 MR. ANDERSON: And these are anticipated  
18 as the future science runs as part of this project  
19 over the course of the next year. I believe that's  
20 the last of our slides.

21 We are open for questions now.

22 VICE CHAIR PETTI: So, just another  
23 question, is it a two-year LDRD or a three-year LDRD?

24 MR. ANDERSON: It's a two-year LDRD.

25 VICE CHAIR PETTI: Thanks.

1 CHAIR HALNON: Other questions?

2 (No response.)

3 CHAIR HALNON: I believe that's the last  
4 topic for today as well, right?

5 MR. DENNIS: A couple of wrap up slides.

6 CHAIR HALNON: Okay. Go ahead and wrap it  
7 up, because I just want to go public comment.

8 MR. DENNIS: Okay. All right. Thanks,  
9 Matt. We'll move onto the concluding side.

10 So, I just wanted to give the Committee an  
11 update on our AI project plan. So, we've briefed you  
12 on this in development of the former AI strategy and  
13 project plan, which supported that.

14 And so, this is just sort of an update.  
15 In keeping with Niav's comment about we're really  
16 pumping out the RILs this year, I actually, that is a  
17 typo I now realize, and I think that's one of your  
18 RILs.

19 It should be RIL 2026-06, is going to be  
20 published next week, hopefully, knock on wood. It has  
21 gone through concurrence and will be published very  
22 soon.

23 RIL 2026-06 will document our AI project  
24 plan mock AI tabletop exercise. This RIL is a safety  
25 analysis and evaluation of a prototypical AI/ML use

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1 case.

2 It is a combination of several things and  
3 where this came from and why we got to publishing this  
4 RIL was basically we said, what's the best way to  
5 learn about evaluating doing a safety evaluation for  
6 an AI/ML application?

7 Let's run a tabletop and pick what we  
8 think could be very close to real use case, and then  
9 run it through its paces.

10 So, Argonne National Lab served as the  
11 safety analysis developer. So, in this they're the  
12 applicant role. And then, Sandia National Labs served  
13 as the independent technical evaluator in more of the  
14 role.

15 And so, we ran this through doing an audit  
16 and technically two rounds of request for additional  
17 information, and got to what would be sort of a draft  
18 safety evaluation report and a safety analysis report.

19 And so, the RIL documents this whole  
20 process has the SAR and the SER and comes up with some  
21 suggestions, which Niav and our human factors  
22 colleagues probably don't know this yet, but there is  
23 one that is very much about human factors on the  
24 lessons learned.

25 So, it dovetails quite nicely with what

1 she presented earlier. So, and their RIL, which was  
2 maybe a slip on my part, intentional, I don't know, to  
3 reference their RIL.

4 But this was in service of supporting the  
5 AI regulatory gaps working group, which Amy mentioned  
6 at the outset of this presentation, was looking at  
7 where there's gaps in our regulatory guidance and how  
8 we might go about fixing those. And serves to  
9 support the discussions we had earlier on OLM and  
10 critical reflux and creates sort of a template for the  
11 staff to be able to move forward with having some  
12 metrics and an evaluation methodology for AI/ML use  
13 cases in nuclear applications.

14 And I could not leave this presentation  
15 without giving a promotional plug for our AI workshop,  
16 which will be on September 15. There will be some  
17 other topics related to cybersecurity presentation.

18 So, we encourage the members to register  
19 and attend for the AI workshops. You can find the  
20 agenda. The final agenda is now published on the AI  
21 workshop website.

22 We have a full day of presenters. But,  
23 this workshop also covers the Agency's internal use as  
24 well as industry activities on AI.

25 So, we encourage you all to participate in

1 the workshop. And, with that, my concluding remarks  
2 are, we continue to remain vigilant on monitoring AI's  
3 integration in industry activities.

4 And we do that principally through the AI  
5 workshop and our other traditional stakeholder  
6 engagement activities like pre-application  
7 engagements, like Norbert talked about earlier, our  
8 international collaboration through RegLab, our IAEA  
9 activities, and then just our other bilateral  
10 engagements with other regulators.

11 So, we are trying, again, the strategy was  
12 put in place to be proactive about this, not to be a  
13 roadblock for innovation, but to enable innovation in  
14 a safe and secure manner. And so, that's what a lot  
15 of this is in service of.

16 And also preparing the staff such that  
17 when, as Norbert mentioned, the online monitoring  
18 review actually comes in, we are in a position to  
19 actually review that and make a decision in a timely  
20 manner. And so, that's what a lot of this work on  
21 AI/ML preparedness has been for over the last several  
22 years.

23 So, with that, I thank you all for your  
24 time. I'll turn it back over to the Chair.

25 CHAIR HALNON: Well, first of all, thank

1 you very much. Very informative and well done slides  
2 for that.

3 We'll have to get a magnifying glass out  
4 to take a look at some of the pictures. But, I think  
5 we got the gist of what you were walking us through.

6 So, that's very, very good. Well done.  
7 I appreciate the attendance. I'll open up for any  
8 member questions, follow-ups?

9 MEMBER KIRCHNER: Just quickly a  
10 clarification. Listening in, is there a RIL 2026-01  
11 on remote operations? Did I hear that correctly?

12 DR. HUGHES GREEN: Yes.

13 MEMBER KIRCHNER: Okay. So, can we get  
14 these? Yeah, so we've got -02, which the  
15 characterization of autonomous ops for advanced  
16 reactors.

17 There appears to be a RIL -05 on human  
18 factor engineering.

19 DR. HUGHES GREEN: Yeah, the 2026-05 RIL  
20 is on human factors considerations for functional  
21 allocation.

22 MEMBER KIRCHNER: That's on functional  
23 analysis, yeah. And then, finally there's a -06 now  
24 here.

25 CHAIR HALNON: That's what Matt was just

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1 saying.

2 MEMBER KIRCHNER: Okay. All right.

3 CHAIR HALNON: So, on the record still,  
4 under our SharePoint reference material, how about  
5 making an AI folder and start capturing all these  
6 different documents?

7 MR. DENNIS: The Only one that's not  
8 available is the -06 one. And that will be published  
9 very soon.

10 CHAIR HALNON: Okay. So, yeah, I think we  
11 need to just keep gathering these documents and  
12 sticking them into SharePoint.

13 Christina, you're very good at organizing  
14 SharePoint, so.

15 MS. ANTONESCU: And you can find all of  
16 the RILs on the public website by year. So, the 2026  
17 ones are all in one place.

18 CHAIR HALNON: Great. Thank you. Thank  
19 you. Anyone else?

20 (No response.)

21 CHAIR HALNON: Okay, I'm going to open it  
22 up for public comment at this point. Anyone in the  
23 member of the public listening in, we would raise your  
24 hand on Teams, and I'll take them in the order that  
25 they come.

1 And, if you're on the phone, star five  
2 will raise your hand and star six will unmute your  
3 phone. So, is there any members of the public that  
4 would like to make a comment?

5 (No response.)

6 CHAIR HALNON: God bless you. Okay. I  
7 think I've given enough time for people to find the  
8 button if they needed it.

9 Tom, did you have any closing remarks?

10 MEMBER ROBERTS: Yeah. I wanted to say is  
11 again, thank you for the presentations. They were  
12 very, very useful.

13 And I said at the outset that we would  
14 have a conversation as a Committee if we thought we  
15 needed any follow-up other than, you know, an  
16 occasional November touchpoint, not November this  
17 year, but they seem to fall in November.

18 We're obviously at the most appropriate  
19 place in time. You know, I'm thinking that the one  
20 touchpoint I'd be interested in, is when the INL  
21 Purdue test is done and when they finish their two-  
22 year LDRDs that might fit in the same timeframe for,  
23 you know, November of 2027.

24 If I could just open up for the Committee,  
25 is there anything you want to hear in the near term,

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1 for you to have the next touchpoint be when they have  
2 more to present that's different material?

3 CHAIR HALNON: Yeah, I think we don't want  
4 to take you away from writing rules.

5 (Laughter.)

6 CHAIR HALNON: Because we need something  
7 to put in our SharePoint. But, I think we can target  
8 a six month type of thing just for an update, maybe a  
9 couple hours on.

10 We would give you specific topics, I mean,  
11 targeted topics, and it may be informed by some of the  
12 applications and stuff we're looking at or what we're  
13 seeing in the press.

14 One thing I'd be interested in is a little  
15 bit more about what the industry is doing. I know  
16 you're going to have your workshop.

17 You know, we're limited by the amount of  
18 days that we can work. So, attending a workshop would  
19 burn up one of those days that could be for Committee  
20 operations.

21 So, it's a give and take we have to be  
22 careful of.

23 MEMBER ROBERTS: And I believe we have a  
24 subcommittee meeting scheduled that day already.

25 CHAIR HALNON: Yeah. Okay. That's

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1 another problem. But, you know, the industry is  
2 moving pretty quick.

3 I know that EPRI and the other industry  
4 groups are collaborating and developing crosstalk with  
5 the common AI research modules and stuff like that,  
6 where they're gathering their information. How does  
7 that look?

8 I'm still interested in the AI versus AI  
9 X problem that we may come up with. So, we'll give  
10 you specific topics that maybe that you could address  
11 that work.

12 But, I would target Tom, let's kind of  
13 just touch bases in six months and decide if there's  
14 enough out there to continue the learning process that  
15 we're going through.

16 MEMBER ROBERTS: Okay. So whoever  
17 succeeds, Christina. So, Weidong and I will target  
18 it.

19 CHAIR HALNON: And it doesn't really have  
20 to be in six months, it means that we'll talk about it  
21 then.

22 (Simultaneous speaking.)

23 MEMBER ROBERTS: Somewhere in there, we'll  
24 get all that.

25 CHAIR HALNON: We'll have the call with

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1       you guys to see if there's enough to --

2                   MEMBER ROBERTS: Yeah, yeah. The purpose  
3       would be to see if we have enough to schedule a  
4       meeting near term.

5                   CHAIR HALNON: Josh says that's like --

6                   MEMBER ROBERTS: We'll get on that.

7                   CHAIR HALNON: I think definitely the  
8       conclusion of the Purdue test would be a, you know, a  
9       good opportunity to be informed on what they all are.  
10      That's going to be interesting.

11                  MEMBER ROBERTS: Yeah.

12                  MEMBER KAMMERER: I just want to throw out  
13      one use case. So, while I appreciate the optimism  
14      that the remote autonomous operations is the future,  
15      I think the only real use case that I keep hearing  
16      that being discussed in the near term, let's say, is  
17      remote operations in Arctic regions.

18                  I know Alaska's very interested in that.  
19      The Canadians are very interested in that. You know,  
20      they want microreactors up for a lot of those very  
21      real use cases, but don't necessarily need an  
22      operational team up there.

23                  So, I guess the last presentation that we  
24      saw had a lot of the pieces. But, really those  
25      wouldn't be remotely controlled. They would be

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1 autonomous operations islanded, but not with active  
2 control, because it's hard enough communicating, you  
3 know, in real time, just having a conversation versus  
4 control.

5 So, when we do get back, I think that  
6 would be an interesting use case to talk around,  
7 because that's the one use case that I think is very  
8 real and actually might be coming first as an actual  
9 need, not just as a cool thing we could be doing, I  
10 guess I'd say.

11 Next week I happen to be up in Alaska for  
12 something the Arctic Research Commission started  
13 talking about microreactors in Arctic environments and  
14 additional challenges. And I think that will be a  
15 point of discussion up there.

16 Some Canadians are invited as well. And  
17 so, there are communities up there that are very  
18 interested in that just for your awareness.

19 DR. HUGHES GREEN: So, just to add a  
20 comment, human factors considerations for remote  
21 operations is an area that we're also even a little  
22 bit slightly further along with in our research  
23 process.

24 And we've been discussing with  
25 counterparts at CNSC and ONR, really a lot of the

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1 Europeans are also interested in remote operations.  
2 And so, that's an area that we certainly can entertain  
3 having further discussions about.

4 MEMBER KIRCHNER: I think Tom, it's  
5 probably your area, and the Chairman of the Committee  
6 can assign things. But, I'm thinking this autonomous  
7 operations coming our way with or without AI, or  
8 without AI with guardrails on it, or whatever, I think  
9 it's coming the Committee's way as well as the staff's  
10 sooner than we think.

11 CHAIR HALNON: Yeah, I think you have to  
12 look at it as inevitable. And it's going to be some  
13 spectrum of a little bit supervised to someone coming  
14 in saying, I don't need an operator.

15 MEMBER KIRCHNER: Or in a hub operation in  
16 the remote north or something.

17 MEMBER KAMMERER: Exactly.

18 MEMBER KIRCHNER: And I have a 40-year-old  
19 design I can sell you.

20 MEMBER KAMMERER: Well, I think that the  
21 Department of Defense is now, I'm working on it  
22 separately. But --

23 CHAIR HALNON: Still under transcript  
24 folks.

25 MEMBER KAMMERER: Well, I mean, we saw a

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1 public announcement last week. And then, there's a  
2 challenge there in those particular use cases that you  
3 can't necessarily respond if it's that remote. Right?

4 And so, that's a consideration. What if  
5 it's not accessible when you actually do need humans  
6 there if it is fully autonomous?

7 Those are considerations for staff.

8 CHAIR HALNON: Yeah. Okay. Anything else  
9 real quick?

10 (No response.)

11 CHAIR HALNON: Okay. With that, I'm going  
12 to recess the meeting for today. We will recommence  
13 our meeting at 8:30 tomorrow morning for the planning  
14 and procedures portion of our full Committee meeting.

15 And that'll be the last thing on our  
16 agenda. So, for today, we are recessed.

17 (Whereupon, the above-entitled matter went  
18 off the record at 5:35 p.m.)

19

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# **NRC AI Regulatory Preparedness Introductory Remarks**

**Amy Sharp**  
**U.S. Nuclear Regulatory Commission**

**ACRS Full Committee Information Briefing**  
**September 3, 2026**

# **Nuclear Energy Agency (NEA) RegLab**

**David Smeatham**

Ennuvo

**Matt Dennis**

USNRC, Office of Research

# International Regulatory Sandbox

## ACRS Full Committee Meeting

**David Smeatham – Ennuvo Limited  
Project Operating Agent**

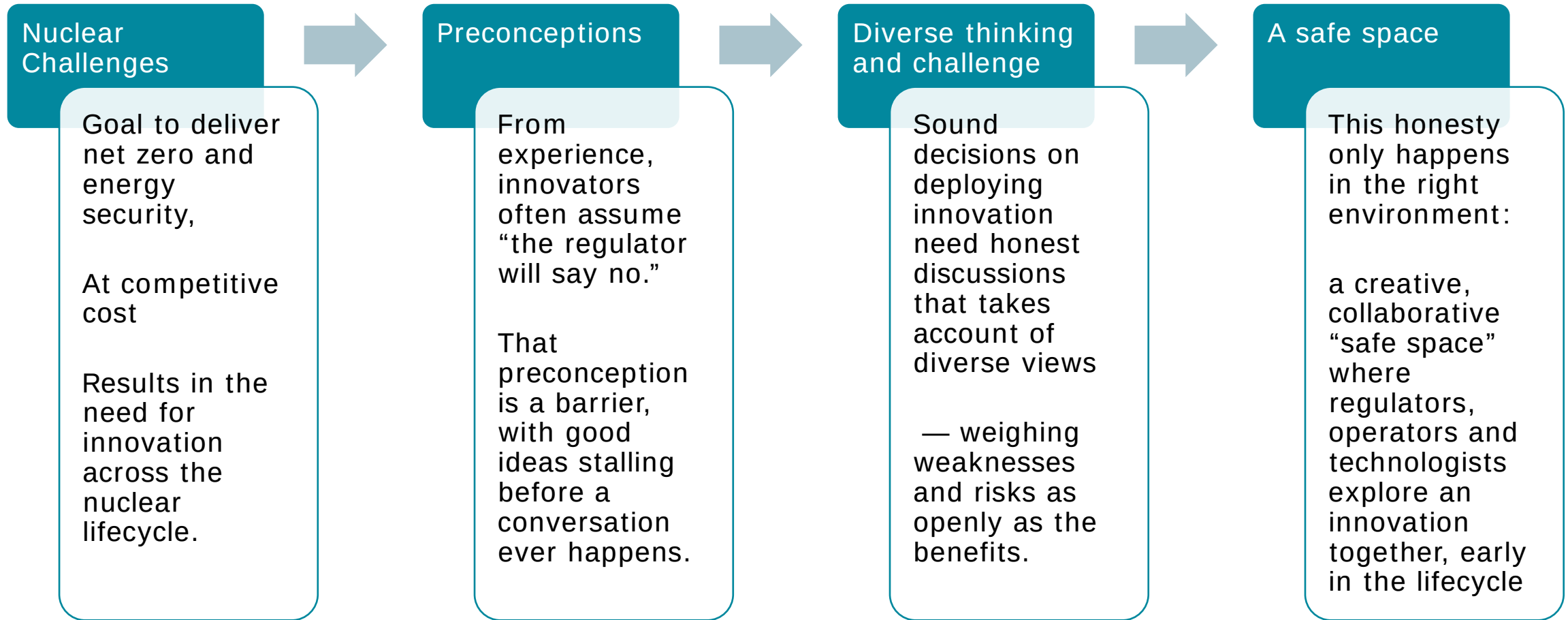
**Faiza Sefta OECD – NEA – Project  
Secretariat**

**Kevin Lee – CNSC – Project  
Management Board Chair**

**3<sup>rd</sup> September 2026**



# Innovation – why RegLab was developed in the first place



# What is RegLab? A regulatory sandbox

## Sandboxing is:

- Intended to reduce regulatory uncertainty.
- Create access to regulatory expertise.
- Help identify risk reduction mechanisms and approaches.
- Reduce the cost and time of entry for innovation.
- Allow regulators to test their arrangements.
- Test technology and process innovation in a controlled environment.
- Accelerate diverse and inclusive practices across the sector.
- Help develop capability.

## Sandboxing is not:

- A short cut for existing regulatory processes.
- A means of changing regulation on a permanent basis.
- An endorsement from regulators for a specific technology or process.

In a RegLab, industry, regulators and academics work together to explore and test regulation of an innovation in a safe environment.

Table-top exercise.

Consideration of hypothetical, but representative, applications of innovation.



# What value do we hope to achieve



A reduction in the regulatory uncertainty because we have regulators, licensees and technologies considering an innovation in a creative, safe environment.



Consideration of innovation at an international level to “bake-in” harmonised thinking at an early stage of the deployment of the innovation.



Help identify risk reduction mechanisms and identify where further work may be necessary so that the value of the innovation can be realised.



Allow regulators and licensees to test their arrangements.

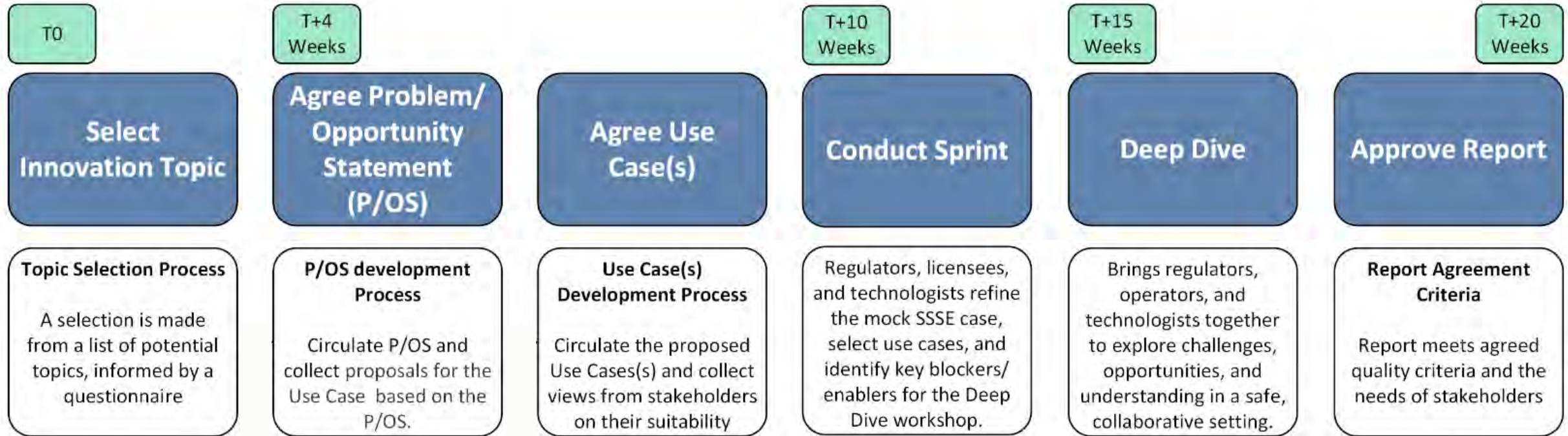


Help develop capability.

# International RegLab Project

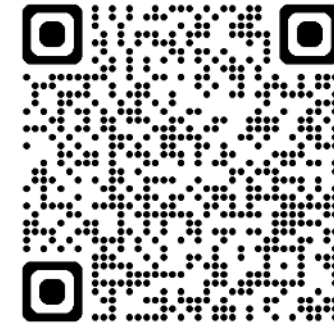


# The RegLab process



# RegLab Pilot

- DIET Toronto – November 24, 2024
- Governance and human-in-the-loop aspects of two artificial intelligence applications
  - defining plant maintenance autonomously
  - generating safety documentation

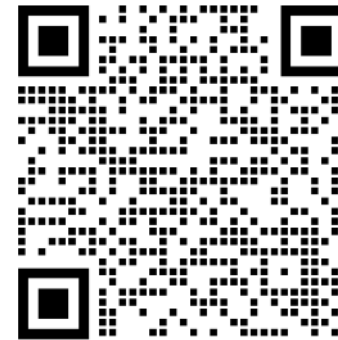


EPRI – RegLab Pilot Report  
(<https://www.epri.com/research/products/000000003002031833>)

# International RegLab Project –RegLab # 1



- DIET Toronto – October 25, 2025
- AI to assist processes and procedures to enhance safety, security, safeguards and environmental protection, reducing costs of operations and maintenance.
  - AI substantiation / justification and explainability
  - Data assurance



Ennuvo – RegLab #1 Report  
(<https://www.ennuvo.co.uk/s/RegLab-1-Final-Report-Mar-26-eno-040-V1.pdf>)

# RegLab 1 Conclusions

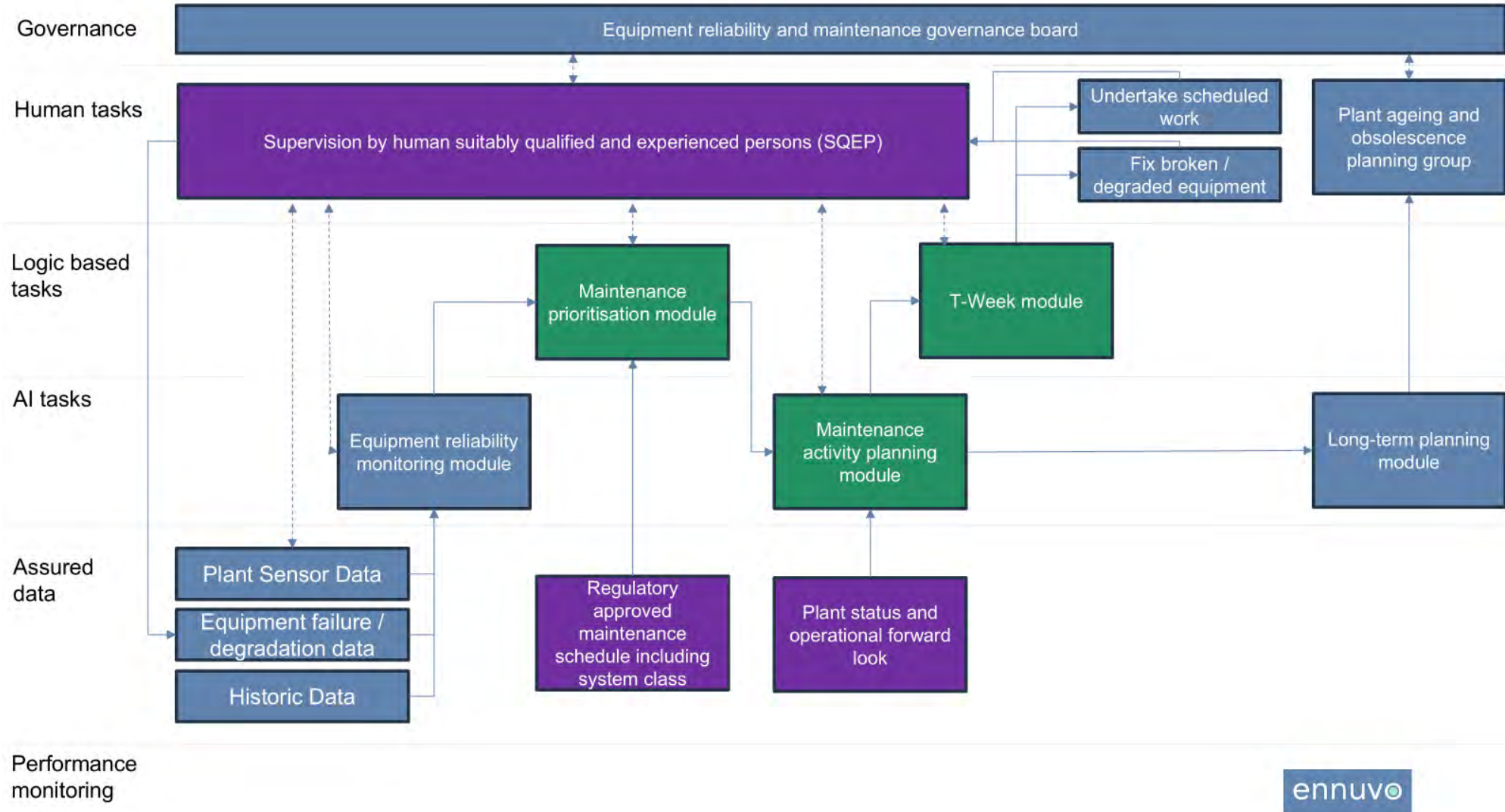
- Participants agreed the use case could materially improve safety, security, safeguards and environmental protection (SSSE) and plant performance, while reducing operating and maintenance cost.
- Two dominant barriers to deployment were identified:
  - Explainability alone is not enough for high-consequence decisions. Explainability must be backed by defence-in-depth, including deterministic, physics-based models alongside the AI.
  - We need a shift in data mindset from “we have the data” to assured data quality, governance and representativeness to support a credible safety case.
- There are disbenefits if not done correctly:
  - Human complacency,
  - Skill degradation,
  - Introduction of new failure modes from added complexity, and
  - “Concerns about black-box” opacity.
- Five recommendations relating to (1) the need for AI good-practice guidance (including assurance framework, explainability, uncertainty, safety envelope, V&V, graded data quality); (2) close the AI skills/competency gap; (3) apply nuclear human-factors knowledge to AI-based decisions; (4) standardise data metadata/taxonomy for safe sharing; (5) evolve the RegLab process itself.
- The process worked: a logical, well-structured, inclusive “safe space” (Chatham House Rule) that enabled candid cross-stakeholder dialogue.

# International RegLab Project –RegLab # 2

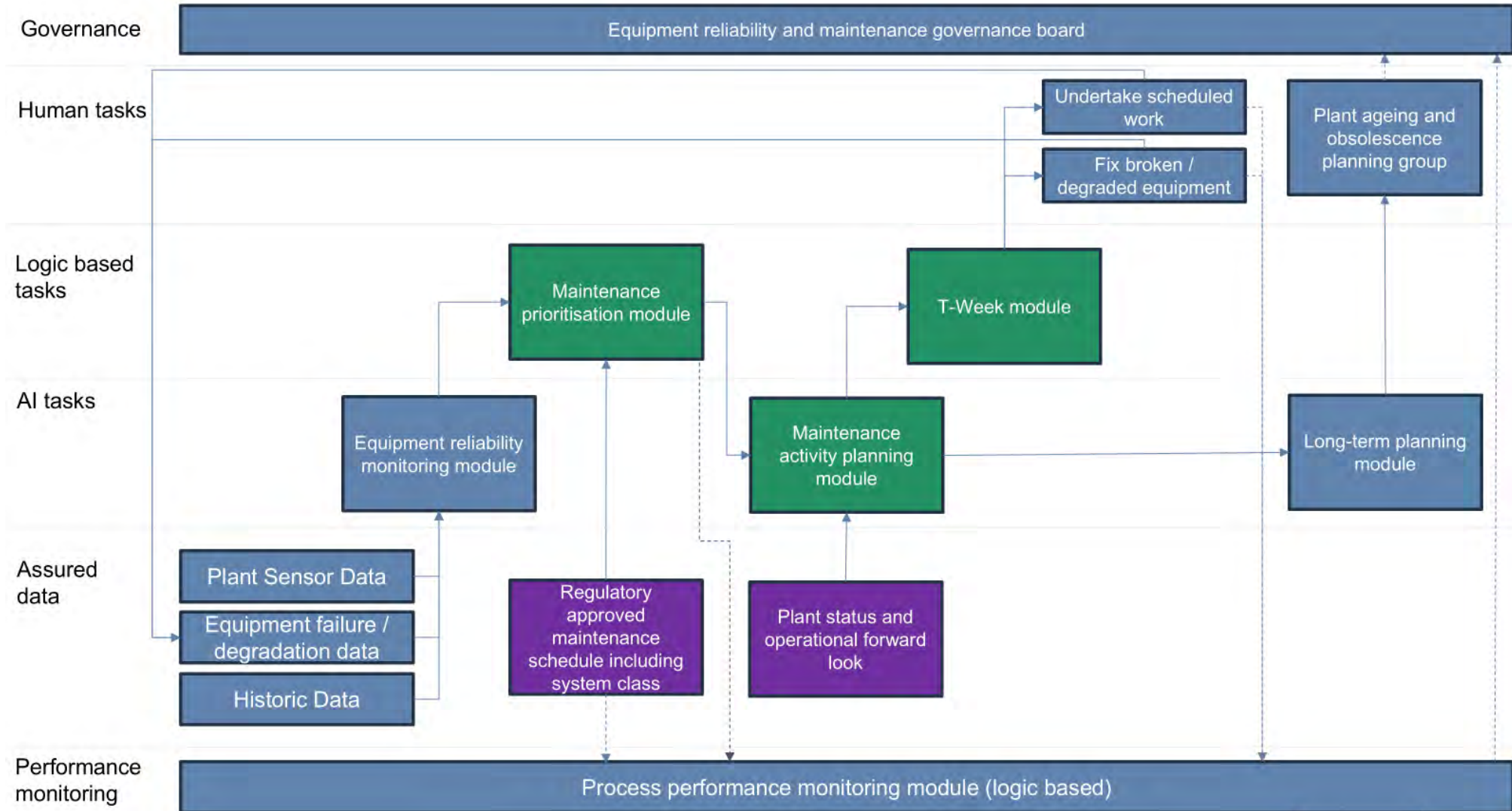


- NEA AI Conference – South Korea – May 26, 2026
- AI Tech Agents analyse plant data, compare it with licensing rules, automate condition-based tasks, and make competent-body-level technical judgements.
  - Autonomy – for the purposes of this use case, autonomy implies agents that operate independently, deciding which tools to use and how to achieve a goal after an initial, high-level prompt.
  - Scenario interrogates deployment of an approved, coordinated set of AI Agents and deterministic, logic-based, modules operating with independent management authority and responsible for the dynamic, end-to-end management of the INPO AP-928 Work Management cycle.
  - In the most autonomous scenario, the agent performs continuous monitoring and autonomous prioritization of the maintenance backlog. It independently executes the auto-release and scheduling of work without requiring real-time human intervention. The human role is only dedicated to governance and periodic auditing.

# Supervised scenario



# Autonomous scenario



# RegLab 2 DRAFT conclusions

- Failure modes sit in the system, not just the AI model. The risk lives in the data feeding the AI and in the interaction between the AI, its operators and the wider plant.
- Human supervision depends on generic properties, not AI-specific ones: independent information, a structured decision process, contextual plant knowledge, and sustained competency. Left unmanaged, supervision decays into tick-box approval and the very competence it relies on erodes.
- Full autonomy does not shift SSSE duties away from the licensee. Rather, it changes how they are discharged, from real-time human judgement to up-front guardrails, verification & validation, and governance evidence designed in from the start.
- In general, the law is broadly sufficient. But while existing frameworks tend to cover AI used as a tool, the gap is mainly communication and capacity, not legislation. As AI becomes more agentic, the licensee centered laws may need to take account of responsibilities within the AI law's distributed, cross-border supply-chain obligations.

# International RegLab Project –RegLab 3



- Virtual – Autumn / Fall 2026
- Considering remote operation of nuclear reactors to evaluate human factors, communication latency, and ensure robust safety oversight.

# How can you get involved

- RegLab works by bringing a diverse group of people together to consider the deployment of innovation in a “safe space”
- We are always on the look out for people with relevant experience that they can share
- We are particularly keen to increase participation by non-represented parties (women, Indigenous group, etc. ..) and are seeking ideas on how to do so.





# Thank you

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Faiza Sefta  
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Kevin Lee  
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# ***Near-Term Industry AI Use Cases***

**Matt Dennis, RES**

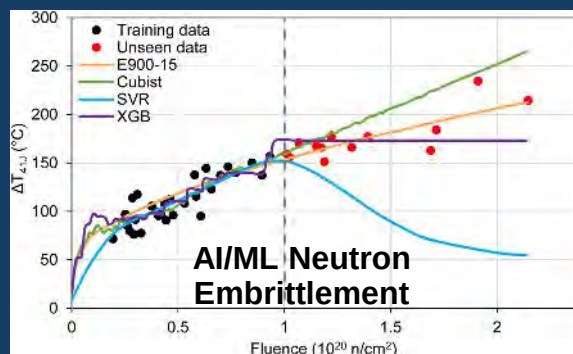
**Stephen Cumblidge, NRR**

**Norbert Carte, NRR**

**Josh Kaizer, NRR**

# Industry AI Use Cases

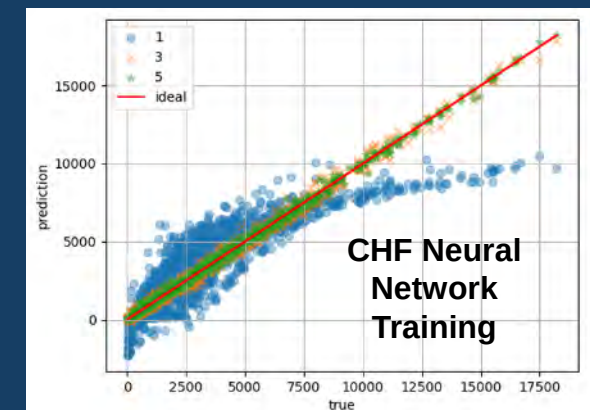
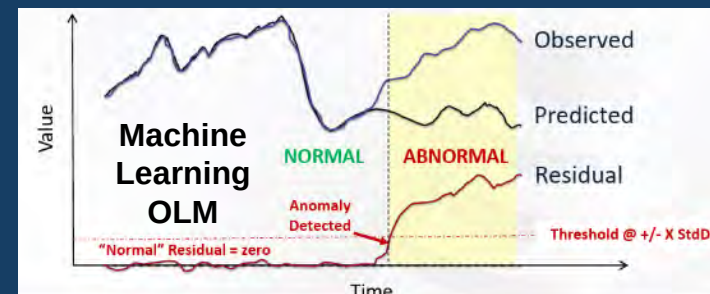
| NRR Staff PoC     | Related AI/ML Activity                                        | Description                                                                                                                |
|-------------------|---------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|
| Stephen Cumblidge | Nondestructive Evaluation (NDE)                               | AI assistant to detect, measure, and classify weld defects and utilize virtual flaws for training                          |
| Stephen Cumblidge | Neutron Embrittlement<br>( <a href="#">SRM-SECY-22-0019</a> ) | ML to develop neutron embrittlement trend curves for extended operational regimes capturing complex, multi-factor datasets |
| Norbert Carte     | Online Monitoring (OLM)                                       | OLM using AI to transition from time-based to condition-based instrument calibration technical specifications              |
| Josh Kaizer       | Critical Heat Flux (CHF) and other Special Computations       | Machine learning regression techniques for predicting CHF and using AI/ML for data-drive alternative computational methods |



<https://doi.org/10.1016/j.jnucmat.2025.156027>



<https://trueflaw.com/ml>



# **AI/ML for Non-Destructive Evaluation and Neutron Embrittlement**

**Stephen Cumblidge**

USNRC, Office of Nuclear Reactor Regulation

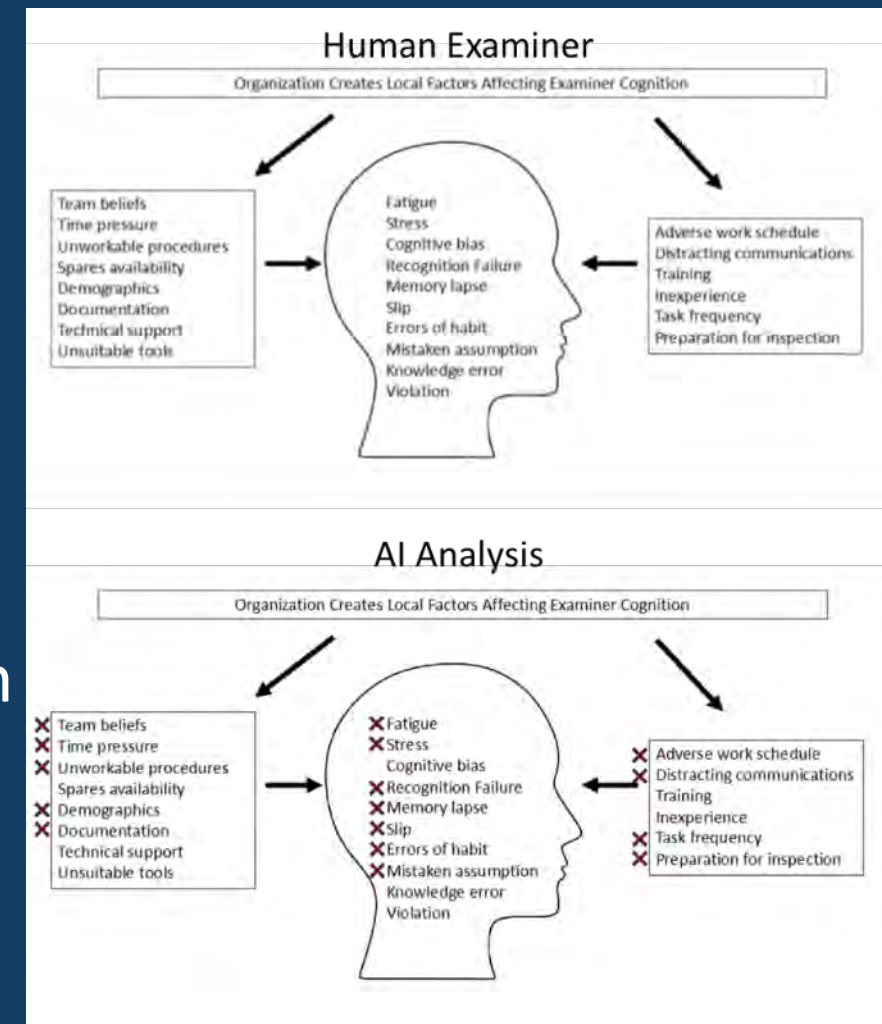
# AI/ML in NDE Data Analysis

- The variety of open-source ML tools has enabled the use of ML algorithms to be developed for many uses
- Work is ongoing by several groups to use these tools to develop automated data analysis algorithms to analyze NDE data
- These ML algorithms can potentially greatly increase the reliability and consistency of NDE in the field
- If used incorrectly, these tools could degrade inspections



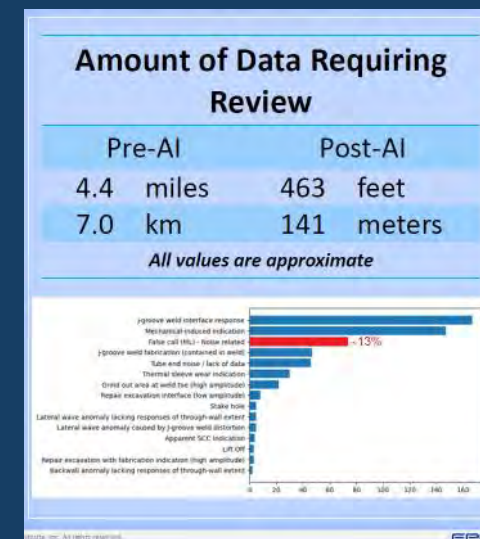
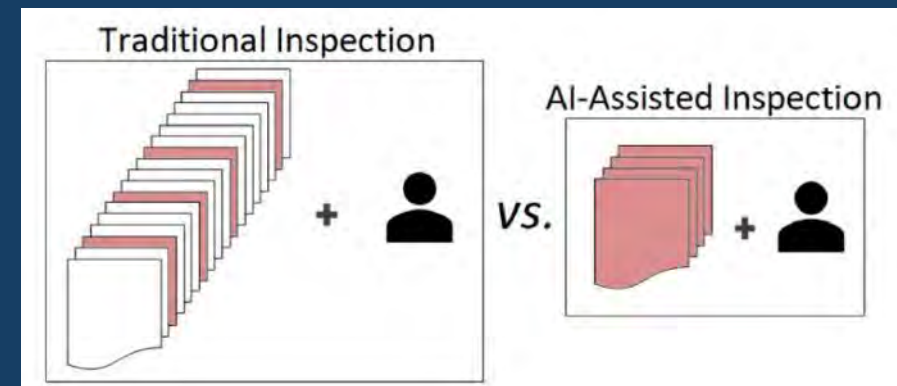
## Possible Benefits

- AI/ML analysis of NDE data has the potential to improve detection of flaws and improve the human factors of an examination.
  - In-service flaws are rare in the nuclear industry. Computers can maintain vigilance in cases where humans can be challenged.
  - Humans and computers make different types of mistakes, and a qualified analyst paired with an analysis run by ML gives the best of both worlds.
  - Reduced dose to inspectors if ML used to support manual UT examinations.



# Proposed Implementation

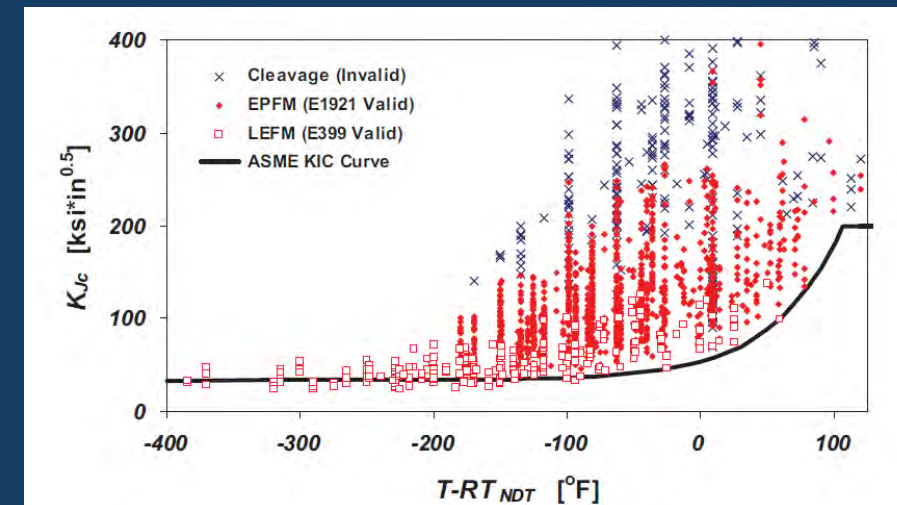
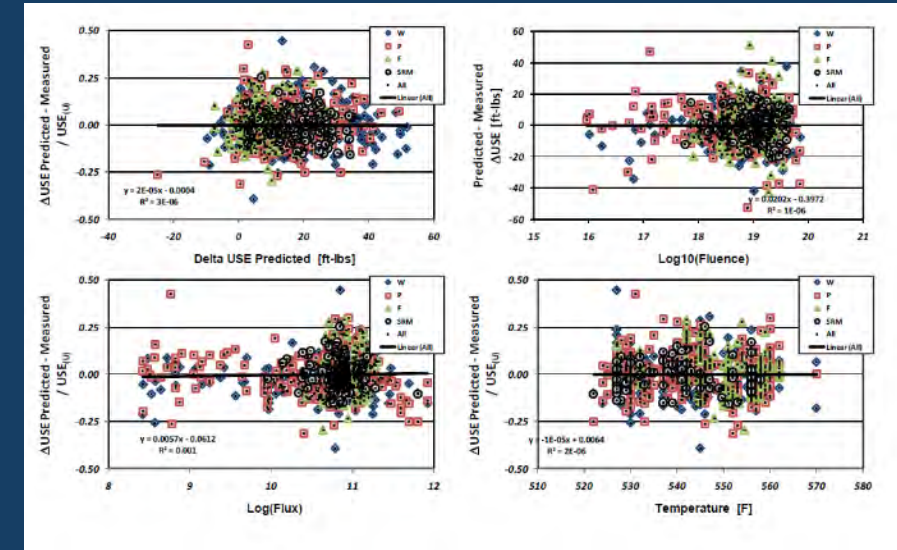
- The approach suggested by EPRI, which is supported by the NRC staff, is for an AI/ML algorithm to flag areas with flaws, and the algorithm must find all flaws in the qualification set
  - The algorithm can produce more false calls than allowed in the given supplement
  - It will be up to the inspector to determine which of the areas flagged by the algorithm contain flaws, and ultimately the inspector is responsible for the results
- The NRC will continue to work with EPRI to monitor developments in the use of AI/ML for NDE data analysis
- Work described in “An Assessment of Machine Learning Applied to Ultrasonic Nondestructive Evaluation” (ORNL/SPR-2023/3245) ([ML24046A150](#))



From EPRI Report 3002023718

# AI/ML for Neutron Embrittlement

- AI/ML tools can be very useful in analyzing complex data sets, such as for predicting neutron embrittlement in reactor pressure vessel steels
- Research, in cooperation with ORNL, will soon begin to:
  - Develop a description of the AI/ML data analysis of Neutron Embrittlement and a prioritized list and detailed description of the most important parameters in such an AI/ML algorithm
  - Develop performance-based metrics that can be used to verify and validate the results of AI/ML calculations of Neutron Embrittlement



# **AI/ML for Online Monitoring (OLM)**

**Norbert Carte**

USNRC, Office of Nuclear Reactor Regulation

**Charles McFeaters**

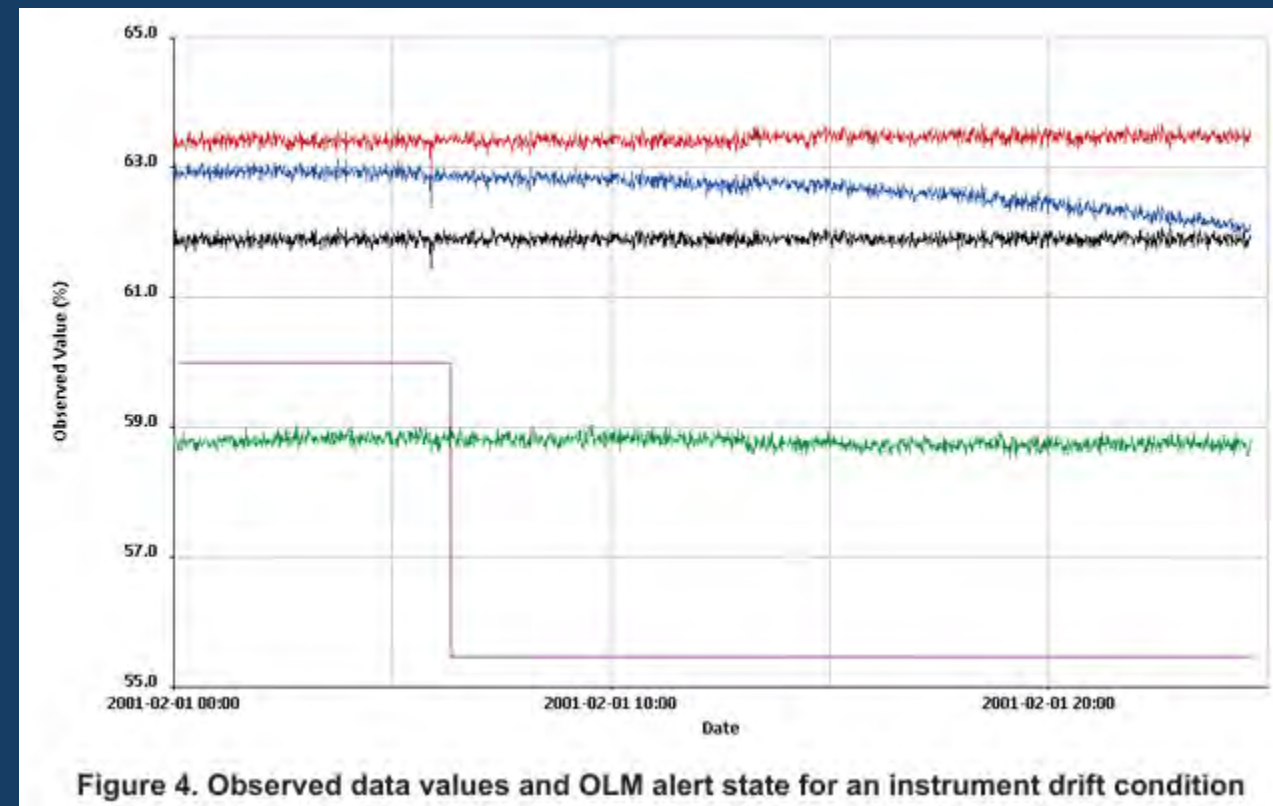
USNRC, Office of Research

# OLM based on ML

- OLM first discussed more than 20 years ago
  - In September 1998 EPRI submitted Topical Report TR-104965, “On-Line Monitoring of Instrument Channel Performance,” proposing the use of analytic redundancy and data-driven techniques to assess instrument channel performance and potentially extend calibration intervals
  - In July 2000 the staff issued a safety evaluation ([ML003734509](#)) with open items outlining 14 technical and programmatic requirements
  - NRC commissioned a series of reports focused on ML-based OLM ([NUREG/CR-6895](#) and [ML14274A306](#))
- In 2021 NRC endorsed an average-based OLM approach ([ML21179A062](#))
  - In 2022 NRC issues first LAR based on this approach ([ML23115A149](#))
- ML-based approach learns normal behaviour in context
- Flags abnormal behaviour for Engineering Evaluation
  - Both steady state and frequency response
- May require calibration

## OLM based on ML

- TS surveillances ensure equipment behaves as expected
  - Calibration ensures accuracy
  - Monitoring ensures consistency of behavior
- Behavior between two calibrations defines normal
- Statistical uncertainty used to establish limit of normal
  - Can identify unacceptable drift or responsiveness



Example sensor calibration drift with respect to redundant peers ([ML24325A535](#))

# ***AI/ML for Critical Heat Flux (CHF)***

**Josh Kaizer**

USNRC, Office of Nuclear Reactor Regulation

# AI/ML for CHF

- Across industry and research institutions, AI/ML techniques are being investigated to improve prediction of critical heat flux (CHF)
- In 2023, the OECD/NEA initiated a series of AI/ML CHF benchmark exercises ([ML25273A292](#)) as part of the Task Force on AI/ML for Scientific Computing in Nuclear Engineering ([link](#))
  - The exercise leveraged a large NRC-supplied dataset ([NUREG/KM-0011](#)) to test multiple ML approaches for improved CHF correlation accuracy
  - NRC staff contributed to the benchmark activity ([ML24207A085](#)) and are aware of commercial vendors that have expressed interest in using neural networks for CHF calculations



# AI/ML for CHF

|              |                                                |   |
|--------------|------------------------------------------------|---|
| <b>TRL 9</b> | Proven in operation                            | ✗ |
| <b>TRL 8</b> | System complete and qualified                  | ✗ |
| <b>TRL 7</b> | Prototype demonstrated in operation            | ✗ |
| <b>TRL 6</b> | Prototype demonstrated in relevant environment | ? |
| <b>TRL 5</b> | Validated in relevant environment              | ? |
| <b>TRL 4</b> | Validated in laboratory                        | ✓ |
| <b>TRL 3</b> | Proof of concept demonstrated                  | ✓ |
| <b>TRL 2</b> | Technology concept formulated                  | ✓ |
| <b>TRL 1</b> | Basic principles observed                      | ✓ |

- Staff have previously engaged in pre-application discussions about AI/ML methods for CHF and are currently awaiting the first application.
- Improved flexibility is proposed for changes to evaluation methods (10 CFR 50.221).
  - Proposed revisions to 10 CFR 50.59 and 53.1550 would allow licensees to implement certain changes to analytical methods without prior NRC approval, provided those changes are undertaken pursuant to an NRC-approved VVUQ program under 10 CFR 50.221, “Credibility requirements for modeling and simulation.” Proposed guidance is provided in DG-1468 (draft RG 1.271).
  - These proposals would shift NRC’s focus from reviewing each model or simulation directly, to assessing structured VVUQ programs determining model credibility.

# **AI and Autonomous Operation**

**Niav Hughes Green, PhD**

USNRC, Office of Nuclear Regulatory Research

**Matthew Anderson**

Idaho National Laboratory

# **NRC Human Factors Research on Autonomous Operations**

**Niav Hughes Green, PhD**

**USNRC, Office of Nuclear Regulatory Research**

# Presentation Scope

- **Purpose:** Provide an overview of human factors research that supports regulatory preparedness for licensing reviews that include autonomous operations.
- **What this segment covers:**
  - Scope of current human factors research on **autonomy and autonomous operations**
  - The impact of higher levels of autonomy on **operator roles and responsibilities**
  - How human factors research supports consideration of **AI-supported autonomy**
- **What this segment does *not* cover:**
  - Part 57 or Part 53 requirements or policy decisions
  - Agency AI governance or AI use
  - Technical considerations outside of the human factors domain (e.g., instrumentation & control or cybersecurity)

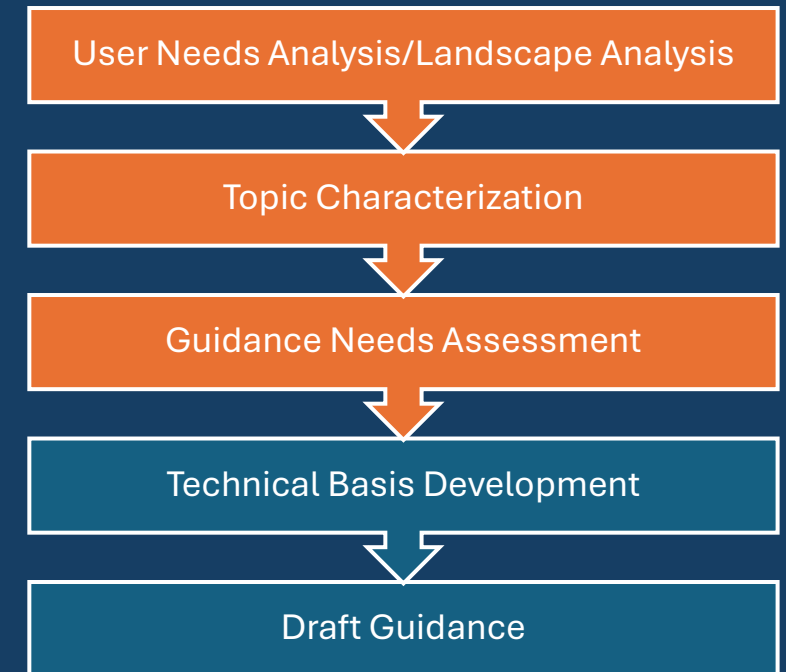


# Human Factors Considerations for Autonomous Operations

Research Initiated with Idaho National Laboratory to:

- Understand range of autonomous concepts anticipated
- Identify human factors considerations and implications
- Gather research findings and lessons from experience in other high-risk domains (e.g., oil and gas, maritime, aviation, and aerospace)
- Develop a taxonomy of human factors considerations important to ensuring safe operation
- Document technical basis and develop recommendations for guidance

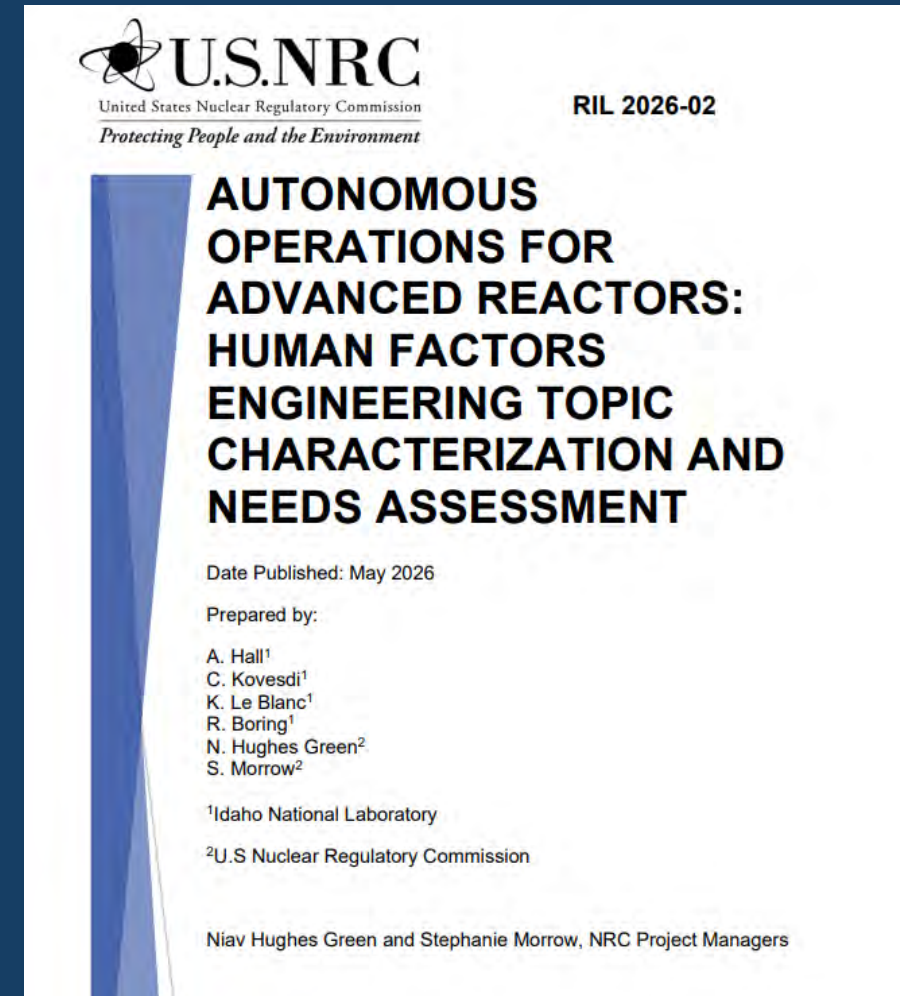
## HFE Guidance Development Process



# Completed Reports



<https://www.nrc.gov/docs/ML2601/ML26013A039.pdf>



<https://www.nrc.gov/docs/ML2613/ML26139A285.pdf>

## **Key (Working) Definitions from RIL 2026-02**

- **Autonomy:** The ability to operate independent of human control.
- **Automation:** A device or system that accomplishes (partially or fully) a function or task.
  - **Automated system:** A system that can operate independent of human control within fixed setpoints, parameters, or predefined scripts.
  - **Autonomous system:** A system that can operate independent of human control or intervention for extended periods in uncertain environments, with the ability to adapt to changing conditions, knowledge, and constraints. **An autonomous system may employ AI.**



## Expanded (Working) Definition of Autonomous Operations

- *Autonomous operation* means the use of design features that enable a defined scope of operational and safety functions to be performed without reliance on human intervention, external command, or active control system input.
  - It may occur at the component, system, or plant level and may be used under normal, abnormal, or accident conditions.
  - It should not be equated to unmanned operation. Even highly autonomous concepts still assume human oversight and human accountability.
  - It could be achieved through inherent physics, passive safety features, deterministic automated logic, adaptive data-based algorithms (e.g., AI), or some combination of these.



# Key Questions in Autonomous Operations

## WHAT

- Is operating autonomously?
- What systems and/or functions?

## WHEN

- Is it autonomous?
- Under normal, off-normal, emergency conditions?

## HOW

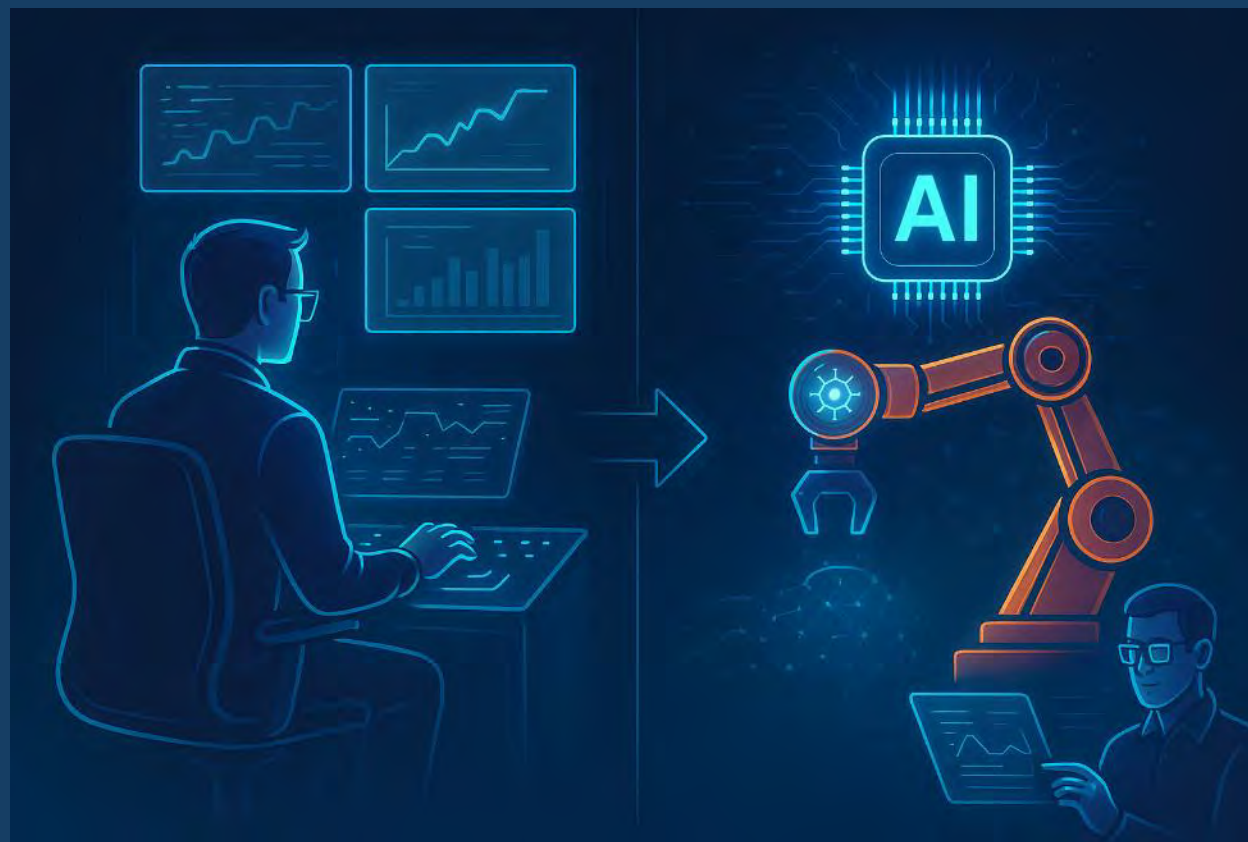
- Is it autonomous?
- Active systems, passive systems, inherent characteristics?
- At different levels, functions, processes, or modes?

## WHERE

- Is the autonomous operation controlled and/or monitored?
- Main control room, local control station, remote center?

## Substitution Myth:

Automation simply replaces human action with automated action.





# Human Factors Considerations with Automation



Situation  
Awareness



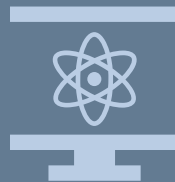
Trust and  
Automation  
Reliability



Workload



Teaming



Training



Skill and  
Knowledge  
Retention



Novel Human  
Error Types

# **Human Factors and Ergonomics Society Policy Statement**

## **AI Guardrails for Safety Critical Applications**

**Explainable**

**Transparent**

**Tested with Humans**

**Safety Alerts**

**Fail Safe**

**User Training**

**Autonomy Validated**

# Design Considerations for Human-Centered Use of AI in Nuclear Power Operations



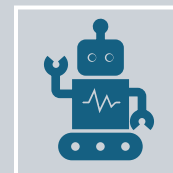
Explainable AI: Provide clear reasoning for AI outputs.



Human-in-the-Loop: Maintain operator authority for critical decisions.



Interface Design: Intuitive displays, alerts, and feedback mechanisms.



Training & Simulation: Prepare personnel for AI-assisted scenarios.



## Concluding Thoughts

- Consider AI as a support tool, not a replacement for human judgment.
  - Clear guidelines for human-AI collaboration in nuclear contexts is needed.
  - Human factors evaluations should occur early and often during AI deployment.
  - Designs with AI should be explainable and transparent to the user.
- RES work positions the NRC to be ready for greater autonomy and potential use of AI.

# ***DOE Remote and Autonomous Operation Research***

**Matthew Anderson**

**Idaho National Laboratory**

3 Sep 2026

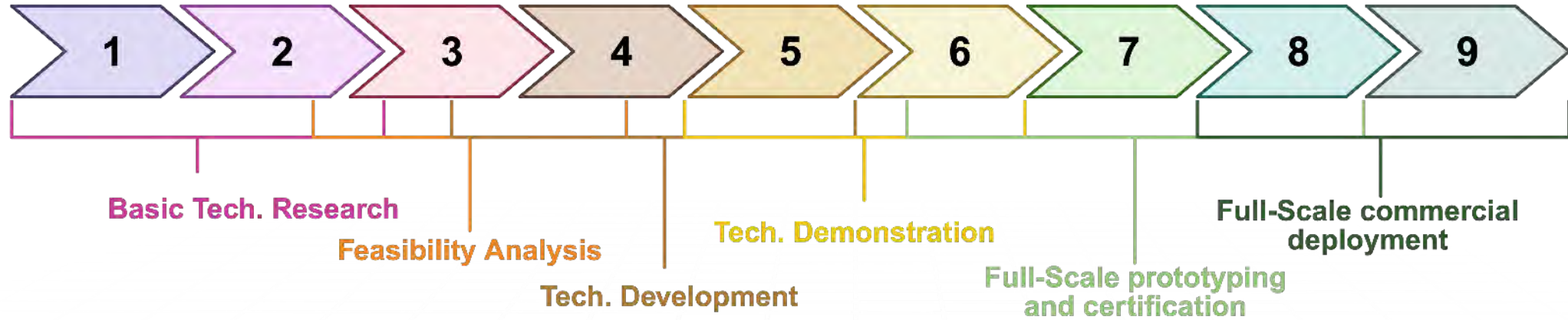
Idaho National Laboratory

# Autonomous and Remote Operation Takeaways

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INL/MIS-26-95247

# Reactors as geographically remote and autonomous distributed energy resource



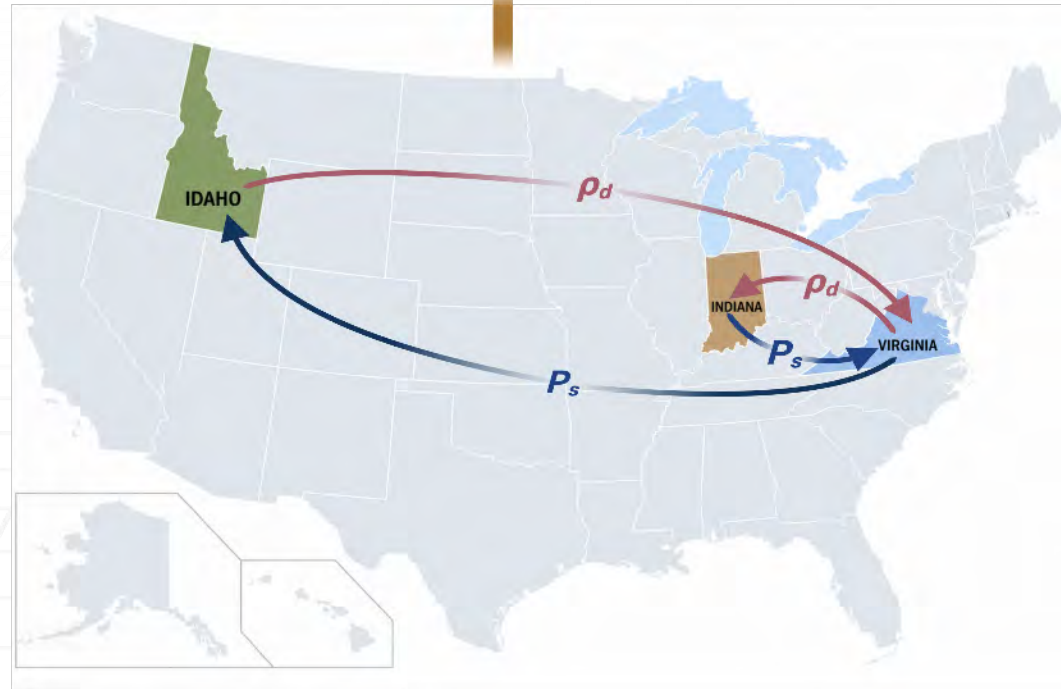
## Why?

- Remote operation may reduce costs (distributed controls of multiple reactors)
- Autonomous operations enable greater flexibility in power generation including load-follow
- Leverage momentum in advanced reactor deployment

# Experimental Demonstration



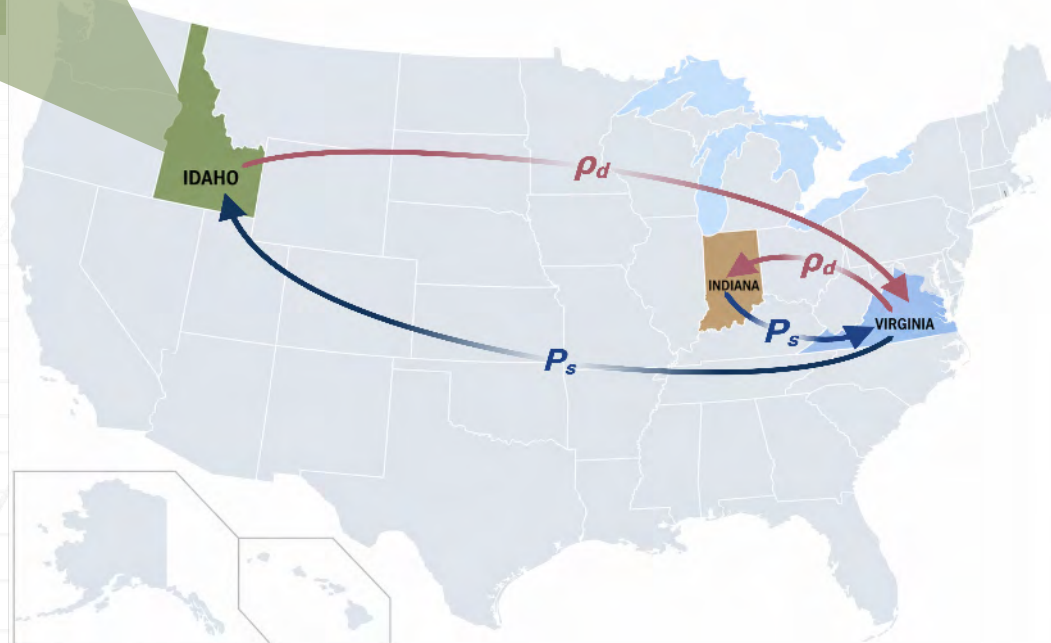
Partial-Scale prototype  
demonstration and  
validation



# AI Data Center Kinetics

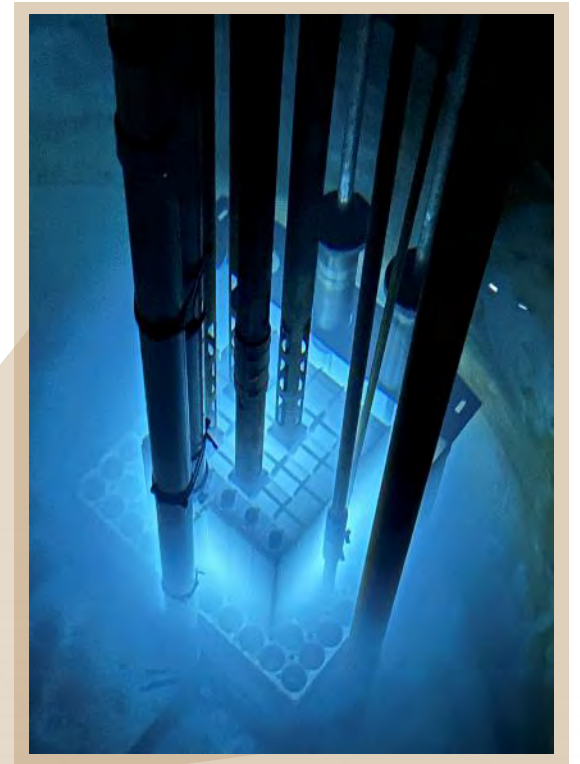
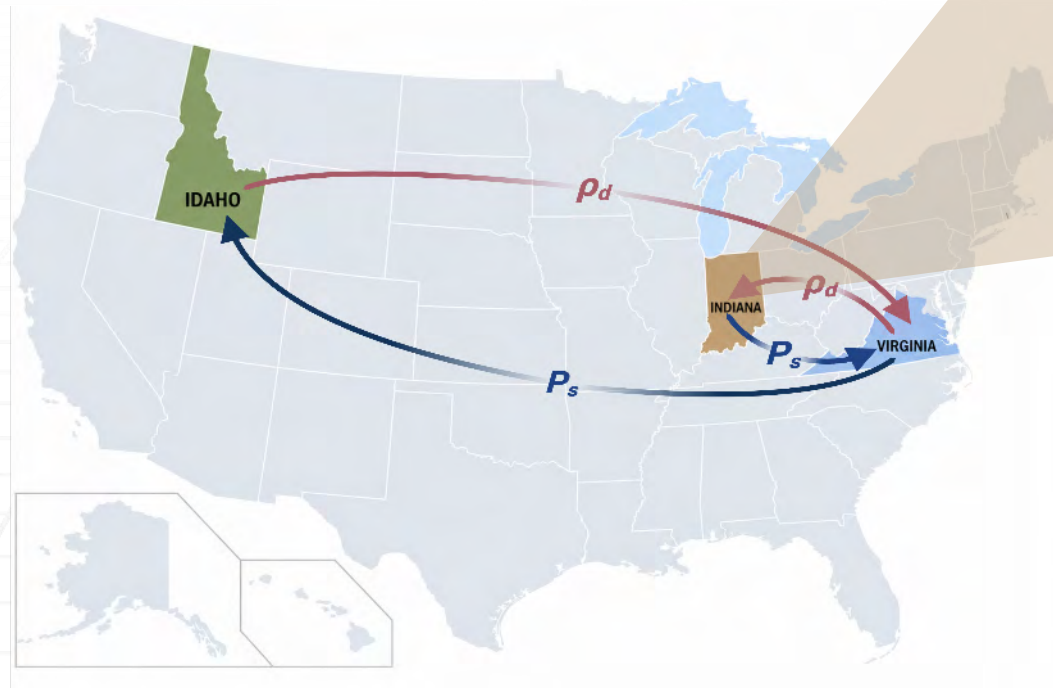


- Hoodoo Lambda Hyperplane deep learning distributed memory system.
- 44 Nvidia A100 tensor core GPUs.
- Co-located autonomous (RL) and low autonomy (2-DOF) controllers.
- Power draw from nodes (aggregated to PUR-1 rating) on MNIST training and LLM inference served setpoint reference.



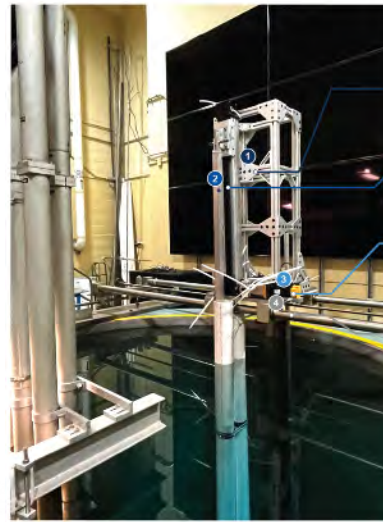
# Reactor Kinetics

- 10 kW<sub>th</sub>-rated PUR-1: Plate-Type MTR HALEU Fuel, Open Pool TRTR.
- Independent (from Reactor Safety System) I&C supports remote communication with Idaho-based controller.
- Co-located Digital Twin (DT) and cyber-physical testbed.
- Testbed's auxiliary moderator displacement rod (AMDR) induced power transients with up to 42 pcm of absolute reactivity.

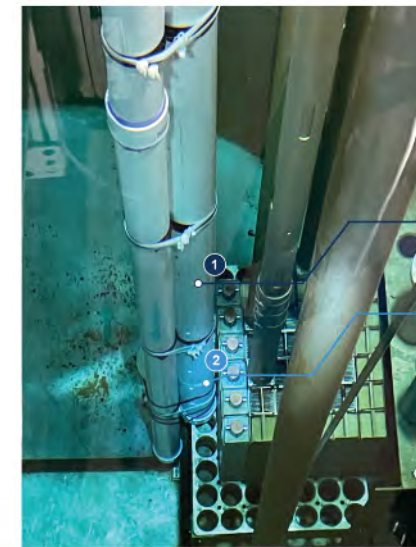




- 1 Cyber-Physical Testbed
- 2 PUR-1 Rods
- 3 Testbed I&C System

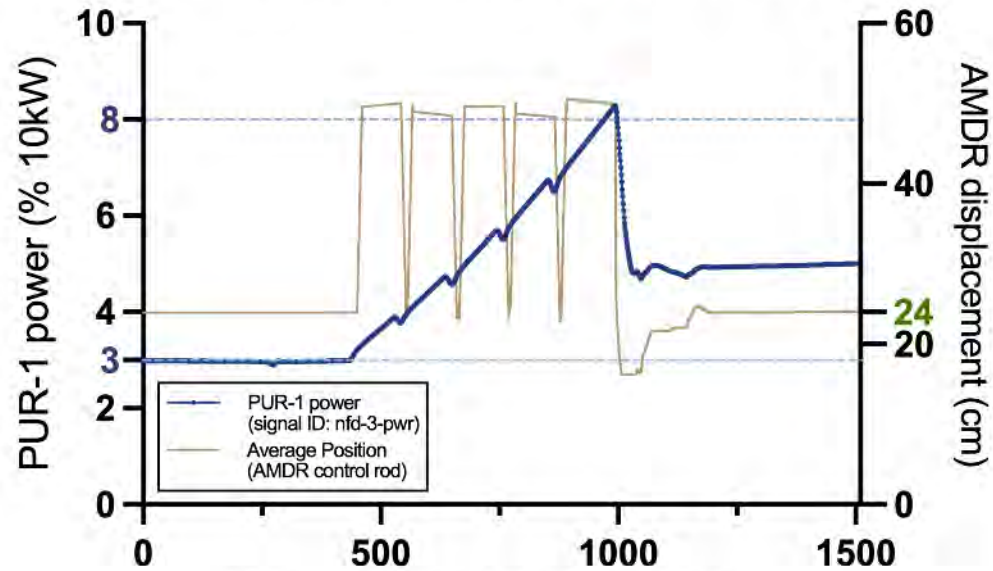


- 1 Linear Actuator Support Structure
- 2 Linear Actuator
- 3 Linear Actuator Servo-Motor
- 4 PUR-1 Moving Platform

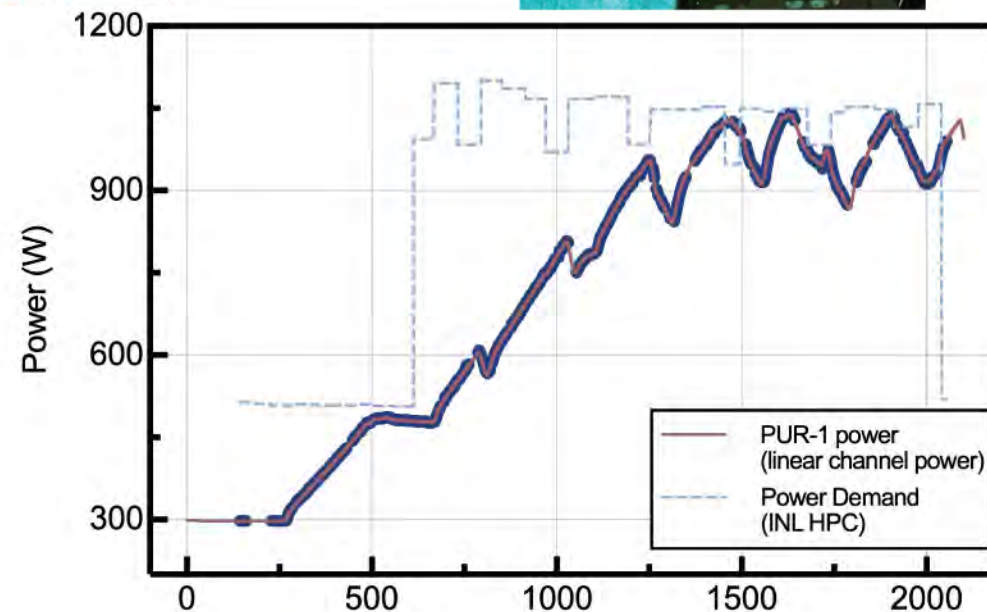


- 1 AMDR Guide Tube
- 2 Grid Location F7

Remote Autonomous operation of PUR-1



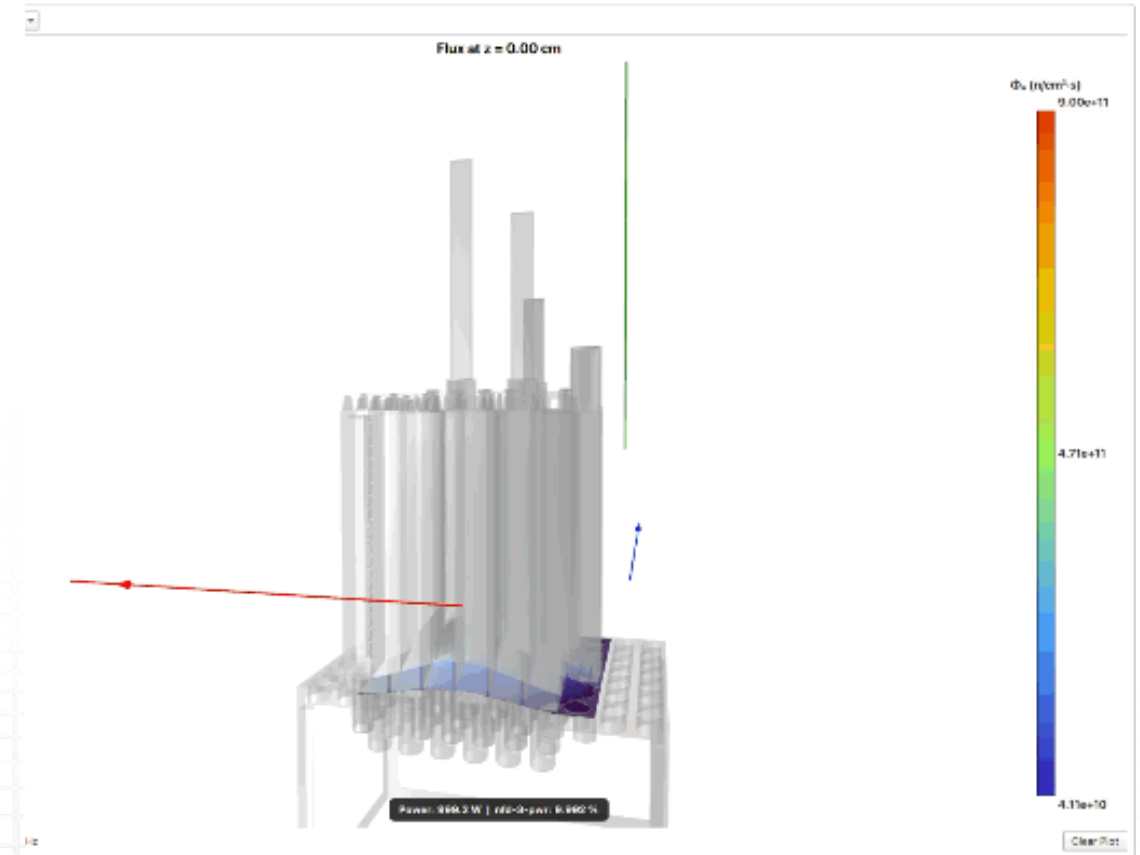
Seconds from start of experiment:  
11:21:06 AM (EST)  
9:21:06 AM (MDT)



Seconds from start of experiment:  
11:50:00 AM (EST)  
9:50:00 AM (MDT)

# Autonomous Control Potentials

- Adaptive ML controllers coupled with DT state estimation
  - complex and emergent solutions within safe operational limits.
- Enable spatiotemporal anticipatory state-aware control.
- The “What’s” in state constraints:
  - Power-peaking factors, hot spots, structural degradation.
  - Accounting doppler and moderator effects, F-P poisoning, power distribution change.
  - Fuel burn-up and long-term state effects.

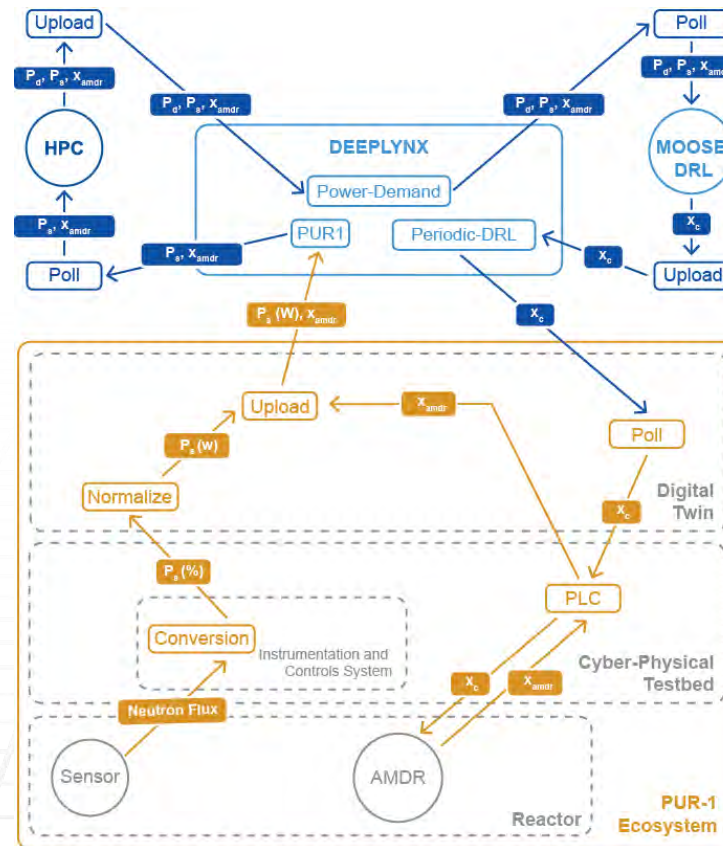


$$\hat{\mathbf{x}}^{DT} = \begin{bmatrix} \mathbf{x}^{\text{obs}} \\ \hat{\mathbf{x}}^{\text{lat}} \end{bmatrix}$$

$$\hat{\mathbf{x}}_{t+k}^{DT} \in \mathcal{X}_{\text{safe}}$$

## Remote Operation Prospects

- Control loop frequencies evaluated at 1 Hz and 10 Hz (operational limit).
- Knowledge engineered data cataloging on cloud server supported centralized control.
- 1 Hz End-to-end round-trip latency within  $\sim 2.5\%$  asymptotic period ( $\sim 153$  s) of AMDR with 5.24 ¢ reactivity.

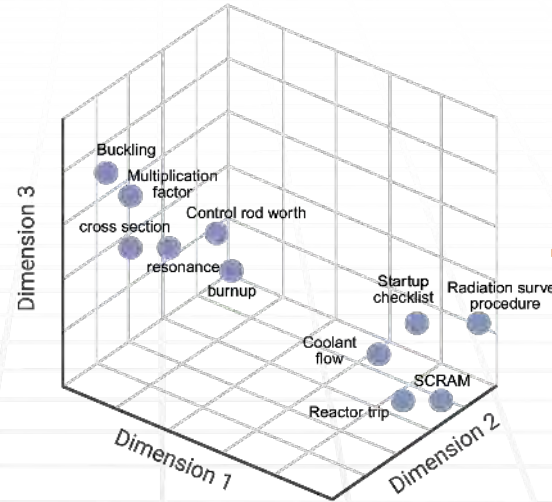
[illegible]

# Reactor Safeguards with Natural Language

- Control input and outputs are pseudo-anthropomorphically mapped.
- Agentic AI interface captures natural language command and embeds it into high-dimensional semantic-space with prior context.
- Facility's regulatory and operator intent context-aware  $c_t$  control is achieved:

$\pi^*$ :

- $\mathbf{c}_t^{(1)}$ : State-demand,
- $\mathbf{c}_t^{(2)}$ : Anticipatory-operational,
- $\mathbf{c}_t^{(3)}$ : Objective-constraint,
- $\hat{\mathbf{x}}_t^{DT}$ : DT state estimate.



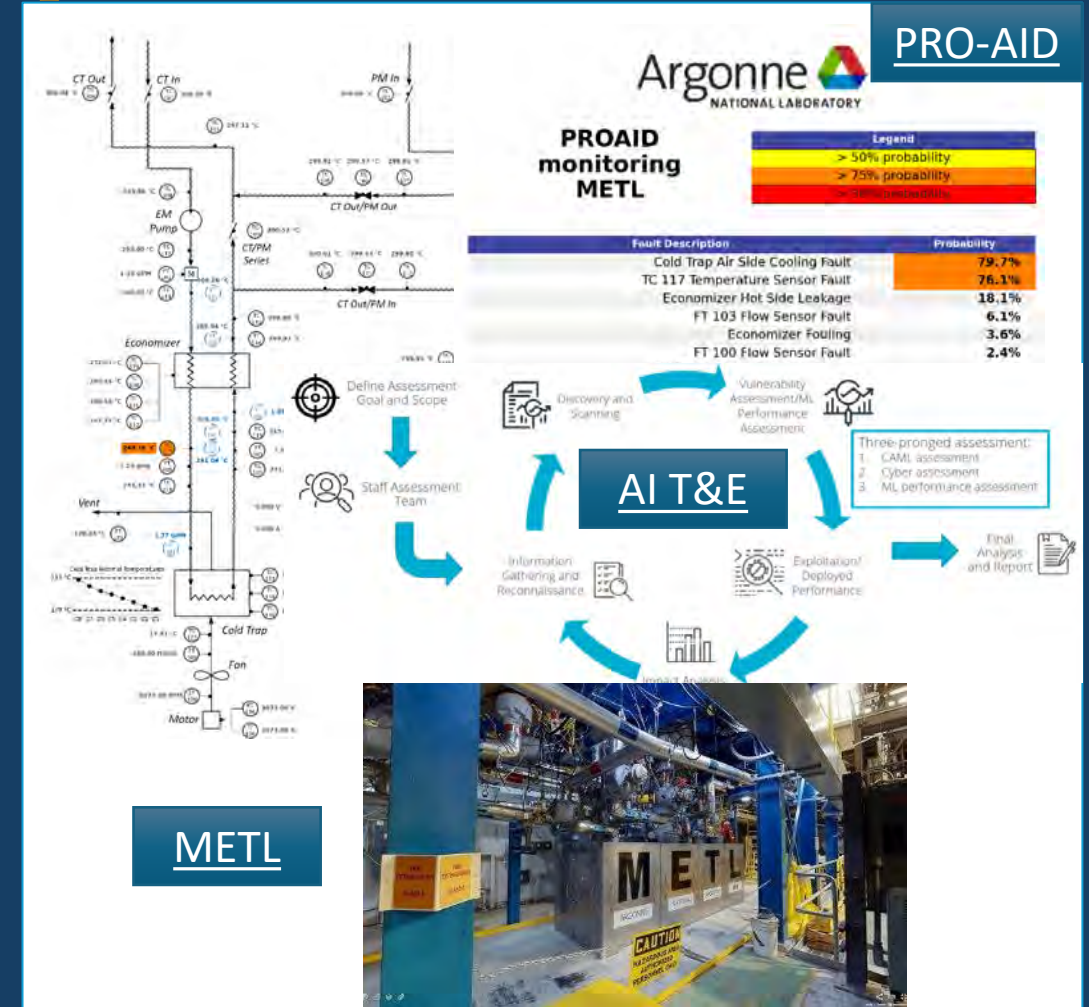
$\mathbf{u}_t \dashrightarrow \text{AMDR}$

$$\pi^* = \arg \max_{\pi \in \Pi} J(\pi; \hat{\mathbf{x}}_t^{DT}, \mathbf{c}_t), \quad (\hat{\mathbf{x}}_{t+k}^{DT}, \mathbf{u}_{t+k}) \in \mathcal{Z}_{\text{adm}}(\mathbf{c}_t), \forall k$$

# AI Project Plan Update

## Mock AI Tabletop Exercise

- Objective is to perform research and development of a comprehensive safety and security evaluation framework for the use of AI in NRC-regulated activities
- Tasks
  - Mock AI nuclear application safety analysis (Argonne National Laboratory)
  - Independent technical evaluator conducting a safety evaluation (Sandia National Laboratories)
- Research Information Letter (RIL 2026-02) publication September 2026
- Results used to further AI Regulatory Gaps Working Group deliberations



# NRC AI Workshops and Symposia



## U.S. Nuclear Regulatory Commission

### 2026 Artificial Intelligence Workshop

Tuesday, September 15, 2026

9:00 a.m. - 5:00 p.m. ET

Virtual or NRC Headquarters, Rockville, MD



<https://www.nrc.gov/public-involve/conference-symposia/data-science-ai-reg-workshops>

# Moving Forward

- **Vigilance on AI:** Monitoring AI's integration in the nuclear sector and assessing regulatory needs
- **International Cooperation:** Leveraging global partnerships to accelerate safe, trusted, and innovative AI adoption
- **Proactive Engagement:** Identifying challenges, gaps, and use cases in AI technologies
- **Skill Development:** Ensuring staff are equipped to leverage and regulate emerging technologies

