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UNITED STATES NUCLEAR REGULATORY COMMISSION'S
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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SAFETY RESEARCH PROGRAM SUBCOMMITTEE

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FRIDAY

JUNE 25, 2021

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The Subcommittee met via Teleconference, at 2:00 p.m. EDT, David A. Petti, Chair, presiding.

COMMITTEE MEMBERS:

DAVID A. PETTI, Chair

RONALD G. BALLINGER, Member

VICKI M. BIER, Member

CHARLES H. BROWN, JR., Member

VESNA B. DIMITRIJEVIC, Member

GREGORY H. HALNON, Member

WALTER L. KIRCHNER, Member

JOSE MARCH-LEUBA, Member

JOY L. REMPE, Member

MATTHEW W. SUNSERI, Member

DESIGNATED FEDERAL OFFICIAL:

HOSSEIN NOURBAKHSH

T-A-B-L-E O-F C-O-N-T-E-N-T-S

P R O C E E D I N G S

2:00 p.m.

MEMBER PETTI: I have 2:00 o'clock Eastern. So I will call the meeting to order. This is a Safety Research Program Subcommittee meeting in preparation for the Advisory Committee on Reactor Safeguards biennial review of the NRC Safety Research Program.

I'm David Petti, Chairman of today's subcommittee meeting and the ACRS lead for the review of the activities associated with the Division of Systems Analysis and the Office of Nuclear Regulatory Research. Members in attendance today are Vicki Bier, Greg Halnon, Jose March-Leuba, Walt Kirchner, Joy Rempe, Ron Ballinger, Vesna Dimitrijevic. I'm checking again. I think that is everyone.

MEMBER SUNSERI: Hey, Dave. This is Matt Sunseri. I'm on.

MEMBER PETTI: Oh, good. Matt's on, Matt Sunseri. We hold this meeting to gather information to support our biennial review of the NRC Safety Research Program. The ACRS section of the U.S. NRC public website provides our charter, bylaws, agendas, letter reports, and full transcripts of all full and subcommittee meetings, including (audio interference).

The meeting notice and agenda for this meeting were also posted there. (Audio interference) comments or a request to make an oral statement from the public. The subcommittee will gather information and analyze relevant issues and facts and formulate the proposed positions and actions as appropriate for deliberation by the full committee.

The transcript of the meeting is being kept and it'll be made available. Due to the COVID pandemic, today's meeting is being held over Microsoft Teams for ACRS and NRC staff. There's also a telephone bridgeline allowing participation of the public over the phone.

When addressing the subcommittee, the participants should first identify themselves and speak with sufficient clarity and volume so that they may be readily heard. When not speaking, we request that participants mute your computer microphone or phone to prevent feedback. So before I turn this over to Ray Furstenau, Director of the Office of Research, other members have a comment, perhaps Joy as our leader for this overall effort?

MEMBER REMPE: Sure, Dave. I think you've covered most parts. I just remind members where we are in the process of we previously heard from Ray and gotten his perspective. And in the upcoming months, we'll be hearing from the other two division in his office.

And Matt and Vesna will be the leads of those meetings. And we're still hoping to get our letter report out by the end of this calendar year. And I think that's all I wanted to mention.

MEMBER PETTI: Okay, great. Ray, you want to --

(Simultaneous speaking.)

MR. FURSTENAU: Sure.

MEMBER PETTI: Thanks.

MR. FURSTENAU: Yeah, sure. Thank you, Dr. Petti. And I just wanted to provide a brief introduction like you mentioned earlier. We had our overall introduction. I guess I'd call it an introductory review in April -- early April, April 8th it was.

And in that discussion, there was one thing that I wanted to revisit here in my introduction that there's one recommendation you made and that the committee made in the last report from 2020 that ACRS said, we support the systematic approach implemented by the Office of Research to prioritize research, emphasizing enterprise risk in the project selection, evaluation, and termination. And I think that's a very important recommendation and something that we really are keeping in mind as we go through all of the division level presentations. We think it is important that we complete research activities as they were scoped out to do.

And even when some aren't providing a value that we then appropriately terminate them if necessary. So it's really completing reviews, providing feedback from our business line partners in NRR, for example, and by doing annual program reviews. And we really want to promote that culture that supports doing the right research at the right time. And that's both in the starts and the stops.

So one thing I wanted to mention and you'll see this in all of the division presentations, the directors and their staff will be providing examples of completion of research activities throughout the presentation. So with that, I'd like to turn it over to Kim Webber. She's the director for the Division of Systems Analysis. So Kim, take it away.

MS. WEBBER: Great. Thanks so much, Ray. So good afternoon. I'm Kim Webber. I'm the director of the Division of Systems Analysis in the Office of

Nuclear Regulatory Research. In DSA, we're having to use more transformative ways to complete our work given the changes the NRC faces, including the aging operating fleet with more decommissioning plants, strong interest in accident tolerant and high burn-up fuel, as well as advanced non-light water reactor designs and legislation that drives us to work more collaboratively and, in my opinion, beneficially with other federal agencies such as the Department of Energy.

From our presentations, you'll see that we're working hard to maintain staff expertise and our analytical tools to support the regulatory offices and the safety mission of the agency. We have completed a substantial amount of work since the last time we met in 2019. And we look forward to the future to be as prepared as we can for what lies ahead. So we have a lot of information to share with you over the next three hours. And I'd to just give you a quick overview of the agenda. Next slide, please.

So on the agenda, I'll provide an overview which will include some information about the DSA resources, staffing levels, core competencies, and useful area of focus. We have a few special topics that we'll briefly discuss and those include a short update on advanced reactor code development activities. And I'll talk briefly about reference plant models.

Additionally, Chris Hoxie and Hossein Esmaili will take about reference plant models. So I know you have a lot of questions on those. Also, Teri Lalain, my new deputy director, she'll present an overview of our code investment plan and the data science artificial intelligence readiness strategies.

We know that there's a lot of interest in those special topics. And so for this briefing, we've only planned about ten minutes to cover each of those three special topics. But we're happy to schedule longer meetings outside of this meeting today if you feel like you'd like more detail on those topics.

Then the branch chiefs, Chris Hoxie, Hossein Esmaili, Luis Betancourt, our newest branch chief to the division, and John Tomon will present on topics in technical areas of interest in the sequence shown on this slide. And then I'll wrap up with a few closing remarks. Next slide, please.

So DSA plans, develops, and manages research programs to develop and maintain broad technical expertise, experimental data, numerical simulation analysis and tools, and the knowledge needed to support reliable and technically sound regulatory decisions. Combined, the technical research areas in DSA are very broad and include fuel performance, reactor physics, reactor systems, source term, accident progression, severe accident, accident consequences, radiation protection, and health physics research. DSA is comprised of four branches which are shown on this chart.

The branch names and their chiefs are shown in the bottom boxes. So Chris Hoxie is the chief of the code and reactor analysis branch. Hossein Esmaili is the chief of the fuel and source term code development branch. Luis Betancourt is the chief of the accident analysis branch. And John Tomon is the chief of the radiation protection branch. Next slide, please.

In DSA, we have 54 staff on board with a number of vacancies that are actively being filled. We also have contract funding that is used to augment the staff with specialized expertise from the labs and commercial contractors. This slide shows the distribution of resources across the various technical program areas in the left-hand column along with the key computer codes and DSA contacts in the right-hand column.

About 50 percent of our resources support fuel, neutronic, and thermohydraulics research. And a fairly significant portion of our resources support advanced reactor readiness activities. DSA staffing and contract levels have been relatively flat over the last few years and are essentially flat into 2023.

From a workload management perspective, we finished milestones, many of which are in user need requests and research assistant requests. And the advanced reactor code development plan is on a monthly basis. For example, we have finished a lot of research and code development activities for near term ATF concepts, or Accident Tolerant Fuel concepts, and high burn-up fuel in addition to generic advanced reactor readiness activities.

Each of the chiefs will highlight research activities their branches have completed since the last ACRS biennial review meeting. And there are more details on DSA completions in the backup slides. Growth areas for DSA over the next few years include code development activities for plant-specific advanced reactor and small modular reactor licensing support, building organizational capacity for data science and artificial intelligence, source term analysis for high burn-up fuel and advanced reactor designs, and new regulatory guidance in the radiation protection area. Next slide, please.

This slide shows the core positions and key technical competency areas needed to implement the work of the division. Core positions correspond to staffing plan position titles. And most of the positions within the division are reactor systems engineer and health physics. There are a few nuclear engineers additionally.

The red color competencies represent our current areas of focus relative to hiring and building new skills. As compared to the list of competencies we presented in 2019, we have filled prior gaps in the area of fuel performance. Based on our anticipated workload over the next few years, we're hiring to fill gaps in neutronics and reactor physics, thermohydraulics code development, severe accident source term, and health physics areas.

We recently hired one data science staff and three summer interns and are cross training other staff in Luis Betancourt's branch, anticipating growth in the data science and artificial intelligence areas. We have been experiencing some difficult hiring neutronics code developers and severe accident source term staff and are working with our human resources office to develop strategies to bring folks with those skills in-house. One of the concerns that I have is that with the growing interest in advanced reactor technologies and the growing industry in that area, we'll be competing with the same or similar skill sets with the national laboratories and industries. Next slide, please.

So here's a short list of many of the DSA priorities. I'm not going to talk about each one because either Teri or the branch chiefs will discuss them during their own presentations. But I did put in parentheses the names of the speakers who will discuss the topics in a little bit more detail. Next slide, please.

So as you've heard Ray, me, and other RES managers say before, the Office of Research has an important mission which is to develop and maintain staff expertise and analytic capabilities, including computer codes, that enable regulatory readiness through our research excellence. Shown here are some of the strategies DSA is using to achieve that outcome. We continue to anticipate future licensing submittals through our professional relations and frequent dialogues with our NRC partners such as in NRR.

We talked to folks from other government agencies and international organizations. And we also learned new information from external stakeholders. Our focus is to be ready to support potentially diverse needs of the regulatory offices.

Regarding forward looking research, both Teri and I promote and encourage our staff to share new ideas with us and with each other to optimize the way we work. As an example, our senior IT specialist, Anthony Calvo, and our technical assistant, Ken Armstrong, have been working really hard over the last few years with our IT department to ensure we have the high performance computing capabilities within RES and the NRC and that we have reliable connections with the national laboratories to be able to work from anywhere. We're leveraging the future focused research and integrated university programs to look out farther in time to better understand the technologies the nuclear industries may use.

We're hiring and training staff in new areas like artificial intelligence, machine learning, and fusion where we anticipate industry growth areas. Chris Hoxie will talk about our activities in the fusion area. Also DSA optimizes its use of resources and information by completing high quality work on time, such as with the state of the art reactor consequence analysis or SOARCA study. The inputs to the Level 3 PRA study and with the NuScale confirmatory analysis, this allows us to shift our attention to new and higher priority research activities, such as the priority areas I listed on the previous slide.

This also includes leveraging international experimental programs which the branch chiefs will discuss and the many memoranda of understanding with the Department of Energy, with the Electric Power Research Institute, and other organizations like the DOE's Nuclear Reactor Innovation Center. We also participate in NRC's transformation activities, including the Be Risk Smart and Innovate NRC 2.0 programs, which will be discussed in more detail by DE and DRA during their division presentations later this summer. You'll hear examples of these strategies in the presentations that follow. Next slide, please.

CHAIR BROWN: Kimberly?

MS. WEBBER: Yeah?

CHAIR BROWN: This is Charlie Brown.

(Simultaneous speaking.)

MS. WEBBER: Oh, hey, Charlie.

CHAIR BROWN: Doing fine. Thank you. Can you go back to the earlier slide for a minute?

MS. WEBBER: Which earlier slide?

CHAIR BROWN: The one you go.

MS. WEBBER: Okay.

CHAIR BROWN: That is just fine. It just triggered my thoughts when you -- forward focused research and you talk about artificial intelligence/machine-less learning. Where would you anticipate -- I'm a little nervous about that, if it doesn't sound like that in my voice.

What's the application you would think of using that for in terms of your -- I mean, I don't want models to get changed because the machine thinks it's smarter than the people are. I don't want data being analyzed in a manner that it decides it wants to do it some other way. I don't want instrumentation to be built to think it could get smart and analyze all the data and determine whether the -- whatever, as opposed to manmade algorithms.

MS. WEBBER: Right.

CHAIR BROWN: So that's why I asked the question.

MS. WEBBER: Yes, so if I understand your question, your question is, what work are we doing in the AI/machine learning area. Is that your question?

CHAIR BROWN: And how does it anticipate to be -- anticipated to be applied is what the real question is.

MS. WEBBER: So I think Teri will talk a little bit more about this. But --

CHAIR BROWN: Okay.

MS. WEBBER: -- we're -- so we're hearing that there are potentially uses of AI and machine language and learning in a couple of areas. The industry is interested in optimizing their maintenance strategies and their outages. And so they may use something called the internet of things which basically puts sensors on pumps and valves and other equipment.

And that will help them determine whether maintenance of those components needs to be done sooner or can be delayed a little bit later. That's one particular application. We're also hearing that there may be interest in the industry to use some artificial intelligence algorithms to sort through corrective action program reports and see if there's commonalities so that they can see if there are trends in those data which is kind of an initiative to help them more efficiently evaluate the significant of those reports.

So those are some of the areas that we're learning about. And I think Teri will explain in her presentation where we are at this date. But just to provide a one liner on where we are, we're really at the infancy stage of learning about those technologies. And I don't want to preempt Teri, so I'll let her talk --

(Simultaneous speaking.)

CHAIR BROWN: No, that's fine. Just -- I'd just like to -- as soon as you said internet of things and people putting all this information out there, that means it's spread all over the place. So if he can talk about how you would -- if you're going to do something with IoT -- which I've read tons about from the IEEE documents, they love it -- and how you -- with the packing circumstances and the inability to protect it properly.

And that's a big threat. And so that's why I'm not -- particularly if it's going to use feedback and, oh, you don't have to do maintenance. But the data, if you were looking at it by a person and it's been modified. And you didn't know that.

MS. WEBBER: Yes, yes. So --

CHAIR BROWN: So anyway, if we can just

address those issues, I'd be appreciative.

MS. WEBBER: Yeah, I think Luis Betancourt, the branch chief who has the lead for that area, has his hand up. So I'll see if he wants to chime in.

CHAIR BROWN: Oh, he can wait. It doesn't have to -- it can wait till you get to him. That's --

MS. WEBBER: Okay.

CHAIR BROWN: Whatever suits you all.

MR. BETANCOURT: I was going to mention that I'll cover that in my presentation shortly.

CHAIR BROWN: Pardon?

MR. BETANCOURT: I'll cover that in my presentation shortly.

CHAIR BROWN: Okay. That works for me. Thank you very much.

MS. WEBBER: So Charlie, just so you know, that's Luis Betancourt, one of the branch chiefs.

CHAIR BROWN: Yeah, I know him.

MS. WEBBER: But Teri Lalain, she's my deputy director and she will address some of that in her presentation as well.

CHAIR BROWN: Okay. Thank you --

MS. WEBBER: Okay.

CHAIR BROWN: -- very much. Yeah, I

appreciate it.

MS. WEBBER: Okay, sure. Okay. Could we go to the next slide, please? Yeah, all right. I love this slide actually. This is one of my favorite slides in the slide deck.

It shows DSA completions by the numbers. As you can see we've completed a substantial amount of work since the last time we met with you for a biennial review. And this chart shows the number of major code releases completed, the number of reference plant models completed to date, the Accident Tolerant Fuel, high burn-up and advanced reactor reports that we completed, the SOARCA study, the NuScale confirmatory analysis, the number of NUREGs and Reg Guides that we've completed, and also the abnormal occurrence and the radiation exposure information and rear system reports, among a number of things that are shown on this slide.

I also want to point out that we have a substantial number of international cooperative agreements. And we leverage those significant -- we leverage significant contributions from those agreements through our code sharing program and through other arrangements. So let's go onto the next slide, please.

So this is the last slide I have for my overview. But before I move on to one of the special topics, I wanted to highlight some challenges that we're facing. So relative to workload management, DSA is involved in many high visibility research activities, some of which I showed you on the prior slides.

For example, in almost all of our technical areas, we're anticipating a lot of user need requests and research assistant requests driven confirmatory analysis needed to evaluate the safety of new small modular reactor and advanced reactor designs while also completing code development activities for the operating fleet. Although we are leveraging our network of professional relations with the Department of Energy, the national laboratories, and the international community, the NRC doesn't have plant and design-specific information for most of the near term ATF and high burn-up fuel concepts and the plant-specific advanced reactors. I give my staff all the credit for getting our codes as ready as they possibly can be and for continuing to develop their skills and their expertise.

But we really need the plant and design-specific information and experimental data to validate our codes before the licensing submittals come in if, when called upon, we're going to successfully support the shorter deadlines that NRC is anticipating. In the human resources area, we need to have a full complement of highly skilled staff as I previously discussed. Thus, it's critical that we identify and use hiring and retention strategies with the help of our human resources offices. Next slide, please.

MEMBER PETTI: Kim --

MS. WEBBER: Yeah.

MEMBER PETTI: -- just a question.

(Simultaneous speaking.)

MEMBER PETTI: I really resonated when you talked about the human capital issue and your ability to attract new people. It's happening everywhere. I get emails because I was a member of the advanced reactor community. Hey, Company X says I need somebody with this capability. Where can I get them?

I said, get in line. Everybody is competing for the same resource. So I wonder -- I was very intrigued when you talked about the cross training. But you seem to be focused on just a subset of the different groups you've got. Any chance of cross training more broadly as a strategy?

MS. WEBBER: Well, so cross training is

always an option that we have, although as you know that some of the skill sets are pretty complex and technical.

MEMBER PETTI: Yeah.

MS. WEBBER: And so for instance, in the neutronics area, we just don't have enough people on staff to do the amount of work that we need to complete for all the different types of work that we have. So for us, it's a numbers game. It's really hard to train some folks to become neutronics reactor physics people if that's just -- it's such a technically complex area.

So it's really hard to cross train that. But we have recently hired Mike Rose and we have another new hire, Alice Chung. And they're learning that areas. So as they learn and work with our more seasoned neutronics experts, they're building those skills to support this larger workload that we're anticipating.

MEMBER PETTI: So can you hire non-U.S. citizens? Or is that --

MS. WEBBER: No, we cannot.

MEMBER PETTI: You cannot?

MS. WEBBER: No, the --

MEMBER PETTI: Okay.

MS. WEBBER: -- NRC cannot, no.

MEMBER PETTI: Yeah, okay. Because Europe has a very large group of people, and their budgets are not in good shape. And it's a great talent pool if you could've gotten into it. Okay.

(Simultaneous speaking.)

MEMBER PETTI: Thanks.

MS. WEBBER: Okay.

MEMBER REMPE: Kim?

MS. WEBBER: Hey, Joy.

MEMBER REMPE: I also have a question if you're done, Dave.

MEMBER PETTI: Go ahead.

MEMBER REMPE: Okay. So you mentioned about the need for data, and you actually mentioned Accident Tolerant Fuel. And as we know, Halden facility is no longer available. And I'm aware of the FIDES program.

But during his discussion last time with Ray, he mentioned that some folks are pursuing a risk-based approach where they may be able to avoid some of the data. And so I'm just wondering how much data there are for Accident Tolerant Fuel which relies on high assay low enriched uranium. And I know research did a PIRT that I'm sure Hossein Esmaili will talk about --

MS. WEBBER: Yeah.

(Simultaneous speaking.)

MEMBER REMPE: -- later on with respect to the need for certain data gaps to be filled. And I've just been wondering if we're going to -- I'm wondering how well that is being communicated to the community, that there is --

MS. WEBBER: Yes.

MEMBER REMPE: -- a need for data.

MS. WEBBER: Yeah, I think that's a great question, Joy. And I really appreciate you bringing it up now and every time that we meet with you. So we have regular standing meetings with the Department of Energy, especially with Bill McCaughey in the Accident Tolerant Fuel area and the advanced reactor folks and the NEAMS computer code team.

So through those DOE meetings, we get insights on what kind of experimental programs are going on in the national laboratory complex. We also have -- especially some of my staff and NRR staff meet with the vendors who are thinking about Accident Tolerant Fuel and high burn-up fuel. So they are also aware of the kind of approaches that are being used in the context of potentially licensing ATF and high burn-up fuel.

We have some limited information from one of the vendors for Accident Tolerant Fuel. And we're also participating in a number of international experimental programs which I think Hossein will talk about. So as much as we're trying to beat the bandwagon on, hey, letting folks know that we really need certain data and we've communicated the data needs that we have, we're still not being able to yet receive a lot of that data. So that's why I wanted to put a high point on it during my talking points or during my discussion.

MEMBER REMPE: Okay. Thank you.

MS. WEBBER: You're welcome. Okay. Should we go to the next slide, please? Okay. So let me -- we're starting now into the special topics part of the meeting. And so I want to move to the next slide, please. I'll be talking about advanced reactor readiness. Next slide.

So since the last biennial review meeting, we completed and published a set of six documents that describe our co-development plans for advanced reactors. As you know -- as many of you know, Volume 1 through 5 identify the computer codes that we plan to use for our independent safety analysis gaps in the co-development capabilities and data, verification of validation needs along with a specific code development tasks and methods. Now in some of those volumes, we do discuss what kind of experimental data are needed.

These co-development activities encompass analytical capability in the fuel performance, reactor physics, systems analysis, accident progression, source term, accident consequence, and citing and licensing code areas. Next slide, please. So as I mentioned previously, the ultimate goal of any of the --

MEMBER PETTI: Kim, just a question --

MS. WEBBER: Yeah, sure.

MEMBER PETTI: -- on a previous slide. Are you anticipating some sort of a report on the second bullet, the gaps?

MS. WEBBER: Well, so the gaps in the experimental data, some of those are described in, for instance, Volume 1. I noticed when Steve Bajorek wrote that volume, he did dedicate a section to that volume to describing what he thought were some of the experimental gaps in the data. But these volumes took a pretty substantial amount of resources to develop.

MEMBER PETTI: Yeah.

(Simultaneous speaking.)

MS. WEBBER: And so -- they did. And quite frankly, I think when we look towards using the reference plant models more and more as we go on in time, we'll probably identify additional gaps that we have relative to the experimental data.

MEMBER PETTI: So it's more of a punch list you guys are keeping than -- going at least to this point to a report?

MS. WEBBER: Yeah, yeah.

MEMBER PETTI: Great, thanks.

MS. WEBBER: Pretty much.

MEMBER PETTI: Yeah.

MS. WEBBER: Okay, thanks. Could we have the next slide, please. So I just want to take a few minutes to talk about a three-stage approach that's shown on this slide. So Stage 1 involves the development implementation of the plans that are described in those Volumes 1 through 5.

This includes the development of reference plant models which I know that you're all interested in for not only the BlueCRAB suite of codes but also MELCOR. And those reference plant models are based on publicly available non-light water reactor designs. And both Chris and Hossein will talk about those during their presentations.

But I do want to mention that the primary purpose of those reference plant models is to test the codes, fix the bugs, perform some code validation exercises, and develop the staff expertise with advanced reactor designs. So as you know by developing the codes and running the codes, the staff become familiar with those plant operations and the likely accident scenarios that could happen. And I mentioned that as we -- you'll see that we've done a lot of work with the reference plant models but to build those. But we still have more work to do to exercise those plant models as we go forward.

Stage 2 involves developing plant-specific models using plant-specific design information obtained during pre-application meetings and audits with the NRC applicants. So the purpose is to ensure that our codes are even more ready to support licensing by having that plant-specific information. And a key assumption that we're making which could also become a challenge is that the applicants are willing to provide us with that design-specific information prior to their licensing submittals.

So as my staff participate, they're requested by NRR to participate in pre-application meetings and audits with these applicants. They will better understand where the key uncertainties are and where small margins lie. And they'll communicate their insights to their counterparts in real time. So the more that we're involved in those pre-application meetings and audits, the better we are equipped to know where we need to focus our attention.

Stage 3 involves refinement of the plant-specific models using information in the license applications and performing confirmatory analysis as requested by NRR. And we're working with NRR to figure out what that kind of workload will look like. As you may know, the advanced reactor applicants are choosing to use different licensing strategies.

Some are using a construction permit operating license approach. Others are using the Part 52 design certification combined license approach. And there's only one applicant that we know of to date that is interested in using the license modernization plan.

So we're trying to be ready to support whatever the needs are that NRR may request of us. So this strategy is critical to helping focus the technical reviews, including the request for additional information and the safety evaluation reports on the most safety significant and risk significant topics. So it's my belief that if we can understand the margins, the uncertainties, and use the codes wisely, we'll focus the reviews on the most important things. Next slide, please.

MEMBER REMPE: Kim, I have a curiosity question. DOE has put out a budget where they're emphasizing a couple of designs which in a way I was wondering if that would make NRC's life a little easier since there's so much more money, if it gets approved by Congress, that would be going to those designs. And has DOE's decision to focus a bit more helped NRC in their strategy?

Or you still need to accommodate everybody, because some of these other designs are getting a lower amount of money. But I would think that their funding limitations might be more a concern and they might not be coming in as soon. Has it helped you at all?

MS. WEBBER: So that's a great question. I appreciate you asking it. So in 2020 when DOE identified two vendors for the advanced reactor demo projects and they also provided risk reduction awards to other vendors, that helped us understand where some of the money is going. Now it's really important that we focus on the two advanced reactor demo projects, the Natrium Sodium Fast Reactor and then also the X-energy high temperature gas reactor.

And so I think we're moving pretty far along with the reference plant models for those designs. We still don't have plant-specific design information. And that's something that through the pre-application activities and the topical reports, that will be submitted to the NRC over the coming months that we'll be looking for that kind of information.

When it comes to the risk reduction awards, we're watching to see what happens. And all of that funding is helping us to understand, I guess, from the perspective of DOE priorities relative to funding and their perspectives on where they think the technologies are the most mature. So that is helping us. Okay. Any other --

MEMBER REMPE: Thank you.

MS. WEBBER: -- questions? You're welcome. Slide 14, please -- or 16. So this is the last slide I want to cover before I transition it over to Teri. So today, we largely concentrated on Stage 1.

In addition to completing our advanced

reactor code development volumes, we've also completed a significant number of the reference plant models. For systems analysis and through accident analysis, we've also completed two fuel code assessment reports for both metallic and TRISO fuel. So those are assessed reports for the FAST, our FAST fuel performance code.

And our next steps include completion of a few additional reference plant models through this year, completion of public -- the workshops on source term demo projects which Hossein will talk about and the MACCS radionuclides screening analysis and near-field atmospheric transport and dispersion modeling and then exercising the MACCS code with some of these source terms. We're also finishing the consolidation of the radiation protection code over the next few years. And we really need to initiate our Volume 5 plans to prepare for the nuclear fuel cycle analysis. So at this point, I'd like to turn the presentation over to Teri Lalain.

MS. LALAIN: Hi, good afternoon. I'm Teri Lalain, Deputy Director for DSA under Kim Webber. We'll take a moment and briefly introduce myself. So I joined the NRC in March of 2021 coming in from the Department of the Army.

During my Army tenure, I served as the capabilities divisions chief at the U.S. Army Test and Evaluation Command Headquarters where I ensured the readiness of the Army's estimated five billion dollars of test instrumentation used across the Army ranges to assess the effectiveness and safety of items that were going to be used by the solider. And we'll talk a little bit more about that during this briefing.

I also served as a branch chief at the Edgewood Chemical Biological Center leading a multi-disciplinary research team in the mitigation of chemical warfare agent hazards, including methodology, vapor source term, and subsequent scenario analyses for human health-based exposure assessments. And I'm a graduate of the NRC SES CDP. So I appreciate this opportunity to brief you today on the work we've been doing, NRC scientific computer code investment plan. Next slide, please.

So for background, in FY21, budget to the Commission SRM asked research to work with the technical offices to review in a holistic way the existing inventory of codes that the NRC uses to develop a long-term investment plan to support future use and research requirements. Next slide, please. So in FY20, the DSA team completed a thorough assessment and identified 42 scientific computer codes used for confirmatory analysis in support of regulatory decision making.

The majority of the codes resided in research DSA, some in DRA and DE, and a few in NMSS. From the assessment, the team further identified the status and investments being made to these codes. Eight codes were identified as not needing to be actively used and are projected to be needed for use in the next five to ten years. So those codes replaced in a long-term archival minimal maintenance status. And typically, these codes are maintained by the Radiation Safety Information Computational Center at Oak Ridge National Laboratory.

There are 34 codes in active use. And all of the codes in active use require routine maintenance to fix bugs, ensure stability and operability with current operating systems. So this type of maintenance is performed on a consistent basis. And the resources are captured in the budget annually to ensure usability of the code.

There are three types of code development activities that have been defined in the code investment plan. The state of the practice, so those are the technological updates that are at a similar pace with the advancements made by industry. The code owners work with their users to identify the improvements that are needed to stay current.

And all of these codes will require that development at some point in time for readiness. Code modernization involves the modification or rewriting of the fundamental code structure to incorporate new capabilities, address obsolescence issues, reduce analysis run times, ensure operability with their codes, and adhere to monitor software development and IT best practices. Currently, there are four codes that are modernization -- FAVOR, MELCOR, RASCAL, and SAPHIRE -- and you'll hear more about these codes in the branch briefings.

Code consolidation efforts improve the NRC's efficiency for code management. It reduces the number of codes that are maintained individually into a single code that has the expanded capabilities. Currently, seven radiation protection codes are being consolidated down to three codes to create RAMP: atmosphere, effluent, and habitability.

Backup Slide No. 86 in the deck has a summary of the modernization and consolidation efforts that are underway. I want to give the SA team a shout out for the work they did to do this current state assessment because this assessment is the core foundation onto which we can build the investment plan. Next slide, please. So balancing a portfolio of capabilities, there's never enough resources to do everything.

It's important to have a process, though, to ensure that the right capability is ready at the right time. So during my tenure with the Army, I led my team in the review and prioritization of hundreds of requests for capability, maintenance, and modernization. And we had to ensure the best state of readiness for the command considering the resource constraints and also being able to readily adapt to changes in programs and priorities.

Just prior to joining the NRC earlier this year, I led the Army team to complete the DoD budget formulation for FY23 to 27, so a five-year planning period. So I mention that because the DSA team helps several brainstorming sessions to look at how we're going to create an investment process for our codes. We looked at NRC past practices, the budget formulation process as well as looking into aspects of the Army investment process.

And the team was able to leverage its practices from both the NRC and the Army to develop the code investment process. In the interest of time today, I want to be very high level on the aspects of the code investment life cycle. So code maintenance and readiness needs to happen -- back up, yeah, there we go -- to ensure readiness.

The annual process starts with the identification and maintenance of development needs for each code. Requests for any code development would be further supported with information as to when is the modified code needed, what analysis or work request would that modified code support, and the impacts if the modifications are not resourced. That will enable prioritization of the needs with the program offices to meet that right capability at the right time.

The prioritization will inform the budget formulation process to do the resource planning. And as these are resource, the code development can be performed and the updated codes distributed. But the bulk of the activity that will come out of the co-development plan will be in that first cycle to prepare that initial list of requirements and timelines.

Once that foundation is established, the annual cycle is a review and updates to the requirements and the prioritization. Next slide, please. So our next steps, we are working on the completion of the draft code investment plan. As we're doing that, we're going to start coordinating with the other code owners to discuss the approach and work toward the collection of the maintenance and development requirements for each code.

In parallel, we'll be socializing the plan with the program offices. Once we have the requirements documented, we'll work with the program offices to prioritize those requirements so that we're ready to inform the budget formulation process. And then each year going forward, we'll do an annual review of the requirements, make the necessary updates to the requirements themselves, and the prioritization.

So I do look forward to a future opportunity to have the DSA team discuss the code investment plan in more detail with you and all the great work that's been done to get us established with our code management. Next slide, please. Okay. Next, thanks. All right.

MEMBER PETTI: Can I have a question? This is Dave. Can you give me just a little bit of historical perspective? This sounds really good. I like it. Were there things missing that weren't in the process before prior to this that you were able to bring the Army piece in, so the best practices that helped NRC move to a better product in the end, if you will?

MS. LALAIN: Yeah. So there were several things. The work that the team did to do that holistic current state assessment put all the codes together which is a key piece to be able to actively manage them as a portfolio. From the Army processes, it is that portfolio management that is key so that you're looking at prioritization, not on each code as 42 different things.

But you're looking at the suite of capability for the agency and being able to make your decisions and priorities considering what is most important when you look across all of the mission activities that those codes need to be able to support. So it broadens the lens to help you with the portfolio of management is the key thing of all the work that's been done to bring this process together.

MEMBER PETTI: That helps a lot. Great. Thanks.

MS. LALAIN: Yeah.

MEMBER KIRCHNER: Teri, this is Walt

Kirchner. In this -- looking at this investment plan, could you just share with us what kind of a time frame you're thinking of given that sometimes code development is a multi-year process but the budgeting is an annual process. Is your investment plan going to look at a five to ten-year kind of horizon?

MS. LALAIN: So that is what I do want to work toward. The template that we are using, the collective requirements looks out over a five to seven-year. We know that will be initially a little bit of a challenge.

If it's coming from DoD, I'm used to planning on a five to ten-year. I got to work with everyone to bring that here. I know some of the codes already have looked out several years.

But yes, that's going to be key because ask you shift requirements and as resources are there, the last thing you want to do is start something you can't finish or delay something. So that's, again that holistic management. You need to understand the timing. So we are going to work toward that.

MEMBER KIRCHNER: Thank you. I think in our past reviews of your division which I led, one of the things that was of concern was as you looked at your portfolio and managing it, perhaps -- and I'll go back, like, four years -- it was too short term, an outlook, so to speak, like, three years or less. And hence, the kind of decision making and planning you would do is different than if you take a longer holistic approach as you mention. So good, thank you.

MEMBER DIMITRIJEVIC: This is Vesna Dimitrijevic. Hi, Teri. I have a question. I'm actually impressed with this illustration of MACCS in different colors. So if you would -- give us -- I'm curious about -- because I'm especially curious of this as it relates to using 103 (phonetic) in regulation. So if you go -- can go in little more details on some of the inputs like regulatory framework or risk and uncertainty. What is actually considered there?

MS. LALAIN: I'm going to hold your question till we get to Luis Betancourt's brief. In AAB, we have a whole section the MACCS code in that briefing.

MEMBER DIMITRIJEVIC: Okay. He's going to use the same illustration --

MS. LALAIN: Yeah.

(Simultaneous speaking.)

MEMBER DIMITRIJEVIC: All right. Okay.

MS. LALAIN: Okay. So shifting gears,

artificial intelligence. So the fields of data science and artificial intelligence provide new opportunities for organizations to improve processes, leverage historical and current data, identify research needs, and even explore autonomous control and operation. So as I mentioned coming from the Department of Army, one of the areas in my portfolio was artificial intelligence applications, and that included the test infrastructure and to assess the performance and the safety of autonomously controlled systems.

So coming to the NRC, the NRC and a nuclear industry have similar interests and share some of the same questions regarding the potential of these capabilities. As more AI tools become widely adopted, research is looking into how these tools may be applied and how to be able to be ready to adequately evaluate the use of these AI technologies and NRC regulated activities to ensure public health and safety. And the RES staff is engaged in and already performing some great work in these areas that we'll be highlighting in both my briefing and in Luis Betancourt's briefing today. Next slide, please.

So where are we now? We're exploring use cases to leverage AI tools for business process improvements to better estimate resources for licensing actions by comparison to prior to licensing actions. We're also looking at AI tools such as natural language processing to search and extract relevant information to make our documents and information more readily available. And Mr. Luis Betancourt will tell you more about the specific DSA activities in his briefing.

I also want to acknowledge that there are activities across research, including the RES bot (phonetic) and digital twin efforts in the Division of Engineering who will be meeting with you later this summer. We're taking a strategic look at planning for the workforce needs in the years to come. Kim had covered a few of those earlier in her remarks. So we did hire a full-time data scientist and several interns with data science backgrounds.

We also continue to remain focused on ensuring our people have the right training, skills, and abilities to accomplish the work we see coming in, in the future. The staff are building their foundation in these new areas through training and the use cases. And in the future, we anticipate having tailored training plans available based on the particular AI application they may be working. Next slide, please.

So where are we heading? So RES is taking the lead to prepare an NRC AI strategy to look ahead at the areas and skills that would be needed to address AI efforts. The strategy team currently consists of members from DSA, DRA, and DE in research.

So as we build the strategy, we need to find the future state of AI. The RES team is working across the program offices to learn about their current activities and needs. And research is hosting a series of workshops this fiscal year.

The first one is next week to serve as an introduction to AI. The second workshop is to discuss the current state of AI, getting more into use cases and ongoing projects not only within NRC but at DoD, vendors, and the national laboratories. The third workshop is focused on the identification of those future applications. Where do we see AI being used in the future?

And those workshops are a key part of us defining the future state for the AI strategy. Okay. So I've mentioned this AI strategy. We're organizing the strategy based on the potential application because each application would have a different need in the AI tool that's used, the resources, the skill sets and training for our staff, and the approach for NRC to be ready.

So some of the potential applications include the NRC internal business improvements. It could be the use of AI in analyses, as we heard earlier, the use for optimized maintenance applications, and even all the way over to the what ifs of an AI system to autonomously control. As part of the strategic planning and our current use cases, we can start to identify the tools and the training to develop the NRC expertise and the AI.

We're working toward a draft strategy coordinated with RES in the next few months. Once that's in place, we're going to expand the strategy team to include our partner offices so we can continue as a team to refine the strategy and what the plan will be towards implementation. We recognize that the AI area is an evolving landscape and that we must continue to look forward to stay aware of the upcoming research challenges so that we can start preparing today to be ready for that tomorrow. Next slide, please.

MEMBER REMPE: Teri, this is Joy again. Where is this AI effort? Is it still just a future focused research project? Or has it become a user need? Or where is it in the NRC research framework?

MS. LALAIN: Yeah. So Luis will get more into that in his briefing. We do have a user need with NRR that we're doing some work with. We are looking ahead to some FFRs.

The strategy itself is actually bigger than that. It really is looking at what areas and what we need to be ready for so that when work would come in that we're ready. So it's a little bit higher level for the strategy.

MEMBER REMPE: Okay. Thank you.

MS. LALAIN: Yeah.

MEMBER PETTI: And is the strategy across the agency and you guys are taking the lead? Is that --

MS. LALAIN: So we are taking the lead. We have collected what the other offices are currently doing in the area. We're getting the framework of the strategy together within research first.

So we can look at how as Research we would assess these systems. And we're going to widen as we get the framework of the strategy in place to membership onto the strategy from the other offices. So we're still in that stage of getting that framework together of what we think needs to be in that strategy, and then we'll expand the team and refine from there.

MEMBER PETTI: Thanks.

MEMBER BALLINGER: This is Ron Ballinger. Sometimes these programs precede what can only be described as glacial paces. With respect to AI, is there an effort to take a look at what may be done quickly and get off the ground rather than wait for some future document that identifies things great detail probably but avoids getting out of the blocks a little bit earlier? When you talk with your staff and somebody sits across the table and says, I think we can do this right now. Is there any thought to --

MS. LALAIN: Yes.

MEMBER BALLINGER: -- some kind of implementation scheme that takes advantage of the staff and something you can do right away? There's lots of databases at the (audio interference) plug in code words, you get an answer. But sometimes with AI, if you just look for patterns, you don't plug in code words. You get different results. And that's my story and I'm sticking to it.

MS. LALAIN: No, good question. So within the strategy, those areas I listed you could treat as kind of that capstone case. We eventually want to be able to do X. To do X, though, with a series of smaller use cases -- you can look at it as a series of smaller use cases to do Activity A and Activity B and Activity C, help us start to get that learning in there, give us immediate accomplishments in that area as we work toward what might be that larger use case capstone type case. Luis, was there anything you wanted to add to that?

MR. BETANCOURT: Yeah, I think this question is a valuable one. I think what Kim mentioned at the beginning, we're still at the infancy phases. But that doesn't mean that we are building our capabilities or learning about these technologies because as you mentioned, we need to be ready when potential applicants or licensees are going to be coming to us with a license application that uses AI.

And what we're doing right now with those -- and Teri is going to cover that in the next slide -- we're learning from other industries like Army, NAYS (phonetic) and so forth. So we can actually ask the right questions. In other words, like, we need to assess the what if scenarios, what is it that we need to be able to take credit in a safety evaluation?

We need to be able to confirm how AI systems behave and make predictions to make sure that they're within the licensing basis. But all of these are questions that we are basically asking ourselves right now. And that will be part of the AI strategy moving forward.

MEMBER BALLINGER: But what I'm saying is you have a very (audio interference).

MS. LALAIN: I'm sorry, Ron. You were breaking up.

MEMBER BALLINGER: Yeah, I got a speaker that's acting up. But what I'm saying is you already have, I'm sure, a very valuable staff that can -- may be able to provide input so that you don't have to wait for things. And my question was, is there some kind of plan that you can take advantage of to get out of the blocks?

MS. WEBBER: Yeah. So Ron, this is Kim Webber. So we've actually -- in DSA, we've been working in this area for over a year now. So we have worked with our counterparts in NRR who are also working in the data analytics area.

We've been identifying these use cases to learn, for instance, how to do text analytics. One of our staff, Trey Hathaway, is really heavily involved with text analytics. And that work started over a year ago.

So really what Teri is describing to you is that while we're doing the use cases in parallel, we also need to strategize. And what Teri is leading in our division is the development of this strategy so that we can encompass a lot of different potential industry use cases. And so we're building the skills through these smaller projects to learn the technologies and capabilities.

And again, that started over a year ago. And now what Teri is talking about is to really pull all the pieces together, not only with the Office of Research but potentially across the agency, because there's a lot of growing interest in this area all across the agency. So we're trying to get organized instead of everybody doing their own thing. Does that help?

MEMBER BALLINGER: What I'm saying is you're operating in parallel, not in series.

MS. WEBBER: Yes.

MS. LALAIN: Yes.

MR. BETANCOURT: That's correct.

MS. WEBBER: Right.

MEMBER BALLINGER: Okay. Thank you. Because remember AI is, to some extent, a buzzword.

MS. WEBBER: Sure.

MEMBER BALLINGER: We all know this. And a lot of -- I think your staff is probably already doing -- been doing what they would call AI. But --

MS. WEBBER: Yes.

MEMBER BALLINGER: -- now they just didn't realize it.

MS. WEBBER: Yeah.

MS. LALAIN: Yeah.

MEMBER DIMITRIJEVIC: This is Vesna Dimitrijevic. I don't have a question. I just want to make comment that this slide shows certain pessimism in this area because you have a telescope directed to the cloud in the sky. And then you have a total chaos on chessboard. So it seems to me that your expectations in this area are not so optimistic. So it's just a side comment on how I see this slide, so --

MS. LALAIN: I appreciate the --

MEMBER KIRCHNER: I agree. Vesna, I agree. I'm looking at that chessboard and saying, my goodness. There's a total collapse on the black side of the player's pieces. What the hell is going on? This doesn't look like --

MEMBER DIMITRIJEVIC: Yeah, and the king is making impossible moves. So I don't know. All right.

MEMBER REMPE: So if we're making comments, I have a comment. This is kind of interesting where research is taking the lead across the agency to do a strategy. Is this something that -- I don't recall of something offhand that you guys have done this before. So I kind of think it's a good idea. Is it new as I think it is? Or I just am not thinking of something at this time?

MS. WEBBER: It's new. And I think we still need to talk with partners across the agency to figure out what the right model is. So because DSA and the other divisions in the Office of Research started doing different use cases, they did future focused research proposals that were supported with funding behind, research is really looking more into the AI technologies and capabilities.

And a lot of other partners across the agency are looking into data analytics, how to represent our data. So this is all evolving. We're sharing this to you at an early stage just to give you an idea of where we're headed.

(Simultaneous speaking.)

MEMBER KIRCHNER: Kim and Teri, this is Walt again. Just remarking on Ron's comment, AI often becomes a buzzword, and it means a lot of things to different people. It may help to define your strategy by defining what you mean by AI because now early -- there are examples, for example, now in the industry where people are using what I'll call big data and analytics and then developing preventive maintenance strategies that revolve around analyzing that data and such.

And this is something that -- without making a plug for any one company or industry, General Electric has taken to great lengths in the jet engine business. And there's a lot to be learned from what they've done. But that's only one aspect of AI.

When I was a graduate student and I hate to admit that was 50 years ago, AI was really more about robotics. And when people talked about artificial intelligence, they were talking about replacing the human in the loop. And that gets to Teri, your comment about autonomous operations and such. And that's an entirely different level --

MS. LALAIN: Yes.

MEMBER KIRCHNER: -- of complexity and regulatory uncertainty than doing data analytics for preventative maintenance or tech spec compliance. So I think it might help up front to kind of define what

AI means to you and the agency and then start assessing things because, as Ron said, it's often a buzzword. And people will claim what they're doing as AI when it's just evolutionary technology whereas the robotics or whatever it was called at MIT, that lab, they had a different thing entirely in mind which was replacing the human. Just an observation.

MS. LALAIN: Perfect comment. So I'd like to add a little bit more information too, though. So for the first workshop we have coming on, it is that introduction to AI. And we know in the training and the things that we're going to across the agency, we have to establish that common vocabulary.

When we say AI, we mean this. If we say machine learning, we mean that, and all the other terms that go into it because exactly, the definitions have more -- as we're putting definitions in the strategy, we're citing the source, if we took it from somewhere else or if we're defining our own. So absolutely.

MEMBER BALLINGER: This is Ron again. You might consider asking the -- the industry what they consider the definition of AI is, also.

MS. LALAIN: Great point -- will definitely do that.

MEMBER BALLINGER: Because they would probably have a very different definition than some theoretical dictionary kind of thing.

MS. LALAIN: Good point. Thank you for that. And then as far as the applications, yes, that's why the AI strategy is broken out by different types of applications because you're exactly right -- to do some data mining is very different than one of the programs I was working on as I left Army was an autonomous, self-driving vehicle. So that was taking the human out of the loop for logistics and transport convoy operations. So very different need in what it was going to take to assess the performance and safety of that type of system.

So -- and that's why we want to break it out by what these capstone applications of AI would be, because then we can visualize what we would take to get there. Great comments, thank you for that.

MEMBER HALNON: This is Greg Halnon and I've got a comment also that I do hear in the industry the word AI being thrown around from everything -- mainly around inspections and monitoring. Are you guys tied in with the inspection branch in the regions as well to help educate some of the inspectors who might come up against, you know, a smart, young, engineer saying, we know this because our AI said it and it -- you know, that doesn't compute well with the inspector that may have been around for 25 or 30 years.

MS. LALAIN: So we're not there yet -- so thank you for that comment. We are still in our -- our early part of the AI strategy and the plan. So thank you for that.

MEMBER HALNON: Yes, I think they're going to -- they're going to run up against it fairly quickly so some preliminary education might be good when you get to a point where you can, you know, unwind the staff on it.

MS. LALAIN: Great. Okay, next slide, please. Okay, so we cannot be successful in our AI strategy without fostering strong working relationships to ensure that we're sharing that experience, the knowledge, and where possible collaborate to enhance our regulatory process and decision making. Establish cooperative partnerships with other organizations are key to leveraging that ongoing research. NIST has recently created a cross-government AI standards working group that's going to provide insights into the standards being developed and implemented by other agencies. Some of our partners will also be participating and presenting in those workshops that I mentioned.

So as I opened with the ability to assess the safety of AI systems is a question shared by other organizations, we just started having conversations with the different Army organizations doing AI work, including the group that is doing the internet things, to see what future partnerships that we may be able to establish with the agencies that may be further advanced in looking in how they would assess the performance and safety of some of these types of tools.

Finally, we recognize that actively engaging with all stakeholders will bring new ideas and approaches that's going to inform and shape how we undertake our regulatory activities. And all of that is key for success. And thank you so much for your time and questions today. I really appreciate it. There's nothing further for me. I'd like to introduce Dr. Chris Hoxie, Chief of the Code Reactor Analysis branch for his technical presentation.

DR. HOXIE: Hello everybody. My name is Chris Hoxie. I am Chief of the Code and Reactor Analysis Branch. I am here today to talk about multi-physics codes for nuclear reactor systems analysis. And I realize that coming after something fun like AI that you guys are doing -- I'm up against a tough task here.

The codes my branch are responsible for is the TRACE code. It's the NRC's flagship thermohydraulics systems analysis code. The PARCS code, which is a widely-used, nodal neutronics code, and the SNAP code, which is our graphical user interface. It helps the end users be more productive.

The types of reactors that we conduct analysis on include America's operating fleet, new reactors -- for example, small modular reactors -- research and test reactors, and advanced non-LWRs. We also participate in international experimental programs such as ATLAS and ETHARINUS. And we -- actually take the lead on some of them, like the ARTHUR-RBHT. I'll talk more about those later. This is just a title slide. So let's get on to slide 2.

First one says that code -- computer code development maintenance and V&V and application are one of the things we do. And that is true. But I want to make a couple of points. Computer codes in general, and TRACE in particular, have to be continuously developed. You see, I'm responding to, you've been working on TRACE for 20 years, aren't you done yet? And they've -- what I respond to that is, there are at least two reasons why you do have to continuously develop. The first is the computer hardware and the technology is just mind-blowing. It just continues to evolve and so you have to adjust your methods and your codes so that they develop them, if you will -- so that they work in the new environment.

We are working, for example, to paralyze TRACE so that it can better leverage the tens -- or hundreds, or sometimes even thousands of cores that we're seeing on the computers we run. The second reason is that -- people love to say, oh, it's first principled and so, you know, we can quit doing these experiments. I'm here to tell you that TRACE is not a first-principle code and to my knowledge none of the other popular ones in the world are totally first-principle either. And therefore, we end up having to utilize empirical correlations and in general these correlations are derived from representative experiments. So that's the answer to that.

The other thing we do is verification and validation. It's actually -- if you're looking at the challenges, it's harder to do verification and validation -- it costs more than writing the code itself. In other words, you can throw together a code and I could bring it to the ACRS and they'd say, why the heck should you -- we believe you? You haven't verified and validated it.

And then -- and the last thing that we do in my branch is we do code applications. What I mean by that is, in generally our CRAB engineers -- that's -- my acronym happens to be CRAB for the Code and Reactor Analysis Branch -- to perform audit or confirmatory calculations are what we usually do. We'll see a little bit more about these in a later slides. Slide three?

This was put on, and you'll see the branch chiefs that follow me will have a -- a thing -- and we're just trying to show sort of, like, where our branch plays in the thing. This slide lets you triangulate in on reactor, engineered safety features, and auxiliaries systems transport and storage. As you will see as we go through DSA's capabilities today, the four branches pretty much cover the waterfront. However, if you're just looking at my branch, not so much more -- not so much so.

We do almost nothing in auxiliary systems, transport, or storage. However, for reactors and engineered safety features, we cover a lot. The diagram allows you to draw the nexus between plant systems and features, and regulations that pertain to those features. For example, if you're talking operating fleet of our Bs and Ps, 10 CFR 50-46 is very important. Let's go to slide four.

This is a multi-physics reactor systems analysis development and regulatory applications. The slide pretty much speaks for itself. What I am here to tell you is that the NRC-developed codes are used in a wide variety of analyses and types to support the agency's mission. Slide five.

These are branch priorities. NRC engineers that work for me are generally driven by the agency's user need process. NRR is RES's customer. RES takes its assignment from the user need requests and from research assistance requests. And NRR sends that they -- NRR sends those over to us and reports -- in licensing topical reports, I should have said, and which have been the replies for approval of a technical methodology. That's another area where we do reviews.

Research reactors that use HEU, by the way -- there are still a few of those, and so we get tied in on those -- the three that -- and this is public information -- widely known. HEUs that use at NIST at

MURR and at MIT. And they're working, of course, to tune it down, so to speak. Slide six, international test programs.

The Code and Reactor Analysis Branch currently supports and participates in three international test programs. The programs are ARTHUR/RBHT -- that's one. ATLAS-3 and ETHARINUS. These experimental programs provide experimental data which are used to validate and verify the NRC's TRACE code. Here's a little bit more about ARTHUR and RBHT. ARTHUR is a $1.5 million , 3-year collaboration between the NRC and OECD/NEA organizations from some 12 countries. The scope of ARTHUR includes ten open tests and five blind tests. The RBHT facility -- which is the center of all this, it's the -- you know, where they do the work -- provides relative experimental thermohydraulic data for accident analysis of new and conventional LWRs. RBHT provides high-quality data. RBHT results -- demonstrate important effects of spacer grids on bundle thermal hydraulics. RBHT also provides detailed droplet size and velocity information. RBHT supports ARTHUR by performing tests that generate unique post-CHF film boiling heat transfer uncertainties.

RBHT itself, the facility, represents a

more-than-$15 million investment by NRC since the year 2000. And in passing I'll say that RBHT could be modified to investigate ATF -- just a thought. ETHARINUS and ATLAS are integral test facilities that provide data to help verify tests. The owners of these facilities watch for trends in the nuclear industry, and then they modify the experimental facility to allow simulations to -- be pre-formed that yield new data and many times fill gaps in the experimental database.

Recent examples of mods made to be allow modeling and are safe for natural circulation flows -- very important for many of the small modular reactors that are coming in. Slide seven. I'm sorry.

MEMBER KIRCHNER: Could you just give us the location of each of those experimental facilities? For the record?

DR. HOXIE: Yes, you can go back. Sure. And you can just Google these names and you'll find them. The -- I tried to -- that's a world map. The RBHT's at Penn State in the United States. ETHARINUS is Europe-based and they actually have deals over in, I think Netherlands, Germany -- but again, if you just Google ETHARINUS it will tell you all about it. And then ATLAS-3 is run by the Korean folks, and so it's

-- that's how come it's over on that side of the -- so I actually tried to pay attention to the map in the background.

MEMBER KIRCHNER: No, I just wanted you to put it on the record. Thank you -- thank you.

DR. HOXIE: Sure. Okay, I'll -- this is the author RBHT slide. And I think I've actually sufficiently covered in a previous slide, but I do want to say a few more things. I include this one on RBHT -- to celebrate the people. These are just some of the international group that we get the pleasure of collaborating with -- led by Dr. Steve Bajorek and Dr. Kirk Tien of my staff, we enjoy and benefit from the collaboration with some of the best minds in the world. The work that they've been doing recently I consider to be seminal work, sometimes called pivotal, or of landmark studies. To back that up, I cite the Best Paper Award bestowed on the NRC PSU team. It -- the paper was mostly written by a grad student, Grant Garrett, who was the lead author -- by the ANS's Thermal Hydraulic Division for the American Nuclear Society. And this was the award for 2020. It was delayed in being -- you know, we've been in a pandemic so they only recently made the award. Slide eight.

Okay, this is one -- those other ones are current ones that are active. This is one that we had at one time and we did some experiments and so we don't -- we are not doing more work there right now, but let me give you a status of what happened to the things that we did. We did put out one NUREG. It's listed there -- NUREG CR-72-72. And so here -- here we go. After NRC performed the KATHY anticipated transients without scram instability tests, the staff concluded a preliminary -- concluded a preliminary analysis of the data and this analysis informed both NRR's review of MELA Plus LARA (phonetic) applications, that were present at the time, and RES's execution of confirmatory analysis. The preliminary analysis of the data indicated that the failure to rewet could occur at lower surface temperatures than previously thought. And this prompted licensees and the staff to begin performing ATWS-I (phonetic) analysis using more conservative -- a more conservative model of the minimum stable film boiling temperature. This approach has been used in many recent licensing actions.

The preliminary analysis however is just that, and a more detailed and thorough analysis is still ongoing. Resources have been prioritized to support the licensing actions, but now RES is performing a detailed assessment of TRACE against the KATHY data. We expect this effort will be completed during the late summer of 2021 and will quantify the conservatism associated with the preliminary analysis approach.

In the fall of 2021 we will complete a statistical analysis that will allow us to develop a list of candidate trace consecutive models for changes to improve agreement between TRACE and data. At this point the RES staff will take a -- take stock of the results and a decision will be made about a final rather than an interim analysis approach for any future ATWS-I analyses. Slide nine --

(Simultaneous speaking.)

MEMBER KIRCHNER: Could you take a technical question on this? Can we -- afford the time? Just a quick diversion. If you -- if you're using TRACE --

DR. HOXIE: Sure.

MEMBER KIRCHNER: -- and adjusting -- this is Walt Kirchner. And yet you're adjusting the Tmin to try and match the data, like in oscillations and instability tests, that's a -- that's a backhanded way of going about determining Tmin. You may get agreement and not have the right -- necessarily the right phenomena and Tmin and -- and just get an agreement at a systems level. So it begs the question to me, are -- are you going to look at doing -- or are you proposing a new research program on Tmin phenomena? Would that come as a logical conclusion if you are concerned that the Tmin is actually lower than you thought it was? So you -- so that you're not using a systems test to try and backup your -- your conclusions, but you're using a -- a more targeted phenomenological test to examine the issue?

DR. HOXIE: I think those are excellent points. I -- I would -- that -- at some point you're going to ask us, how could we help? I want you to know that, if you -- one of the things you suggested there was, hey, you might have to look a little bit more carefully. Maybe a separate effects, or -- or do something more detailed about the Tmin. And I can just tell you with resources being what they are right now, that would be very hard to swing. But I agree that it is something that's -- that's important. But we're learning as we're going along and I think we could discuss more. I have other folks, like Steve Bajorek and Staudenmeier -- do you guys want to add anything?

MR. BAJOREK: Yes, I think one of -- this is Steve Bajorek. I think one of the -- the benefits and good characteristics of KATHY is it could be operated at high system pressure. I think it was full system pressure. I mean, it's -- you know, ten -- ten bar, something like that.

(Simultaneous speaking.)

DR. HOXIE: That's right.

MR. BAJOREK: And that is very difficult to find. Other studies on Tmin have shown that as you go to higher pressures, your minimum film boiling temperature gets closer to a homogenous nucleation temperature. Things that have been done at only low pressure have resulted in several correlations that don't have that correct pressure effect. If you want to get Tmin correct, okay, you -- you need to not only look at some of the local parameters -- the flow, the rewetting, the surface conditions on here, but also the pressure in order to get it right.

We've considered developing a smaller, shorter bundle like RBHT to do it. But as Dr. Hoxie pointed out getting the -- the funding for something like that is -- is extremely difficult. So we're going to try to maximize what we can get out of -- of KATHY, and hopefully at least come up with a -- a model for Tmin that is conservative for these types of conditions.

MEMBER KIRCHNER: Yes, thank you Steve. This is Walt. I -- I was just thinking, this might be a candidate for a university research grant kind of follow-on kind of activity.

MR. BAJOREK: It would be good. I think it's great. When I was at Kansas State we had a high -- we had a very small, high-pressure facility and that helped show that this Tmin turned around. But the -- the picture is incomplete. That was a pool boiling study. We really need some of the flow characteristics and to change some of the surface -- surface characteristics. And I'd almost like to -- like to, you know, almost thank Ivan Catton who recently passed away. He was a -- ACRS chair for a number of years and boy, he drilled that into me that you have to look at numerous parameters in order to get a phenomena like that correct. But thank you, good question.

MEMBER KIRCHNER: Thank you.

MR. STAUDENMEIER: Yes, I've -- this is Joe Staudenmeier. I have one additional comment on it. If you look in a code like TRACE, there's apparent Tmin and real Tmin. And the apparent Tmin in the experiment in matching that -- like, inverted annular film boiling correlations, and transition boiling correlations, and -- and Tmin itself correlations all come into play into what -- getting quenches right like that. And you can adjust any one of those three parameters and change quenches in the code. And getting everything right together can be difficult so you really have to make sure that all of those things are behaving in the right way in the code because they all combine together to give what the apparent Tmin is in quenching inside the code calculations.

MEMBER MARCH-LEUBA: Hey, this is Jose March-Leuba. Unfortunately almost everything I know about this test and mechanism is all proprietary, so we cannot talk about it in here. But on a related question, great, the NUREG 72-72 has been issued. Last time we talked, the data itself was still proprietary. And see, the biggest value for our money here will be to be provide the data to the other vendors so they could tune -- at a minimum, fudge their codes so they reproduce the results.

So what is the status of the proprietary review of the raw data? Chris?

DR. HOXIE: Yes, we're working towards, you know, helping in that area. We -- we do want to release as much information as we can. And, you know, that's the goal. We're not there yet.

MEMBER MARCH-LEUBA: Yes, at a minimum, we know we have a recommendation to use the homogeneous nucleation correlation, and we require it. When they do the calculation (indiscernible) they tune their codes to this data. So keep -- keep -- keep hitting them -- those lawyers -- and see if we can get the data published. Thank you.

DR. HOXIE: Yes, I will mention that some of the data -- and that is -- in that NUREG, and I would have thought that -- I'll have to check on that. I'm not the key. But I thought at least those data sets that were, you know, graphed and everything else in the NUREG probably are available. But I'll have to look.

MEMBER PETTI: Hey, Chris --

DR. HOXIE: Yes?

MEMBER PETTI: -- just a -- a point of order. I was looking at the agenda. Are each of you four going to take the same amount of time?

DR. HOXIE: That was the idea, and I'm -- I'm about up, aren't I?

MEMBER PETTI: You are imposing on the others and it would be nice for us to take a break at some point. I was thinking after yours was done. You still have a number of slides. So just see if we can turn up the RPM a little.

DR. HOXIE: I will do so. Okay, this is the BlueCRAB suite and it -- we use it for analyzing advanced non-LWRs. All the blue is DOE codes. Like I said, it costs too much. I could write the code to have TRACE do that. But it would cost me a fortune to V&V it. And so DOE has already done the work, so why not use it? So that's where we are with that. Next slide.

This is the status -- the -- of the plant models. I think you guys beat on that pretty well before, but what this shows is that there are seven models available of the reference plants. And -- it's -- I'm just going to go real quick, okay? We have closed a modeling gaps in that we have developed a simple model of heat pipe for use with the micromodel. We have identified data needs for microreactors and have been working with INL providing suggestions on design of test articles and test matrixes.

Gaps in modeling in molten salt reactors are being addressed often based on PIRTs that NRC developed a couple of years ago. Significant work is in progress at the labs to address salt properties and unique modeling issues, such as delayed neutron precursors circulating in your primary system. We are concerned about the need to run our codes on HPCS systems. Like I said, it's always changing. We've overcome those very nicely and we have the computing resources we need.

And last point, validation is proceeding. DOE is doing much of it, but we have done some of our own validation using FFTF and CEFR. So -- and in the future, when we obtain the actual designs, we will then look at gaps based on Reg Guide 1.203 by looking at scaling and the range of conditions for the database. So those are all coming out. Let's go to the next slide, fusion reactors.

I'm just going to declare that this is self-explanatory. All I want you to know is that there are -- vendors, or people who want to build fusion reactors in the United States, and we're trying to be ready for them. Next slide.

MEMBER PETTI: So, Chris, let me just say that I think you should focus on tritium technology and tritium behavior because anything that's coming in near term is not going to be a true reactor that has what I call fusion nuclear -- you know, the blanket and all that. It's going to be about, I've got some tritium, I'm going to puff it into the plasma chamber, make sure it's safe, make sure the workers don't get dosed. So that, in my opinion, would be where the focus should be nearer term.

DR. HOXIE: Yes, you see the third bullet there -- evaluate accident progressions --

MEMBER PETTI: Yes.

DR. HOXIE: -- releases and potential doses, yes.

MEMBER PETTI: Yes, yes.

DR. HOXIE: I agree completely, Dave.

MEMBER PETTI: Great, thank you.

DR. HOXIE: Next slide. Just real quick, yes we do computational fluid dynamics. I'll just say in -- to abbreviate it. CFD validation and benchmarking in anticipation of future work is ongoing. The Himeris-2 (phonetic) project work that we're doing is benchmark is such an example. And the second point is CFD is used to support fuel storage and transport -- transportation issues. And we have three user needs from NMSS in this area. And so that will do for that. Next slide?

MEMBER KIRCHNER: Before you go on, Chris, I know you've been -- this is Walt again. In your CFD analyses, I've seen some of the work you've done in the past -- as you mentioned -- can you do -- can you trace boron concentrations?

That's a leading question.

DR. HOXIE: I don't know, and I'm looking to -- to the -- is Chris Boyd or Ghani (phonetic) or Steve -- I think -- we'll have to get back to you on it.

MR. BAJOREK: Well you can -- in TRACE you can do it in a global sense. You know, in a large region you can tell how much boron is there. But if you're going to try to get it into details and natural circulation -- TRACE, you kind of have to hold your -- hold your nose and look at the results. CFD does a much better job of tracking things in -- in local regions. But when you start to get two phased conditions, that's where it has trouble. So it's a -- it's an area that's difficult for both of -- both -- both areas to really deal with right now and it's going to need more work.

MEMBER REMPE: Has there ever been any sort of experimental validation of boron circulation?

MR. BAJOREK: There's -- there's been some in PKL, which is -- now has that name --

DR. HOXIE: ETHARINUS, yes.

MR. BAJOREK: ETHARINUS. Again, it's more of a global-type of a distribution. ETHARINUS and PKL is kind of a large, one-dimensional type system. So you can see where it's at in the system. But if you're looking at internal recirculation as is what's important in some of the small modular reactions -- reactors, excuse me -- we really don't have the experimental database for that.

MEMBER KIRCHNER: Steve, do you -- this is Walt again. Sorry for the interruption. Do you -- do you deal with the CASL folks at all? I don't see that on your list of DOE codes, but and obviously that's for a PWR, but --

(Simultaneous speaking.)

MEMBER KIRCHNER: -- any connections with them? Because this is an issue they've looked at.

MR. BAJOREK: Yes, we -- we do talk to them and I think they have done a -- a study for us a number of years ago when we were looking at GSI-191. I think at the time they had a difficult time with that, again, because when you start to apply some of the CFD types of methods that they were using, when you get boiling and two-phase flow, that's where it started to have trouble. But yes, they're -- that's -- that's the type of direction that we would want to go to put into TRACE, like a sub-channel capability much like they're doing with -- with COBRA-TF now in CASL.

MEMBER KIRCHNER: Okay, I can pursue this with you offline. Thank you very much.

MR. BAJOREK: Thank you.

MEMBER MARCH-LEUBA: This is Jose. So Steve, would you say that TRACE does a pretty good job with one-dimensional boron propagation -- boron transport?

(Simultaneous speaking.)

MEMBER MARCH-LEUBA: -- have problems with numerical diffusion and all this good stuff, but --

MR. BAJOREK: Yes, I think --

(Simultaneous speaking.)

MEMBER MARCH-LEUBA: As long as you're one-dimensional, you're good. If you're three-dimensional you start getting problems.

MR. BAJOREK: I agree. You said it very well. One-dimensional in more of a global sense, TRACE doesn't do too bad. It will tell you when you're very close to precipitation. But if you're looking at smaller concentrations where numerical diffusions can take over in a 3-D geometry, sorry. It's -- it's not going to -- it's not going to give you trustier results. But thank you.

DR. HOXIE: Okay, and last slide please. I'll abbreviate. If the slide is fairly self-explanatory. We have accomplished a lot and I am very proud of my engineers. We look forward to executing the future plans that are on the slide. And with that, I've reached the end of the presentation? Any questions, or -- I think you've been asking as we go.

MEMBER REMPE: Chris -- Chris, this is Joy, just to make sure -- is it true that so far all the reference plant evaluations have been accomplished using SCALE and MELCOR? Has anything else been used in the BlueCRAB suite?

DR. HOXIE: The answer is yes.

(Laughter.)

MEMBER REMPE: What else has been used for the reference plant evaluations that we search -- in presenting?

MR. BAJOREK: This is Steve again. We started off by developing a microreactor model. It was based on the INL special purpose reactor A. We developed that and then we modified it to look much more like the Applicant. Same fuel product. Geometry was very similar. And we used that to address a user need request -- to look at some specific issues and concerns that they had regarding that type of a reactor.

We used those results and we've given those back to NRR. And they've used those for a number of RIAs and they're working with the Applicant to -- to resolve those. The things that we also found, we have been working with INL experimentalists in order to give them suggestions and recommendations for their experimental work in order to close some of the gaps that we foresee. We've also developed a model for the PB-FHR, which is similar to another applicant.

However, again we've taken that model and we've added other features in to give it the right bypass and natural circulation and are at the point very soon that we'll be able to start doing some simulations. In anticipation of that application coming in, we also have four or five other models that we've completed and we're -- we're testing them out right now. That -- that's just more of a examining the codes and making sure it's doing what it should be doing. But at least two of models we're -- we're pursuing more with the applicant it has in mind.

MEMBER REMPE: So again, what codes are you using besides SCALE and MELCOR? Could you -- I mean, it sounds like -- are you using a CFD code?

What are the other codes you're using so far?

MR. BAJOREK: For the microreactor model we've used MOOSE for the thermomechanical expansion, which is very important for that type of a reactor, SAM to model the heat pipes. And we used a very -- we developed a simplified components. We heard you when you said, keep it simple. And we've been using GRIFFIN to give us the neutronic feedback.

MEMBER REMPE: Okay, thank you.

DR. HOXIE: Okay, I'm done.

MEMBER PETTI: Okay. Well, why don't we take a 15-minute break and we will then firstly -- unless we speed up -- go beyond the agenda, but hopefully not more than 30 minutes at this point. So let's recess until the top of the hour.

(Whereupon, the above-entitled matter went off the record at 3:46 p.m. and resumed at 4:00 p.m.)

MEMBER PETTI: Okay, good.

MR. ESMAILI: Okay, good afternoon.

MEMBER PETTI: Go ahead.

MR. ESMAILI: Sorry. So, good afternoon. My name is Hossein Esmaili. I am the fuel and source term code development branch chief.

As of last September, many of you know Richard Lee, but he retired last December, so I am new in this position. He had already done a great job of building the branch with highly skilled staff who continue to do amazing work.

And I actually have some of the staff, FSCB Staff here in case there are some specific questions as I'm trying to, my best to learn the other areas because my background has been in severe accident analysis.

Next slide please. So one of our main function is the continued development of the state of practice computer codes in these three areas.

For neutronics, for us, it's SCALE, for fuel it's FAST, and for severe accident it's MELCOR. So to be successful in the validation of our computational tools, we leverage domestic international resources participating experimental programs.

In the international area, we not only obtained access to data of the reduce cost, we also shared the codes with our partners through various programs. It just helps us in the code improvements.

And of course, in the end what we want to do is to maintain staff technical expertise. And this is very important, actually, because one way to do this is by exercising the code to see how different systems work.

So having a code and seeing how different technologies work is a great learning experience. It's been for me, and I think it's been for a number of people in the branch.

And finally, we engage with internal and external stakeholders to support agency risk-informed regulatory decision making.

Next slide please. I really like this slide. I saw this the first time a few years ago back in 2019. This is when John Monninger was presenting in terms of, you know, what we do in terms of confirmatory analysis.

So the main reason we develop and maintain these computer codes is to support our regulations and licensing reviews.

This is a convenient picture. It tries to link the role of the codes with specific regulations. The codes cover a wide range of areas. Fuel performance, reactor systems analysis, containment analysis and source term analysis.

This is the same slide that Chris Hoxie was using, but since we have SCALE and FAST and MELCOR, we cover larger areas.

We use the codes for normal operation,

design basis accidents and severe accidents. They're used for confirmatory analysis and audit calculations to support decision making.

And one area where the burden of the proof is on us, is potential rulemaking. For example, we use the code extensively in post-Fukushima work, such as the spent fuel pool study or containment protection and release reduction.

In the next three slides I just want to give a brief overview of these three codes, and what they are, how they are used, how they are assessed and how they support our regulations.

Next slide please. So I'm going very fast. By this time I was expecting to be interrupted, but that's okay.

(Simultaneous speaking.)

MR. ESMAILI: So this is, sorry, was there a question? Okay.

So this is a theme for all the codes. This picture shows, what we see here is in the middle, is the code. In this case it's FAST.

The input to the code is the programs and phenomena. These are what we have in the left boxes in the columns. And what you see on the right is a support for the program office.

FAST, is the fuel analysis under city, state and transients. This calculates the term of mechanical response of the nuclear fuel under city, state and accident conditions.

It is used to support licensing reviews in NRR by assessing specific specified acceptable fuel design limits, evaluating render fuel codes and methods and providing initial conditions for design basis analysis. It's also used to perform spent fuel cooling analysis to support NMSS reviews.

So I don't intend to, if there are no questions, I don't intend to go over this slide in great details. I will just talk about the priority items in the later slide.

Okay, so next slide. So one of our top fuel priority is the development of the research information letter.

This was summarized experimental research, experimental research program.

(Simultaneous speaking.)

MR. ESMAILI: Is there a question? I'm sorry, I --

A summarized experimental research programs and data on this topic. It will introduce, this will introduce limits for FFRD, fuel fragmentation and relocation.

A related phenomena becomes significant. For example, when the burn-up, when the fragmentation is significant that can lead to a dispersal if the cladding fails. And once that fails, the best fraction of dispersible fuel, as a function of the burn-up.

So, it's currently undergoing internal review. We will be happy to present information in this area at a future ACRS meeting and dive deeper.

So this is, I wanted to socialize this with, you know, take this opportunity to socialize this review and see if there is an interest on the part of ACRS. We can come back and give a more, dive deeper into it.

So, of course, when it comes to new fuel designs and technologies we work very closely with other program offices participating in meetings with fuel vendors. And also, we basically have like monthly meetings, et cetera, that we talk about our progress and what the industry is doing, et cetera. This will help us focus our research and to keep up with industry priorities.

Second bullet, FAST. In FAST Version 1.0 was released in April of 2020. We anticipate the release of the later version of the FAST 1.1 this year.

And work is ongoing to couple FAST and TRACE to the MOOSE framework. We will streamline the coupled codes analysis.

Actually, this was very good for me. I participated in my first meeting yesterday on this FAST/TRACE coupling. And so it's a very interesting work.

Data generated in SCIP III and SCIP IV will support FFRD data and insight development.

NRC is still part of the Halden Reactor project till 2023. But you have been briefed on the Halden project and the upcoming FIDES project.

FIDES was launched in this year, in 2021, with four Joint Experimental Projects, or JEEPs. This covered CODEX cladding creep, high burn-up fuel performance through power ramps and high burn-up fuel performance during reactivity initiated accidents.

Other programs that we are involved in, in terms of a fuel, is EPRI and NSRR. This is the work that's don't in JAA in Japan, and SPARE.

EPRI and NSRR continue to produce new data on reactivity initiated accident performance for advance fuel and cladding. This can be used for code validation for new fuel design.

SPARE really focuses on saving materials from the Halden project. From the final disposals. Halden has been shutdown as of 2018, as you were told back in February. And the goal is to transport the selected fuels from the Halden facility.

So the last point, when it comes to codes familiarity by the Staff, and I think this is when we briefed ACRS some time ago on what we were doing with non-LWR. One of the points that you all made was that we continue with our tools, but we should be aware of other tools and understand them.

And so, in the spirit of what you suggested after that briefing, on non-LWR plans, the FAST team is actually using BISON. They have gone to some workshops so they're learning what's in the code. And it's become, from what I sense, becoming very, very useful for us.

Next slide please.

MEMBER REMPE: Hossein, this is Joy.

MR. ESMAILI: Yes, ma'am.

MEMBER REMPE: On that slide, I was just kind of waiting until you were done. I'm going to ask you sort of the question I was asking Kim earlier, since you mentioned this NRC meetings with fuel vendors and DOEs.

One, has the Staff emphasized that they do need some data, and how receptive are the vendors and DOE to such comments?

I know you have done this PIRT and it seemed to me that, because it's publicly available, that ERI did, that that sure came out in the PIRT. And are they taking note of this saying, yes, we'll get that data. Because I am not quite sure whether we'll get some of the integral test data that, during the radiation testing since we don't have Halden.

MR. ESMAILI: So, Joy, that severe accident, that PIRT that you're talking about falls under the severe accident area, so I'm just going to get to that a little bit later.

MEMBER REMPE: Sure. Whenever.

MR. ESMAILI: But you are right.

MEMBER REMPE: That's fine.

MR. ESMAILI: But you are right. And I will tell you what we are doing actually.

But you are right. We are, we do have these periodic meetings and every chance we get we emphasize the need for data.

And I think I understand this. There are programs that we are actually participating in, you know when I get to some other ones, and then they're like QUENCH-ATF for example.

We are looking at chromium-coated. This is something that we are interested in and the industry is interested in, EPRI is interested in. And they're participating in these programs.

And so, yes, we are emphasizing the need for data, but at least in some of the areas we are not waiting back for those data. So when it comes to our codes, we are building the infrastructures so when data becomes available we can actually use this data in our tools.

Hopefully that answers your question.

MEMBER REMPE: It does. Thank you. I will have a question later on, on this same topic, when you get to the codes because I had a question on how you're doing the updates to MELCOR, but I'll wait.

MR. ESMAILI: Sure. Thanks. All right, next slide please.

So, in terms of neutronics the Staff has been developing, assessing and using SCALE for about 40 years now. SCALE, it was a consolidation of separate computer codes that were difficult to maintain.

And basically not that much different from

MELCOR. MELCOR was also a collection of different computer codes that we kind of integrated together.

So the code now supports Staff and nuclear data evaluations and hybrid regenerations, criticality, radiation transport, decay heat and sensitivity and certainty analysis. It's used by NRC and in 61 countries. About more than 10,000 users and 33 regulatory bodies. So it has a very wide user base.

It's used to support licensing activities in NRR and analysis of spent fuel criticality generating nuclear physics, decay heat parameters for design basis accident analysis. And also, extensively by NMSS. The review of consolidated interim storage facilities, burn-up credit, et cetera.

And you know, it does, the data that's generated by SCALE is of course, we have something down there that we do use that for MELCOR. And once I get into this non-LWR project I will explain how we are doing that.

When it comes to parts, this is actually under Chris, we put it here, this is under Chris Hawk's branch. It's our core simulator. It provides problem specific nodal data, so I don't want to discuss that too much here.

Next slide please. So in terms of neutronic priorities, this summer we plan to issue a production version of SCALE 6.3. This will include updates to the code, which will be useful for both light water reactors and non-light water reactors.

And we will also make available a better release of SCALE 7. That's coming soon. And SCALE will focus on enhancing existing capabilities for non-LWRs.

For ATF, HALEU, and high burn-up. We have developed a detailed plan that is divided into two phases.

In Phase one we looked at the impact of HALEU, evaluated currently certified transportation packages for transportation on irradiated, extended enrichment uranium in various fuel forms, impact of HALEU and high burn-up and ATF. This includes chromium-doped and chromium-coated FeCrAl and lattice physics phenomena.

And in Phase 2 we start to look at entire analysis and back-end. And so, these are the type of things that we have been doing in SCALE.

And most of you know that when you are using SCALE, we used that extensively also, if you're interested, Joy, in our MELCOR analysis. This is for

SOARCA and we're doing this for non-LWR.

And to that point, for Volume 3, SCALE is supporting MELCOR and source term demos.

And with Volume 5 we just brief you, I think this was some time ago, I forgot. Yes, it was April or February, that we briefed you on Volume 5.

And we just received some resources. And our initial effort will be to develop the reasonable scenarios that could support us in each of those ten reports that we expect to develop.

So we're starting to do some work on Volume 5. But right now our focus is on Volume 3 and the demo calculations.

We also plan to have the next SCALE workshop in August or September time frame. So that's coming up.

This is a major workshop involving users from around the world. And as I showed you, there are many users around the world.

In terms of PARCs, again, this is in Chris Hawk's branch, but Staff in FSCB are supporting Chris in the CRAB branch. And specifically, Kim mentioned Mike Rowe. And I have two staff, Mike Rowe and Andy Billing, who are doing this plant input text.

Comes to familiarity, to code familiarity by staff. We are focusing on BlueCRAB. So Andy and some of the folks, they attend the BlueCRAB meetings. And Andy is specifically looking at the GRIFFIN code.

Next slide please. All right. So, this is our severe accident code. MELCOR is our severe accident code.

It's a system level code simulating the entire spectrum of accidents and phenomena from initiation of the accident to core fuel degradation and fission product release from the fuel and transport, to the containment and to the environment. Because a large user base, both domestic and international, I have it at the bottom. This was some time ago. There were about 1,000 code users. One-third of them are in the U.S.

Internationally the code is distributed as part of NRC's cooperative severe accident research programs. And as you can see here, the code requires SCALE input for decay heat and fission product inventories.

And the output would be in the form of source that can be directly read by MACCS. And what I have shown here is some of the programs that we are currently involved in on the left-hand side.

Like DENOPI, this is the program at RSN, the FIDES, the ROSAU project that's there. And what type of phenomena we looked at because when we are looking at MELCOR it's a repository of our knowledge.

Okay, so next slide please, if there's no questions. All right. So, in terms of severe action source and priorities, one area that we are focusing right now is code modernization.

This is a multi-year program. The basic idea is to separate numerics from the physics. And to work on major code packages on each here.

As some of you may know, that MELCOR is a modular code, it's divided into different packages. And so, this year we are focusing on the term of hydraulic package and trying to modernize that package. And in the later years we are getting into core package, radionuclide package, et cetera.

Is that where you wanted to ask a question, Joy, or, okay.

MEMBER REMPE: Actually, yes. Thank you. Many years ago, I know we were engaged in a meeting, and we talked about when you analyze a severe accident with ATF that there was some difficulties in the way MELCOR was configured because it could not look at the channel boxes and other zircaloy or stainless steel components separately from the fuel.

And it was, it needed to have some major reconfiguration done so you could more accurately assess the effect of the ATF but still allow oxidation of these other components that could produce hydrogen and other combustible gases. Has that been done yet or where are you guys on that?

MR. ESMAILI: Not in the modernized code, Joy. As I said, this year we are just focusing on the thermal hydraulic parts of the code.

And in the next two years, in 2022 and '23, the major emphasis would be on the core package. And that is where we are going to make those changes.

This is something that Sandia and co-developers have been asking for a long time. They wanted to make basic changes so it would be easier to introduce new components and materials.

For example, one of the things that we saw, this is not ATF, but when we were looking at nitrite and effects, like the code can calculate, for example, the oxidations, et cetera. And we can simulate the effect of air ingress and oxidations, but for us to actually produce a ZrN layer, for example, a zirconium nitride layer, it would have involved a lot of work.

So we are hoping that the, so, the way we are going to do that is that it's going to be much easier for us to introduce new components, et cetera.

However, because of the work on ATF, we are continuing, for example, we are doing assessments of MELCOR against the FeCrAl test. This is the QUENCH 19. QUENCH 19. This is the test that was done at Karlsruhe Institute of Technology.

We are doing some comparisons. We did a current version of MELCOR, we think we can do that with QUENCH 15.

So for in the near time we are relying on the current version of MELCOR, which is our workhorse. In the coming years we are just trying to make that easier to introduce components, et cetera.

MEMBER REMPE: So for right now, when someone presents a MELCOR calculation to me and claims that, look, I get a couple more hours because I use ATF, I'm going to look at it a little suspiciously and say, did you consider the other components that can oxidize? Is that a fair thing for me to be saying back to them?

MR. ESMAILI: I don't think so because we are, we are actually, even in this current version of the code, we are actually producing some generalized oxidation model. So it would be easy for us to oxidate other, you know, oxidations of other materials also.

And in most cases, Joy, like, let's say chromium-coating, right, we just have a thin chromium-coated layer, right. And what QUENCH-ATF is going to give us is that it's going to give us data on the oxidation kinetics of this chromium-coating.

And what the severe accident PIRT, this was concluded, and I think I'm going to get into that on the next slide, but what the severe accident PIRT, the panelist discussed is that where we need to put our priorities. You know, how important is a chromium layer on top of the, is it going to significantly affect the melt progressions.

And so far, based on what we have seen, and again, the report is public, is that we can handle a lot of those things. A lot of this problems that, or issues that they raise, to sensitivity calculations because right now we are actually looking at the high burn-up. And they have said, you know, look at this, this is important, this phenomena is, for example, from physical properties, et cetera, is important.

But we can handle that right now, true sensitivity. The code has the capability for us to do some of those analysis right now.

MEMBER REMPE: So I should ask then how they approximated it --

MR. ESMAILI: Yes. Yes. And --

MEMBER REMPE: -- better understand that --

MR. ESMAILI: Yes.

MEMBER REMPE: -- because they can't quite do it. In addition, there is no data for a lot of these other things too, but anyway, thank you. I think I have explored this enough.

MR. ESMAILI: Yes, okay. All right. So, this year we are also --

Okay. So actually you, I'm back at my talking point. So we are looking at the code improvements for ATF, high burn-up. These are based on the insights from severe accident PIRTs, as I just explained to you.

We are, of course, leveraging international research. This is through our participation in the CSARP, MELCOR code assessment programs.

And we have two international programs, other international programs. One is the European MELCOR user group and the other one is the Asian MELCOR user group.

So we do participate in these programs. There are 27 countries that we actually have bilateral agreements with. And we share a lot of information. A lot of them are code users. And so, we benefit from these users doing the code-to-code comparisons.

And I think you know that it has been code, crosswalk comparisons between MELCOR and ASTEC. ASTEC is the French code. And there has been actually crosswalks for, between MELCOR and MAAP, MAAP is the U.S. industry code. And so we benefit from our understanding of how accidents progresses.

So, in terms of OECD/NEA projects, we are involved in a number of them. I have listed some of them here.

There are two projects that are Fukushima related. This is PreADES and ARC-F. These are coming to an end this calendar year, but there are plans for a follow-on work. This is something that the, our Japanese colleagues are very interested in continuing this work.

And we are looking at, we are participating in these programs. We are leveraging, sometimes we are participating just to understand what type of information is available.

And then we can make the decision whether the information becomes available, do we need to make any changes in our code or does it improve the code capabilities. So, it's important for us to participate, to some extent.

So, ESTER is a program that we just started. This studies long-term regulatory releases mechanisms that focus on re-degradation of surface deposit inside the RCS and the containment and on iodine chemistry.

We think it's very important for us to understand this. Especially when we are dealing with some of these long-term accident conditions.

ROSAU, this is a very big project. This is another OECD project. It's conducting experiments. This is at Argonne National Lab on effects of molten core-concrete interaction using particular materials.

These are relatively large scale. This project has benefits for the U.S. NRC and the Nuclear Industry. Some of them are participating in this program.

This would improve our knowledge for applications with potential accidents involving, for example, sprex (phonetic). We have briefed all of you before on severe accident water additions, severe accident water management as part of post-Fukushima containment protection, release reduction. And this would be additional data to have confidence in our code capabilities.

DENOPI is an IRSN project. This is investigating spent fuel pool fuel coolability. This is something that we discuss in SECY-160100.

At the time there was, after the Fukushima and there was a review by the National Academia of Sciences, that they wanted us to look at the MELCOR and how it does things and the validation basis. So as part of that, we are participating in this DENOPI project.

And this is mainly one aspect of it that we are very interested in is spray cooling of fuel assemblies.

Finally, there is MUSA. This is management uncertainty of severe accidents. We focus on uncertainty analysis methods that are used to quantify it. So as part of our contribution we provide specific insights from SOARCA for reactor spent fuel pool study and for the spent fuel pool evaluations.

And we are not doing, so we are relying mostly on the studies that we had done before. As I mentioned, SOARCA, spent fuel pool. And this is something that Mike Salay and Tina Ghosh are involved in. And I am also, to some extent, because I was involved in the spent fuel pool evaluation.

For light water reactors, for the small modular reactors, the water-based NuScale FSAR is completed. We are currently working on the GE-BWRX-300 containment analysis using MELCOR. And we are also exploring the need to do a severe accident analysis. And the same is true for the Holtec.

We are a little bit further along with the GE-BWRX-300. Shawn Campbell, from my Staff, he has already built a MELCOR input deck and we are exercising this currently as we are going through this audit.

Next slide please. So, in terms of MELCOR we are using it extensively in Site Level 3 PRA, reactor and spent fuel pool.

MELCOR analysis have been, for the reactor, spent fuel has been completed and we are in the process of, I think, the MACCS folks are trying to use that to do the consequence analysis.

Three people from my branch, Mike Salay, James Corson and Shawn Campbell, have been very, very instrumental in providing support to NRR because they are currently going to a revision for Reg Guide 1.183.

They have been providing information on fuel handling accident analysis, reevaluation of settling velocity distribution on multi-group methods.

This actually has to do with the size distribution, settling velocity and MSIV. You know, what type of aerosols do you find in the containment versus in the main steam line.

And just recently, the impact of FFRD on source term. This is the work that we just completed. We are trying to wrap that up. And this is going to be another input to this Reg Guide 1.183 revision.

In terms of non-LWR plant reactor designs, Kim already discussed this. We are focusing on Volume 3 and 4 when it comes to MELCOR.

Source term demonstration calculation using SCALE and MELCOR. We have already done two staff only meetings, and we are getting ready to do the public meetings in the coming months.

We are focusing on three reactor designs. I think Chris Hawk's, he mentioned heat pipe reactor, INL design aid. And for a high temperature gas cooled reactors we are using PBMR-400. And we are doing PBFHR for a pebble bed molten salt cooled reactor.

One area that we are also working on, and this is actually a little bit between INL and Sandia, is that we are trying to migrate old MELCOR fusion version to MELCOR 2.2. I think this is, Dr. Petti was discussing this.

The older version of MELCOR has been used extensively by the, by our international partners. Especially some of the European partners, they are looking at either.

But these are the old cold versions. What we are trying to do right now, we are trying to get some resources, in the coming years, to migrate all those models that was developed by Brad Merrill of INL into the newest version of the code.

Accident tolerant fuels, the severe accident PIRT that has been significantly, so we looked at significant human logical issues to improve MELCOR. This work was completed recently in April of, I mean, two months ago. And the report has been made public.

We are in the process of issuing, there is a NUREG CR. This actually was a good piece of work because not only did they look at ATF and high burn-up and other stuff, but they could baseline it against conventional fuel and understand where, okay, Joy, I think you have, yes, this is where you were asking.

MEMBER REMPE: Well, I didn't want to

interrupt you while you were talking, but with respect to this PIRT, I think it is a good document. And could you send the link to Hossein so he'll make it available to all the members because it is --

MR. ESMAILI: Absolutely.

MEMBER REMPE: -- publicly available. Sorry to interrupt you.

MR. ESMAILI: No, no, no, absolutely. I am actually hoping that you would interrupt. All right. And so I will send you the link to that.

And so, for accident tolerate fuels, the other thing that we are actually starting on is the QUENCH-ATF, I described that a little bit earlier. The focus on that one, these are the experiments that's done in the QUENCH facility at KRG in Germany.

We are going to look at chromium-coated cladding under both design basis and beyond design basis conditions. You know, under design basis you're just looking at clad ballooning, et cetera. And in beyond design basis severe accident we are just going to look at the hydrogen production, et cetera.

It's my understanding that the, I think we are at the end, almost, on signing the agreement. But KIT has been actually getting ready to have actually, I think they're trying to get some samples from

Westinghouse to start as soon as possible.

Next slide please.

MEMBER PETTI: Hossein, just a question.

MR. ESMAILI: Yes, sir.

MEMBER PETTI: These bulleted lists, they're not in any priority?

MR. ESMAILI: No, not at all. We are working on --

MEMBER PETTI: Okay.

MR. ESMAILI: -- all of them because, you know, I forgot what the bullets were, can you go back.

(Laughter.)

MEMBER PETTI: So yes, I mean, the accident tolerant fuel is the last thing, that doesn't mean it's the lowest priority?

MR. ESMAILI: No. We are all high priority for us. Non-LWR is high priority, that Reg Guide 1.183 is high priority, the ATF. Every single one of them is high priority.

But we are managing all the work. We have a combination of in-house staff. And also we are leveraging DOE, industry at Sandia to do the work for us.

MEMBER PETTI: Okay.

MR. ESMAILI: So everything is high

priority for us right now.

Next slide please. So, some selected accomplishments, future plans. We had three major code releases, FAST, MELCOR and SCALE.

As I mentioned, FAST, that was done in April. MELCOR was done in December of last year. But since that time we have made substantial and significant changes into MELCOR actually, as we are doing this source and demonstration calculations.

Severe accident PIRT, that one is done. But we are checking that insights because right now we are in the process of actually generating source, the high burn-up source, they're using MELCOR for the higher burn-up fuel. We are looking at burn-ups of up to 80 gigawatt days per metric ton of uranium.

And so those calculations are going to be, are going on. These are going to be, look like Tables 1, 2 and 4 in Reg Guide 1.183. So we have to have the, we are hoping to have that by this fall.

MEMBER REMPE: So, aren't there some uncertainties in these source terms because of the lack of high burn-up data to characterize how interactions with fission gas release affect the cladding or the, it just seems like, I mean, are you putting caveats saying, of course, we don't have data for all of this?

MR. ESMAILI: So, in terms of fission product release, you know, we are relying on the (indiscernible) experiments, you know, were done, were core right. They were done all the way to up to about 72 a gigawatt day. So this is actually the release models that we are using for our current.

In terms of, so what the PIRT panel has identified was, for example, some physical properties, right. Or the porosity of the debris, ex cetera.

We are trying to handle those two sensitivity calculations. We don't think there is a need to go to experiments because we cannot resolve at that level.

And it is common thread with what we have done before. We have done the high burn-up source calculation back in 2011. Right.

This is the work that was done at Sandia. At the time, actually, Dr. Powers and everybody was involved in. This is just a redo of what we have done before, with insights from this PIRT.

MEMBER REMPE: So I'm going to push it further. There is actually, are there are data for the high burn-up fuel in conjunction with the claddings proposed for ATF, for all of the different designs?

MR. ESMAILI: I am not aware, Joy. Here we are just looking at the high burn-up. This is --

MEMBER REMPE: Okay, so you're not using ATF --

(Simultaneous speaking.)

MEMBER REMPE: -- just doing the high burn-up fuel.

MR. ESMAILI: No, no, no.

MEMBER REMPE: Okay. That's where I'm kind of going.

MR. ESMAILI: That's correct. That's correct.

MEMBER REMPE: I don't think there is data and there is going to be --

MR. ESMAILI: No, no, there is not.

MEMBER REMPE: -- interactions.

MR. ESMAILI: Absolutely not. Right. And again, we are trying to absorb what the panels have told us. The high burn-up is a redo of the 2011.

We are focusing on the chromium-coating for next year. And we are just trying to see what we can do. And the other ones are going to come later. If they come.

So, we have multiple international, did I answer your question, I'm sorry? Yes.

MEMBER REMPE: Yes, you did. I'm sorry, I was on mute.

MR. ESMAILI: Sure. So, we have multiple international agreements, FIDES, QUENCH-ATF. These are, you know, we actually, actually getting everybody to sign off on these international agreements takes a long time, so we have started on all of those.

Just recently back in the beginning of June we have conducted CSARP/MCAP. We did European medical user group meeting two months ago. This was supported by Hungary.

And we have an upcoming Asian MELCOR User Group. This is being coordinated by Singapore. As I said, we have a SCALE MELCOR, SCALE user workshop that's coming up.

So I have a little bit of advertisement here for the, we have completed the input decks for the non-LWRs. And we are going to have public meetings, that you can see at the bottom here.

Actually, next Tuesday, if you have nothing to do, we have, on June 29th, we have the heat pipe reactor. This is a public meeting from 1:00 to 4:00.

If you go on the NRC website, you can

click on this and it gives you all the information on how to join that meeting.

The gas cooled reactor is coming up on June 20th. This is where, in all these cases, where the Oak Ridge team and the Sandia team and NRR, we get together and discuss what we had done and what to expect. So it's very informative.

Pebble bed, we have not done the staff only workshop yet. It's going to come up in August, followed by the public workshop on September 14th of 2:00 and 3:00 2021.

So we are on track to finish all of these reference calculations. I think that's the last slide. Thank you.

MR. BETANCOURT: Okay. So I guess this means, thank you, Hossein. So, good afternoon, Members. My name is Luis Betancourt, I am the chief of the accident analysis branch.

As Hossein mentioned, I recently started in this position around three months ago. And I have been very impressed by the work that the branch has done in the last two years, which I hope to highlight today.

So I think it has been a couple of years since I had the pleasure to be in the front, in the hot seat in front of you, so I am very happy to see many familiar faces again. And I look forward to your questions.

So today what I plan to cover in my presentation is what are we doing to ensure readiness in the area of consequence analysis for both the assisting fleet as well as the integrated terminologies and how are we planning to prepare some agency to adequately evaluate the use of data science and artificial intelligence in our regulatory activities and how we do plan to leverage these technologies to enhance our business processes as well as identify future research needs.

Next slide please. So, pictured on this slide is four train, or four major areas for the branch. So from a historical perspective, one of our primary focus areas has been the analytical, as well as experimental research projects in the areas of progression, response and offsite consequences of postulated severe analyses, as you know.

Consequence analyses is an essential tool that is used to inform determinations of reasonable assurance of adequate protection, understand that there are power hazards, measured development regulations, as well as help us appreciate the importance of nuclear safety.

In the area that our branch is actually developing expertise in capabilities, at least in the area of data science and AI, one of the main reasons that we are focusing the expertise in our branch is because our staff gained valuable experience in data science, one that we're generating and working with these large data sets in the uncertainty analysis, as well as the Level 3 PRA story.

So even though some of that workload associated with those two PIRTs are going to be coming to completion in the next two years, we do expect an increase in the workload in these areas for future plant designs.

We're also leveraging resources to develop and regulate some of the analytical tools that we have, such as the MACCS code, in order to be able to advance the scientific and technical knowledge base and consequence analysis.

And finally we do maintain a broad expertise in this area. So we do have provide consultation to support the program offices in the recent forum regulatory decision making.

Next slide please. So as you heard from Hossein's presentation, we're planning to use this slide to convey, at a high level, where do we fit in the picture of supplying the program offices.

So, in our case we fit in the area of under protection against radiological release where we primarily used the MACCS computer code, which is a sequence consequence coexistent to be able to simulate the impacts of severe accidents at nuclear power plants under surrounded environment for a variety of applications.

And that would include the evaluation of SAMES and SANDES (phonetic), the regulatory cost benefit analysis, consequent studies like SOARCA, the Level 3 PRA studies, as well as evaluations for emergency planning. And our branch also helps in the development of the code and consistent standards relating to consequence analysis for the non-light water reactor PRA standard.

Next slide please. I do believe that we have some new members since the last biannual meeting, so I thought this would be a good opportunity to give a high level overview of MACCS and its capabilities.

So MACCS at a high level is a severe accident consequence computer code that is used to develop, to analyze the offsite consequences of a high radiological release of radioactive materials. MACCS was developed by Sandia under the sponsorship of the NRC.

And to answer Vesna's question about the diagram. So, basically from a given release of a radioactive material into the atmosphere, so what see on the diagram are, what are the things that a MACCS model, which is basically the extent of a magnitude and radiological contamination of site doses, protected actions of severe economic impacts and costs as well as health effects.

And one thing that I want to mention, that in order for BMS part of the MACCS code, as well as to have a direct influence in the development of the MACCS code, our branch has to also maintain sufficient subject matters participating in a lot of diverse areas of modeling. And that will include atmospheric transfer phenomena, economic impact evaluation, public response to specific action recommendations, as well as uncertainty analysis.

If you look at the bottom, we do have a broad use of base of around 100, 600 domestic international users, as well as domestic, leading up to 124 organizations. That includes the NRC, the Department of Energy, several research organizations within the Nuclear Industry, as well as Academia.

And usually the MACCS code is distributed through the Caesar (phonetic) program, to the members. Both to the domestic as well as international organizations. Next slide please.

MEMBER DIMITRIJEVIC: Actually, Luis. So my specific questions were related to two pieces of this pie. One was the regulatory framework.

You know, if this, how you said sort of described what MACCS do. But obviously regulatory framework doesn't explain what MACCS do, explain how MACCS is used, right?

I assume, right. How is MACCS used in regulatory framework.

So what does it, what is in this piece of pie?

MR. BETANCOURT: Right. And I do plan to cover that in two slides from now, Vesna, but yes, that's a very good question.

MEMBER DIMITRIJEVIC: My other question is related to another piece of pie I'm interested. This is risk uncertainty, right?

That also doesn't explain what MACCS does. I mean, I assume it doesn't explain some part of, I mean, of the important, the MACCS results. What are uncertainties are associated with them and what risk quantity is used.

So this is also my other question. What does this piece of pie actually describe as appointed here.

MR. BETANCOURT: Yes. So the -- basically at a high level, like you mentioned. It talks about the models, basically the model in the MACCS.

But as I mentioned in the previous slide, so MACCS has a lot of regulatory applications, like you mentioned. Uncertainty analysis, that's a big area of how MACCS is actually being used. We also use it for the Level 3 PRA area studies.

A big area of MACCS that is being used by the program office is in the area of evaluation for emergency planning. And this will be a big area once we receive new applications for small light-water reactors, as well as non-light-water reactors that are going to be having scalable EPCs or MACCS. That plays a key role in that part of the evaluation.

MEMBER DIMITRIJEVIC: One of the things that I'm especially interested in, and I have been pointed, I've been trying to discuss this in the sum of things which we do, is that uncertainty associated MACCS results can be huge, in my opinion, but I have never seen these analyzed.

I mean, for that part, if we considered transfer these, you know, dispersions, and things like that, there is so many assumptions to date that we should track the uncertainty results. So I never really saw any study done with that.

So, if you say MACCS is used in the uncertainty study, I mean, there obviously should be some studies show uncertainties related to the MACCS results.

MR. BETANCOURT: Yes. And one of the things that we are planning to do is in the area of, on the first Fukushima regulatory analysis where there is regard for offsite impacts, and one of the things that Tina is actually working on right now, which I was planning to talk in a later slide, and, Tina, feel free to join in on any given time, we are planning to complete a summary report of this uncertainty analysis of the three model plans that we use for the SOARCA.

And we're planning to finalize the draft in this industry fiscal year. The idea is to complete the final report in Fiscal Year 2022.

So, Tina, I know you're going to mention something else regarding this topic.

MS. GHOSH: Yes. I think I'll just add, I think, Luis, like you said, you're probably going to get more into this in a couple of slides, when we talk about the applications, but if I understood the question I think maybe you were, the question was, how does the MACCS work fit into where we use it for regulatory applications.

So, one of the key areas we've had to use MACCS for were when we did the regulatory analyses for any potential rulemakings following the Fukushima accident. Any time you need to quantify the offsite impacts in terms of dose to people, risk to people, economic impacts, we always use the MACCS code for that.

And so that's basically where we have done some Level 3 type PRA analyses. And for those we also attempted to quantify the uncertainties associated with those inputs for the regulatory analyses. So that's just one example.

Another area we're continuing to work in is updating the cost benefit analysis guidance. So basically that would inform future regulatory analysis.

The ones that we had picked up post-Fukushima were actually done. But certainly, we're also improving the guidance for the future.

So, basically any time we need a Level 3

PRA to do regulatory work, we're using the MACCS code to generate that work. And a lot of the research we've done kind of informs what we say about the potential uncertainty and those quantities that we use.

So, we're building towards kind of improved methods in these areas. I hope that helps. And I think Luis is going to get into the more specific applications.

MEMBER DIMITRIJEVIC: All right. Okay, you said you had made attempt to calculate the uncertainties associated with that. Does that mean you have succeeded or you have some results in those?

MS. GHOSH: Yes. So one example is, we spent quite some years doing a few very detailed uncertainty analysis for the three SOARCA plants that we did the state of the art reactor consequence analyses.

So there for the accident sequences that we looked at, we actually quantified the uncertainty in both the MELCOR portion of the analysis, as well as the MACCS portion of the analyses. So we've actually done quite a few detailed studies in terms of the consequence modeling portion of Level 3 PRA.

So we have some reports that are already published and we're working on making a shorter summary document, which would be easier for a rough, more of casual interest I would say. But we have looked into that a lot over the last several years.

And I think we will continue to look into that a little bit too as part of the Level 3 PRA project.

MEMBER DIMITRIJEVIC: All right. That will be very interesting as I already expressed in our CFR 53 meetings to see those results. Because if we consider using quantitative -- objectives as, you know, the safety measurements, that's very relevant. All right, thanks.

MR. BETANCOURT: Thank you, Vesna, that's a really good question.

So, Lee, can you go to the nest slide? Thank you. So pictured on this slide at a high level are some of the capabilities of MACCS. If you start from the top left and then going clockwise.

So MACCS is the consequence analysis scope, which models offsite consequences from radiological release of materials into the environment. Next to it you have MelMACCS, which is a precursor code that is used to, as an interface between MELCOR and MACCS to extract the source term data from MELCOR and convert it into a format that is useable for MACCS.

Next, to the right, is WinMACCS, which is a graphical user interface that facilitates the use of MACCS.

At the bottom you have SecPop, which is a population and economic data precursor code that can create probability for out of sight data file for any of the sites within the continental U.S.

And finally, AniMACCS, which is a new animation post-processor that takes the output from MACCS calculations and creates a time-dependent animation of atmospheric transport. Basically plots un-resulting error and grand consultations.

Next slide please. So, as part of MACCS development, in June of 2020 we released a major upgrade to MACCS. And some of them major enhancements.

In Version 4.0 it included the option to couple consequence analysis with nuance history atmospheric plant support in this version model. And an option on economic model to calculate the EDP losses in place of the expected rate of return of regulatory (phonetic) investments.

To support the agency's readiness,

including review of non-light water reactor designs. In July 2021 we do plan to reduce MACCS Version 4.1 to include the newer ATF models.

We identified these as a development need in one and three of the non-light water reactor code. And in close coordination with the staff, Sandia just recently completed implementation of these models into MACCS, and that's going to be released in Version 4.1. They also finalized a report on this effort, which we plan to put in the public domain.

And we do plan to show this to the MACCS user in the upcoming workshop in September 2021. And one of the things that we're also planning to do is to feature this during an advance reactor stakeholder meeting.

Providing MACCS documentation, we are in the process of preparing three major reports supporting the MACCS code to keep up with the current set of practice activities, which are listed on this slide. Which are the implemental plan report, the MACCS User Guide and the MACCS Theory Manual.

Of note, the MACCS Theory Manual hasn't been updated since 1990. That basically describes the models within the MACCS code.

I want to mention too that this was a

complete overhaul so AJ, in conjunction with Sandia, he did a fantastic job in updating the MACCS Theory Manual. And the idea is to provide a draft of the Theory Manual to the MACCS users before the annual meeting in September 2021.

Finally, we also, MACCS requires ongoing maintenance being viewed, distribution and so forth to ensure that the code is best properly functioning. Some of the activities include fission block operability issues as well as distribution of the code. And these activities and reasons are captured in the (audio interference) annually to be able to ensure their usability of the code.

Next slide please. And I do apologize, since I'm going fast since I know that we're running out of time, so feel free to stop me along the way.

Some of the high level priorities that we have in the branch, like you heard from previously before, we support the product offices through the research work request by performing confirmatory reviews. So SMRs, as well as advance reactors design.

In the area of non-light water reactors, as I mentioned in my previous slide, the release of MACCS Version 4.1 is a big priority for the branch at this point.

Another priority in this area is the area of the radionuclide screening analysis where Sandia is named in the completion of a task to supplement the release of radionuclides that are typically considered in MACCS to address several non-water reactor technologies. So the next step will be to address some of those unique properties from the non-light water reactor assemblies.

This including the impacts on atmospheric transporting dispersion on dosimetry. And we do plan to keep the stakeholders informed through the public website. And I see that there is a question.

MEMBER PETTI: Yes. Luis, this is Dave. At one of the earliest meetings I can remember asking Kim about tritium and how good a job does MACCS do for tritium given both the fusion application but also some of these molten salt applications where lithium as a component you're going to get tritium releases from the plant.

You know, in the past the accuracy probably didn't need to be all that great because it wasn't a big issue in light water reactors, but these other systems it could become the dominant radionuclide.

MR. BETANCOURT: Right. And I agree. And

I don't know if Keith is on the phone line. And I think that's actually part of the work that he is doing on the radionuclide analysis. So, Keith, are you there?

MR. COMPTON: Yes, I'm here. This is Keith Compton from AAB.

So, yes. Just a few observations. One thing I would note is that MACCS has been used in the past to model tritium releases from DOE facilities. You have to be a little bit careful about it because you have to model the skin absorption aspects of it properly. But it has been used.

But as you noted, that's one of the things that I think we identified that on the new reactor technology code plan that we're going to be assessing what additional changes need to be done.

We know that tritium is going to be something we're going to have to deal with much more explicitly, so I think that there is work planned for that.

I am not aware of the current status. I don't think that we have started that work quite yet, but it's on our plan for us to get to it.

MEMBER PETTI: So early in my old fusion days there was a German code that's now, I think, become more international called UFOTRI.

MR. COMPTON: Right.

MEMBER PETTI: And it was considered the best. So there is stuff out there. There is some good stuff to compare to.

MR. COMPTON: There absolutely is.

MEMBER PETTI: Yes.

MR. COMPTON: And I think that's one of the things that, and that's kind of going to be a theme, at least for me, going through a number of these new reactor technologies is look at see what has already been developed and used and accepted and re-purpose that before charging off and trying to solve problems from scrap.

So, yes, we're aware of UFOTRI. I'm not very familiar with it, but we know it exists and so --

MEMBER PETTI: Great.

MR. BETANCOURT: I don't know if you guys can see the slides up, I think they went away.

PARTICIPANT: Yes, I just want to mention, Luis, we have a Teams issue so I am getting it back up as we speak.

MR. BETANCOURT: Okay. Well, I can continue talking while, I will email the members a copy of the slide so you can follow them on, or should we wait?

MEMBER PETTI: I have them in front of me so --

MEMBER REMPE: Just tell us what page.

MEMBER PETTI: Yes.

MR. BETANCOURT: Okay. I believe that we were on Slide 58. I'm going to wait until you guys tell me once you get to that slide.

MEMBER REMPE: I have it. Go ahead.

MR. BETANCOURT: Yes, that's fine. So let me bring up on my end. Oh, I think, oh, it's back. Okay, thank you, Lee.

PARTICIPANT: No problem.

MR. BETANCOURT: So, the next area that we're focusing upon is completing the SOARCA summary report, which we hope that is going to be providing useful insights in the uncertainty analysis of the three power plants, including Peach Bottom, Surry and Sequoyah.

Our plan is to complete travel, do summary reporting this fiscal year with a final report in Fiscal Year 2022, as Hossein mentioned.

In the area of Level 3 PRA, we continue to conduct those consequence analysis to support this study, including the consequences initiated by internal and external events of power during low power and shutdown operations, as well as spent fuel store involved pools of dry cask.

The staff is also participating in some of the internal reviews of the Level 3 PRA pinnacle advisory group. We'll continue to support the research PRA timeline to complete this study in Fiscal Year 2023 as a key milestone.

Regarding MACCS modernization, I think co-modernization is important for the MACCS tool to ensure long-term visibility. And as you heard from Teri's presentation, the MACCS modernization code has been around in the code investment plan, which is a vison to be a multi-year effort. So once it's completed, issue won't require another large modernization for many years.

Currently, the state of MACCS is that it is currently reflecting legacy program and practices that are several decades old and several parts of the code are written in better programming languages.

For example, when MACCS is written in Visual Basic 6, which right now the vendor is no longer supporting, so one of the things that we're doing is that we just finished the relevant revision of MACCS where we are looking ahead and, and we're trying to figure out, okay, from a literal point of sense, where do we see MACCS being used in the future, in the next coming years.

I do remember when I was preparing for the advance reactor commission briefing, we are planning to expect, between now to 2027, 13 applications for advance reactors. So we are looking, okay, given this environment and looking ahead, what are the things that we need to do for MACCS to be able to properly ensure its readiness for when these applications are going to come in.

So we just developed the operation statement, and our next plan is to start doing a modernization. But however, like Teri mentioned, that's going to become part of the code investment plan. There is also a lot of competing priorities to put in the revision, so that's going to be one of our primary areas in the next fiscal year.

The last, but not least, on the last, I think this is on a certain area, in my personal opinion. Space fission reactors is a, one area that we're supporting where the Department of Energy, DoT and NASA currently engaged in the development of fission reactors to support a variety of proposed missions, including to the moon and mars where, and the NRC plays an important role that we need to support that these nuclear launches are safe and in conformance with international obligations.

So, our branch is supporting the newly established interagency nuclear safety board review where, as part of that effort would, varying the development of a draft play book where it's going to be providing the high level description of how the boron is going to operate, as well as some guidelines for some perspective applicants using space nuclear launches.

We are also engaged with NASA in the area of development standards for space nuclear reactors. Even though there's a long and successful history of using nuclear systems in space, NASA feels standards and regulations currently in place, specifically in the area of space fission reactor.

So one of our main goals is also participating in an interagency working group that, at the moment, they're trying to assess whether or not there is a need for fission consistent standards. So if the study concludes that consistent standard activities are essentially warranted, then NASA is going to be coordinated, their findings would be consistent standards in the U.S. at large.

Next slide please. Also, as we continue to our research we are continually exploring elevation (phonetic) opportunities. As you can see here, this slide captures the extent of international activities that we currently have in place.

In the area of CSARP, we continue to support these meetings to happen annually to be able to share the progress of severe accidents, as well as to report code development assessment status.

IMARK (phonetic), which is an area that we used as a forum to exchange information and research among MACCS users and accident consequence calls. These meetings usually happens in the summer, but due to the COVID-19 pandemic the meetings is going to be now taking place in September of 2021. The members are welcome to attend if they're interested. Registration is essentially open.

Because of the use of the CSARP program, it's spread more across the world. There are also yearly meetings taking place in Europe through the EMUG, as well as Asia, on AMUG.

The EMUG actually just recently happened back in April and finally on our list in general the NRC allows the contribution of the MACCS code to our domestic and international organizations for those countries that have participated in the CSARP program.

Sandia plays a key role in providing user support of the code, distributing the codes, supplying licenses, as well as responding to questions from the broad community on MACCS. Next slide, please.

Okay. On the area of AI I think this is an area that we see that there has been a lot of advancements in technologies across multiple disciplines involving the public and private sector, so both the nuclear industry as well as the NRC has a potential gain for potential processing improvements as well as safety using AI.

So to improve operational performance the nuclear industry has already began to assess how AI can not only can be utilized. We, the NRC, we need to be ready, that we are capable to adequately evaluate these technologies in the regulatory activities as well as how can we leverage them to enhance our internal processes as well as identify future needs.

So while there is an interest of the NRC for doing that, in the long term what we are concerned about is whether regulations of nuclear systems which may use AI to either design or operating their facilities, so, therefore, like while the industry is focusing right now, like what you heard from Kim and

Teri on using AI for improving operational performance, the NRC needs to consider in the long term how do we plan to regulate AI.

We need to consider how we are planning to assess the what if scenarios, how do we plan to credit that in the safety evaluations as well as how do we plan to confirm the AIs behave and make predictions that are within the licensing basis of that plan.

That is one of the reasons that we started developing this strategy that right now the, we are planning that strategy to become Agency wide.

Initially we are in the process of developing that strategy internally where we form a working group with representatives from all of the regional divisions and our plan is to have a draft strategy to be completed within maybe another fiscal year that represents a coordinated strategy for the office and then in Fiscal Year 2022 our plan is to include appointed (phonetic) offices as well as to assess the implementation across multiple business plans.

So we are welcome to ACRS once we have that AI strategy developed to provide comments when that time comes.

In the area of AI workshops I think there was a lot of comments mentioned regarding we need to be able to define what AI is as well as we need to hear about the industry.

So next week Research and NRR, we are basically jointly hosting the first of a three series of public workshops that is going to be providing that for us and opportunity for both the industry and the NRC and relevant stakeholders to discuss the state of knowledge as well as research activities related to AI.

And one of the things that we are planning to do as part of that first workshop is, like some of the Members mentioned, AI can mean something different to different people, so we're trying to have commentary knowledge between us and the industry.

In the next slide I have a link for the invitation. The workshop is going to be taking place on Wednesday.

One thing that we have seen, a recent use case that is serving as a proof of concept to be the attendant capabilities in our branch is the resource tool predictor and the goal of this activity is at a high level to develop a tool that utilizes data as well as test analytics that it will assist in other operating modules in estimating the resources with regard to review in the common licensing application.

So the tool by itself acts as a present -- as analysis where it will look at a library that is already analyzed, it will compare any common licensing action, which is on the PDF, against a large data cell that contains thousands of historical licensing actions that are also in PDFs, and they will return back to the program manager, okay, this is how we, the tool predicts how much time it's going to take to perform this review based upon historical data.

This use case is actually coming to an end and it's actually showing some exciting promises for NRR as well as the other, our appointed offices.

So as we look up to the future we are planning to continue then to find more use cases to serve as a proof of concept for better understanding the capabilities, not only with our branch but for the rest of the Agency.

So even though right now the majority of the focus has been on internal process automation activities, like I mentioned on the resource prediction tool. In the future, and hopefully starting in the next fiscal year, we plan to shape our resources to use these technologies in the area of consequence analysis.

An example that we are currently looking at now is actually we're trying to attempt to systematically cluster the sites based on population surrounding the site, so there will be a tool to try to obtain similarities in the population surrounding the site.

That could be large population close to the site versus farther away. So that's an area that we are starting this summer and we hope to continue in the near future. Next slide, please.

And, finally, this is like a self-evident slide which is a select of self accomplishments in the last two years and some of the plans that we have looking forward.

The Staff had done an incredible job in supporting these technologies, and like Hossein mentioned like I want to also put out a plug at the bottom which is like a link to the data science and AI workshop that is going to be taking place next week, so you guys are more than welcome to attend that.

We are going to be having presentations from members of the Staff, EPRI, as well as the industry. With that being said that concludes my presentation unless any of the Members have any questions before I turn over the presentation to John

Tomon.

MEMBER KIRCHNER: Luis, this is Walt Kirchner. On this AI topic, I think one of the things you really have to, and maybe Research is the right place, I don't want to use the word, I'll use the word but it creates bureaucratic problems, cybersecurity, rather, or maybe a different terminology is AI opens up a potential for huge vulnerabilities in a plant and that is an area that I think from a regulatory and for adequate protection standpoint has to be very prominent in your thinking and plans as you get into the world of AI.

So that's one Member's observation, but I am sure you appreciate the vulnerabilities that this -- Just having things like online -- It's one thing to take data that's recorded and go analyze it somewhere else.

It's a different thing when you get to sophisticated systems that are collecting the data online, as an example, and that's a simple example of where vulnerabilities can be introduced.

MR. BETANCOURT: I agree with you, Walt. That's an area that we need to keep a close attention to and that is one of the things that we are going to be coordinating with answer.

I know that our contact person and the division engineer are looking at that as well. One thing that I want to mention that I forgot to mention during my presentation, there was some conversation before regarding how AIs plan to be used in the industry.

I don't know if the Members are aware that we recently -- our counterparts in the Division of Risk Analysis, they issued a Federal Register Notice asking the industry how are you planning to, how are you using AI at this point as well as future applications.

Members who are interested we're more than welcome to share the responses from that FRN and those responses are available in the public domain.

MEMBER BALLINGER: This is Ron Ballinger. I certainly would be interested.

MR. BETANCOURT: Yes. We'll take an action to provide that to you guys. Anymore questions?

Seeing none, John, you are in the hot seat now.

MR. TOMON: Okay. Well good afternoon, everybody. My name is John Tomon. I am the Chief of the Radiation Protection Branch in the Division of

System Analysis and I am going to discuss functions, activities and accomplishments of the Radiation Protection Branch. Next slide, please.

The Radiation Protection Branch supports the program and regional offices in risk-informed regulatory decision making and radiation protection for nuclear power plants, material users, decommissioning sites, and fuel cycle facilities.

We serve as an agency-wide resource by providing technical support in all aspects of radiation protection to the program offices as well as our regional offices.

Finally, the Branch develops and maintains the radiation protection and dose assessment computer codes to the Radiation Protection Code Analysis and Maintenance Program, referred to as RAMP. Next slide, please.

As shown in this slide the Radiation Protection Branch provides regulatory support through congressional mandates and regulations. Specifically these include the Annual Abnormal Occurrence Report to Congress, the Radiation Exposure Information and Reporting System, REIRS, and the Occupational Health Division 8 Regulatory Guides.

The Branch also interacts with many of the domestic and international radiation protection organizations as depicted on this slide. Next slide, please.

As I stated in the Branch description slide the Branch develops and maintains many of the radiation protection and dose assessment computer codes. This figure displays four general areas of licensing review, which the radiation protection and dose assessment computer codes fall under.

These general areas are severe accidents or emergency response, design basis accidents, normal effluent releases, and decommissioning. The Branch works with our counterparts in the program offices through user need requests and research assistance requests to ensure that these computer codes continue to meet the regulations in the various parts of Title 10 of the Code of Federal Regulations and the NRC regulatory guides. Next slide, please.

The Radiation Protection Code Analysis Maintenance Program, RAMP, is a cooperative research program which promotes the development and maintenance and distribution of the radiation dose assessment codes as delineated in SECY Paper 2014-001.

RAMP provides our user community with a public facing website that provides access to the 17

RAMP codes, technical documentation, help resources, and user group meetings. This slide and the next one show some of the RAMP computer codes and their areas of application.

The RAMP codes depicted on this slide include those for nuclear power plant licensing reviews, such as the Symbolic Nuclear Analysis Package, Radionuclide Transport Removal and Dose Estimation code, referred to as the SNAP/RADTRAD code, the Control Room Habitability code, referred to as the HABIT code, the Normal Effluent Dose Assessment and Siting code, referred to as the NRCDose3 code, the Atmospheric Relative Concentrations and Support of Control Room Habitability code, referred to as the ARCON code, the Radioactive Material Transport and Dose Assessment Code, referred to as the NRC-RADTRAN code, and, finally, the Gaseous and Liquid Effluent code, referred to as the GALE code.

This slide also depicts RAMP emergency response codes, such as the Radiological System for Consequence Analysis code, referred to as the RASCAL code, and the Federal Radiological Monitoring and Assessment Center code, referred to as the TURBO FRMAC code.

It is noteworthy to mention that in

respect to the TURBO FRMAC code the NRC signed a Memorandum of Understanding with the Department of Energy in May of 2020 which provides RAMP members access to the TURBO FRMAC code and training at the RAMP user meetings. Next slide, please.

This slide continues with some of the other RAMP computer codes and their applications in the various licensing reviews. The RAMP codes depicted on this slide include those used for decommissioning, such as the Visual Sample Plan code, referred to as VSP, the Residual Radioactivity code, referred to as the RESRAD code, which was also included in that Department of Energy Memorandum of Understanding that I mentioned on the previous slide.

With that Memorandum of Understanding the RAMP members now have access to the RESRAD code and training at RAMP user meetings as well. This slide also depicts environmental and uranium mining and milling codes, such as the Second Generation Environmental Dosimetry code, referred to as the GENII code, and the radiological impacts of airborne emissions from uranium mining and milling facilities, referred to as the MILDOS code.

Additionally, RAMP contains several other dose assessment and radiation protection codes which do not fit in particular licensing applications but are used by several of the program and regional offices.

Some of these codes include the Phantom with Moveable Arm and Legs, the PIMAL code, the Radiological Toolbox code, and the VARSKIN computer code. The VARSKIN code is of particular note as it was originally designed to calculate doses from the deposition of hard particles but has evolved over the years to include several other dosimetry models requested by the program offices.

These other dosimetry models include the lens of the eye dose model and a wound model, which was incorporated into the latest version of the code referred to as VARSKIN plus. Next slide, please.

In the next five slides I will discuss some of the higher priority work items for the Branch. These items include updates to the Abnormal Occurrence reporting criteria, the Evidence Act, and the REIRS report, updates to Regulatory Guide 8.39, computer code consolidation, and the Branch's forward focus research projects.

For the abnormal occurrence criteria as I stated in one of my beginning slides the Abnormal Occurrence Report to Congress is an annual report that complies with Section 208 of the Energy Reorganization Act of 1974.

It reports unscheduled incidents or events that the NRC determines to be of significance from a standpoint of public health and safety. In the Staff Requirements Memorandum for SECY Paper 2019-0088 the Commission directed the Staff to develop and propose a limited revision to the abnormal occurrence criteria in the medical event and source security areas to better align these criteria with events that are significant from the standpoint of public health and safety.

RES formed a targeted working group composed of the program offices, specifically the Office of Nuclear Materials Safety and Safeguards and the Office of Nuclear Security and Incident Response, and several of the regional offices, in November of 2020 to evaluate the medical event and source security abnormal occurrence criteria.

This working group developed and proposed revised criteria for the medical event and source security area. Currently the Staff's proposed revised abnormal occurrence criteria have been reviewed and commented upon by several stakeholders, including the Organization of Agreement States and the Advisory

Committee for the Medical Use of Isotopes.

The working group is incorporating the comments from these stakeholders and is anticipating having the notation vote paper to the Commission in November of 2021.

The Evidence Act and the REIRS data. The Radiation Exposure Information and Reporting System, REIRS, collects and analyzes licensee occupational radiation exposure records with the objective of valuating trends in licensee performance in radiation protection and for research in epidemiological studies.

This data is reported annually in NUREG Report 0713. In SECY Paper 2020-0067, the Foundations for Evidence-Based Policymaking Act of 2018, the NRC developed its annual evaluation plan, Enclosure 3, which included an evaluation for the Radiation Protection Program.

The Radiation Protection Program was determined to be of high priority to the Agency and was selected for evaluation under the Evidence Act. The objective of this evaluation is to assess the long-term effectiveness of the regulatory programs for radiation protection across a range of NRC licensee categories.

The evaluation will draw on the data compiled from the annual occupational radiation exposures at the NRC license facilities, the REIRS data, and be published in NUREG Report 0713 Volume 41.

The Branch anticipates publishes this volume of the REIRS Report with the radiation valuation plan by the end of September 2021. Next slide, please.

Regulatory Guide 8.39 development. The Commission directed the Staff to revise Regulatory Guide 8.39, Release of Patients Administered Radioactive Material, to update the guidelines for patient information and instructional guidance.

In SECY Paper 2018-0015 the NRC Staff concluded that current patient release regulations are protective of public health and safety and that rulemaking to change the release criteria is not warranted.

However, the Staff determined that a comprehensive update to the NRC's Patient Release Guidelines, including incorporation of guidance currently provided in generic communications as well as updates to the equations, methodologies described in NRC guidance for calculating dose to members of the public from release patients is warranted.

The update to Regulatory Guide 8.39 is being conducted in two phases with the first phase being completed in April of 2020 with the publication of Revision 1 to this regulatory guide.

Revision 1 provided more updated and detailed sets of instructions to providers regarding patient release as well as updated breastfeeding instructions and an entirely new section providing guidance on the handling of a deceased patient that was recently administered a radiopharmaceutical.

The second phase of the update to this regulatory Guide, Revision 2, is currently underway and is and is targeted at updating the equations, methodologies, and calculations for thresholds for administered activity follow radiopharmaceutical treatment.

The additional calculation methodologies will provide flexibility to accommodate patient-specific factors for biokinetics, occupancy, geometry, and attenuation based on patient-specific information while also allowing for emerging radiopharmaceuticals and new treatment protocols.

The updates for Revision 2 of Regulatory Guide 8.39 have been presented to the Advisory Committee for the Medical Uses of Isotopes and their comments are being incorporated by the contractor and the Staff.

The Staff anticipates issuing Revision 2 of Regulatory Guide 8.39 for public comment in December of 2021. Next slide, please.

Code consolidation. As you may recall we all met with the Full Committee back in February of this year to discuss Volume 4, the Strategy for Readiness of Non-Light-Water Reactor Designs for Licensing and Siting Dose Assessment Codes.

As outlined in Volume 4 one of the first tasks was to consolidate several of the licensing and siting dose assessment codes into a consolidated code that is modular, flexible, efficient, and user friendly.

As shown on the graphic on this slide, consolidation task has begun in Fiscal Year 2021. The Staff, with the help of our contractor, have initiated the code consolidation process with the prototype development of the atmospheric transport module.

Additionally, as depicted on this slide, other key aspects of the code consolidation process have also started in Fiscal Year 2021, such as the user interface development, the extensive markup language data transfer system, the quality assurance and verification, and documentation.

In Fiscal Year 2022 we will start the development of the normal source term module that will incorporate the existing light-water reactor normal source term, i.e. the GALE code, as well as developing simple, normal source terms for the various non-light-water reactor designs.

Other tasks, such as environmental transport module, human and biotic exposure, and, finally, the dose assessment modules, will follow into Fiscal Year 2023 with the final product projected for the end of Fiscal Year 2023 or the beginning of Fiscal Year 2024, depending on funding. Next slide, please.

In the next two slides I will briefly touch on the Radiation Protection Branch's forward focus research projects which were approved for Fiscal Year 2021.

The first forward focus research project is titled "Drones and Virtual Reality Tools to Analyze Radiological Surveys in Decommissioning."

This forward focus research project is to transform and innovate decommissioning with the state-of-the-art processes and practices with the use of autonomous systems, i.e. drones, for the purpose of improving the NRC's capability and applications of drones in meeting regulatory limits, improving the foundation, knowledge, and the usage of drones on site radiological characterization surveys and remediation, improving knowledge of scanning systems to update guidance documents, gaining efficiencies in release of large survey areas for unrestricted use, and, finally, including drone processes and computer codes and tools for confirmatory analysis.

The kickoff for this project was in March of this year with the expected deliverable of a Technical Letter Report and several presentations anticipated for January of 2022. Next slide, please.

MEMBER PETTI: I have a question.

MR. TOMON: Sure. Yes?

MEMBER PETTI: Do you see this potentially evolving so that in the event of a nuclear accident the drones could help, you know, characterize plumes and the like?

MR. TOMON: Yes.

MEMBER PETTI: Does this help all the agencies involved?

MR. TOMON: Yes. That has come up in these discussions. Right now, this preliminary work, what we are hoping to learn in a lot of the background that we hope to get from this is things like, first of all, you have to get a drone that is approved for flying in the United States, so making sure those drones meet those requirements.

You need pilot certification for the drone operators as well as figuring out things like the capacity of the drone for the scanning equipment, so how much of a weight load can it hold and maintain with the battery.

MEMBER PETTI: Right. Yes. Yes.

MR. TOMON: So we are hoping for this to -- And, also, you know, some of these drones I found out in some of the meetings we've had is they have pre-timed return to base plans based upon the battery usage.

So, you know, considering all of those weight distributions in the drone for both the radiation detection equipment and the actual computer and the battery for the drone, that's all that -- We hope to gain some initial knowledge from this so that we will have it in the Letter Report so that we can go on and use it in other applications based on some of the information we gain from these analyses.

MEMBER PETTI: Thanks.

MR. TOMON: Yes.

MEMBER REMPE: This is Joy. You know, in

Japan they have been dealing with not just what's on the site but also in the surrounding areas and they have used helicopters as well as drones and complimented it with handheld surveys because of the need to have an accurate assessment of the contamination and the effects of remediation and decontamination activities and they have issued several reports.

The EPA has been following it because of anticipated use for other reasons in the U.S. How much interaction are you having with the reports that have been released from Japan on this effort?

MR. TOMON: So our contractors on this particular effort have been reviewing all that data that has been coming in trying, you know, because what you said is a key important aspect of it because the scan rate of the drone, especially for this particular application in decommissioning, you know, that has to compare to what we base our DCGLs on.

And so, you know, we already know and do that based upon the rate of a human moving over a surface at a certain distance and at a certain rate. So we are trying to make sure that, you know, that we can use the drones in that particular, in the decommissioning space to meet these DCGLs based upon those scanning rates.

So we are still, we are looking at the information, our contractor is, from the work that is being done in Fukushima as well as looking at what we know for the handheld methods of doing these decommissioning surveys to make sure that the drones can meet those DCGLs for the scanning rate and the distances as well.

MEMBER REMPE: Okay. And they have also been developing some pretty nice software to display the results from various sources. So, okay, as long as they are aware of it and they are following it that's all I wanted to inquire about.

MR. TOMON: Yes, ma'am, they are.

MEMBER HALNON: This is Greg Halnon. Are you tied into what they are doing with the TMI-2 containment and drone surveys?

MR. TOMON: I am not 100 percent positive if the contractor has looked into that, but I know there was talk about that when we did the kickoff meeting in the -- When we did the kickoff meeting for this forward focus research we invited our partners over and NMSS DWP to attend and they were very interested in this, of course, because it's in their area of decommissioning.

They did mention that, so I think that's been brought to our contractor's attention, so they are going to go look into that as well. I don't know how much it's going to be used in this particular forward focus research project, but I am hoping that if it's at least reviewed in part of the data review that we do for it that it's at least mentioned in the Letter Report as well.

MEMBER HALNON: Okay. Because I think that it's really fresh data right now that they have probably gotten real close to either doing it or will be doing it soon.

MR. TOMON: Yes, sir. Okay. So if there not anymore questions on this slide we can go to the next slide, please.

This other slide, this other slide focuses on the other forward focus research project awarded to the Radiation Protection Branch, which is titled "Can I Pet My Pets, a Dosimetry Risk Analysis for the Veterinarian Use of Radiopharmaceuticals."

This research developed out of a need to address a regulatory gap related to the emergent veterinary treatments of pets from veterinary-administered radiopharmaceuticals.

The Staff is developing the technical

basis to reduce the regulatory uncertainties with respect to licensing and medical administration of radiopharmaceuticals to animals under Title 10, Part 20, of the Code of Federal Regulations.

The project kickoff occurred in March of 2021. The contractor is completing the technical literature review and gathering information to support the dosimetry analysis for dogs, cats, and horses.

The goal of this research is technical reports that can serve as initiators for regulatory guidance development, Staff publications, and/or presentations. The expected project completion is January of 2022. Next slide, please.

Since the last Advisory Committee on Reactor Safeguards Review in 2019 the Radiation Protection Branch has had the following specific accomplishments.

The Branch has released ten major updates to the various RAMP computer codes and in the sake of timesaving I am not going to go through and list all of the different codes that we have updated, but we have had ten major releases to the 17 different codes we've had in RAMP.

Additionally, the Branch has published eight new NUREG reports in support of the various computer codes, two abnormal occurrence NUREG reports, and two Radiation Exposure Information Reporting System, REIRS, NUREG reports.

Several of the NUREG reports for the computer codes include NUREG user guides, technical basis manuals, and default parameter values and distribution manuals.

Also, the RAMP program continues to grow through the annual domestic international user meetings and the addition of several new international RAMP bilateral agreements.

Since the last meeting with the Committee RAMP has signed four new international bilateral agreements with the Ukraine, Poland, Mexico, and Nigeria.

The RAMP team has continued to provide virtual user group meetings both domestically and internationally during the pandemic.

And, finally, as discussed in one of the previous slides, the Branch's future plans continue to focus on code consolidation of the RAMP computer codes. Next slide, please.

This is my final slide and it's just going to briefly go over some of the international activities we do in the Branch. Since 2014 the RAMP international community has steadily grown to include 14 countries with formal bilateral agreements with the NRC and over 40 international users of the RAMP free codes.

Additionally, the Branch is also directly involved in activities for the Committee on Radiation Protection and Public Health, CRPPH. We serve on the Committee's bureau providing inputs on emerging issues, including recommendations on the CRPPH's program of work.

The Branch also supports the Information System on Occupational Exposure North American Technical Center which provides nuclear power plants worldwide with an electronic network for the exchange of occupational experience in the area of occupational exposure management and the implementation of ALARA.

And, finally, the Branch reviews and provides comments on International Commission on Radiological Protection Reports and the International Atomic Energy Agency safety documents for the NRC.

With that, I thank you for allowing me to present on the Radiation Protection Branch's activities and will answer any additional questions the Committee Members have at this time.

MEMBER KIRCHNER: John, in your portfolio does the longstanding linear dose argument, I guess that would be under ICRP, is there any activity there or has that kind of gone in limbo post-Fukushima?

MR. TOMON: Yes and no. There have been some petitions for rulemaking that have come in that we have worked on, but that's as far as really like I can talk about it because we haven't, there hasn't been any official release from the Commission on that rulemaking, but we have looked at that.

There have been some petitions for rulemaking in that regard and we do actively participate in those petitions for rulemaking, but there has been some talk of that, yes, sir.

MEMBER KIRCHNER: Does that naturally come to you or does it go to one of the other, our fellow committees working for the Commission?

MR. TOMON: It usually it comes to us. Usually when the -- Most of them come in through a petition for rulemaking and usually because of our position, our unique position in the Office of Research, we are recognized pretty much throughout the Agency, when one of that type of rulemaking petitions comes in the members of my staff are particularly sought out.

People like Dr. Terry Brock and Dr.

Stephanie Busch-Goddard are routinely sought out to sit on that petition for rulemaking panel to give their expert opinion on it.

So, yes, the Agency recognizes when that comes in and usually when that petition for rulemaking comes in through NMSS it gets, eventually we get asked to sit on that because they realize what we bring to the table there.

MEMBER KIRCHNER: Thank you.

MR. TOMON: Yes, sir.

MS. WEBBER: Okay. And then I think I have one last slide, it's a closing remark slide. Yes. Go to the next one, Lee, if you could.

So, you know, in closing I hope through our presentations this afternoon you have been able to see that DSA is completing our research in co-development activities, that we are continuing to focus on filling gaps in many of our technical skill areas through hiring new staff, augmenting skills through training, and cross training staff when necessary.

I also hope you have been able to see that DSA anticipates and pivots to new research activities to ensure that we are ready to support regulatory needs on the horizon and we do that through a variety of means as you have seen throughout the presentations.

We really appreciate your active engagement and all of your questions. We are always open to feedback and suggestions and these interactions with you really help us excel when it comes to producing relevant high quality research products and activities.

I know that our Technical Assistant, Ken Armstrong, has captured about a half dozen action items and I just wanted to see if you would like him to coordinate with Hossein.

And with that I would like to close at least the Staff's portion of the meeting.

MEMBER PETTI: I think that's fine to coordinate with Hossein at this point.

MS. WEBBER: Great.

MEMBER PETTI: Before we open it up for public comment and any other comments from the Members, I want to personally thank you, Kim, and all of the presenters. You had a tough job. This is a fairly broad division.

MS. WEBBER: Yes.

MEMBER PETTI: And I will say you set the bar pretty high I think for the other two divisions.

We'll see how well they do. It was a tough job to do and only being 15 minutes over is really quite good. I know I --

MS. WEBBER: I am sure they'll do equally well.

MEMBER PETTI: I know I have plenty of information to write what we need to write for the letter, at least in the first draft. There is plenty of good information here. Now, any other Members?

MEMBER REMPE: So this is Joy. I wanted to add my thanks, too. I actually think these interactions are very helpful in helping us keep abreast of what's happening.

I was particularly interested in the AI initiative you guys have started and I think that's an interesting avenue for RES to lead up.

MEMBER PETTI: Well, I don't hear anything from other Members, so, Thomas, can we open the public line?

MR. DASHIELL: The public line is open for comments.

MEMBER PETTI: Any comments from the public?

Well, it is late on a Friday, I guess not. Okay, Thomas, you can close the public line.

MR. DASHIELL: The public line is closed.

MEMBER PETTI: Unless anybody else has any comments I, again, want to thank everyone. I think it's been very productive and we will adjourn the meeting. Have a good weekend.

(Whereupon, the above-entitled matter went off the record at 5:45 p.m.)

Advisory Committee on Reactor Safeguards Biennial Review

Raymond Furstenau
Director, Office of Nuclear Regulatory Research
June 25, 2021

Welcome

- The Office-level ACRS Meeting occurred April 8
- RES acknowledges ACRS' recommendation to complete research activities that have achieved their regulatory purpose or are no longer needed
- RES conducts annual program reviews, completes work requests, and promotes a culture that supports research starts and stops at the right time
- RES will provide completion examples at the Division meetings

Advisory Committee on Reactor Safeguards Biennial Review

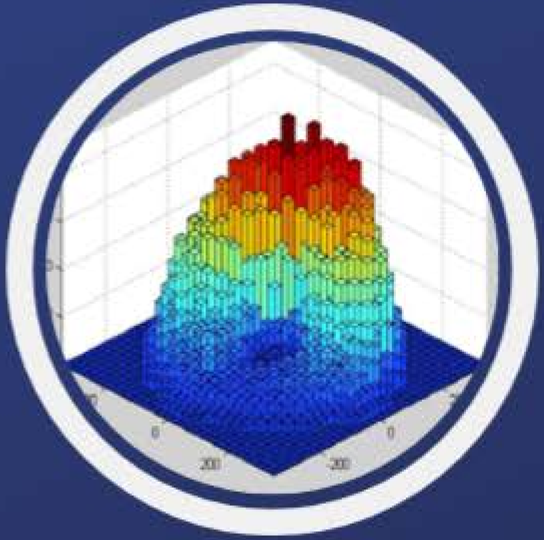
Kimberly Webber, Ph.D.
Director, Division of Safety Systems
Office of Nuclear Regulatory Research

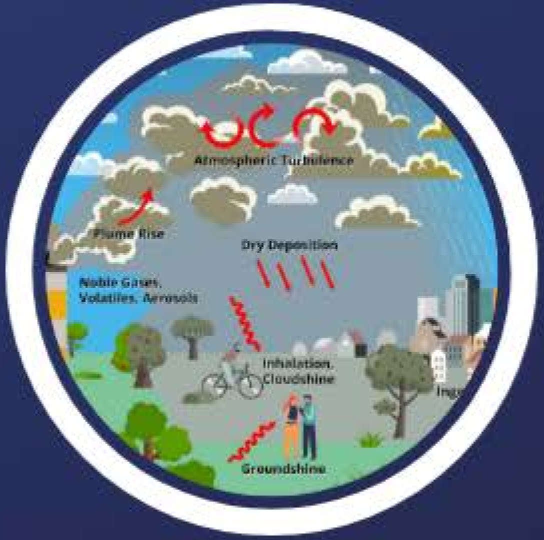
Agenda

- Overview of the Division of Systems Analysis (K. Webber)
- Specific Priority Topics (K. Webber and T. Lalain)
- Discussion of Technical Research Activities
  - Multiphysics Nuclear Reactor System Analysis (C. Hoxie)
  - Fuel and Neutronic Analysis (H. Esmaili)
  - Accident Progression and Source Term Analysis (H. Esmaili)
  - Consequence Analysis (L. Betancourt)
  - Radiation Protection Analysis (J. Tomon)
- Closing Remarks (K. Webber)

Division of Systems Analysis Overview

Plans, develops and manages research programs to develop and maintain broad technical expertise, experimental data, computer codes, and knowledge needed to support reliable and technically sound regulatory decisions





Code and Reactor Analysis Branch	Fuel & Source Term Code Development Branch	Accident Analysis Branch	Radiation Protection Branch
Chris Hoxie	Hossein Esmaili	Luis Betancourt	John Tomon

Division of Systems Analysis - Landscape by Program

Technical Program Area (Cost Center)	Resources (FY 2022)	Key Computer Codes	Contacts
Fuel and Neutronics Analysis	27%	SCALE, FAST, and PARCS	Chris Hoxie Hossein Esmaili
Thermal-Hydraulics Analysis	24%	TRACE, SNAP, and CFD	Chris Hoxie Steve Bajorek Chris Boyd Ghani Zigh
Accident Progression and Source Term Analysis	8%	MELCOR	Hossein Esmaili
Consequence Analysis	9%	MACCS, WinMACCS, MelMACCS, and SecPop	Luis Betancourt
Radiation Protection Analysis	9%	RADTRAD, RASCAL, GALE, VARSKIN, HABIT, RESRAD, REIRS, and AO	John Tomon
Advanced Reactor: Implementation Action Plan for Code and Tool Development	12%	Code listed above plus DOE Codes	Steve Bajorek All Branch Chiefs
Licensing and Rulemaking Support (e.g., SMR and non-LWR)	11%		

Division of Systems Analysis - Key Competencies

Core Positions	Competencies
Nuclear Engineer	**Neutronics and Reactor Physics**
	Nuclear Materials Criticality Safety
Reactor Systems Engineer	Fuel Behavior
	Thermal-Hydraulics - Code Development. Validation, and Maintenance
	Thermal-Hydraulics - Code Assessment and Plant Transient Analysis (includes CFD)
	Severe Accident Code Development. Validation, and Maintenance
	Severe Accident Progression and Source Term
	Consequence Analysis Code Development. Validation, Maintenance, and Applications
	Economic Modeling
	Data Science
Health Physicist	Radionuclide Transport and Decommissioning
	Radiation Dosimetry
	Radiation Health Effects
Cross-cutting	**Advanced non-LWR support**

*Excerpted from Attachment 6 to SECY 98-079, April 9, 1998, with updates
Working to Maintain/Build Core Capability (red)

Division of System Analysis Priorities

- Code Investment Plan (T. Lalain)
- AI/ML Tools for Regulatory Applications (T. Lalain, L. Betancourt)
- Code Development and Maintenance (All BCs)
- IAPs for Advanced non-LWRs (All BCs)
- Code Enhancements and In-Kind Contributions through RAMP, CAMP and CSARP Code Sharing Programs (All BCs)
- SMR Licensing Reviews (C. Hoxie, H. Esmaili)
- TRACE Plant Deck Modernization (C. Hoxie)
- ATF, High Burnup and High Enrichment (H. Esmaili)
- Consequence Analysis for EPZ and PAR (L. Betancourt)
- Forward Focus Research Projects (C. Hoxie, J. Tomon)

Regulatory Readiness through Research Excellence

- Anticipate Near Term and Future Submittals
  - Strong relationships with NRC partners, government/international organizations, external stakeholders
  - Develop and maintain staff expertise and analytical tools
- Forward Looking Research
  - Encourage new ideas and ways to do things differently
  - Leverage Forward-Focused Research and IUP R&D Grants
  - Focus on New Areas: Artificial Intelligence/Machine Learning, Fusion
- Optimize Use of Resources and Information
  - Complete work like SOARCA, L3 PRA, and NuScale and shift to regulatory priorities (e.g., non-LWR).
  - Leverage international (e.g., OECD) experimental programs
  - Leverage MOUs to foster collaborations with DOE, EPRI, NRIC
- Participate in NRC innovative and transformational initiatives, such as Be riskSMART and InnovateNRC 2.0

DSA Completions BY THE NUMBERS

Since 2019 ACRS Meeting

DELIVER RESULTS

12 Major ATF MILESTONES

22 Major Code RELEASES

State of the art Reactor Consequence Analyses (SOARCA)

PARTNERSHIPS

$4M FROM CODE SHARING

12 Cooperative Code Developments Meetings STEWARDSHIP

66 International Cooperative AGREEMENTS

CONFIRM SAFETY

7 Reference Plant Models Systems Analysis

6 ADVANCED REACTOR REPORTS

3 Reference Plant Models Accident Analysis

NuScale Research Plan

15 NUREGs PUBLISHED

4 Abnormal Occurrence and REIRS Reports

2019 ACRS meeting was in September

Challenges

- Workload Management
  - Managing competing high priority activities, requiring similar skillsets and timeframes
  - Access to advanced reactor design information, models, and data prior to formal licensing and topical report submittals, including for those non-LWR designs that are less mature
- Human Resource Management
  - Maintenance of core capability will be closely monitored
  - Hiring personnel from in-demand areas

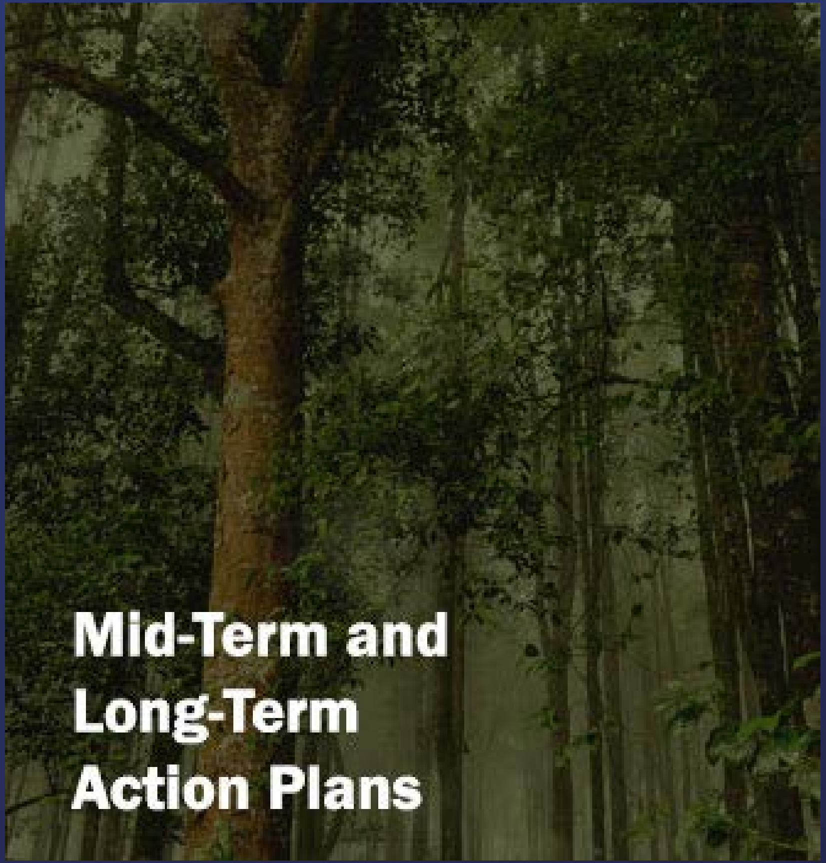
Division of Systems Analysis

Special Topics

Advanced Reactor Readiness

Code Investment Plan

Data Science and Artificial Intelligence



Advanced Reactor Readiness

Advanced Reactor Code Development Reports

- These Volumes outline the specific analytical tools to enable independent analysis of non-LWRs, technical "gaps" in capabilities, V&V needs.
- Gaps in experimental data are currently being identified.

Advanced Reactors
Three-Phased Approach for Confirmatory Models

Stage 1 – Generic Readiness for a Reactor Technology

Code infrastructure development, reference plant model/source term demonstration, generic models that benefit all non-LWR designs (IAP Strategy 2 Volumes)

Stage 2 – Readiness for a Specific Application

Model build of a preapplication based design)

Stage 3 – Model build, Analysis, and Review of a specific application under licensing review

Conduct confirmatory analysis, generation of RAIs, and input to SER

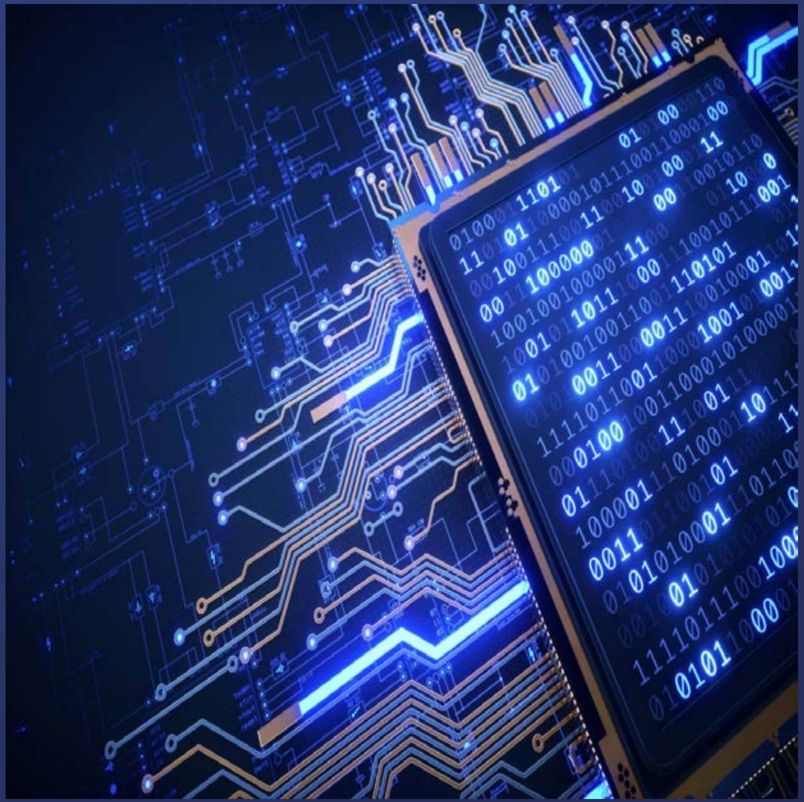
Advanced Reactors Progress and Next Steps

Completed

- Code Development Reports
- 7 Reference Plant Models for Systems Analysis
- 3 Reference Plant Models for Severe Accident Analysis
- Fuels (FAST) code assessment reports for metallic and TRISO

Under Development

- Ref. Plant Models for Systems Analysis – PBMR (est. 6/22)
- Ref. Plant Models for Severe Accident Analysis – MSR (est. 11/21) and SCFR (est. 6/22)
- Source Term Demonstration Project (est. 9/21)
- MACCS radionuclide screening analysis (est. 9/21)
- MACCS near-field atmospheric transport and dispersion model improvement (est. 9/21)
- Development/consolidation of Radiation Protection Codes for non-LWR analysis (Vol. 4)
- Initiation of Plan for Nuclear Fuel Cycle (Vol. 5)



NRC Scientific Computer Code Investment Plan

NRC Scientific Computer Code Investment Plan

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SECRETARY

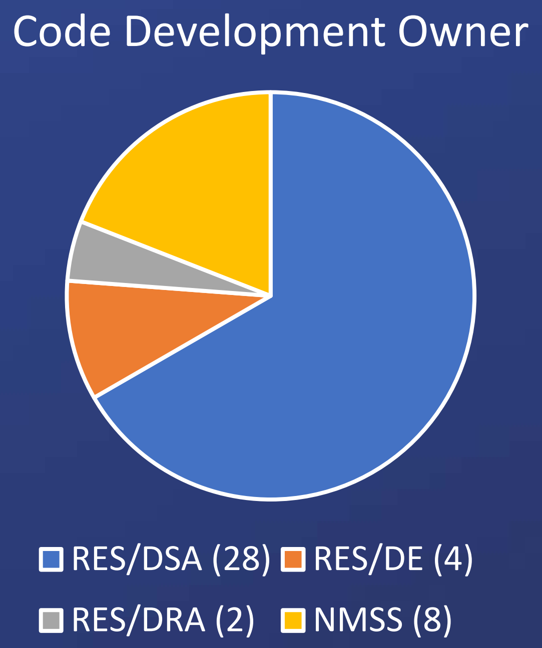
August 28, 2019

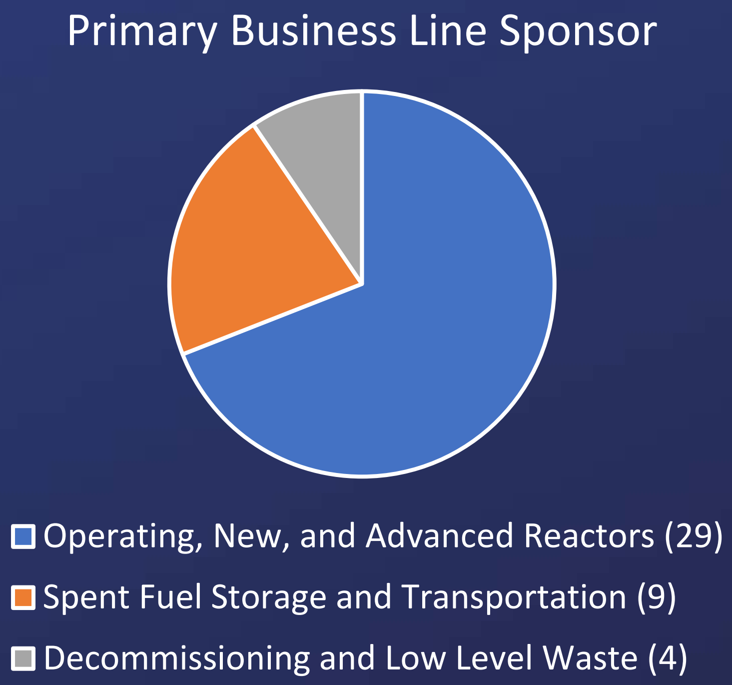
Office of Nuclear Regulatory Research (RES) was asked to:

> "work with the technical offices to review in a holistic way the existing inventory of codes that the NRC uses to develop a long-term investment plan to support future use and resource requirements."

COMKLS-19-0002

NRC Scientific Computer Code Current State Assessment

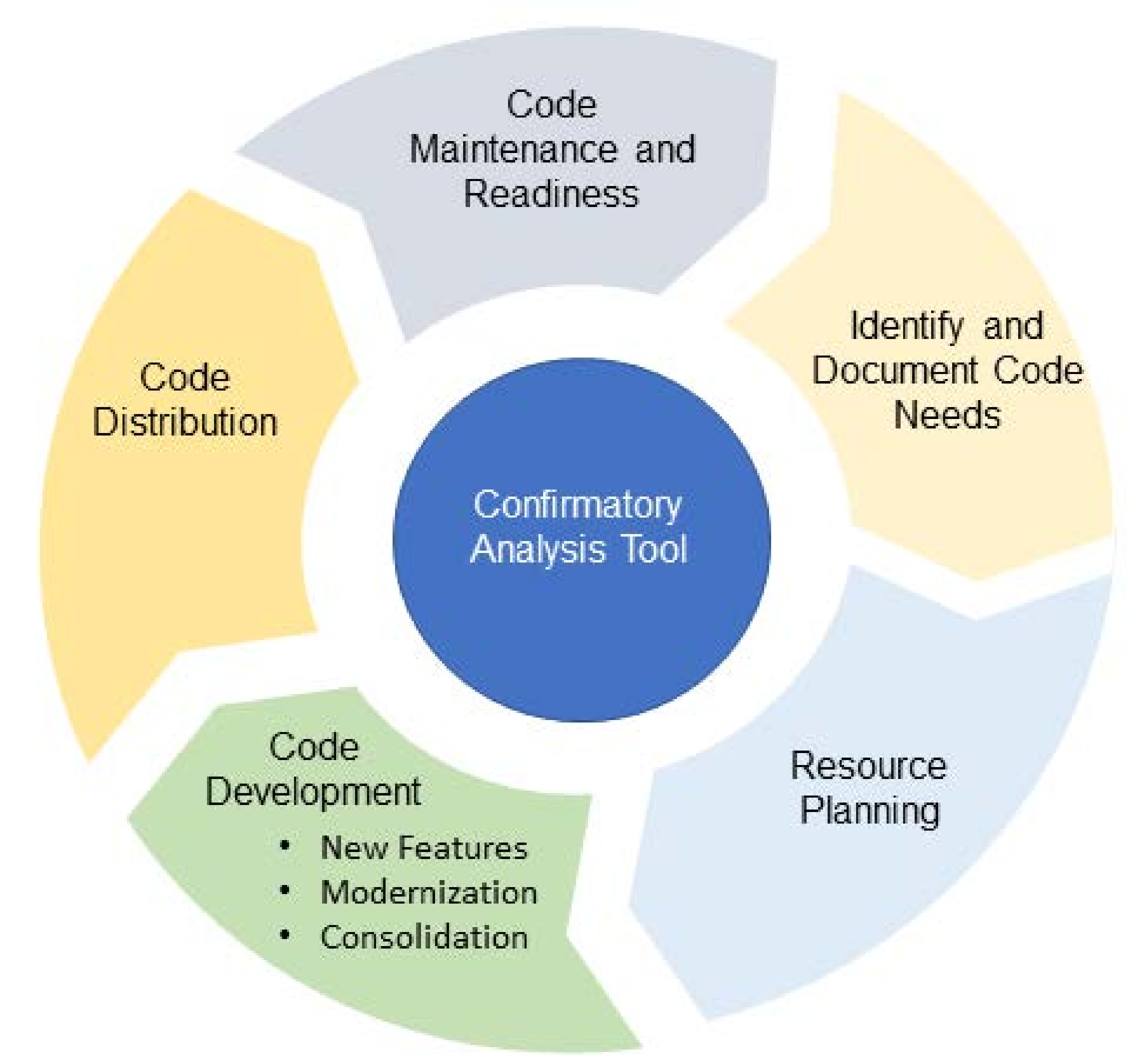




Code Investment Areas (42 Codes)

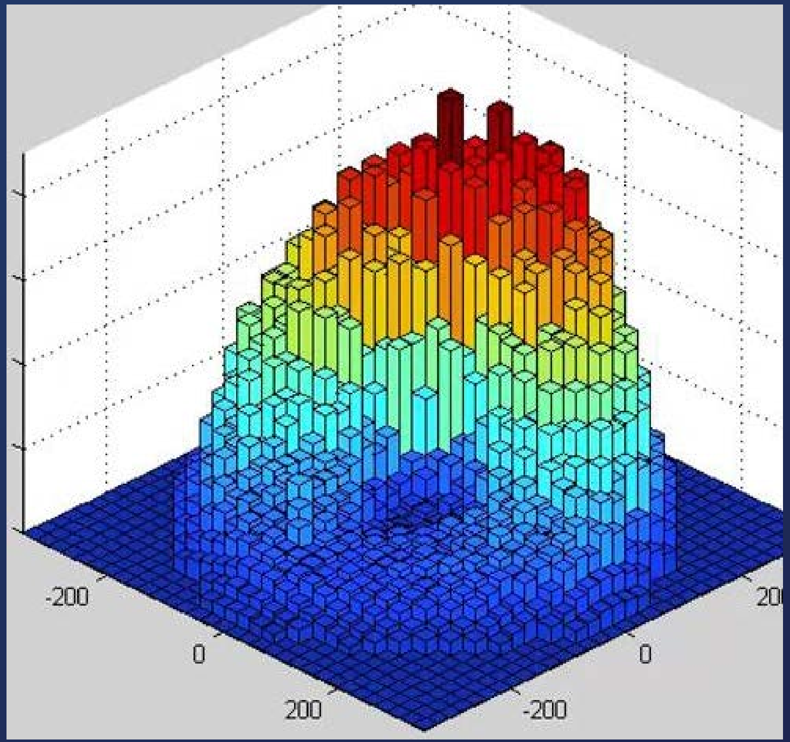
- Archival (minimal readiness) – 8 codes
- Active Codes – 34 codes
  - Maintenance – All
  - State-of-Practice Development – All
  - Modernization – 4 codes (3 more identified)
  - Consolidation – 7 into 3 codes (R/P codes)

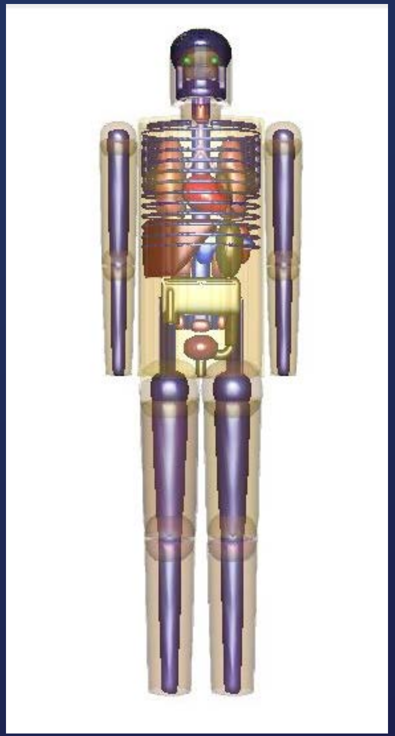
The Scientific Computer Code Investment Process

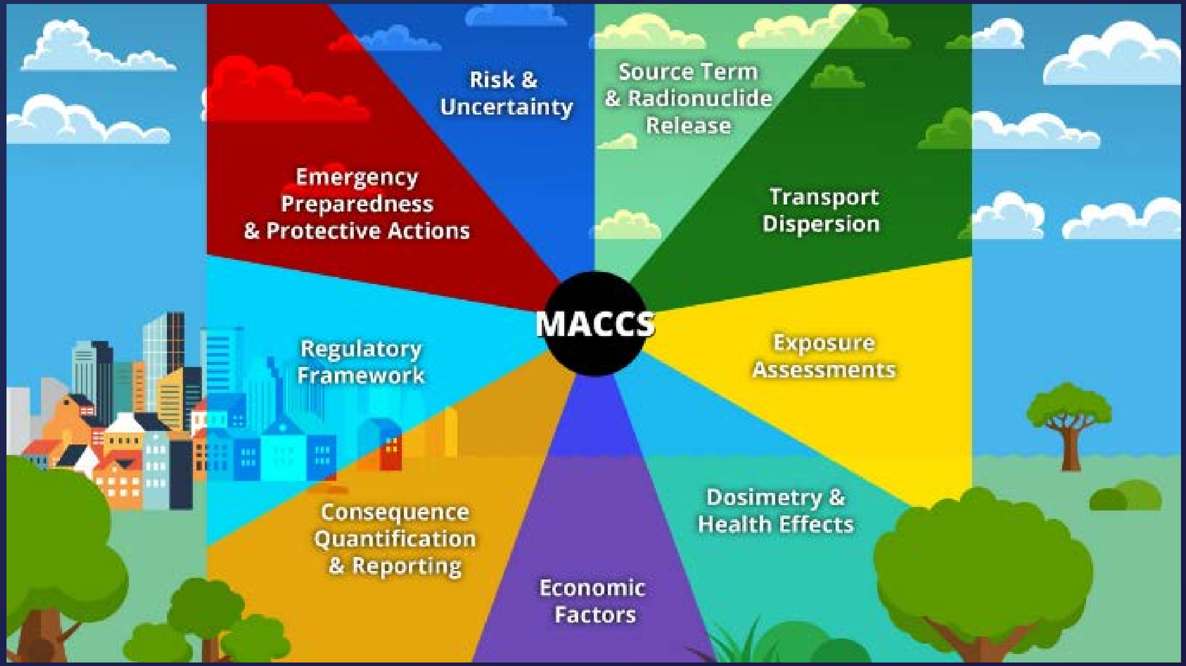


The Scientific Computer Code Investment Process Next Steps

- Complete draft plan
- Coordinate with code owners and program offices
- Document code requirements
- Inform budget formulation



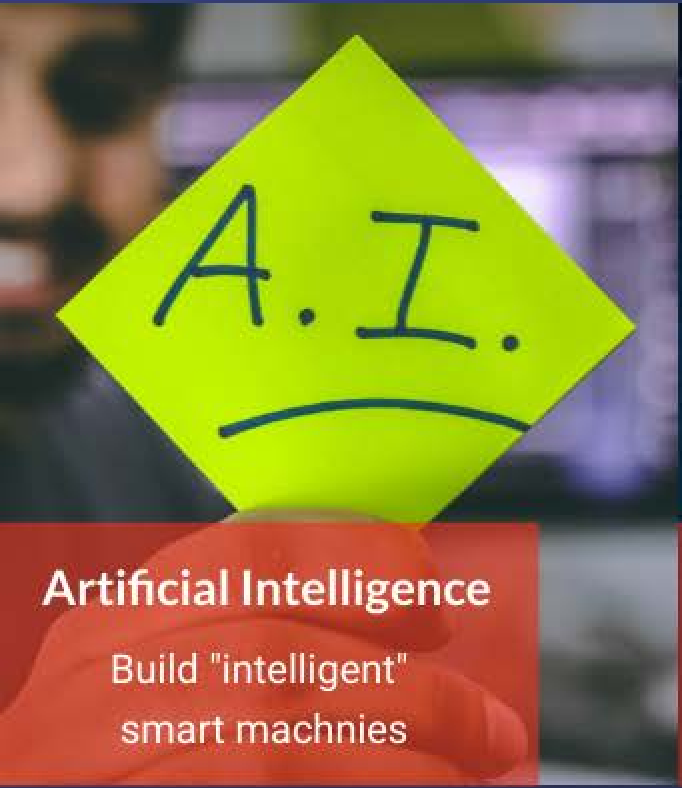




Data Science and Artificial Intelligence

Theresa Lalain, Ph.D.
Deputy Director, Division of Safety Systems
Office of Nuclear Regulatory Research

Data Science and Artificial Intelligence Overview



Artificial Intelligence

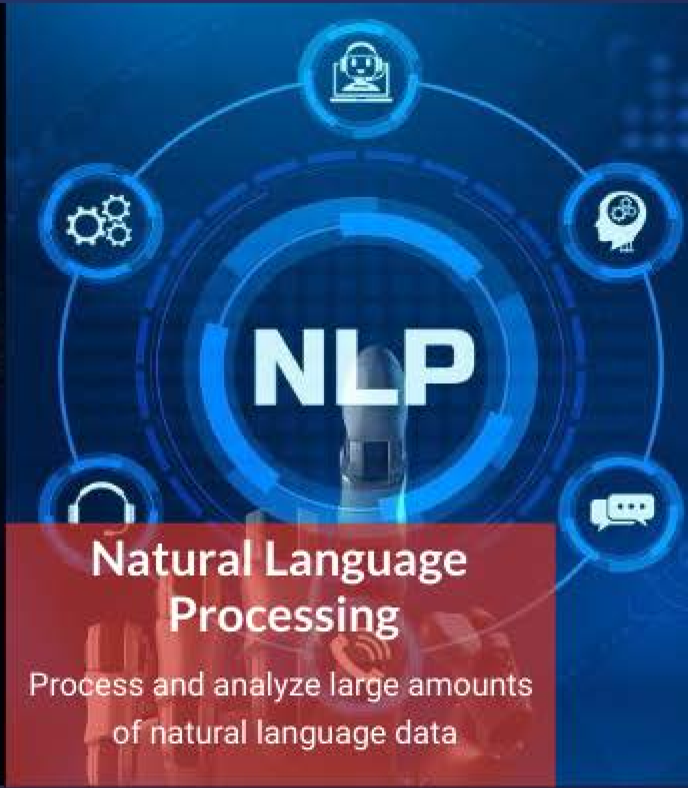
Build "intelligent" smart machnies

Machine Learning

Learn from data and deliver predictive models

Deep Learning

ML methods based on artificial neural networks



Natural Language Processing

Process and analyze large amounts of natural language data

WHERE ARE WE NOW?

Several AI/ML use cases are underway

- Resource Prediction Analysis
- Robotic Process Automation
- Autonomous Control Algorithms
- RESBots (RES/DE)
- Digital Twins (RES/DE)

Building the technical capabilities

- Hired one full-time staff and three data science interns
- Performing independent studies in AI and ML
- Offering internal NRC training via Skillsoft/Percipio

WHERE ARE WE HEADING?

- Developing AI Strategy
- Assessing the Current and Future States of AI
- Identifying New AI/ML Use Cases

Fostering Partnerships

Sharing experience and knowledge to enhance our regulatory processes and decision-making

SHARING KNOWLEDGE AND SEEKING STAKEHOLDER INPUT

DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA

FEDERAL REGISTER
The Daily Journal of the United States Government

National Laboratories

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

NIST

LWRS
LIGHT WATER REACTOR SUSTAINABILITY

arpa·e
CHANGING WHAT'S POSSIBLE

LEVERAGING RESEARCH ACTIVITIES

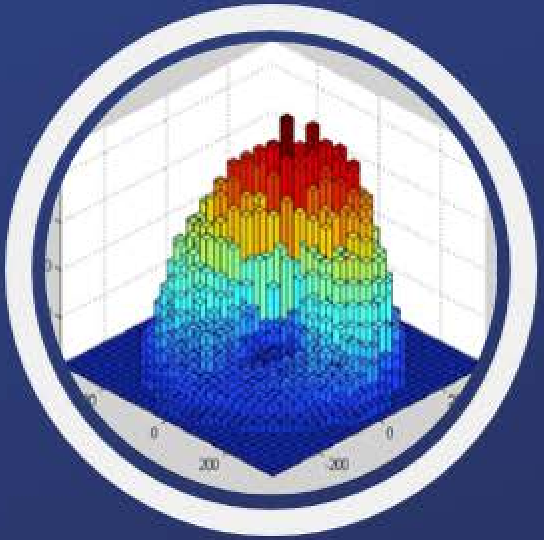
DATA SCIENCE AND ARTIFICIAL INTELLIGENCE REGULATORY APPLICATIONS WORKSHOPS

Virtual - Microsoft Teams Meeting

Website: https://www.nrc.gov/public-involve/conferences.html

NRCAIWorkshop@nrc.gov

Discussion of Technical Research Activities

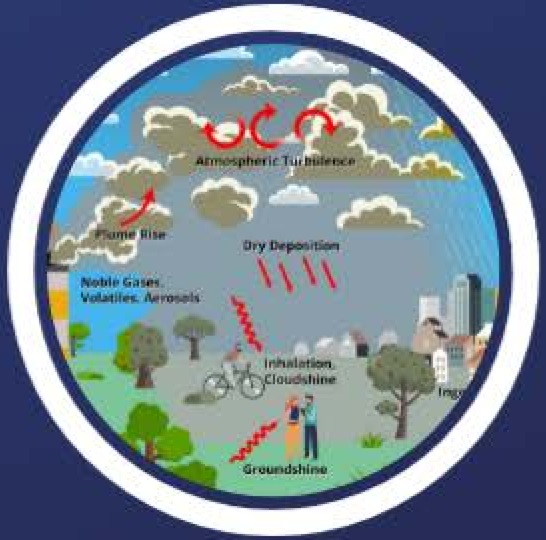


Multiphysics Nuclear Reactor System Analysis

Chris Hoxie

Fuels and Neutronics Analysis

Hossein Esmaili



Consequence Analysis & Data Science and AI

Luis Betancourt

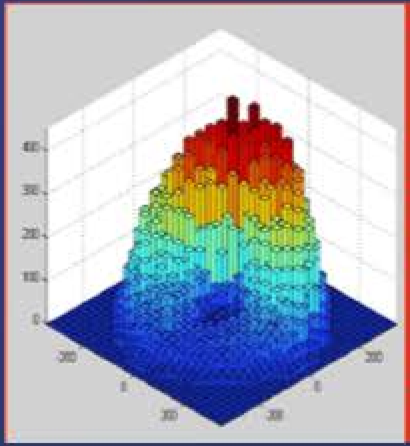
Radiation Protection Analysis

John Tomon

Multiphysics Nuclear Reactor System Analysis

Dr. Chris L. Hoxie
Code and Reactor Analysis Branch

Branch Description



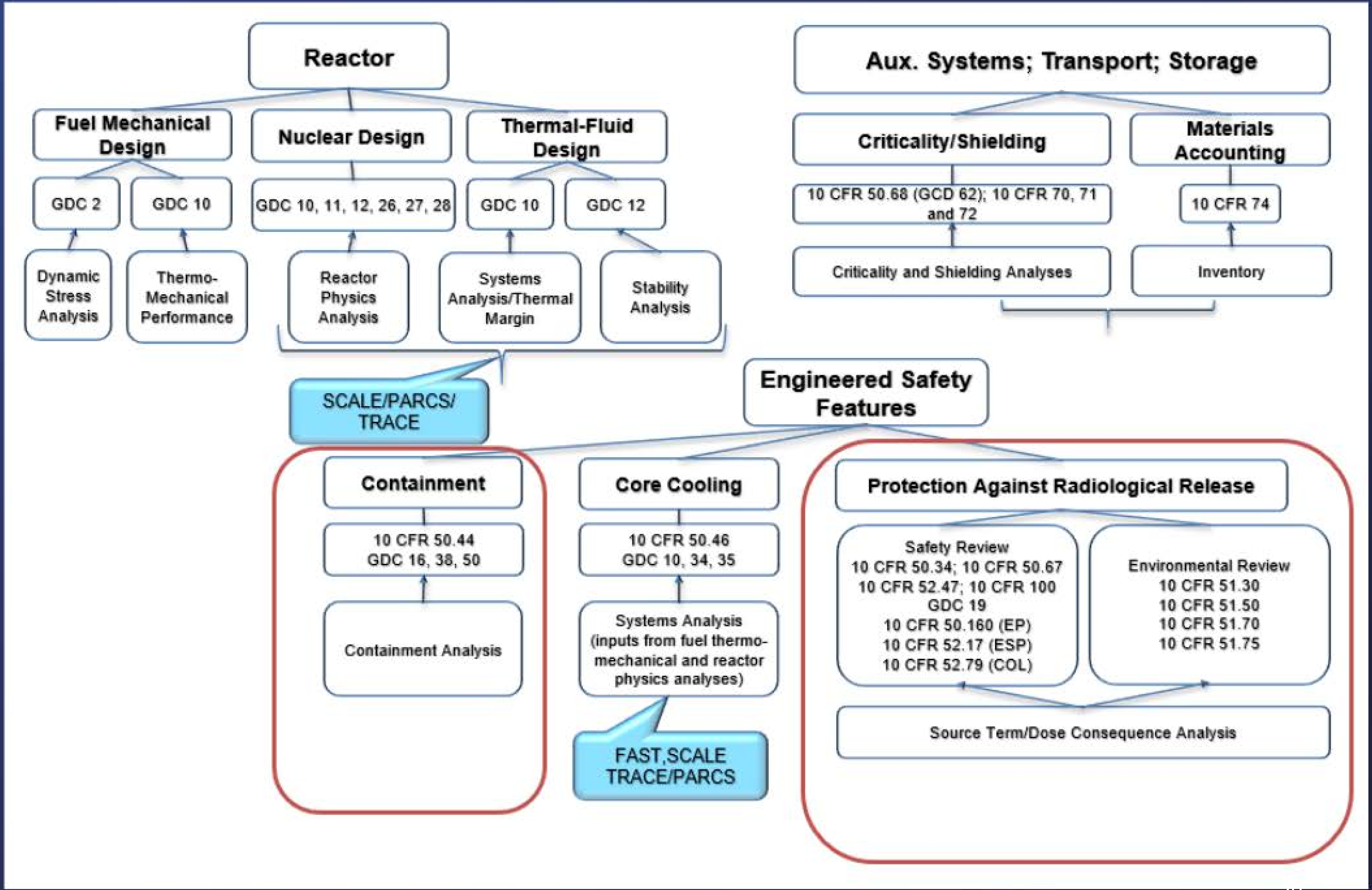
Performs code development, maintenance, verification & validation, and application of multiphysics computer codes for performing nuclear reactor systems analysis for regulatory applications (e.g. audit calculations)

Leverages DOE and NRC resources to participate in experimental programs for data needed to develop and validate analytical tools

Maintains staff technical expertise in technical areas that CRAB is responsible for - RES Knowledge Management Mission

Engages internal and external stakeholders to support Agency risk-informed regulatory decision making

Regulatory Support



Multiphysics Nuclear Reactor System Analysis Development & Regulatory Applications

TRACE, PARCS, SNAP are used for

- Ch - 15 DBA, LOCA, transient, and accident analyses for license amendments in operating plants
- Support for Design Certification
- Evaluation of Generic Safety Issues
- Analysis of Plant Events

Blue Crab Suite used for Advanced non-LWRs DC

Branch Priorities

TRACE, PARCS, SNAP, and Blue Crab Suite Development and Maintenance to support Agency mission

New and Advanced Reactor Licensing

- Holtec SMR-160, GEH BWRX-300, NuScale NPM-20 SDA Application
- Non-LWR Advanced Reactors (growth area)

Operating Reactor Licensing

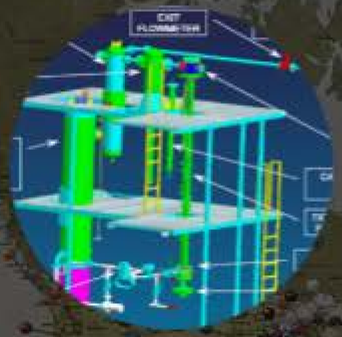
- TRACE Code Maintenance, Plant Model Maintenance, and Plant Model Development
- Extended Burnup Fuel Assembly & Core Analysis (PARCS)
- Accident Tolerant Fuel

SHINE Radioisotope Production Facility Licensing

Research and Test Reactor LARs, License Renewal, and HEU-LEU Core Conversion

Generic Issues

International Test Programs



ARTHUR/RBHT

Advanced Reflood Thermal Hydraulics Uncertainty Resolution and the Rod Bundle Heat Transfer Facility

ETHARINUS

Experimental Thermal Hydraulics for Analysis, Research and Innovations in Nuclear Safety

ATLAS-3

Advanced-Thermal-Hydraulic Test Loop for Accident Simulation 3

Advanced Reflood Thermal Hydraulics Uncertainty Resolution (ARTHUR) and the Rod Bundle Heat Transfer (RBHT) Facility

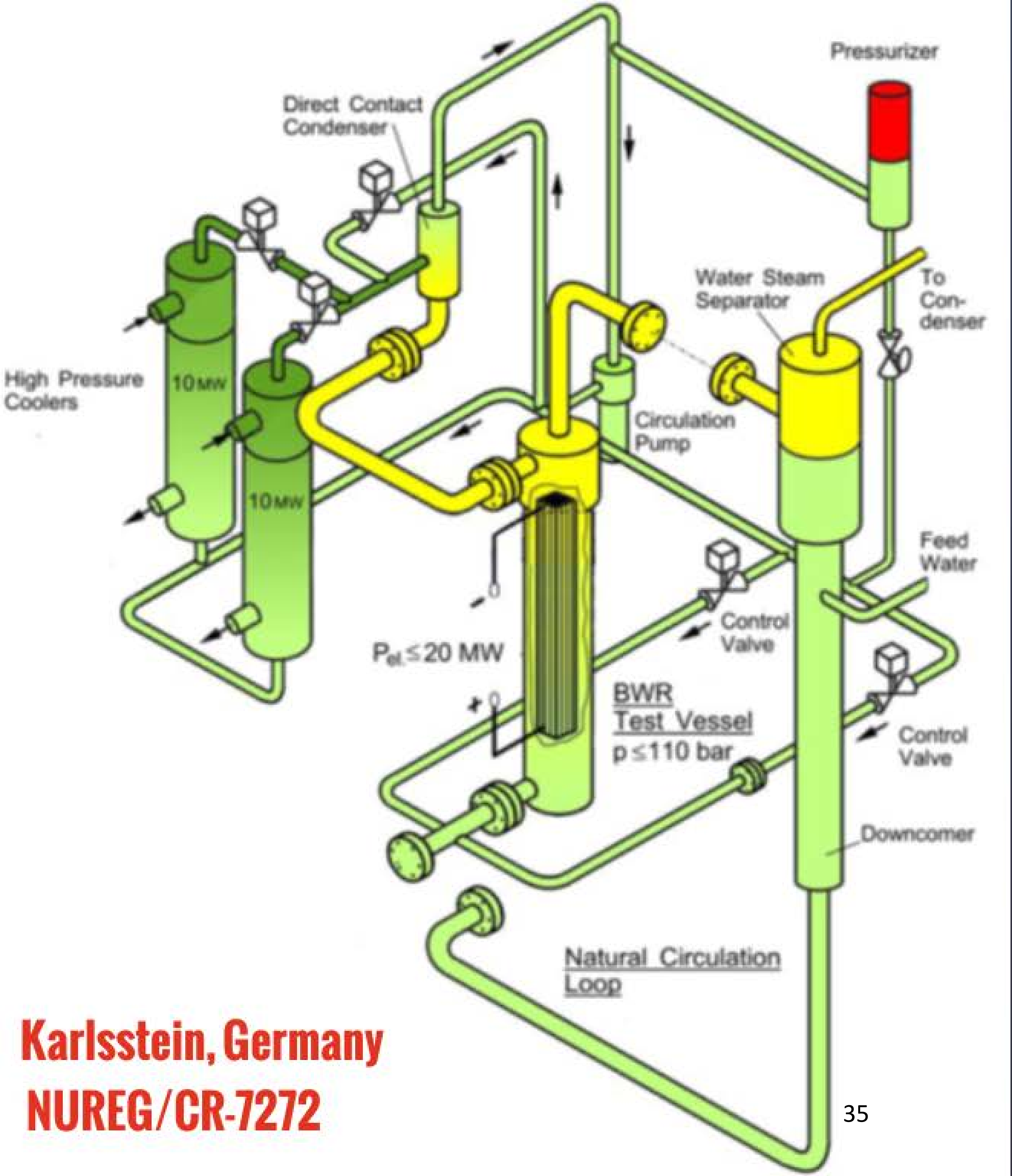
- RBHT provides high quality data for assessment and model improvement in TRACE code
- RBHT results demonstrate important effects of spacer grids on bundle thermal hydraulics
- RBHT also provides detailed droplet size and velocity information
- Tests generate unique post-CHF film boiling heat transfer data to benchmark each participant’s code of choice and to quantify uncertainties

Thermal Hydraulic Test Facility KATHY

Natural Circulation Instability Tests

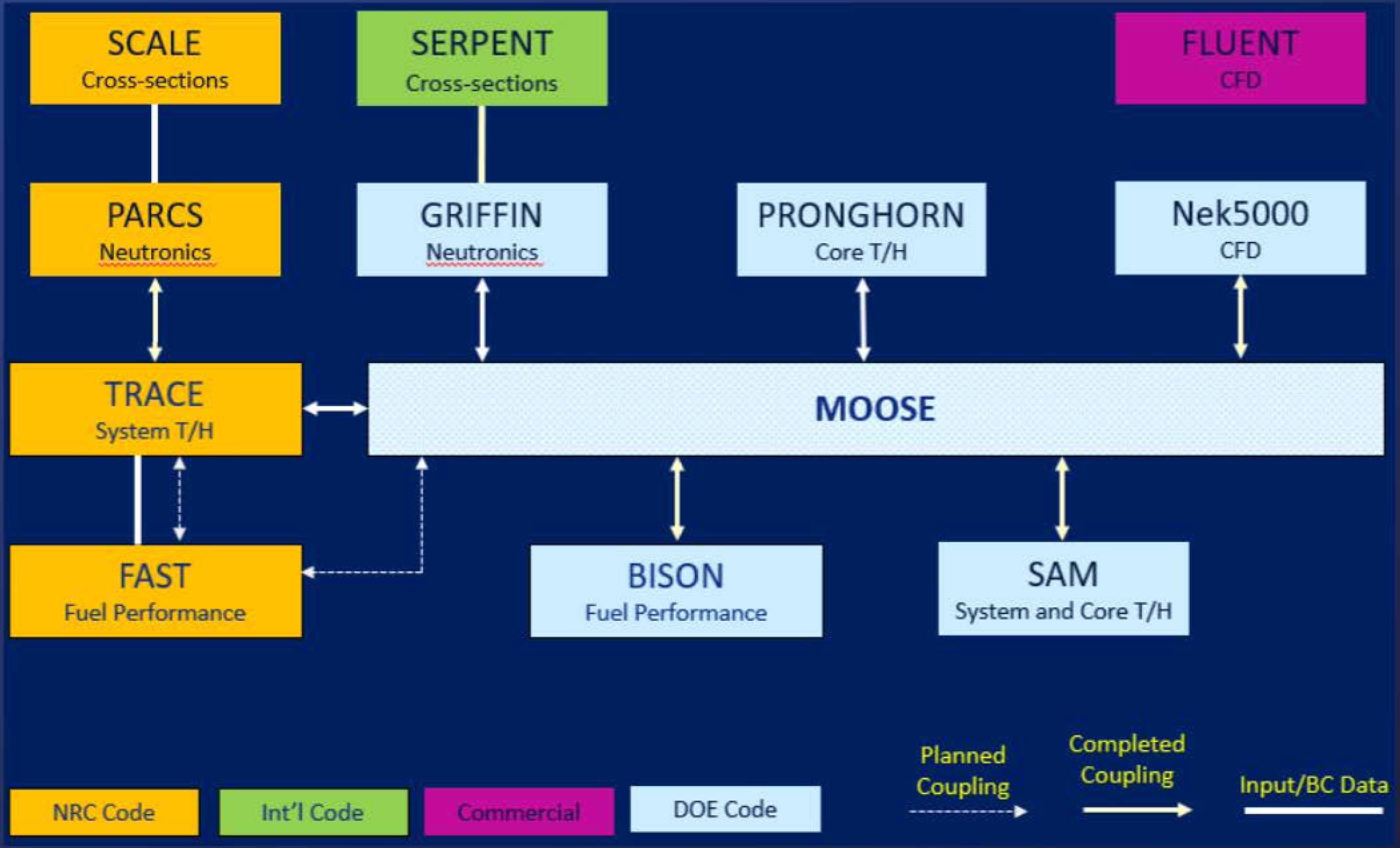
- Stepping up test assembly power in oscillating flow until failure to rewet occurs

- A second type of test introduced a simulated neutronic feedback to dynamically change the power



Karlsstein, Germany
NUREG/CR-7272

Comprehensive Reactor Analysis Bundle BlueCRAB



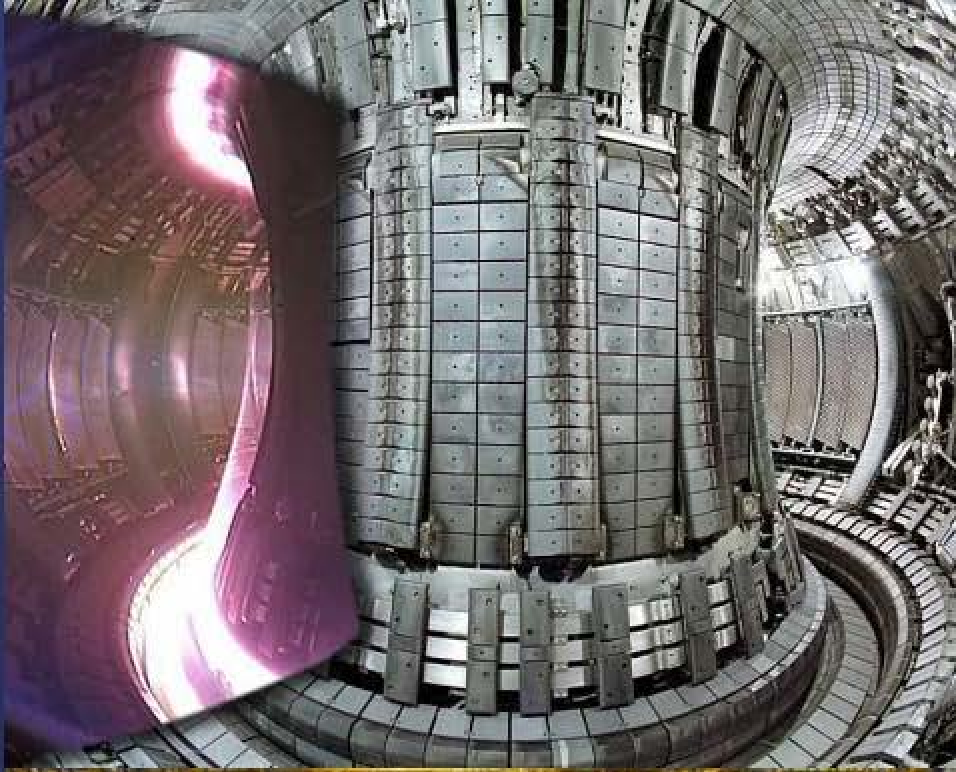
Reference Plant Model Status

Reference Plant	"Supports"	Design Type	Model Available?
SPR A	Oklo "Aurora"	HPR (annular fuel)	Yes
Mega-Power	Westinghouse "eVinci"	HPR (monolith)	Not started
PB-FHR	Kairos	MSPR (pebble bed)	Yes
ABTR	TerraPower/GEH "Natrium"	SFR	Yes
HTR-PM	X-energy "X-100"	PBMR (pebble bed)	In Progress
MHTGR	Framatome	HTGR (prismatic)	Yes
MSRE	Terrestrial	MFSR (thermal)	Yes
EVOL	TerraPower	MCFR (fast)	Yes
AHTR	N/A	MSR (prismatic)	Yes
ALFRED	Westinghouse	LMR	Not Started
N/A	General Atomics	GGFR	Not Started

Fusion Reactors

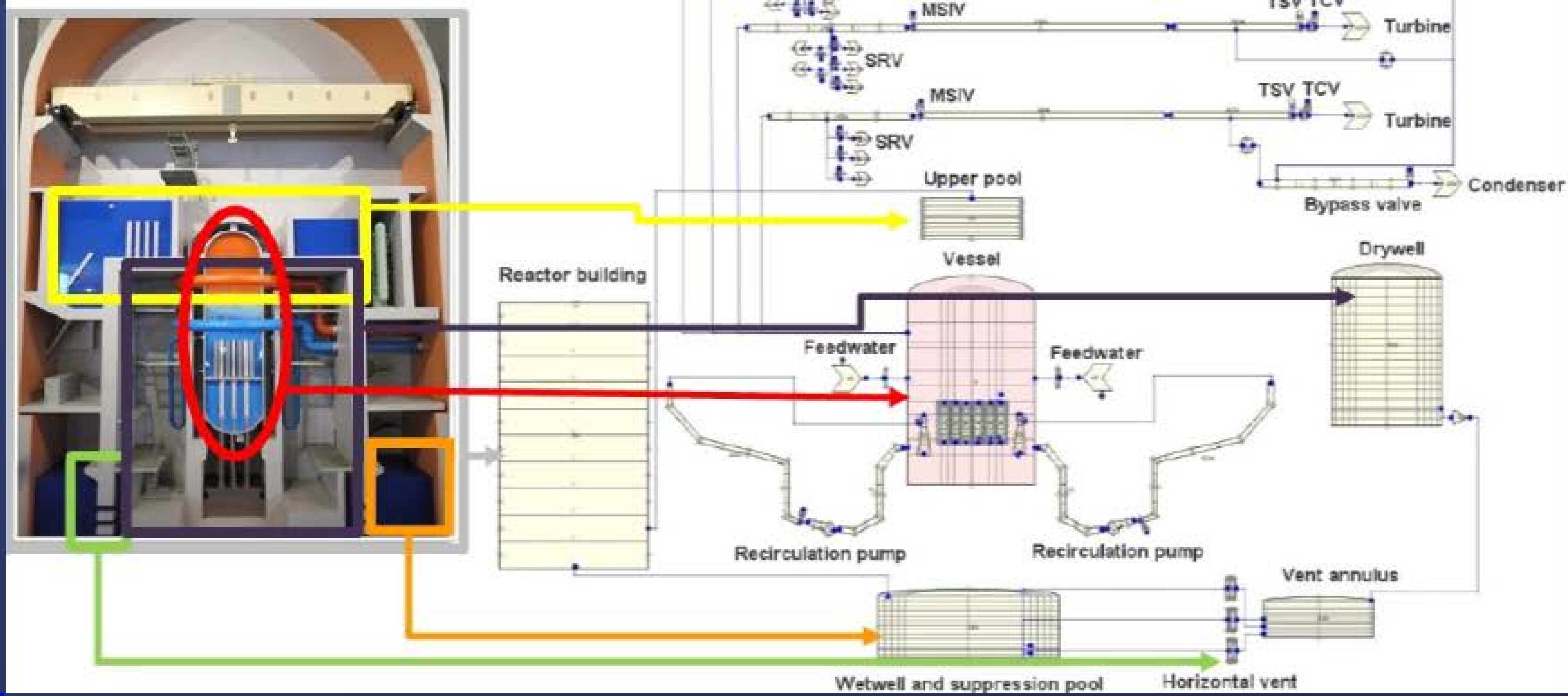
DSA participation on NRR team to prepare for regulatory reviews of fusion technology includes:

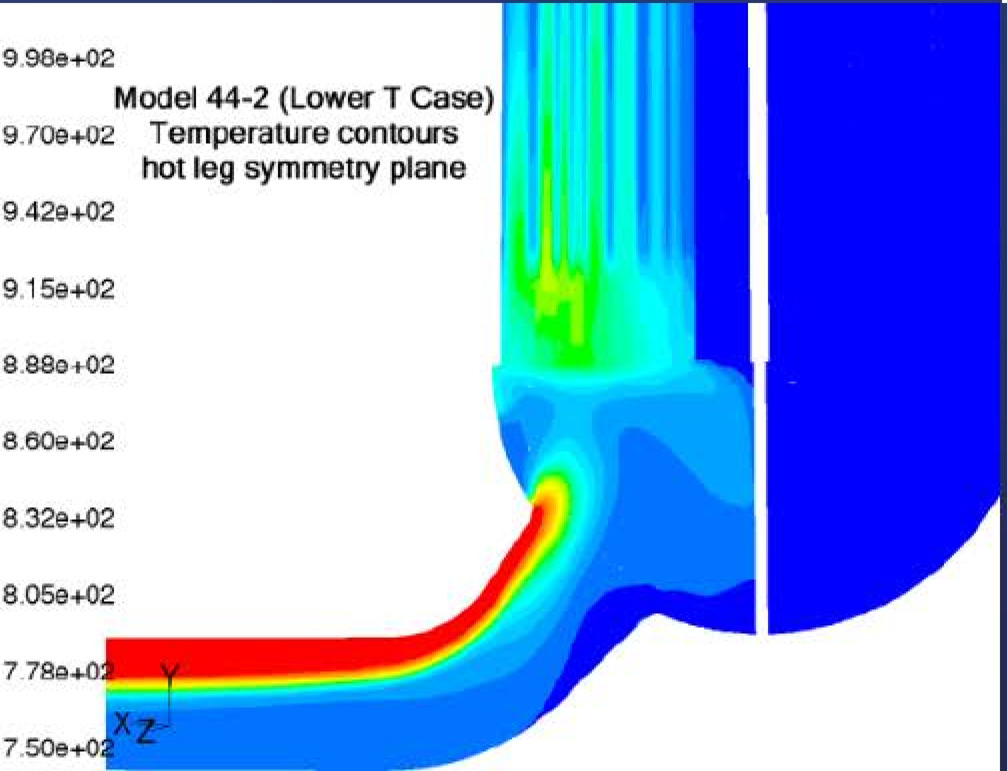
- Supporting development of fusion reactor regulations
- Developing fusion reactor technology expertise
- Evaluating accident progression, releases and potential doses
- Proposing Future Focused Research project



Photos courtesy of ITER

ADDITIONAL ITEMS OF NOTE





- Computational Fluid Dynamics Status
- Future Focused Research Program
  - TRACE/PARCS Modernization Feasibility Study
  - Upcoming Fusion reactor proposal for MELCOR
- Code Application and Maintenance Program

Selected Accomplishments & Future Plans

Selected Accomplishments
- Released new versions of TRACE, PARCS and SNAP (FY21)
- Completed several BlueCRAB Advanced Reactor reference plant models (FY20 and FY21)
- Completed regulatory support for NuScale Design Certification Application (FY20) and SHINE (FY22)
- Completed Plant Decks for Oconee (FY20) and Palo Verde(FY21) and Point Beach (FY21)

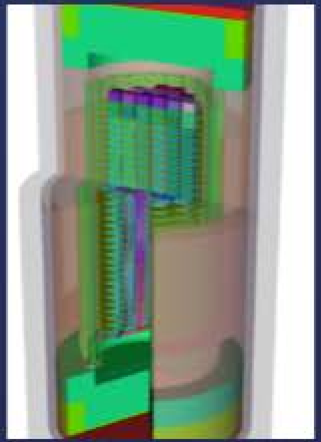
Future Plans
- Perform confirmatory analyses for ATF/HBU, SMR and Advanced Reactor licensing actions
- Complete implementation of Advanced Reactor code development plans
- Modernize TRACE/PARCS plant decks and TRACE/PARCS codes
- Assess TRACE against data from CSNI/NEA experimental programs, including RBHT

Fuel, Neutronics, Severe Accident Progression and Source Term Analysis

Hossein Esmaili, Ph.D.
Chief, Fuel & Source Term Code Development Branch

Branch Description

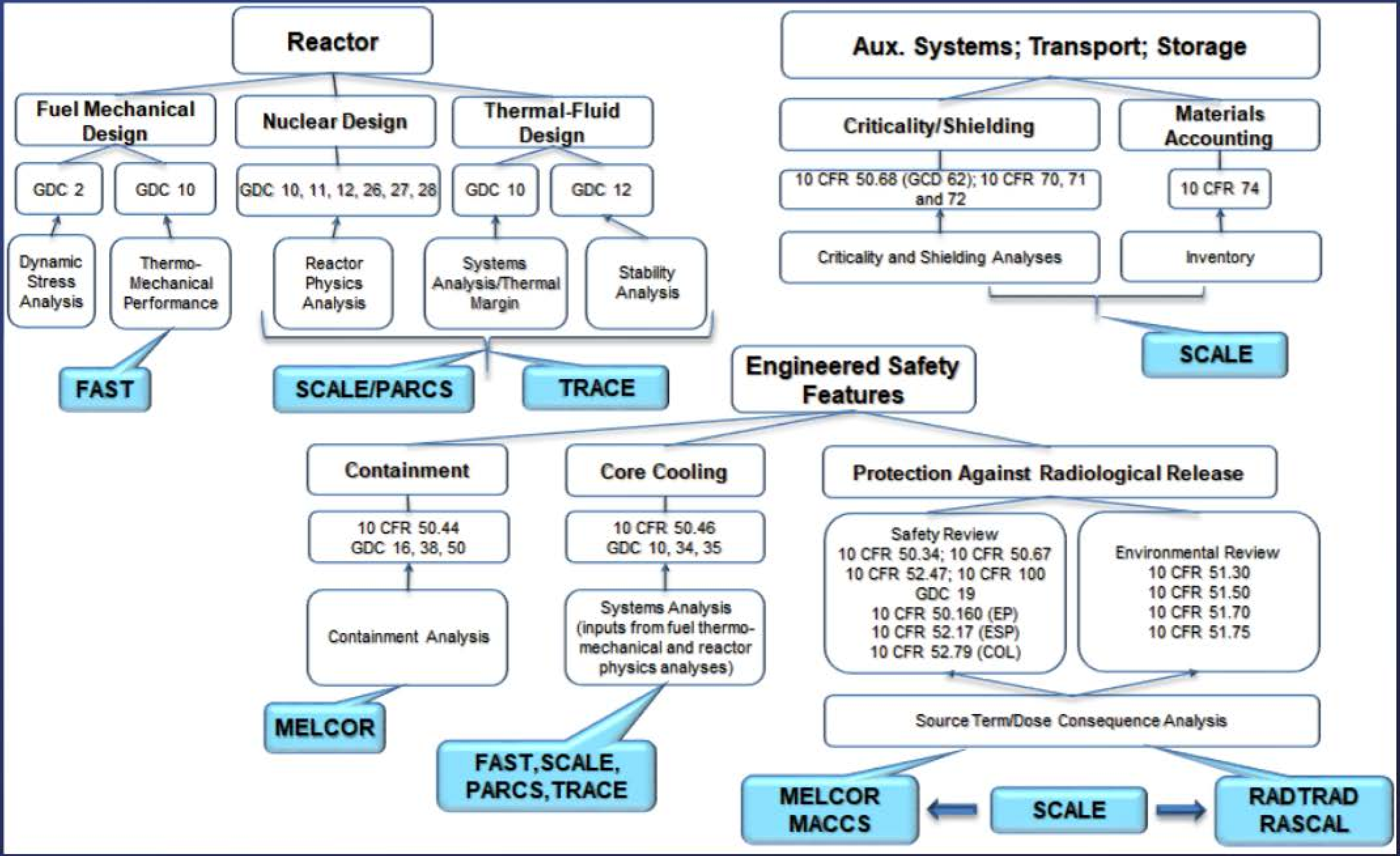
Develop, validate and maintain state-of-practice of neutronics, fuel, and severe accident computer codes for regulatory applications



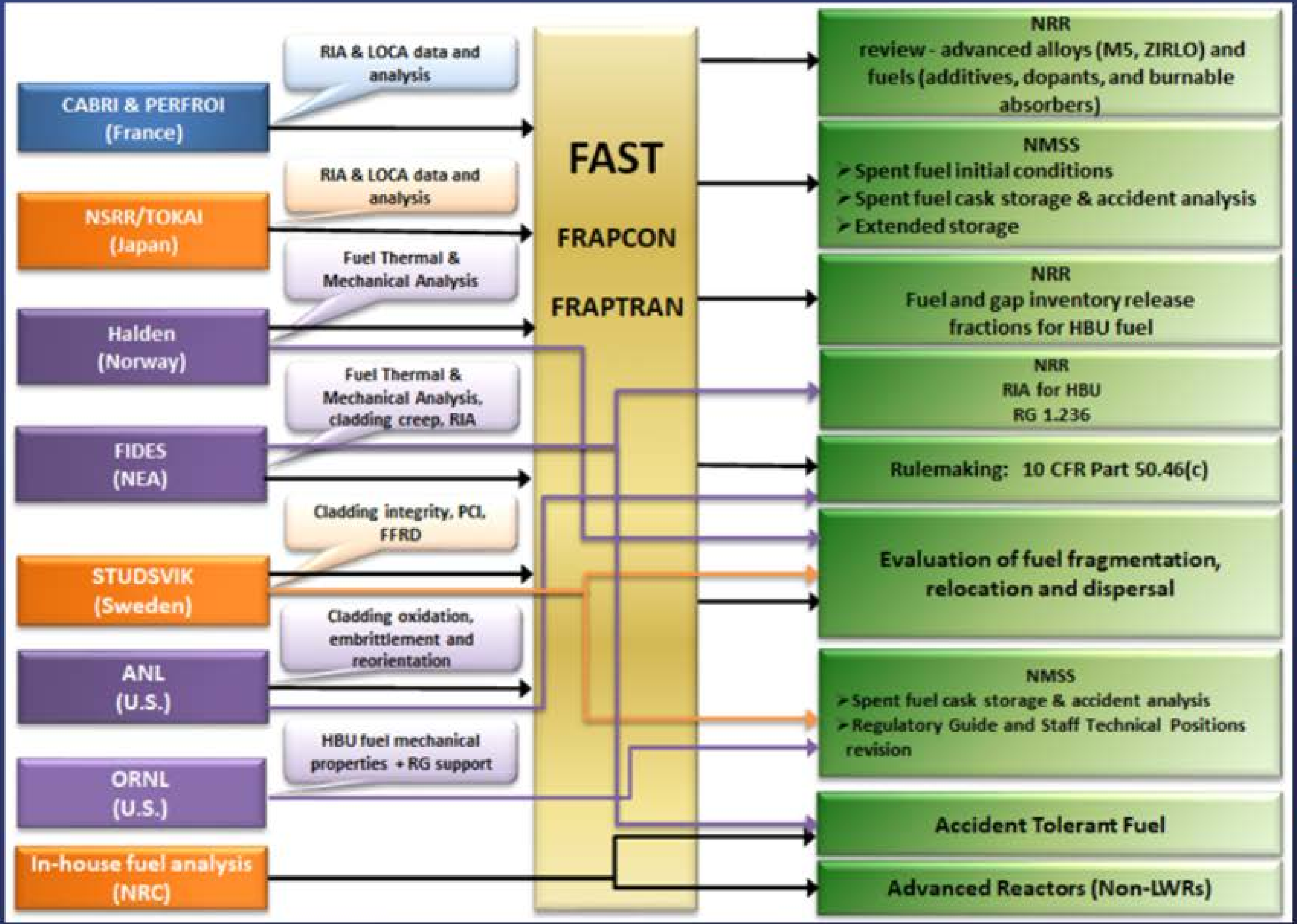
Leverage NRC, domestic, and international resources to participate in experimental programs for data needed to develop and validate analytical tools

Maintain staff technical expertise & engage with internal and external stakeholders to support Agency risk-informed regulatory decision-making

Regulatory Support



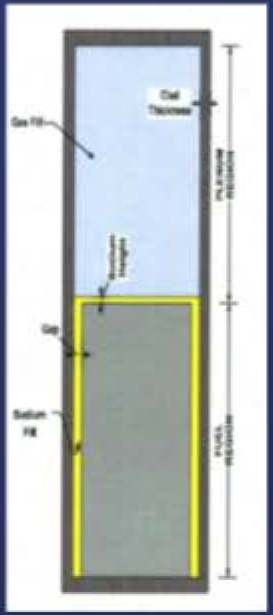
Fuel Code Development & Regulatory Applications

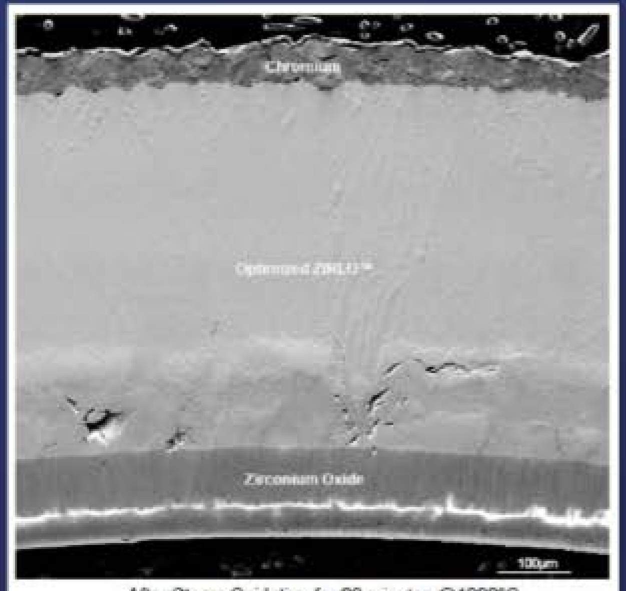


WHAT IS IT?	FAST (Fuel Analysis under Steady-State & Transients) calculates the thermal-mechanical response of nuclear fuel under steady-state and accident conditions.
HOW IS IT USED?	FAST is used to support licensing reviews in NRR by assessing specified acceptable fuel design limits, evaluating vendor fuel codes and methods, and providing initial conditions for design basis accident analysis. It is also used to perform spent fuel analyses to support NMSS reviews.
WHO USES IT?	FAST and the FRAP codes are used by more than 75 domestic and international organizations, including other regulatory bodies, technical scientific organizations, and utilities, for safety and core reload applications.
HOW IS IT ASSESSED?	FAST is built on more than 30 years of assessment stemming from the FRAPCON / FRAPTRAN codes, as well as experience with fuel vendor codes and data. It offers more than 200 assessment cases that cover the UO2/Zirconium fuel system, and new cases added for metallic fuels.

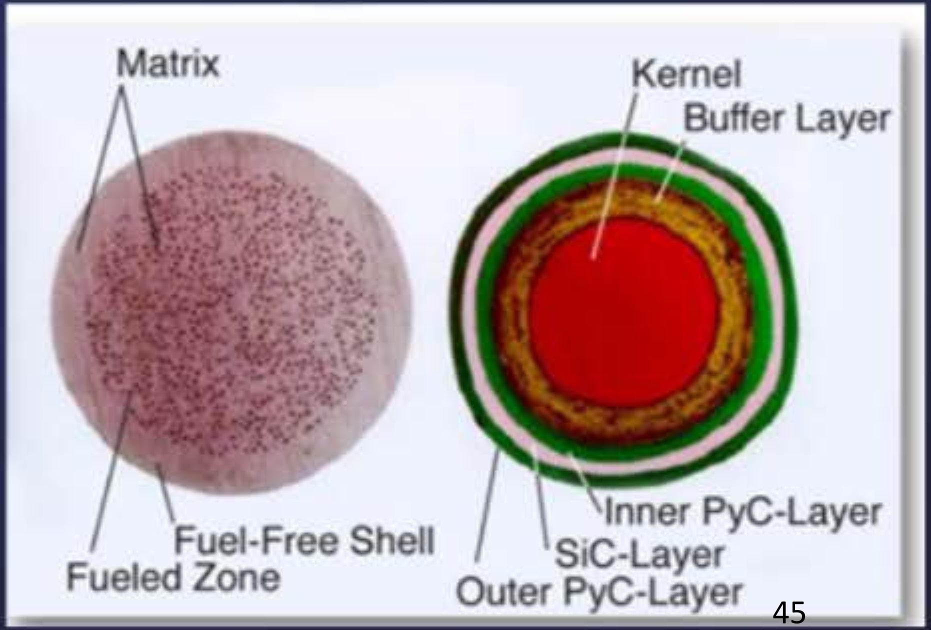
Fuel Priorities

- ATF/HBU/EE Research (NRR/NMSS)
  - Research Information Letter on FFRD
  - NRC meetings with fuel vendors and DOE
- FAST code development (including ATF/non-LWR reactor designs)
  - Version 1.1 (2021) Transient and DBA analysis
  - Assessment (2021) Metallic fuel (March) & TRISO (June)
  - Coupling to TRACE
- SCIP III & IV (NRR/NMSS)
  - Data to assess the burnup threshold for fine fuel fragmentation
  - Mechanical properties important for spent fuel storage
- Halden (NRR)
  - Opportunities for new insights from old data are under discussion
- FIDES (NRR)
  - OECD research program to investigate cladding creep behavior
- Other International activities including CABRI, NSRR, and SPARE
- Develop in-house familiarity with DOE codes (e.g., BISON)

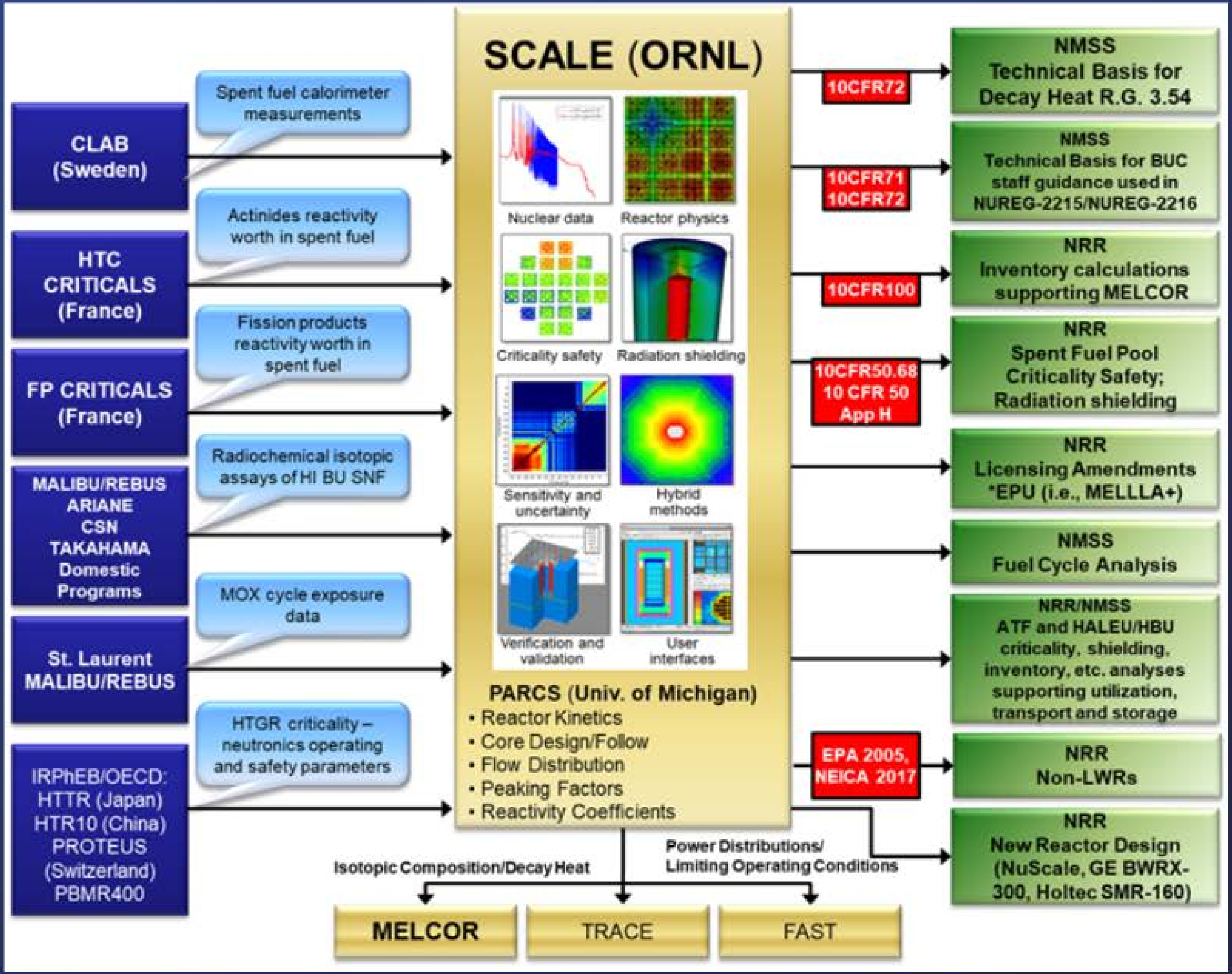




After Steam Oxidation for 20 minutes @1200°C



Neutronics Code Development & Regulatory Applications



WHAT IS IT?

The SCALE code system is a modeling and simulation suite for nuclear safety analysis and design. It is a modernized code with a long history of application in the regulatory process.

HOW IS IT USED?

SCALE is used to support licensing activities in NRR (e.g., analysis of spent fuel pool criticality, generating nuclear physics and decay heat parameters for design basis accident analysis) and NMSS (e.g., review of consolidated interim storage facilities, burnup credit).

WHO USES IT?

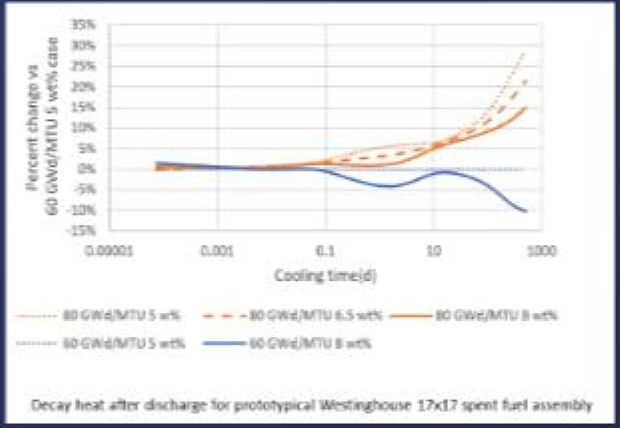
SCALE is used by the U.S. Nuclear Regulatory Commission and in 61 countries (about 10,000 users and 33 regulatory bodies).

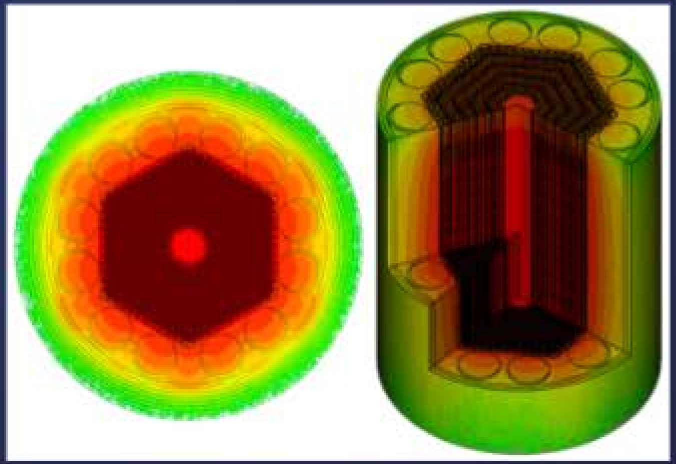
HOW IS IT ASSESSED?

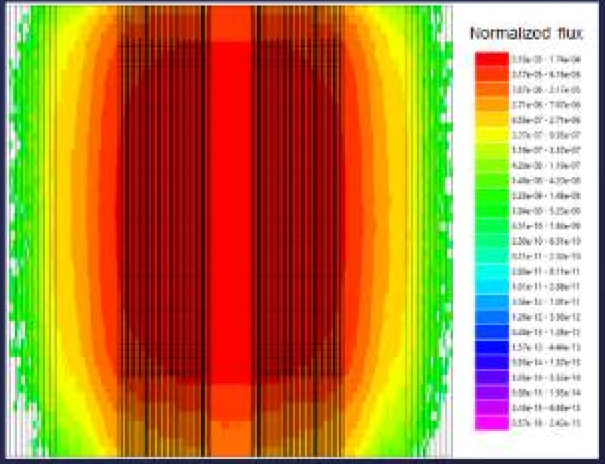
SCALE has been validated against criticality benchmarks (>1000), destructive assay of fuel and decay heat for PWRs and BWRs (>200)

Neutronics Priorities

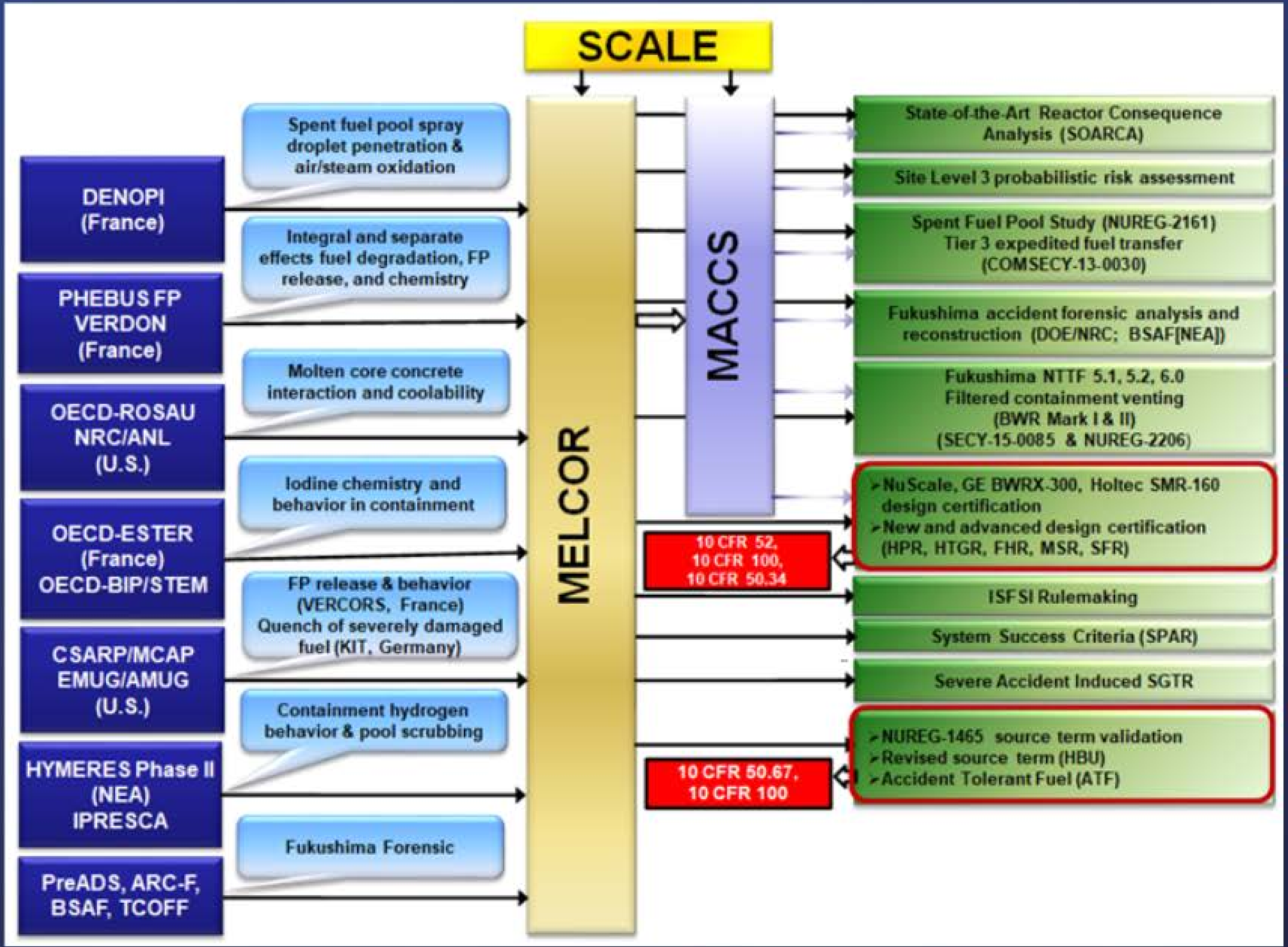
- SCALE (NRR/NMSS)
  - SCALE 6.3 release
  - ATF/HALEU/HBU Plan
  - Non-LWR plan (Volumes 3 & 5)
  - User group workshops and training
  - Develop a shielding guidance document
  - Perform radio-chemical assay work to support validation of codes
- PARCS (NRR)
  - PARCS v3.3.6 Release
  - ATF/HALEU/HBU Plan
  - TRACE/PARCS plant input decks
- Develop in-house familiarity with DOE codes (e.g., Serpent, Griffin)







Severe Accident Code Development & Regulatory Applications

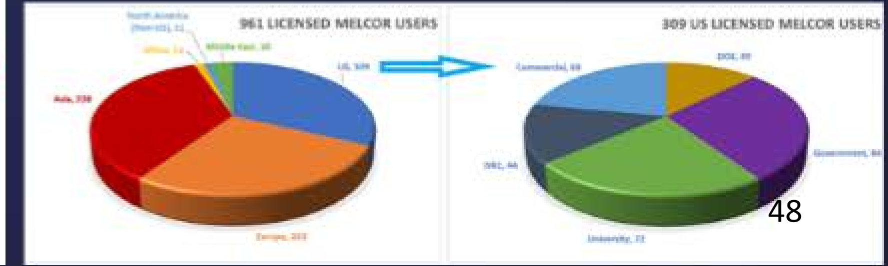


WHAT IS IT?
MELCOR is an engineering-level code that simulates the response of the reactor core, primary coolant system, containment, and surrounding buildings to a severe accident.

HOW IS IT USED?
MELCOR is used to support severe accident and source term activities at NRC, including the development of regulatory source terms for LWRs, analysis of success criteria for probabilistic risk assessment models, site risk studies, and forensic analysis of the Fukushima accident.

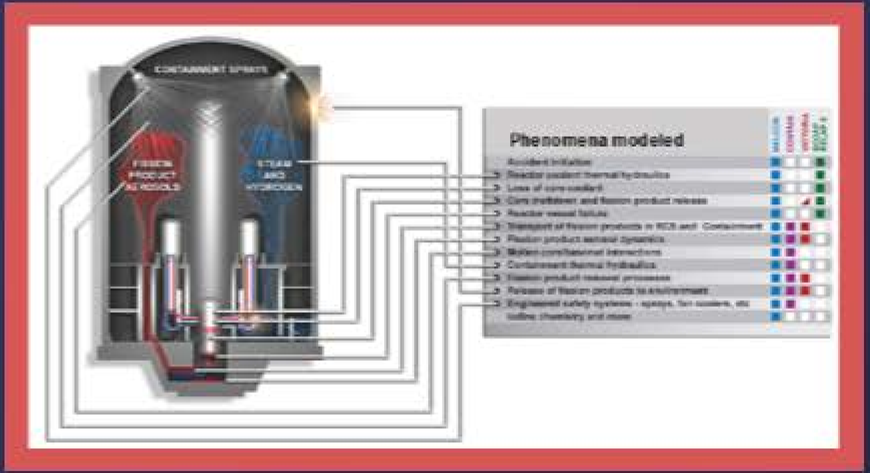
WHO USES IT?
MELCOR is used by domestic universities and national laboratories, and international organizations in around 30 countries. It is distributed as part of NRC's Cooperative Severe Accident Research Program (CSARP).

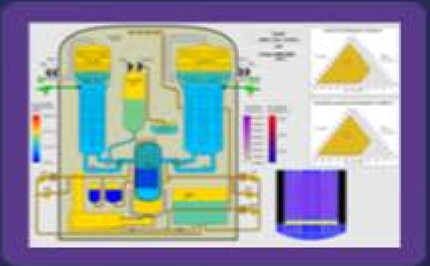
HOW IS IT ASSESSED?
MELCOR has been validated against numerous international standard problems, benchmarks, separate effects (e.g., VERCORS) and integral experiments (e.g., Phebus FPT), and reactor accidents (e.g., TMI-2, Fukushima).

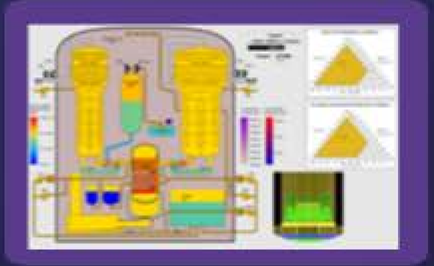


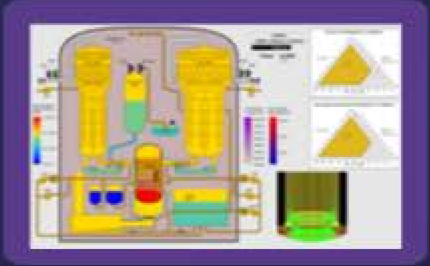
Severe Accident Priorities (1/2)

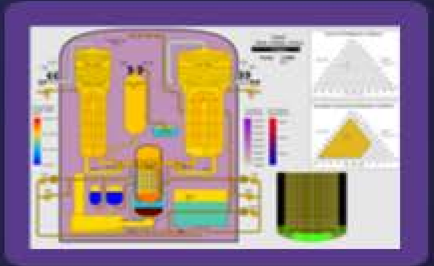
- MELCOR Development
  - Code Modernization
  - Modify code and perform analysis for ATF/HBU & non-LWRs
  - International technical meetings (CSARP/MCAP/EMUG/AMUG)
- OECD/NEA projects
  - PreADES (2018-2021)
  - ARC-F (2019-2021)
  - NEA Reduction of Severe Accident Uncertainties (ROSAU) (2020-2024)
  - Experiments on Source TErm for delayed Releases (ESTER) (2020-2024)
- DENOPI: IRSN project to investigate SFP fuel coolability (SECY-16-0100)
- MUSA: Management and Uncertainties of Severe Accidents
- Small Modular Reactor (NRR)
  - Final safety evaluation report for NuScale (August 2020)
  - Holtec SMR-160 and GE-BWRX-300





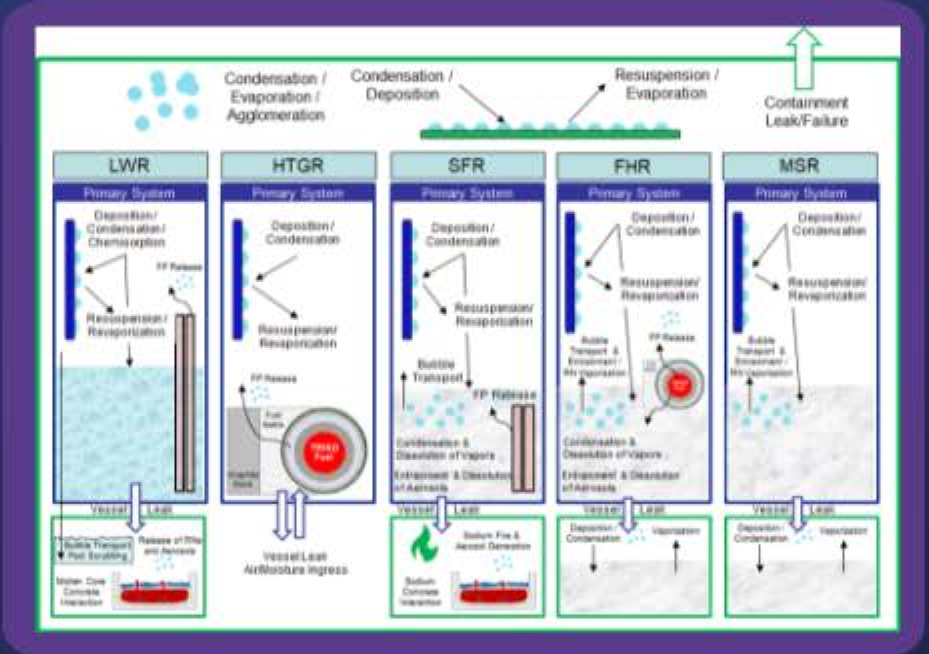


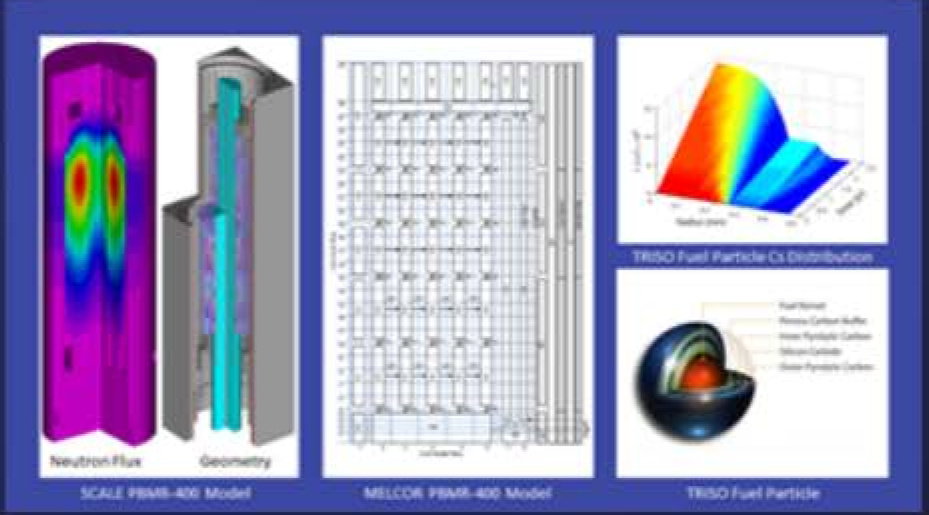




Severe Accident Priorities (2/2)

- Site Level 3 PRA (RES)
  - In-house MELCOR analysis for reactor and spent fuel pool
- RG 1.183 Revision (NRR/DRA)
  - Fuel Handling Accident analysis
  - Re-evaluation of settling velocity distribution and multi-group method
  - Impact of Fuel Fragmentation, Relocation & Dispersal on source term
- Non-LWR Advanced Reactor Design (NRR/NMSS)
  - NRC Integrated Action Plan Strategy 2 (Volumes 3 and 5)
  - Source term demonstration calculations using SCALE/MELCOR
  - Migrate old MELCOR fusion version to MELCOR 2.2 (INL/SNL)
- Accident Tolerant Fuel (ATF) (NRR/NMSS)
  - SA-PIRT: Significant phenomenological issues and improve MELCOR
  - QUENCH-ATF: Near term Cr coated cladding under DBA/BDBA





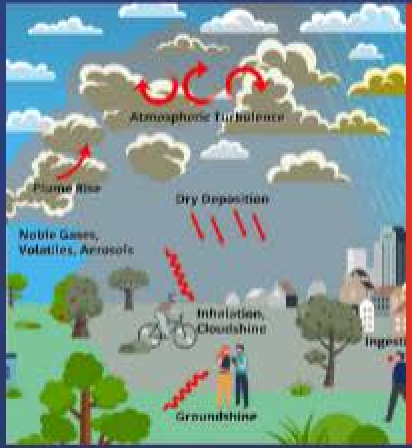
Selected Accomplishments & Future Plans

- Major Code Releases
  - FAST 1.0 (4/2020) - ATF materials and metallic fuel rods
  - MELCOR 2.2.18019 (12/2020) - ATF, non-LWR
  - SCALE 6.2.4 (production) and 6.3b4 (new features for ATF/HALEU/HBU and non-LWR)
- Severe Accident PIRT for ATF/HBU/HALEU and ongoing HBU source term
- Multiple international agreements (e.g., FIDES, QUENCH-ATF) and collaboration
- Successful completion of international technical review meetings
  - 2021 CSARP/MCAP, 2021 EMUG, 2021 upcoming AMUG
  - 2021 SCALE user workshop
- Completion of three non-LWR input models for SCALE/MELCOR (public meetings are scheduled for June/July/September) - plans for SFR and MSR in FY22

Consequence Analysis & Data Science and Artificial Intelligence

Luis Betancourt, P.E.
Chief, Accident Analysis Branch

Branch Description



Plans, develops, and manages analytical and experimental research projects on the progression, response, and offsite consequences of postulated severe accidents

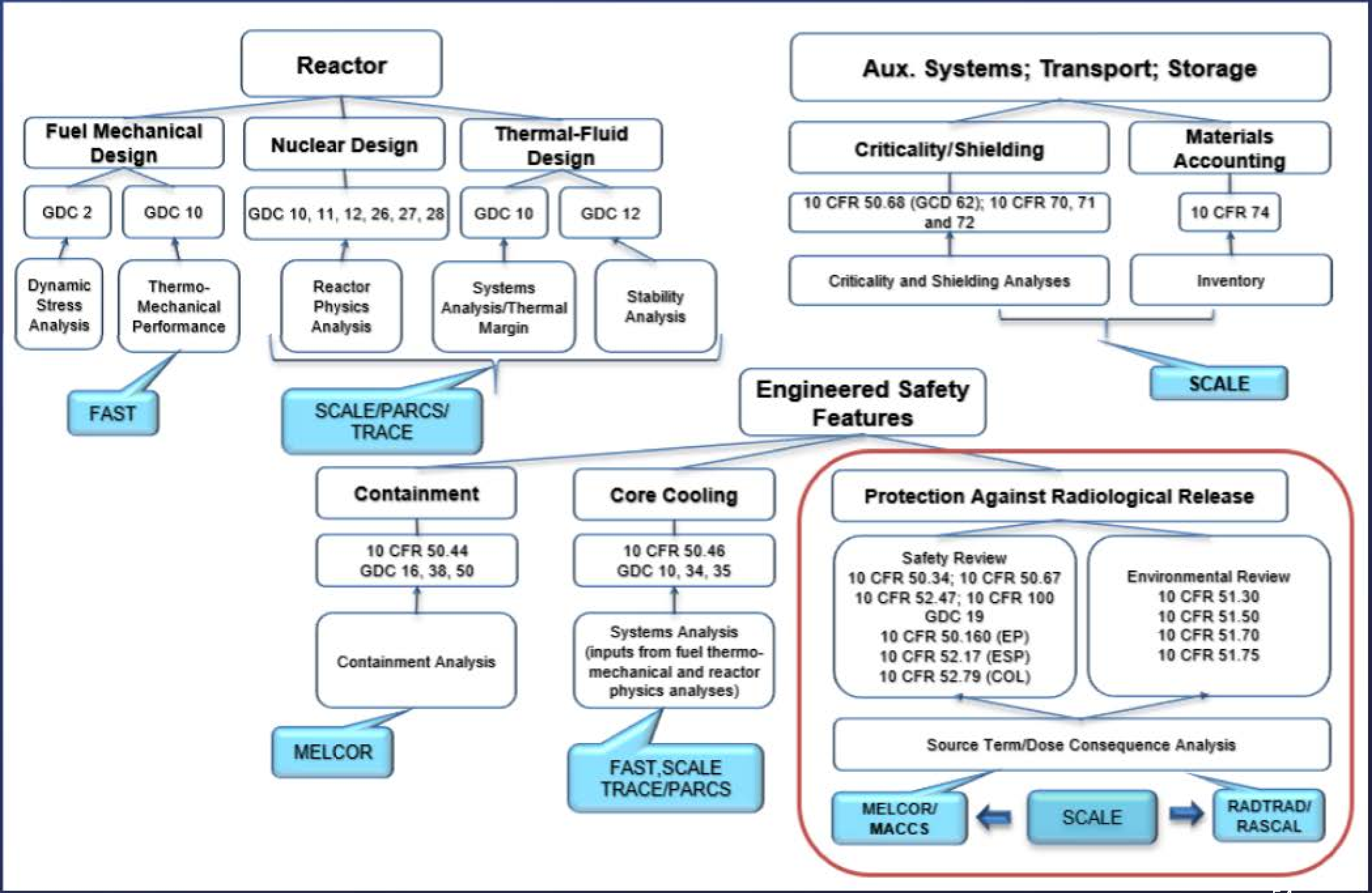
Building expertise in data science and artificial intelligence to support regulatory reviews that utilize these new capabilities

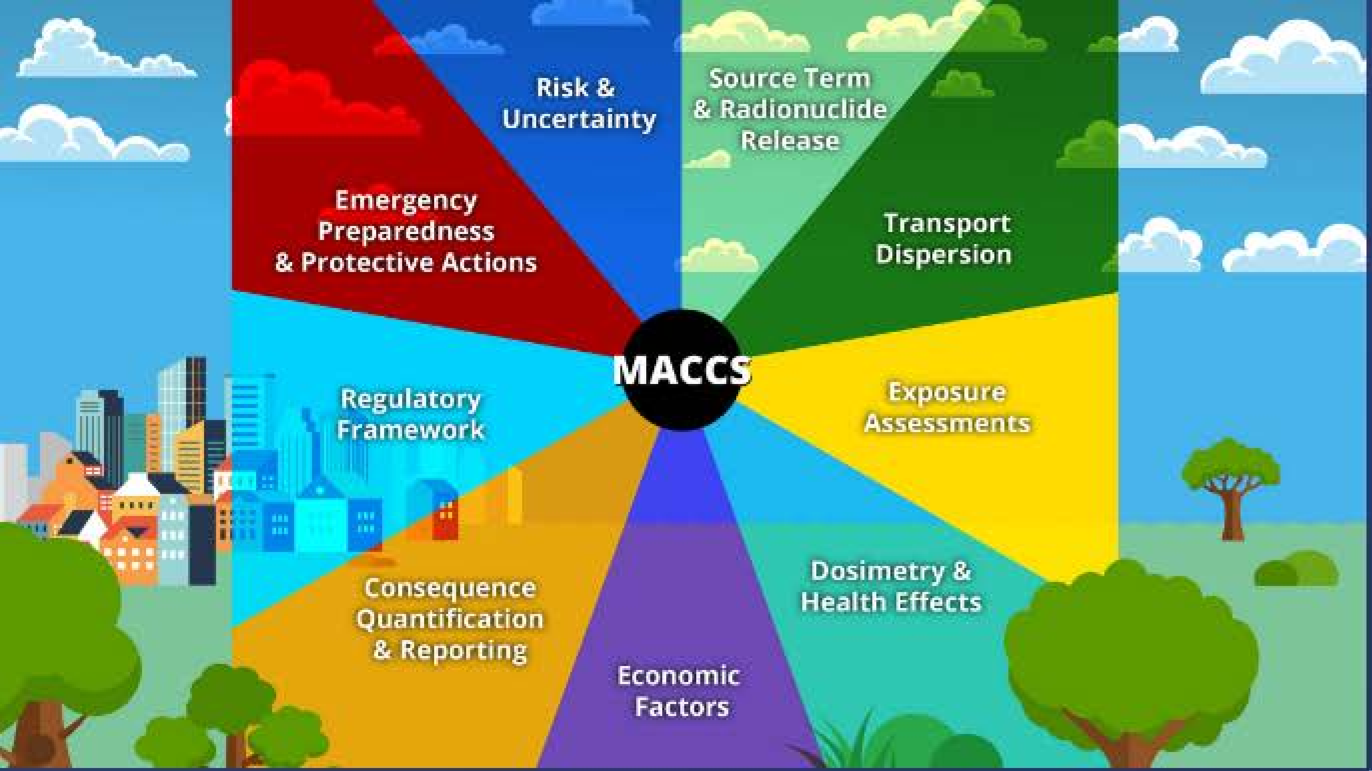
Leverage NRC, domestic, and international resources to develop and validate analytical tools for evaluating the consequences of severe accidents

Maintain staff technical expertise, engage with internal and external stakeholders to support Agency risk-informed regulatory decision-making

Regulatory Support

Consequence Analysis



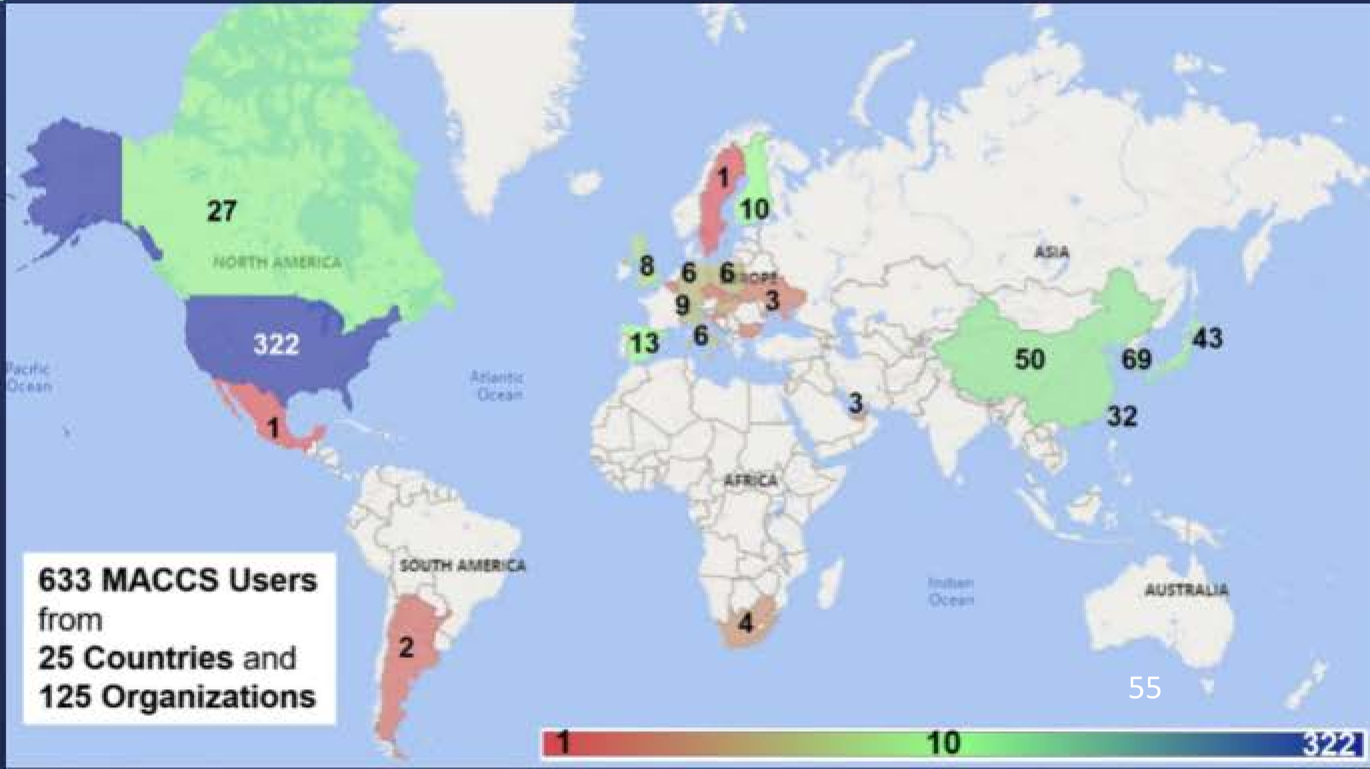


MACCS Overview

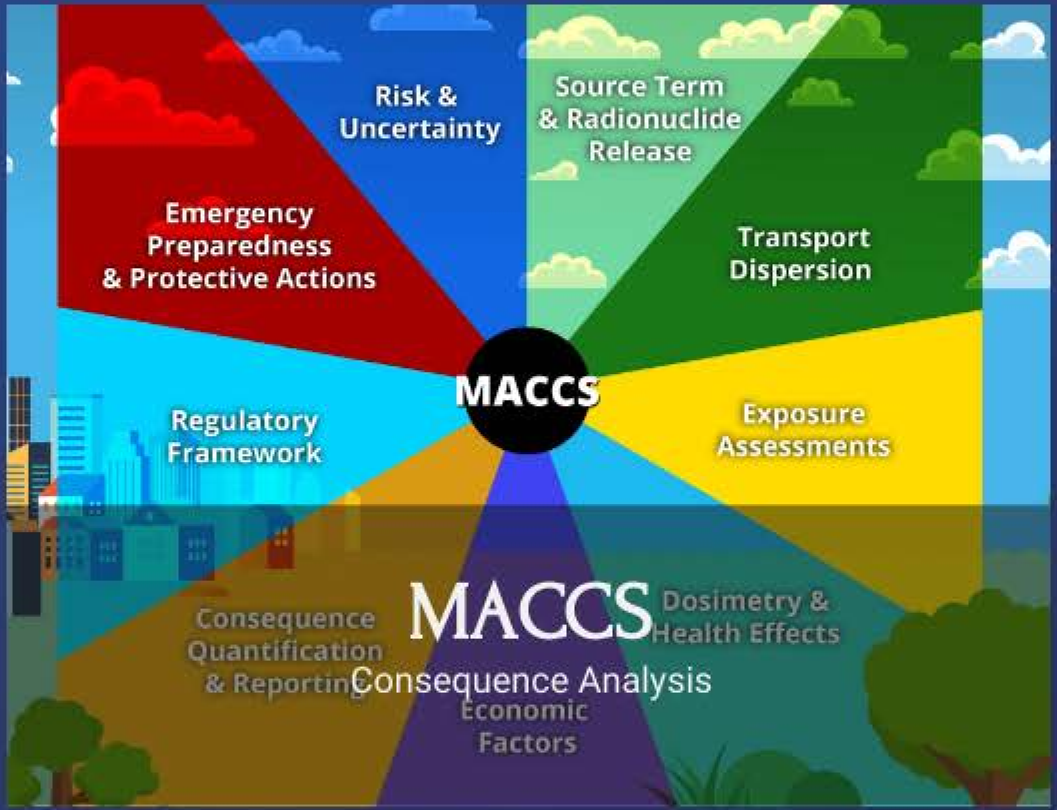
MACCS is the only code used in the U.S. for calculating dose, health, and economic impacts from an atmospheric release of radioactive nuclides.

MACCS Users

MACCS has over 600 users in 25 countries in 125 international organizations

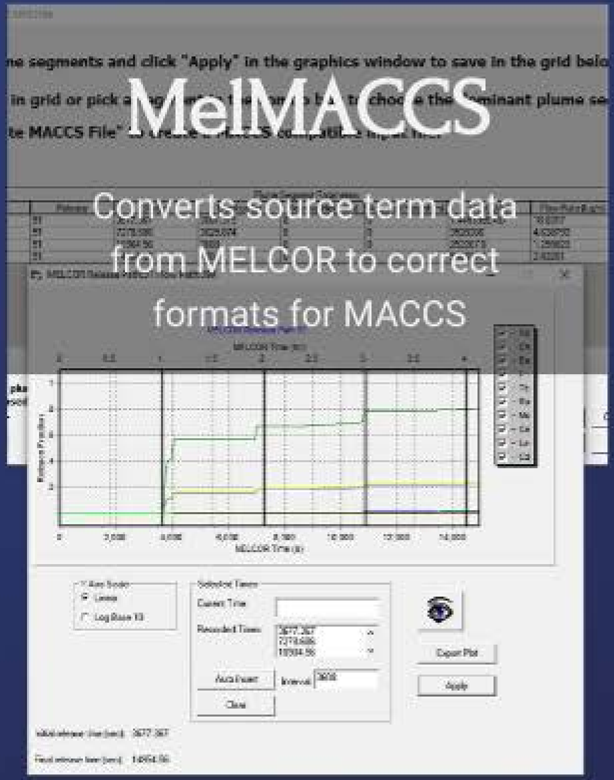


MACCS CAPABILITIES



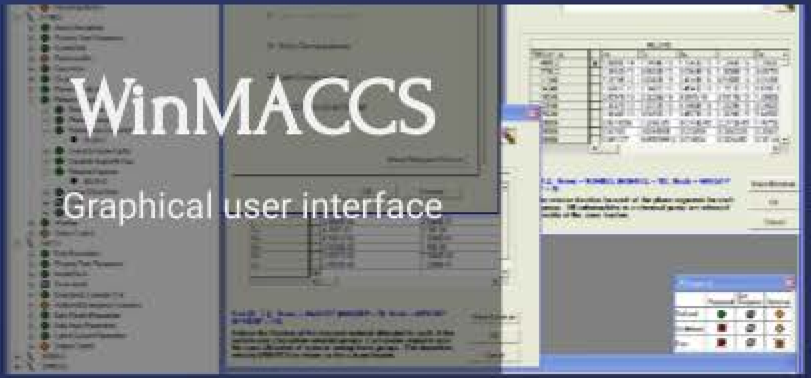
MACCS

Consequence Analysis



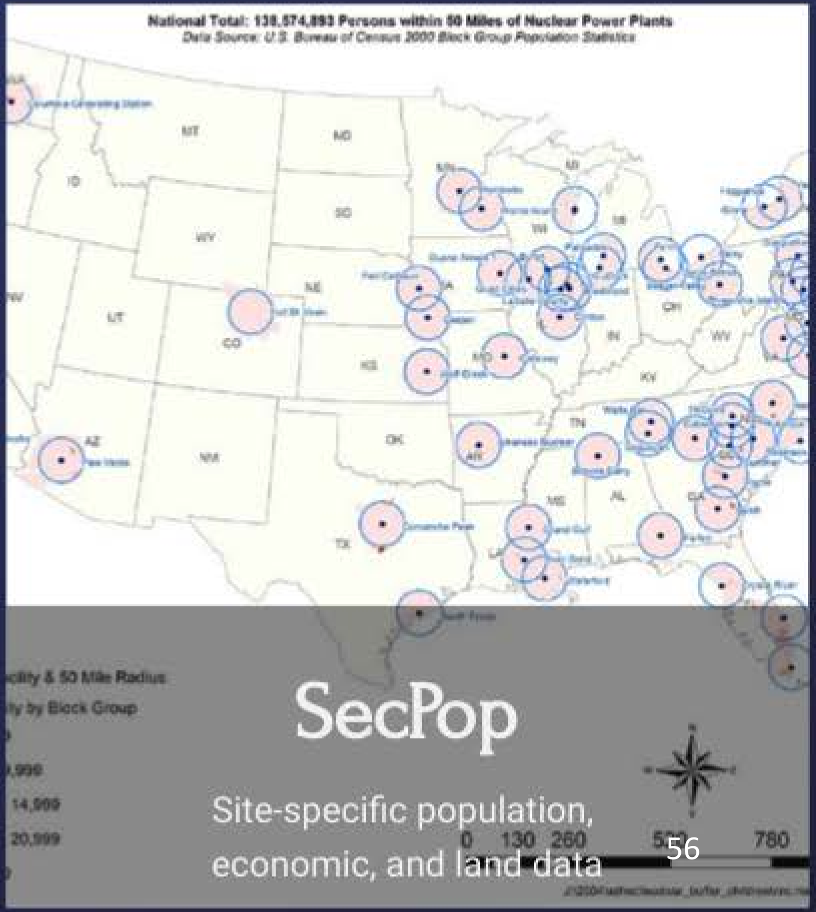
MelMACCS

Converts source term data from MELCOR to correct formats for MACCS



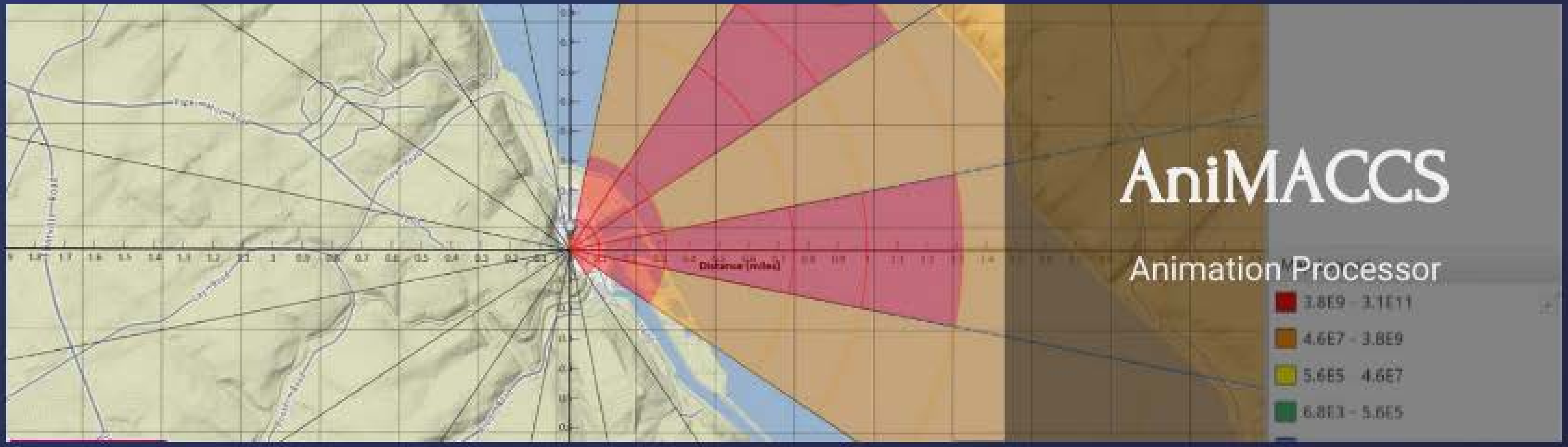
WinMACCS

Graphical user interface



SecPop

Site-specific population, economic, and land data



AniMACCS

Animation Processor

MACCS Development

Released major upgrade to MACCS v4.0

- Incorporates alternative ATD models using NOAA's HYSPLIT code
- Incorporates alternative economic cost-based model using GDP-based input-output model

Pending release of MACCS v4.1 in Summer 2021

- Additional ATD models are being added into MACCS v4.1 for near-field consequence analysis

MACCS Documentation

- Input parameter guidance
- MACCS User Guide
- MACCS Theory Manual

Ongoing code maintenance, documentation, V&V, distribution, and development

Specific Priority Topics

Consequence Analysis

Perform confirmatory analyses for SMR & Non-LWRs

Release of MACCS v4.1 to incorporate near-field ATD models for SMR and non-LWRs

Complete SOARCA UA Summary Report

Complete Consequence Analyses Supporting Level 3 PRA study

Plan for MACCS Modernization

Supporting NASA for Nuclear Space Launch Safety and Space Reactor Consensus Standards

International Activities

CSARP/IMUG	AMUG	EMUG	Code Distribution	Training and KM
Meetings annually in Summer	Meetings annually in Fall	Meetings annually in Spring	Code distribution and user support worldwide	Training and knowledge management

Specific Priority Topics

Data Science and Artificial Intelligence

AI and Data Science Strategy Plan

AI and Data Science Workshops and Seminars

Resource Prediction Tool

AI/ML
Use Cases

Selected Accomplishments & Future Plans

- Releases of MACCS v4.0/4.1 incorporate near-field ATD Models for SMR and non-LWR licensing (FY20/21)
- Successful completion of international technical review meetings
  - 2021 EMUG and 2021 upcoming IMUG
- Supporting the update of cost-benefit considerations in regulatory analysis (FY21)
  - Issued draft Appendix H, "Severe Accident Risk Analysis" to NUREG/BR-0058 for public comment
  - Completed draft Appendix K, "Morbidity Valuation" to NUREG/BR-0058
  - Completed draft and final NUREG-2242 for replacement energy costs for nuclear power plants
- Completed NUREG/CR-XXXX, "Non-Radiological Health Effects of Evacuations and Relocations" (FY21)
- Complete SOARCA UA Summary Report (FY21)
- Complete AI Strategy (FY22)
- Complete consequence analyses supporting the Level 3 PRA study (FY23)

https://www.nrc.gov/public-involve/conference-symposia/data-science-ai-reg-workshops.html

Radiation Protection Analysis

John Tomon, CHP

Chief, Radiation Protection Branch

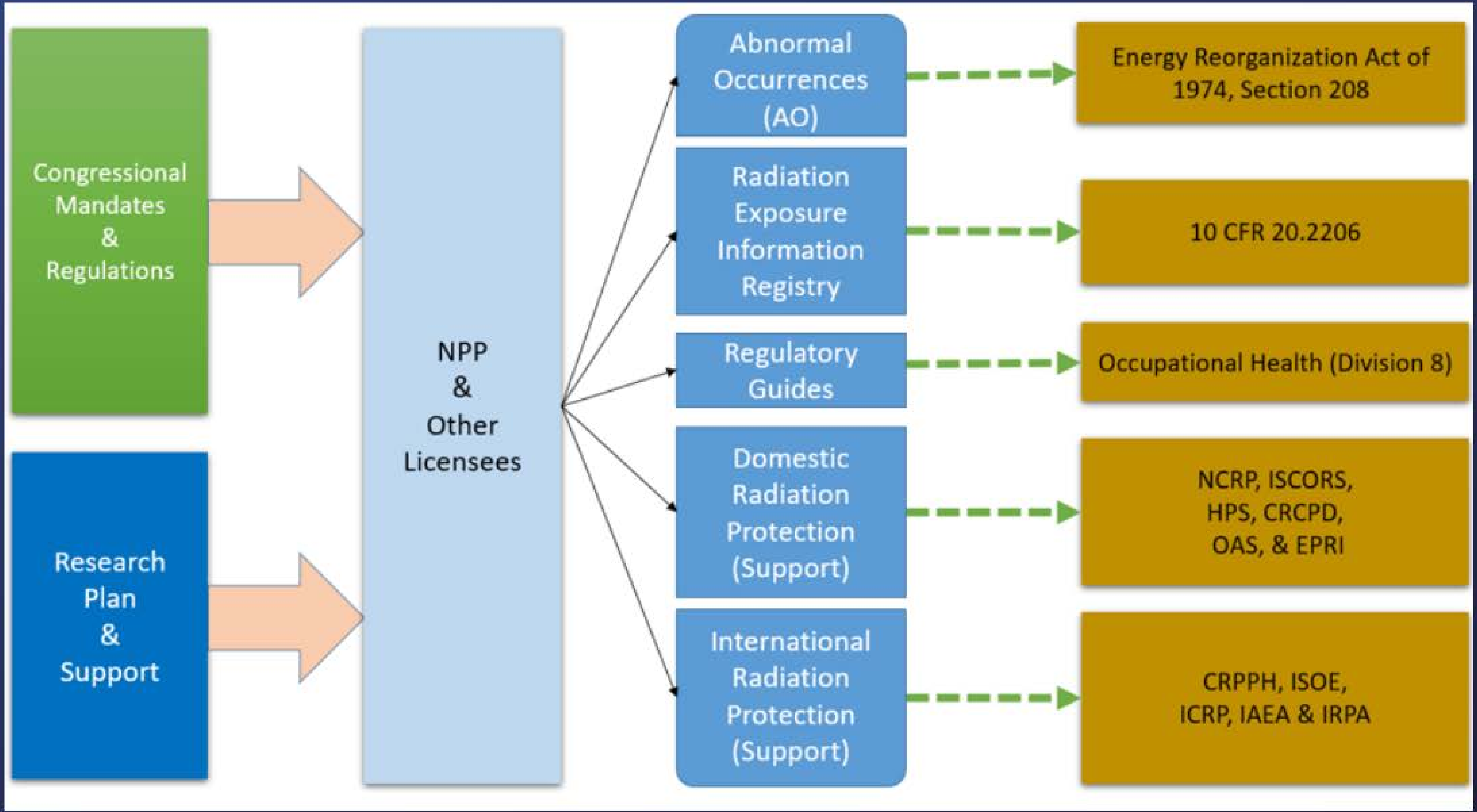
Branch Description

Plan, develop, perform, and manage research programs supporting risk-informed regulatory decision-making in radiation protection at nuclear power plants, materials facilities and users, decommissioning and fuel cycle facilities

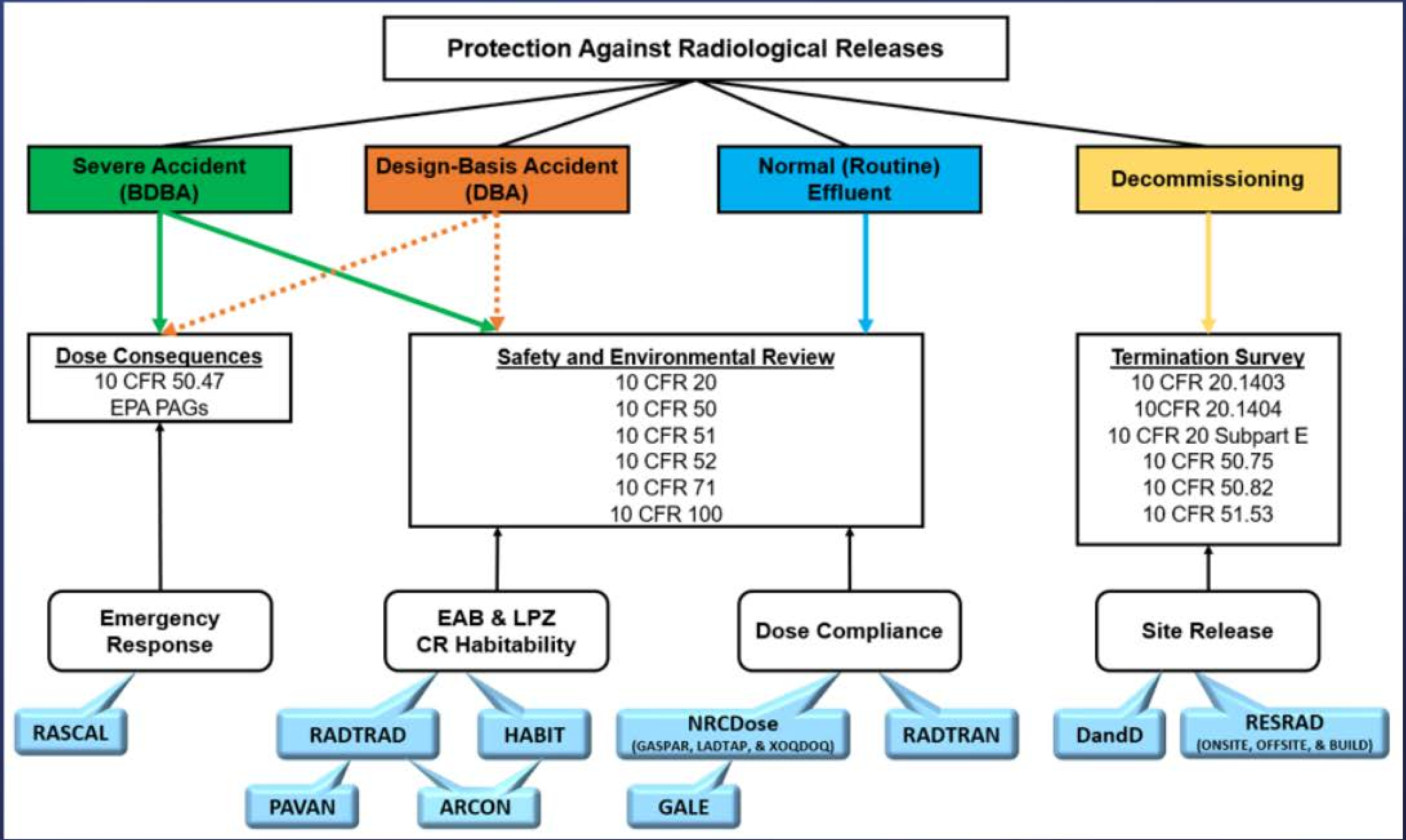
Serves as an agency-wide resource by providing technical support in all aspects of radiation protection to program offices as well as to NRC's domestic and international regulatory and scientific counterparts

Develops and maintains computer codes for assessment of radiation doses to workers and members of the public and executes research in radiation dosimetry and health studies

Regulatory Support
Radiation Protection

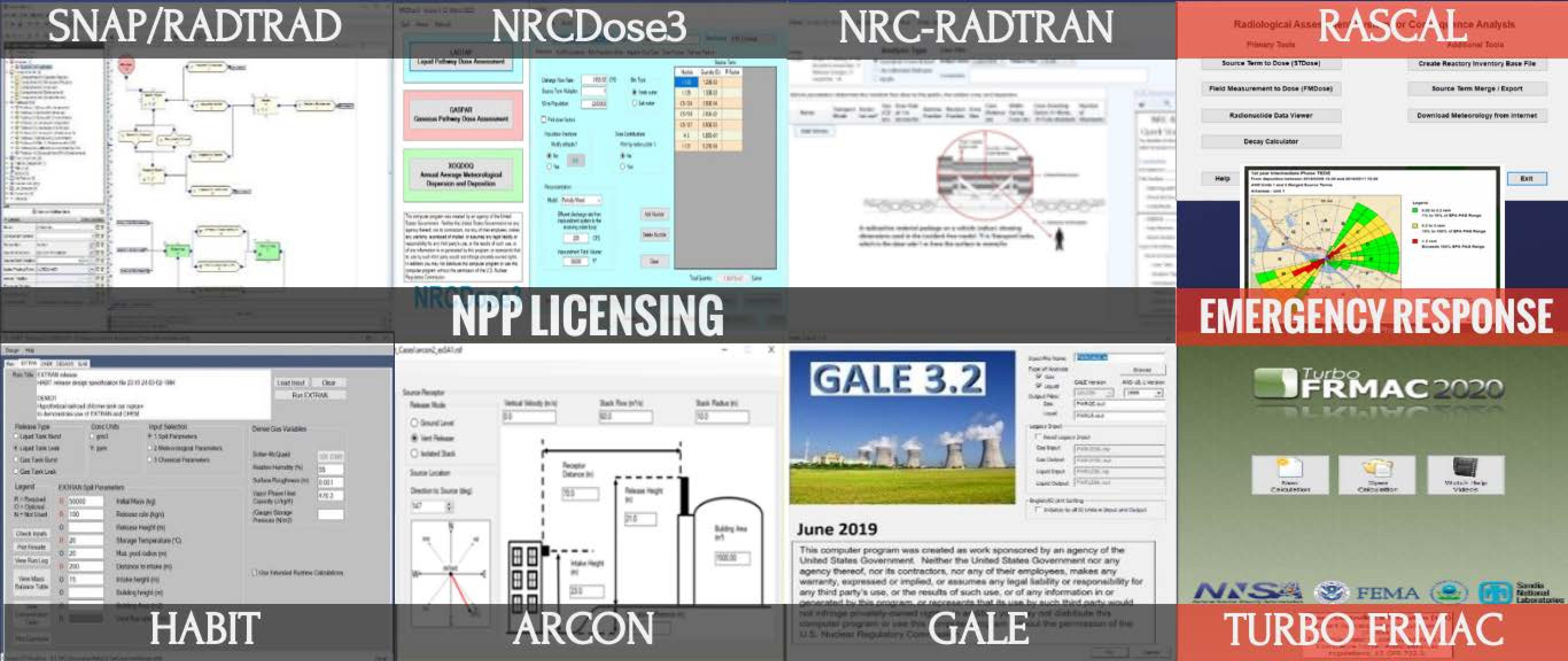


Regulatory Support
Computer Codes



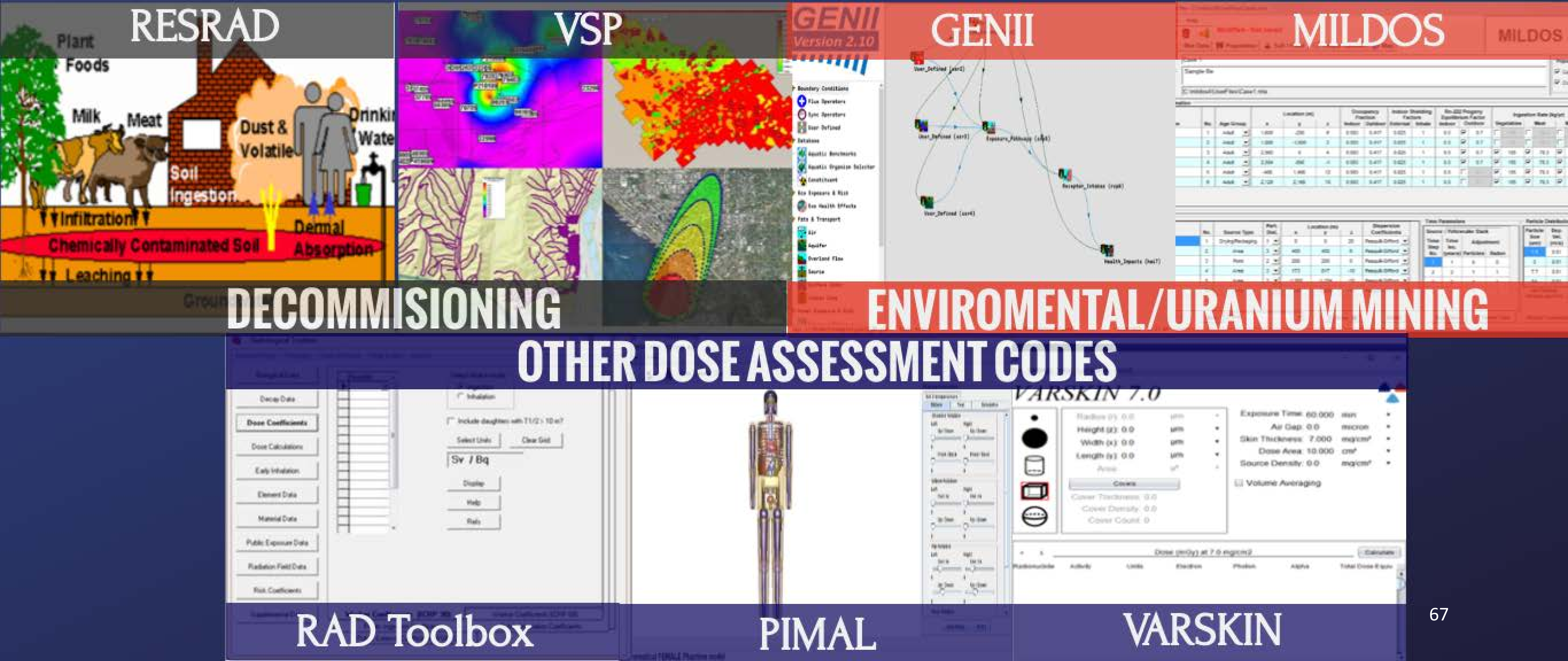
Computer Codes

Radiation Protection Code Analysis and Maintenance Program (RAMP)



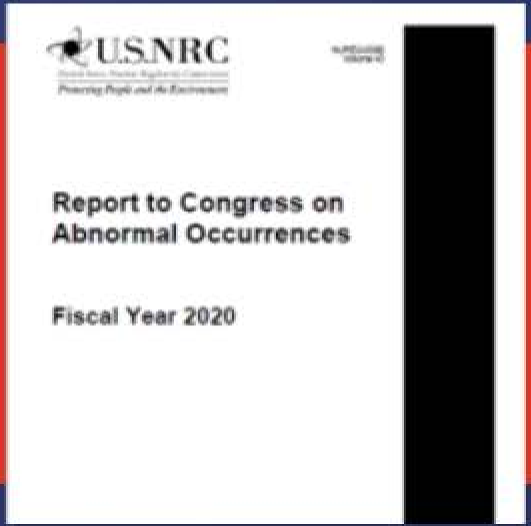
Computer Codes

Radiation Protection Code Analysis and Maintenance Program (RAMP)



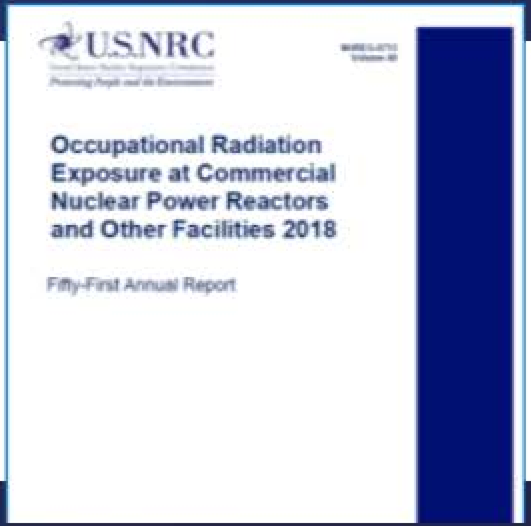
AO Criteria & Evidence Act

Abnormal Occurrence Report (NUREG-0090)

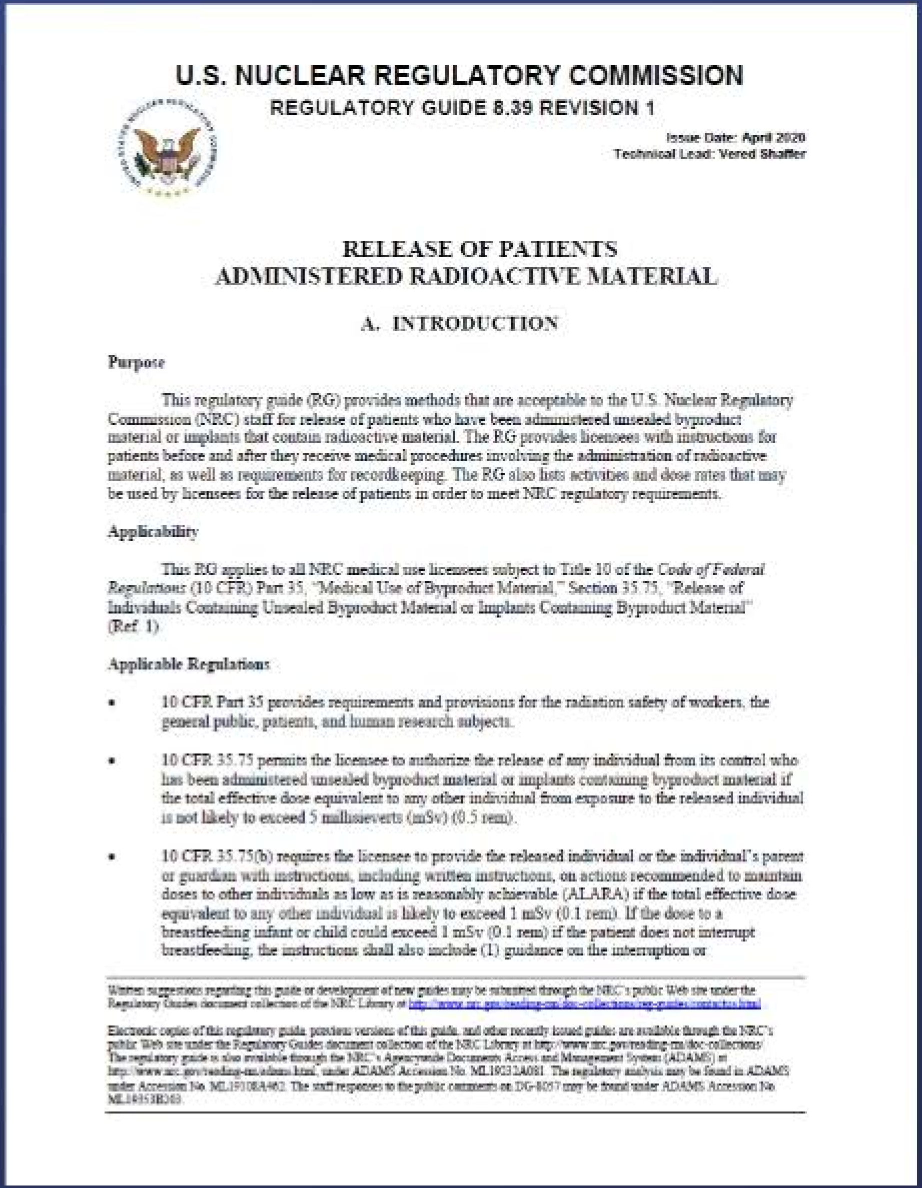


- SRM-SECY-19-0088 - Commission directed the staff to develop and propose a limited revision to the AO criteria the medical event and source security areas
- Final Commission Notation Paper November 2021

- Evidence Act - SECY-20-0067 Enclosure 3 - Radiation Protection Program Evaluation Plan
- To be published in NUREG-0713, Volume 41



Radiation Exposure Information and Reporting System (NUREG-0713)



U.S. NUCLEAR REGULATORY COMMISSION

REGULATORY GUIDE 8.39 REVISION 1

Issue Date: April 2020
Technical Lead: Vered Shaffer

RELEASE OF PATIENTS
ADMINISTERED RADIOACTIVE MATERIAL

A. INTRODUCTION

Purpose

This regulatory guide (RG) provides methods that are acceptable to the U.S. Nuclear Regulatory Commission (NRC) staff for release of patients who have been administered unsealed byproduct material or implants that contain radioactive material. The RG provides licensees with instructions for patients before and after they receive medical procedures involving the administration of radioactive material, as well as requirements for recordkeeping. The RG also lists activities and dose rates that may be used by licensees for the release of patients in order to meet NRC regulatory requirements.

Applicability

This RG applies to all NRC medical use licensees subject to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 35, "Medical Use of Byproduct Material," Section 35.75, "Release of Individuals Containing Unsealed Byproduct Material or Implants Containing Byproduct Material" (Ref. 1).

Applicable Regulations

- 10 CFR Part 35 provides requirements and provisions for the radiation safety of workers, the general public, patients, and human research subjects.
- 10 CFR 35.75 permits the licensee to authorize the release of any individual from its control who has been administered unsealed byproduct material or implants containing byproduct material if the total effective dose equivalent to any other individual from exposure to the released individual is not likely to exceed 5 millisieverts (mSv) (0.5 rem).
- 10 CFR 35.75(b) requires the licensee to provide the released individual or the individual's parent or guardian with instructions, including written instructions, on actions recommended to maintain doses to other individuals as low as is reasonably achievable (ALARA) if the total effective dose equivalent to any other individual is likely to exceed 1 mSv (0.1 rem). If the dose to a breastfeeding infant or child could exceed 1 mSv (0.1 rem) if the patient does not interrupt breastfeeding, the instructions shall also include (1) guidance on the interruption or

Written suggestions regarding this guide or development of new guides may be submitted through the NRC's public Web site under the Regulatory Guides document collection of the NRC Library at [illegible]

Electronic copies of this regulatory guide, previous versions of this guide, and other recently issued guides are available through the NRC's public Web site under the Regulatory Guides document collection of the NRC Library at http://www.nrc.gov/reading-rm/doc-collections/. The regulatory guide is also available through the NRC's Agencywide Documents Access and Management System (ADAMS) at http://www.nrc.gov/reading-rm/adams.html, under ADAMS Accession No. ML19232A081. The regulatory analysis may be found in ADAMS under Accession No. ML19108A462. The staff responses to the public comments on DG-8057 may be found under ADAMS Accession No. ML19353B203.

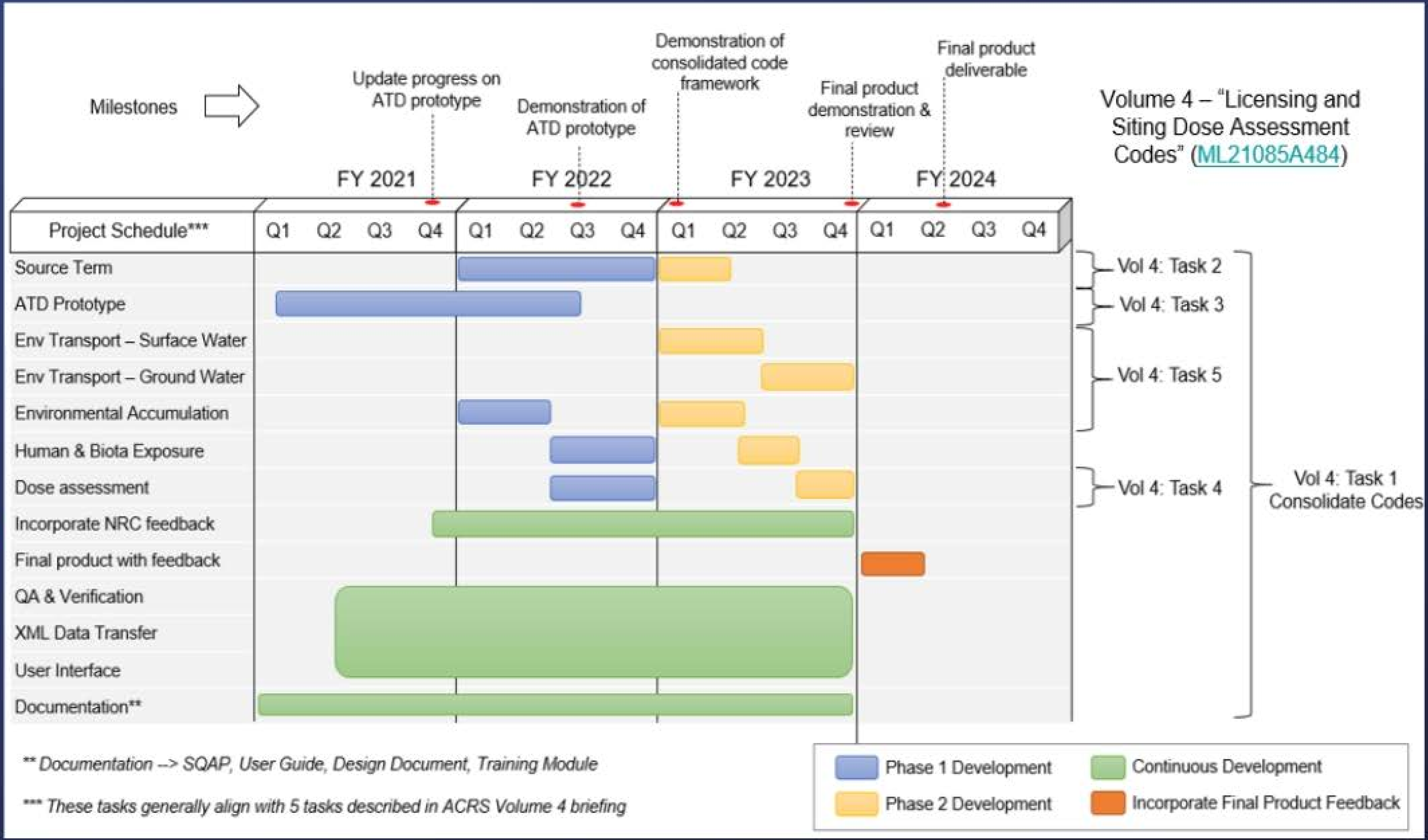
ADAMS Accession No. ML19232A081

RG 8.39 Development

Release of Patients Administered Radioactive Material

- Revision 1 (April 2020)
  - Commission Directed
  - Updated & more detailed provider instructions
  - Added section on death of patient administered a radiopharmaceutical
  - Updated breast feeding instructions.
- Revision 2 (ongoing)
  - Public comment: Winter 2021
  - Updated dosimetry methodology
  - Patient specific dosimetry methodology
    - factors for biokinetics, occupancy, geometry, and attenuation

CODE CONSOLIDATION

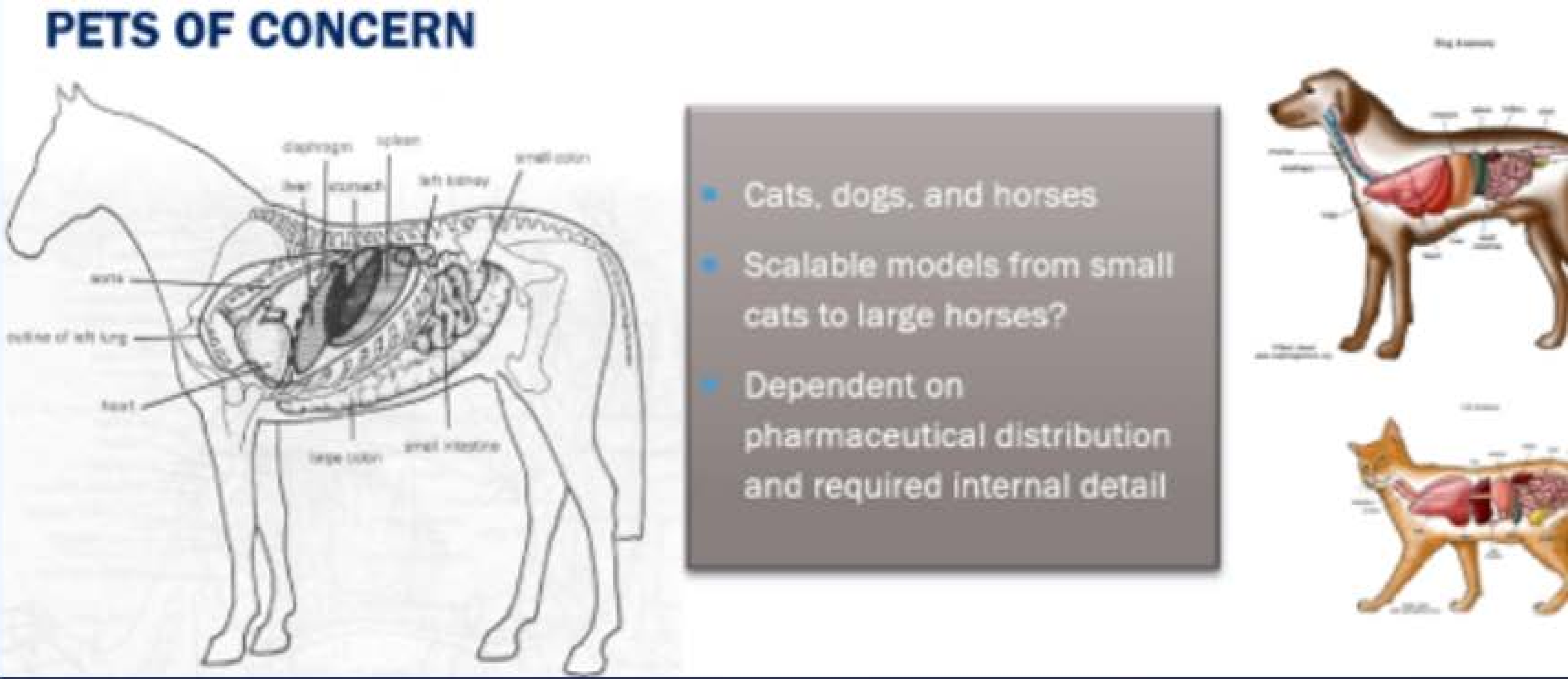


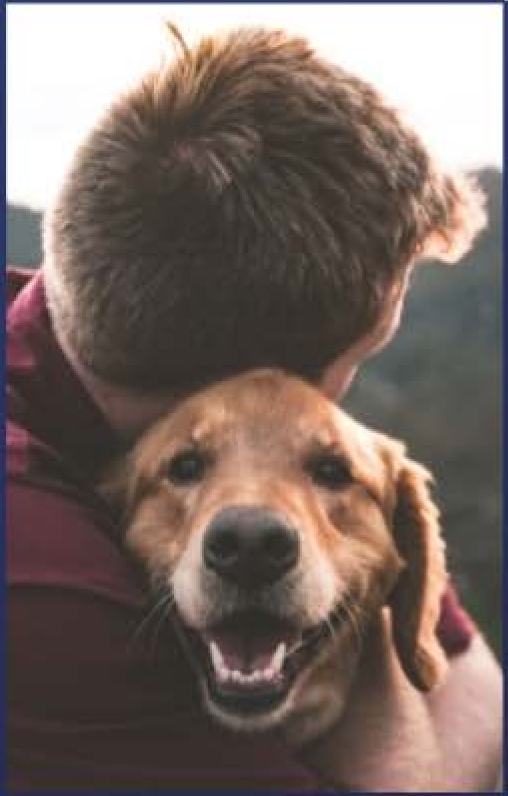
FUTURE FOCUSED RESEARCH PROJECTS

Drones and Virtual Reality Tools to Analyze Radiological Surveys in Decommissioning

- The plan is to demonstrate the ability of drones, coupled with radiation detectors, to support decommissioning radiological surveys.
- Drone flight tests will be conducted at the Pacific Northwest National Laboratory's Large Detector Array Facility, where permits are in place to use radiation sources and Federal Aviation Administration licensed drones.
- Results from this work will be finalized in calendar year 2022

FUTURE FOCUSED RESEARCH PROJECTS



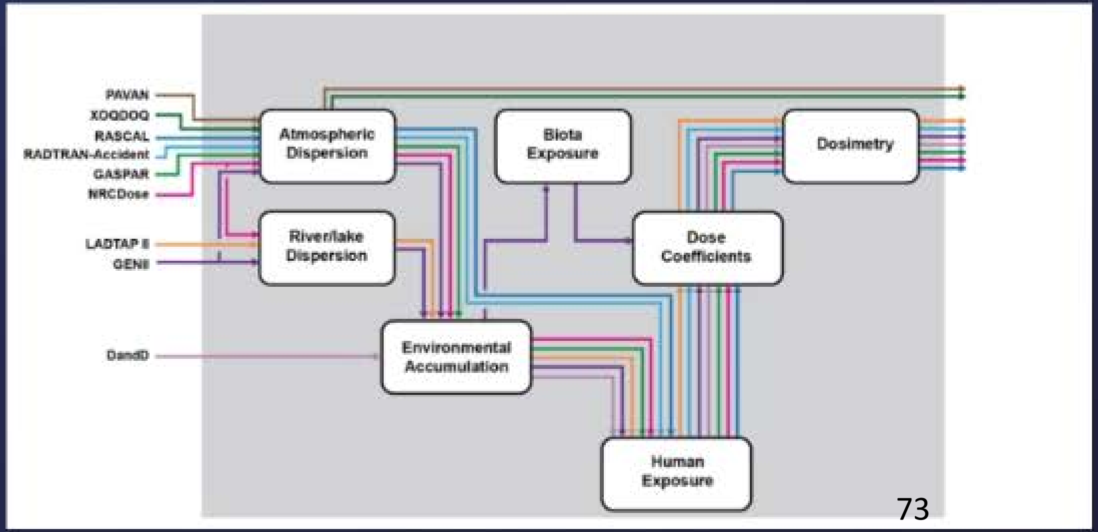


"Can I pet my pets????" A Dosimetry Risk Analysis for Veterinarian Use of Radiopharmaceuticals

- Address a regulatory gap related to emergent pet radiation treatments from veterinary administered radiopharmaceuticals.
- Technical report on internal and external animal to human dose assessments (dosimetry for individuals in contact with animals that had radiation therapy).
- Serve as initiator for radiological veterinary guidance development.

Selected Accomplishments & Future Plans

- Major Computer Code Updates/Releases
  - Over 10 updates to the various RAMP computer codes
- NUREG & Regulatory Guide Publications
  - Published 8 NUREG Reports in support of the RAMP codes
  - Completed 2 AO Reports to Congress
  - Completed 2 REIRS NUREG Reports
  - Issued Revision 1 to RG 8.39, "Release of Patients Administered Radioactive Materials "
- RAMP Program
  - 2 Domestic & 2 International Meetings (virtual)
  - 4 New International Agreements
- Future Plans
  - RAMP computer code consolidation



International Activities

RAMP	OECD/NEA	ISOE	ICRP
Radiation Protection Computer Code Analysis and Maintenance Program	Committee on Radiation Protection and Public Health	North American Technical Center	International Commission on Radiological Protection

Closing Remarks

Kimberly Webber, Ph.D.
Director, Division of Safety Systems
Office of Nuclear Regulatory Research

Closing Remarks

- We value ACRS feedback
- We are open to suggestions on approach, structure, and topics
- We are looking forward to other RES Division interactions

BACKUP SLIDES

Acronyms (1/5)

- ABTR - Advanced Burner Test Reactor
- ACRS - Advisory Committee on Reactor Safeguards
- AHTR - Advanced-High Temperature Reactor
- AI - artificial intelligence
- ALFRED - Advanced Lead Fast Reactor European Demonstrator
- AMUG - Asian MELCOR/MACCS User Group
- AO - abnormal occurrences
- ARTHUR - Advanced Reflood Thermal Hydraulics Uncertainty Resolution
- ARCON - Atmospheric Relative Concentrations code
- ATD - atmospheric transport and dispersion
- ATF - accident tolerant fuel
- ATLAS - Advanced-Thermal-Hydraulic Test Loop for Accident Simulation 3
- BlueCRAB - Comprehensive Reactor Analysis Bundle
- CAMP - Code Application and Maintenance Program
- CFD - computational fluid dynamics
- CFR - Code of Federal Regulations
- CRAB - Code and Reactor Analysis Branch
- CRCPD - Conference of Radiation Control Program Directors
- CRPPH - Committee on Radiation Protection and Public Health
- CSARP - Cooperative Severe Accident Research Program
- CSNI - Committee on the Safety of Nuclear Installation
- DBA - design basis accident
- DC - design certifications
- DE - Division of Engineering
- DOE - Department of Energy
- DRA - Division of Risk Assessment
- DSA - Division of Safety Analysis
- DT - deuterium-tritium
- EMUG - European MELCOR/MACCS User Group

Acronyms (2/5)

- ETHARINUS - Experimental Thermal Hydraulics for Analysis, Research and Innovations in Nuclear Safety
- EPRI - Electric Power Research Institute
- EPZ - Emergency Planning Zone
- EVOL - Evaluation and Viability of Liquid Fuel Fast Reactor System
- FAST - Fuel Analysis under Steady-state and Transient
- FFRD - Fuel Fragmentation, Relocation and Dispersal
- FIDES - Framework for Irradiation Experiments
- FY - fiscal year
- GALE - Gaseous and Liquid Effluents Code
- GCR - gas-cooled reactor
- GDC - general design criteria
- GDP - gross domestic product
- GEH - GE Hitachi Nuclear Energy
- GENII - Second-Generation Environmental Dosimetry code
- GGFR - Gas-Cooled Fast Reactor
- HABIT - Computer Codes for Evaluation of Control Room Habitability
- HALEU - high-assay low-enriched uranium
- HEU - high enriched uranium
- HPR - heat pipe reactor
- HPS - Health Physics Society
- HTGR - high temperature gas reactor
- HTR-PM - High-Temperature Gas-Cooled Reactor Pebble-Bed Module
- HYSPLIT - Hybrid Single Particle Lagrangian Integrated Trajectory model
- IAEA - International Atomic Energy Agency
- IAP - Integrated Action Plan
- ICRP - International Commission on Radiological Protection
- IMUG - International MACCS User Group

Acronyms (3/5)

- INL - Idaho National Laboratory
- IRPA - International Radiation Protection Association
- ISCORS - Interagency Steering Committee on Radiation Standards
- ISOE - Information System on Occupational Exposure
- IUP - Integrated University Program
- KAIROS - Kairos Power
- KAYHY - Karlstein Thermal Hydraulic Test Loop
- KM - knowledge management
- LAR - license amendment request
- LEU - low enriched uranium
- LMR - Liquid Metal Reactors
- R&D - research & development
- MCAP - MELCOR Code Assessment Program
- MACCS - MELCOR Accident Consequence Code System
- MCFR - Molten Chloride Fast Reactor
- MFSR - Molten Fast Salt Reactor
- MHTGR - Modular High Temperature Gas-Cooled Reactor
- MILDOS - Uranium mining and milling facilities code
- ML - machine learning
- MSPR - Molten Salt Cooled Pebble Bed Reactor
- MSR - molten salt reactor
- MSRE - Molten-Salt Reactor Experiment
- MUSA - Management and Uncertainties of Severe Accidents
- NASA - National Aeronautics and Space Administration
- NATC - North American Technical Center
- NCRP - National Council on Radiation Protection and Measurements
- NEA - Nuclear Energy Agency
- NIST - National Institute of Standards and Technology
- NMSS - Office of Nuclear Material Safety and Safeguards

Acronyms (4/5)

- NOAA - U.S. National Oceanographic and Atmospheric Administration
- non-LWR - non-light water reactor
- NPP - nuclear power plant
- NRC - Nuclear Regulatory Commission
- NRC-RADTRAN - Radioactive material transport dose assessment code
- NRCDose3 - normal effluent dose assessment and siting code
- NRIC - National Reactor Innovation Center
- NRR - Office of Nuclear Reactor Regulation
- NPM - NuScale Power Module
- NuScale - NuScale Power, LLC
- OAS - Organization of Agreement States
- OECD - Organisation for Economic Co-operation and Development
- Oklo - Oklo Power LLC.
- PAR - Protective Action Recommendations
- PARCS - Purdue Advanced Reactor Core Simulator
- PB-FHR - Pebble Bed High Temperature Reactor
- PBMR - Pebble Bed Modular Reactor
- PiMAL - Phantom with Moveable Arms and Legs code
- PIRT - phenomena identification and ranking table
- PRA - probabilistic risk assessment
- R&D - research & development
- RAD Toolbox - Radiological Toolbox code
- RADTRAD - Radionuclide Transport and Removal And Dose Estimation code
- RAMP - Radiation Protection Computer Code Analysis and Maintenance Program
- RAR - research assistance request
- RASCAL - Radiological Assessment Systems for Consequence Analysis

Acronyms (5/5)

- RBHT - Rod Bundle Heat Transfer
- REIRS - Radiation Exposure Information and Reporting System
- RES - Office of Nuclear Regulatory Research
- RESRAD - Residual Radioactivity code
- RG - regulatory guide
- SCALE - Standardized Computer Analyses for Licensing Evaluation
- SCIP - Studsvik Cladding Integrity Project
- SDA - standard design approval
- SMR - small modular reactor
- SNAP - Symbolic Nuclear Accident Package
- SOARCA - State-of-the-Art Reactor Consequence Analyses
- SPR A - Sandia Pulsed Reactor A
- SRM - staff requirements memorandum
- TerraPower - TerraPower, LLC
- Terrestrial - Terrestrial Energy
- TRACE - TRAC/RELAP Advanced Computational Engine, or expanded, Transient Reactor Analysis Code, Reactor Excursion and Leak Analysis Program, Advanced Computational Engine
- Turbo FRMAC - Federal Radiological Monitoring and Assessment Center code
- UA - uncertainty analysis
- UNR - user need request
- VARSKIN - Skin dose code
- VSP - Visual Sample Plan code
- V&V - Verification and Validation
- Westinghouse - Westinghouse Electric Company LLC
- X-energy - X-Energy, LLC
- XML - extensive markup language

DSA Completions (1 of 3)

Fuels and Neutronics Analysis

- Accident Tolerant Fuels (ATF) literature reviews and core neutronics evaluations
- FIDES and QUENCH-ATF participation and sharing of data
- Updates to SCALE, FAST, and PARCS computer codes

Multiphysics Nuclear Reactor System Analysis

- NuScale Research Plan
- NuScale Riser Hole Licensing and ACRS Support
- Updates to TRACE and SNAP computer codes

Accident Progression and Source Term Analysis

- ATF Severe Accident PIRT
- Update to MELCOR computer code

DSA Completions (2 of 3)

Consequence Analysis

- State-of-the-art Reactor Consequence Analysis (SOARCA)
- Update to MACCS computer code
- Supported the update of cost-benefit considerations in regulatory analysis
  - Issued draft Appendix H, "Severe Accident Risk Analysis" to NUREG/BR-0058 for public comment
  - Completed draft Appendix K, "Morbidity Valuation" to NUREG/BR-0058
  - Completed draft and final NUREG-2242 for replacement energy costs for nuclear power plants

Radiation Protection Analysis

- Abnormal Occurrence (2 NUREGs) and REIRS Reports (2 NUREGs)
- Updates to ARCON, GALE, GENII, HABIT, MILDOS, RADTRAN, SNAP/RADTRAD, NRCDose3, RASCAL, RESRAD, VARSKIN, and VSP computer codes
- 8 NUREGs supporting various computer codes (e.g., user guides and technical basis manuals)
- RG 8.39, Revsion 1, "Release of Patients Administered Radioactive Material"

DSA Completions (3 of 3)

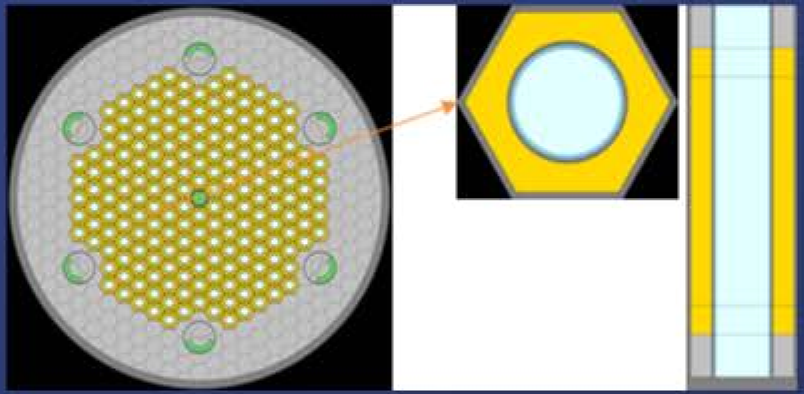
Advanced Reactors

- Code Development Reports
- 7 Reference Plant Models for Systems Analysis
- 3 Reference Plant Models for Severe Accident Analysis
- Fuels (FAST) code assessment reports for metallic and TRISO
- Preliminary Assessment of Oklo Heat Pipe Performance

NRC Scientific Computer Code Investment Plan Ongoing Major Investments

Activity	Brief Description of the Activity	Start	Completion
Code Consolidation: RAMP – Atmospheric	Consolidation of ARCON, PAVAN, and XOQDOQ into a single code	FY21	FY22
Code Consolidation: RAMP – Effluent	Consolidation of GALE and NRCDose into a single code	FY22	FY23
Code Consolidation: RAMP – Habitability	Consolidation of SNAP/RADTRAD and HABIT into a single code	FY23	FY24
Code Modernization: FAVOR	Modernization of FAVOR to transition to state-of-practice software development practices; conversion to object-oriented, parallel, Fortran 2018 source code; consolidation of 3 subprograms into 1; major upgrades to QA and V&V program and pedigree	FY20	FY22
Code Modernization: MELCOR	Modernization of MELCOR to transition to state-of-practice software development practices to incorporate a more flexible code maintenance approach and enhance modeling of advanced technologies	FY18	FY24
Code Modernization: RASCAL	Modernization of RASCAL to transition to state-of-practice software development practices to incorporate a more flexible code maintenance approach and enhance modeling of advanced technologies	FY17	FY23
Code Modernization: SAPHIRE	Modernization of SAPHIRE to transition to state-of-practice software development practices to incorporate modern software development tools to support long-term maintenance and more complex models	FY20	FY24
Code Modernization: PARCS	Being evaluated	TBD	TBD
Code Modernization: TRACE	Being evaluated	TBD	TBD
Code Modernization: MACCS	Being evaluated	TBD	TBD

Microreactor "Reference Model"




Preliminary Assessment of Two Alternative Core Design Concepts for the Special Purpose Reactor

INL
Idaho National Laboratory

- This work focus on developing a reference plant model for heat pipe microreactor
- Based on the “Design A” microreactor described by Sterbentz et al [INL/EXT-17-43212, Rev. 1] , with several simplifications
- Reduction in the number of heat pipes and fuel cells from 1134 in INL design to 192
- Safety shutdown control rod in the center of core
- Rotating control drums at the corners of the hex-shaped core region

Core Design Parameter	Value
Fuel Power (MWt)	5
Fuel Enrichment (wt%)	18.1
Number of Heat Pipes	192
Average Heat Piper Power (kW)	25
Core Height (cm)	100
Effective Side Reflector Thickness (cm)	34.6
RPV Inner Diameter (cm)	113.4
RPV Wall Thickness (cm)	2.5