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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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643RD MEETING

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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FRIDAY

MAY 5, 2017

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ROCKVILLE, MARYLAND

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The Advisory Committee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B1, 11545 Rockville Pike, at 8:30 a.m., Dennis Bley, Chairman, presiding.

COMMITTEE MEMBERS:

DENNIS C. BLEY, Chairman

MICHAEL L. CORRADINI, Vice Chairman

PETER RICCARDELLA, Member-at-Large

RONALD G. BALLINGER, Member

CHARLES H. BROWN, JR. Member

MARGARET CHU, Member

WALTER L. KIRCHNER, Member

JOSE MARCH-LEUBA, Member
DANA A. POWERS, Member
JOY REMPE, Member
GORDON R. SKILLMAN, Member
JOHN W. STETKAR, Member
MATTHEW W. SUNSERI, Member

DESIGNATED FEDERAL OFFICIAL:
KATHY WEAVER

ALSO PRESENT:
ALEXANDER ADAMS, JR., NRR
MICHAEL BALAZIK, NRR
GREGORY BOWMAN, NRR
ROY BROWN, Government Affairs, Curium
MICHAEL CORUM, Northwest Medical Isotopes
GARY DUNFORD, Northwest Medical Isotopes
CAROLYN HAASS, Northwest Medical Isotopes
LOUISE LUND, NRR
JOHN NAKOSKI, RES
SEAN PETERS, RES
STEVEN REESE, Northwest Medical Isotopes
HAROLD SCOTT, RES
MARK TAGGARD, RES
DAVID TIKTINSKY, NMSS

ANDREA D. VEIL, Executive Director, ACRS

KIMBERLY WEBBER, RES

MICHAEL WEBER, RES

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

8:30 a.m.

CHAIRMAN BLEY: Good morning. The meeting will come to order.

This is the second day of the 643rd meeting of the Advisory Committee on Reactor Safeguards. During today's meeting the Committee will consider the following: Northwest Medical Isotopes Overview, Future ACRS activities/report of the Planning and Procedures Subcommittee, biennial review and evaluation of NRC Safety Research Program, and preparation of ACRS reports.

The ACRS was established by a statute and is governed by the Federal Advisory Committee Act, FACA. As such, this meeting is conducted in accordance with the provisions of FACA. This means that the Committee can only speak through its published letters. We hold meetings to gather information to support our deliberations.

Interested parties who wish to provide comments, can contact our offices requesting time after the *Federal Register* notice describing the meeting is published. That said, we also set aside 10 minutes for spur-of-the-moment comments from members of the public attending or listening to our meetings.

Written comments are also welcome.

Ms. Kathy Weaver is the designated federal official for the initial portion of the meeting. There she is.

Portions of the session on Northwest Medical Isotopes may be closed in order to discuss and protect information designated as proprietary. And we'll leave that up to you guys to warn us if we're encroaching in that area.

The ACRS Section of the U.S. NRC public web site provides our charter, bylaws, letter reports and full transcripts of all Full and Subcommittee meetings, including the slides presented.

We have received no written comments or requests to make oral statements from members of the public regarding today's session.

There is a telephone bridge line. To preclude interruption of the meeting the phone will be placed in the listen-in mode during the presentations and Committee discussion.

A transcript of portions of the meeting is being kept and it is requested that the speakers use one of the microphones, identify themselves and speak with sufficient clarity and volume that they may be readily heard.

At this time I will turn this meeting over to Dr. Chu to begin this discussion.

Margaret?

MEMBER CHU: Thank you. This is our first briefing on the Northwest Medical Isotopes, NWMI, construction permit application, and we're very pleased to have the introductory presentations from the NWMI representatives and NRC staff here today.

I'm Margaret Chu, Chairman of the NWMI Subcommittee.

This will be an information briefing as we are preparing to review the construction permit application, and I'm expecting this briefing will help us streamline and focus our review.

As Dr. Bley has said, this is an open meeting to the public, however if it becomes necessary to discuss proprietary information, then we will ask the NRC staff to confirm that only people with clearance and need to know are in the room, and we will have the technicians disconnect the telephone bridge line that's open to the public.

Okay. Now unless any of the ACRS members want to say something first -- no? Now I will invite Al Adams, Chief of Research and Test Reactor Licensing Branch of NRR to start the briefing.

MR. ADAMS: Thank you very much. Good morning.

As was said, my name is Al Adams. I'm the Chief of the Research and Test Reactor Licensing Branch in the Division of Policy and Rulemaking in the Office of Nuclear Reactor Regulation. I'm giving these opening remarks for Louise Lund, the director of our division, who sends her regrets that due to a last-minute issue cannot be with us today.

The Division of Policy and Rulemaking and the Division of Fuel Cycle Safety, Safeguards and Environmental Review in the Office of Nuclear Material Safety and Safeguards are pleased to be here today to conduct an informational briefing for you on the Northwest Medical Isotopes construction permit application. In addition, Northwest Medical Isotopes is here today to present the technology of its proposed facility.

The NRC staff received a construction permit application for a medical isotope production facility from Northwest Medical Isotopes in the summer of 2015. This is the second construction application received by the NRC to construct a medical isotope production facility.

As most of the Committee members are

aware, the NRC issued a construction permit to SHINE Medical Technologies, Incorporated in February of 2016.

Similar to SHINE, Northwest Medical Isotopes is proposing to produce the important isotope molybdenum-99. This isotope decays to technetium-99 metastable, which is used for numerous medical applications worldwide.

NRR and NMSS staff appreciates this opportunity to present our licensing approach for the Northwest Medical Isotopes facility and look forward to continued engagement with the ACRS over the course of our review of the Northwest Medical Isotopes construction permit application. We also appreciate the ACRS and its staff for working with us to support and efficient review schedule.

At this time I'd like to turn the briefing over to Michael Balazik to start the staff's presentation.

MR. BALAZIK: Good morning. As Al said, my name is Mike Balazik. I'm the project manager for Northwest Medical Isotopes. I work in the Research and Test Reactor Licensing Branch within the Office of NRR.

Al's already introduced himself, but I'd like to introduce David Tiktinsky. He's a senior project manager in the Fuel Manufacturing Branch in the Office of Nuclear Material Safety and Safeguards.

So we're on slide 3. Before I get started, and Dr. Chu already mentioned this, but I just want to say that our entire presentation for today's briefing contains public information. If during today's discussion we broach into proprietary information, I ask that any knowledgeable NRC staff member or even a little help from Northwest Medical Isotopes to identify the information as such and we can discuss this during a closed session if needed.

So let's go ahead and get started. The purpose of today's meeting is to provide you an overview of the Northwest Medical Isotopes construction permit application. Also on a high level the staff is going to touch on some of the activities and technologies that Northwest is proposing. And also we'll share the licensing approach of the proposed facility.

So Northwest is proposing to produced molybdenum-99 by fissioning low-enriched uranium targets. These targets will be irradiated at existing university research reactors. Currently Northwest has identified two research reactors: University of

Missouri in Columbia and Oregon State University, to do these targeted irradiations. Northwest has indicated there's a potential for a third reactor to be named in the future.

MEMBER REMPE: So this is the first time that you're -- you've had to be here for this project, but I see you're used to us interrupting.

MR. BALAZIK: That's fine.

MEMBER REMPE: I'm curious. I know finances aren't really our bailiwick, but it is part of their ability to get free fuel from DOE, right? And if they make too much money, they don't qualify for that free fuel. And I know, isn't University of Missouri doing JIM production still and aren't they kind up against that limit already? And does this affect their license?

MR. ADAMS: Well, so are we talking about the fuel for the reactor?

MEMBER REMPE: Yes.

MR. ADAMS: So DOE supports university research reactors. One of the ways they support them is with fuel support. I believe the University of Missouri does reimburse DOE, not completely, but they do have some reimbursement back to DOE.

MEMBER REMPE: Because they are above that threshold. And I was curious. I didn't know that.

MR. ADAMS: So there is a threshold in the regulations. It's in 50.22 and it's the definition of if you're a commercial research reactor. And it's a very -- it's an unusual definition. What it says, if more than 50 percent of the cost of running the facility is devoted to commercial activities, you're a commercial reactor. It's not -- it's how you spend your money, not where you get the money from. The theory behind that regulation was to allow commercial activities to be a generator of cash for research.

This is something we look at when we initially grant licenses and renewals licenses. The University of Missouri license was renewed last January, and what percentage of the cost of running that reactor was diverted to -- devoted to commercial activities was evaluated, and they were below the 50 percent threshold. And the answer is, yes, as this project moves on, that would be a question we might address with the University of Missouri, how do these additional activities affect that ratio?

MEMBER REMPE: Okay. Thank you very much.

VICE CHAIR CORRADINI: So since we've stopped you, so there were a couple of ANS papers on this fuel in Oregon State. Is it the same fuel in

Missouri? I'm only going to open literature publications.

MR. ADAMS: When you say the fuel that runs the reactor?

VICE CHAIR CORRADINI: No, there's going to be -- at least based on the Oregon State paper at ANS, there's going to be fuel rods inserted that are specific to this, then taken out in an appropriate -- to them be processed. So is that the technology we're talking about?

MR. ADAMS: Yes.

MR. BALAZIK: And just to be clear, every time we say the word "fuel," it's kind of like we have to ante up. These are targets. We have to refer to these as targets, because if we start to designate as fuel, there's a whole different set of regulations. So even though it contains uranium-235, it's more of a target in the core.

VICE CHAIR CORRADINI: But it -- okay. All right. You guys keep me honest about that, but what I'm trying to make sure of is that within the TRIGA facility at Oregon State they're going to put in something that looks like a rod, cylindrical, of their design, and then at some regular intervals they're going to take it out and reprocess it?

MR. BALAZIK: Yes, sir. And realize that there's no differentiating between what's in Missouri and what's at Oregon State. They look exactly the same. There's no difference in design.

VICE CHAIR CORRADINI: That's what I was getting at.

MR. BALAZIK: Yes, sir.

MR. ADAMS: And we've granted Oregon State a license amendment to do very limited irradiations for proof of concept.

VICE CHAIR CORRADINI: Okay. That was going to be my next question.

MR. ADAMS: Neither Oregon nor Missouri has given us a license amendment for running Northwest's normal targets, so that's a review that has not been done yet.

VICE CHAIR CORRADINI: But they do have LARs to do test runs?

MR. ADAMS: Oregon State has a license amendment that was granted that allows them to do limited irradiation of targets for proof of content.

VICE CHAIR CORRADINI: Got it.

MR. ADAMS: Did I say that right, Steve?

MR. REESE: Yes.

VICE CHAIR CORRADINI: Same with Missouri?

MR. ADAMS: Missouri does not have any amendments to run Northwest targets in their reactor at this point.

VICE CHAIR CORRADINI: At this point? Last thing, so how is this all going to be affected in terms of performance in Missouri because of the change-out to low-enriched uranium given the moly -- the new moly fuel that's being considered? Is this -- is the performance in Missouri affected such that this is still doable? A technical question.

MR. ADAMS: We are early in the evaluations of conversion. Right now DOE is estimating the conversion of the high-performance NRC-regulated research reactors will be late 2020s, so --

VICE CHAIR CORRADINI: Until then all is good?

MR. ADAMS: Until then they're running on HU. We do know the impacts of converting: hardening of neutron spectrums and those effects, and how that affects the irradiation of these targets will have to be determined at that point once we have a final fuel design and Missouri gives us a final core design for what the conversion core will look like.

VICE CHAIR CORRADINI: Okay. All right.

MR. ADAMS: Did that answer your question?

VICE CHAIR CORRADINI: Yes, yes. This is good. Thanks, Al. Appreciate it.

MEMBER MARCH-LEUBA: Have you seen an initial core design? The question I want to ask is what's the percentage of power that is being generated by the targets? Is it 0.1 percent or is it 10 percent?

MR. ADAMS: We have not seen an application for placing these targets in the Missouri reactor, so --

MEMBER MARCH-LEUBA: What's your expectation? I mean, is it going to be a minuscule fraction of the power or is it going to be generating sufficient heat?

MR. ADAMS: Well, that's a complicated question because of the design of the reactor in Missouri in that we do know the targets are going to go in the reflector region of the reactor.

MEMBER MARCH-LEUBA: Okay. So --

(Simultaneous speaking.)

MR. ADAMS: And the way the neutronics between the reflector region and the core work are -- is something that would have to be evaluated.

MEMBER MARCH-LEUBA: Going to evaluate it on the basis of both power and delta k over k, right?

MR. ADAMS: Well, that -- part of the evaluation of the target would be all of the safety attributes that you would expect: reactivity effects, power. You'd have the ability remove the power from the target. What impact the target will have on the reactor, what impact the reactor has on the targets, the accident scenarios. Are there any interconnections and how the -- are there accidents in the target that can impact the reactor, vice-versa? Are there any new accidents that are created because you've added the target? So all that remains to be evaluated.

VICE CHAIR CORRADINI: And so he did it, so it's his fault. So, but all this, although we're technically curious, is off the table for this discussion?

(Simultaneous speaking.)

MR. ADAMS: That's right. The irradiation of the targets in various university research reactors so a separate licensing event and one that we have not been asked to do yet.

VICE CHAIR CORRADINI: Okay. And if it does, technically curious us, will we see it or is it not necessary? You guys make that decision?

MR. ADAMS: Normally license amendments

for research reactors follow a different licensing path. Obviously we're going to talk to you about --

VICE CHAIR CORRADINI: But that's what I was guessing is that it's considered a license amendment. You guys take care of it.

MR. ADAMS: Just like we issued the existing license amendment to Oregon State --

VICE CHAIR CORRADINI: Okay.

MR. ADAMS: -- which looked at a lot of these attributes of putting these targets in the Oregon State reactor, which is a very different core design.

VICE CHAIR CORRADINI: Sure. Thank you.

MEMBER REMPE: But since you brought it up and said they had put in a few lead target irradiations, is that --

(Simultaneous speaking.)

MR. ADAMS: Well, they have not performed any irradiations yet. They have a license amendment that allows them to do so.

MEMBER REMPE: And does that license amendment let them pulse reactor while they're doing it or do they have to keep it at a certain power level?

MR. ADAMS: No, one of the constraints in the technical specifications is that while those targets are being irradiated, the reactor --

MEMBER REMPE: That's good to know. Thanks.

MR. ADAMS: -- won't be purposely pulsed.

MEMBER REMPE: Yes. Okay. Thank you.

MR. ADAMS: Did I say that right, Steve?

MR. REESE: Yes, spot on.

MEMBER BALLINGER: One; I won't say last, technical question --

(Laughter.)

MEMBER BALLINGER: -- typically there are restrictions on amount of fissile material that you can stick in there that's not fuel, and it depends on whether it's a moveable or a fixed experiment. Now will the license amendments place a restriction on either one of these reactors in terms of how much they can stick in there, or are they asking for -- to be able to stick in more?

MR. ADAMS: Well, we haven't seen these amendments yet, so I would be speculating, but these are -- would be a form of what we call the field experiment, and fission product inventory is an issue with field experiments. Heat generation, decay heat. So I -- am I answering your question?

MEMBER BALLINGER: Sort of.

MR. ADAMS: So, yes, so there's limits on -- for a field experiment how much uranium-235 can be in the experiment.

MEMBER BALLINGER: And that's a pretty severe restriction, at least in the test reactor I know about.

MR. ADAMS: That's right, but traditionally field experiments have had rather limited inventories. There have been exceptions over the years in that. And one of the reasons field experiments have limited inventories is because of their experimental nature that -- how are they encapsulated? What are the fission product barriers in the experiment? These targets -- and we have a history of looking at targets. As you'll hear later on, the Cynthie Kim facility which made moly in New York State. General Atomics ran thermionic devices for DOE space propulsion research.

There's -- when there's a higher level of quality control on the manufacturing of the targets such that they have the same quality as -- I'll use word "fuel" -- then the amount you can put in the reactor, we start looking at that, and that -- normally that amount increases because of the higher quality assurance and the lower probability of failures.

MEMBER BALLINGER: And I would assume that it would be different depending on whether the target -- notice I'm using the proper term --

MR. ADAMS: Thank you.

MEMBER BALLINGER: -- is in the reflector or in the core.

MR. ADAMS: That's right. What we know at this point is that because of the significant differences in design between Missouri and Oregon, in Missouri it appears that the targets will be irradiated in the reflector. In Oregon State they will be on the grid plate replacing fuel.

MEMBER BALLINGER: Okay.

MR. BALAZIK: Okay. So this is Mike Balazik again. So after these targets are irradiated at this research reactors, they would be transported back to the Northwest facility where they would separate the molybdenum-99 from the fission products. Additionally, Northwest intends to reuse the uranium. So they plan to reuse and recycle the uranium to manufacture targets.

So if you look at the processes, the activities and the associated hazards, this kind of has a feel of fuel cycle. So when we talk about licensing -- and I'll let you know there's no such thing as target fabrication, so I use the word "fuel" there. But I just want to compare it to something, something similar to it.

I would say really one of the big differences in size, amount of material that they have. That's one of the big differences.

Okay. Moving onto slide 5. So Northwest has submitted a Part 50 construction permit application. And I just want to kind of highlight some of the activities; we've already talked about some of them, is to disassemble and dissolve the uranium targets, recover and purify the molybdenum-99, which is the isotope of interest here, and recover and recycle the uranium.

So just a couple notes on the application. Northwest submitted its environmental report which was docketed in May of 2015, and they also submitted a preliminary safety analysis report which was docketed in December of 2015. And we assigned the docket number of 5609.

I would like to add that one specific activity that we're not reviewing under this application is target fabrication. So under Part 50, you have utilization and you have production. Target fabrication, since it is so similar to fuel fabrication, that would be licensed under a separate -- or it could be a combined application under 10 CFR Part 70, but right now we don't have complete information to issue -- to perform safety evaluations for the target fabrication.

VICE CHAIR CORRADINI: But NWMI is going to do that, too?

MR. BALAZIK: They will submit a Part 70 application for review of the target fabrication activity.

VICE CHAIR CORRADINI: So the logic is some research reactor zaps it, it's transported to a place where it's reprocessed, re-fabricated into something that's sent back to the research reactor?

MR. BALAZIK: Yes, sir.

VICE CHAIR CORRADINI: Okay.

MEMBER CHU: Michael, can I ask a question?

MR. BALAZIK: Yes, ma'am.

MEMBER CHU: Now, so when does that 10 CFR Part 70 application come in? I mean, does your construction permit authorization depend on that or not?

MR. BALAZIK: It does not depend on that.

MEMBER CHU: So they can actually start constructing without an approval of the fuel fabrication portion, because it's all in one facility.

MR. BALAZIK: Correct, they can start constructing, but it's just that -- there's numerous ways that we could get around that is, one, we could get an application early to support construction. Or there's also another route to request an exemption from some of the Part 70 requirements. And I don't know if you want to talk to that, Dave, at all or --

MR. TIKTINSKY: Yes, I guess it is an -- it's an interesting unique facility because it does have both the Part 70 and the Part 50 pieces in there, but the construction permit application is to allow construction of the Part 50 portion, the production facility. For anything that we don't have an application for, obviously any construction is at risk from the applicant since we haven't reviewed it yet, but we expect the Part 70 application to come in at a later time after the construction permit -- is what Northwest has mentioned to us. But the exactly timing of that we're not sure about.

There are some parts in Part 70 that relate to 71.21(f) that says that you can't start construction of a facility until nine months after you've issued an -- after you've submitted an application and done an environmental report. So there is a restriction in Part 7 for when you could actually start construction.

So the choices would be either that nine-month restriction is carried out or an request for an exemption, or some other deviation would have to come in from Northwest and be approved by the NRC. But 70 has that nine-month restriction. So right now if nothing else changed, that restriction would apply even after a construction permit was issued.

MEMBER CHU: Okay. Thank you.

CHAIRMAN BLEY: I have a process question for you guys. This is a little unusual to have two different organizations at NRC involved in the licensing -- multiple licensing of closely-related facilities. How is that organized?

MR. ADAMS: Well, I mean, we worked together on the SHINE review, so this is -- we're basically using the same methodology that we used on SHINE. This one's a little unusual. Different activities have different regulatory processes. I mean, I'm not telling you anything you don't know. And that's what we're looking at here is that the production facility follows the Part 50 process and a target manufacturing follows the Part 70 processes, which take you in different places.

Even within the Part 50 process this is a Class 103 license for commercial activity. If for some reason this was -- they're making moly for research and development, this is a 104, we wouldn't be sitting here today. One-oh-three has to come past the ACRS by the regulations; one-oh-four does not. So it's different processes for different activities. And we happen to have several different processes under what Northwest is trying to do in totality.

CHAIRMAN BLEY: In a way this looks easier because for the almost reactor of SHINE you had to invent a new --

MR. ADAMS: Yes, this is --

CHAIRMAN BLEY: -- kind of license. But this just -- this fits into the --

MR. ADAMS: This is sort of --

CHAIRMAN BLEY: -- existing category.

MR. ADAMS: This is sort of half of SHINE with target fabrication added to it.

MR. BALAZIK: So SHINE has a utilization, I'll say the term "reactor," and a production facility. Here at Northwest at their facility they just have a production facility and using existing research reactors for the irradiations.

Okay. And -- yes? Yes, sir?

MEMBER KIRCHNER: Just a question. So you -- I'm not trying to find problems. I'm just thinking about what could go wrong potentially for the applicant. The 70 part is going to come later?

MR. BALAZIK: Yes, sir.

MEMBER KIRCHNER: But isn't it incumbent on the staff to review the two together in terms of hazard analysis and so on? You got -- they're going to be under the same roof, presumably.

MR. TIKTINSKY: So maybe I could help out with --

MEMBER KIRCHNER: I have looked at some of the material, so I know that. So the question right hand, left hand, yes, I get the logic for how you would bin it in 10 CFR, but from a safety analysis, hazard analysis standpoint you've got to look at them together.

MR. TIKTINSKY: Yes, so maybe I can help a little bit on that. So the approach in -- the guidance that we've issued for medical isotopes facilities in 1537, the ISG, basically allows an applicant to follow an ISA approach similar to fuel cycle to demonstrate compliance with the regulations for Part 50. So Northwest Medical Isotopes has prepared an ISA summary, and then their construction permit application talks about all the events and the items relied upon for safety for the entire facility.

So what the staff would consider is really at this point for a 50 is there any impacts from the 70 on the 50 that would impact our ability to make a construction permit decision?

MEMBER KIRCHNER: Thank you.

MEMBER SKILLMAN: Let me ask this, please. Missouri is not an Agreement State. What role will that play in these proceedings?

MR. ADAMS: Well, I'm not sure what you mean by "role." The fact that Missouri is not an Agreement State means that all of the licensing will be within NRC jurisdiction. The interactions that are required by the regulations with the state will occur. For example, there was interactions with the state on the environmental work that was done. So there's no state licensing here, if that's what your question is. There's interactions with the state where it needed to be by regulation.

Obviously there's interaction for emergency planning purposes with local responders, but

I think that's the extent of it. And that's what you see at the -- for example, the research reactor at Missouri, that all of the licensing is NRC for the reactor. And if it was an Agreement State, there might be some activities that could fall under an Agreement State license. Well, there's no Agreement State.

MEMBER SKILLMAN: Okay. Thank you.

MR. BALAZIK: Okay. And Northwest proposes to construct this facility; we've already talked about this, in Columbia, Missouri.

All right.

MR. TIKTINSKY: Okay. I'll talk a little bit now about the activities that Northwest Medical Isotopes is planning on performing and the types of regulatory evaluations that we talked about just a little bit, but this sort of breaks it down into a little more detail.

So the target processing is a 10 CFR Part 50 activity related to the disassembly, dissolution and concentration, and the moly recovery and purification. It's really just a reminder that at this stage we are only reviewing the 10 CFR Part 50 construction permit application.

The next part of the facility is the

uranium recovery and recycle. So basically as Mike had mentioned, they are going to recover the uranium and reuse it and create -- make more targets. That separation activity is also a Part 50 activity. The waste management portions of it, the encapsulation, the storage for decay and the waste shipments is also under the Part 50 review.

Next slide, Mike. So target fabrication, as we had already mentioned, will be a future application under 10 CFR Part 70. The LEU targets for the irradiation, the parts of the target encapsulation and the transportation of those targets. So this would be fresh targets, un-irradiated, to research reactors. The target irradiation will be done at the reactors, as mentioned before. And then also byproduct material licensing for the moly material at the end to actually go out of the facility.

So the licensing approach for this is that the production facility has several hot cell structures and it meets the definition of a production facility. 50.2 is very specific about what a production facility is. It's a facility designed for uses of processing of irradiated materials containing special nuclear material, and it's based on a batch size. So the batch size limitation is 100 grams. If it's below 100 grams, it's not a production facility. For this facility it is over 100 grams per batch, so that's why it puts it into 10 CFR Part 50.

As we talked about, there are some similarities with fuel cycle facilities. It's this definition of production facility that puts it into Part 50 instead of Part 70. So the NRC has historically licensed production facilities, but none of those ones that were licensed are currently operating. The NRC did issue a construction permit to SHINE for the utilization and production facility, portions of the facilities.

And the technology involved in the target fabrication activity is very similar to fuel cycle technology, even though the word "fuel" is different. Actually what you're doing there is very similar to what we do in fuel cycle facilities. And of course the target fabrication does not meet that definition in Part 50 of utilization of a production facility. And the target fabrication, the applicability of Part 70 is basically they're receiving title, own, acquire, deliver, possess, use and transfer special nuclear material.

Scrap recovery. The scrap recovery here is basically as they're developing their targets, the material that doesn't meet specs goes back into the development of the targets. So the sub-part H requirements of Part 70 would apply. They would possess greater than critical mass of special nuclear material. And the processes and targets, associated hazards that needs to be demonstrated by the applicant and the staff will review is very similar to what we do for reviews of fuel cycle facilities.

MR. BALAZIK: This is Mike Balazik again. Now I'd like to touch on some of the regulatory guidance for this review.

The guidance that we primarily use for this type of facility is NUREG-1537, "Guideline for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors." This was augmented by Interim Staff Guidance, and we developed this Interim Staff Guidance primarily for the review of this type of facility, a production facility. It also incorporated some guidance on aqueous homogeneous reactors, but I just want to be clear that there's no utilization facility here at Northwest. But that's just -- that's what we do with the ISG.

MEMBER BALLINGER: What's the ISG number again?

MR. BALAZIK: I believe it has the same --

it's tied to -- is there a specific number for it, or is it just tied to 1537?

MEMBER BALLINGER: Because I just tried to find it. I couldn't find it.

MR. ADAMS: Well, we'll get you the accession numbers for it.

MEMBER BALLINGER: Okay.

MR. BALAZIK: Yes, I can -- and the ISG was largely based on the guidance in NUREG-1520, which is for fuel cycle, because even though this facility, because of batch size is being licensed under Part 50, we look at what's the appropriate technical yardstick to evaluate it. Well, it's the guidance in 1520. So that's what the ISG did is took guidance out of 1520 and incorporated it into 1537.

There's other guidance that we used. If you look at the ISG in 1537, there's a not of ANSI standards that are referenced. For example, ANSI Standard 15.8 for quality assurance, and also ANSI Standard 15.16 for emergency planning. So lots of other guidance we used for the review.

Here are the review areas that are spelled out in NUREG-1537. As you can see, the chapters that are bolded, those are what we will be presenting to the ACRS Subcommittee this summer.

Now I just wanted to highlight some of the more important regulations concerning construction permit. 50.22, as Al mentioned earlier, puts you in the realm of a commercial facility under Section 103 of the Atomic Energy Act. 15.30 requires submittal of environmental -- yes, ma'am?

MEMBER CHU: Can you go back to the chapters list --

MR. BALAZIK: Yes, ma'am.

MEMBER CHU: -- in the previous -- you were also going to present the integrated safety analysis summary, right?

MR. BALAZIK: Yes, there are some separate presentations that we'll do. For example -- to answer your question, yes. But I just want to give a quick example for conduct of operations. Usually that has a QA plan. We're going to do a separate presentation on QA plan. It also has emergency preparedness. We'll do a separate presentation on emergency preparedness. But ISA accident analysis, we will do a separate presentation on the ISA.

MEMBER CHU: Okay. Thank you.

MR. BALAZIK: Let's see, I think I -- well, for 50.34 -- so we talked about 15.30, submittal of environmental report. 15.34 is the submission of a preliminary safety analysis report. There are some other important regulations that meet both the occupational and public dose that are required under Part 20.

So after we finish our review of the application, what the NRC has to come to is a conclusion: can the applicant construct the facility as described in the PSAR? So what we're looking at there is 50.35, which I'll go to in a little bit more detail on the next slide on when we can issue a construction permit.

I just want to mention a couple notes, and Dave kind of touched on this a little bit, but another important regulation is 70.61, which is performance requirements. And we have guidance in an ISG that basically states that the NRC has determined that the use of ISA methodologies, radiological and chemical consequence and likelihood, establishment of measurement measures -- of management measures are acceptable ways of demonstrating adequate safety for this type of facility.

Just another quick note on the regulations, some that don't apply to the Northwest facility. One of the most significant is Appendix A, General Design Criteria, but as required by 50.34

they're required to have principal design criteria.

Another regulation that doesn't apply is Part 100, which is siting, but during our review using 15.37 it looks at a lot of the requirements in Chapter 2 for siting requirements that are similar to Part 100.

MEMBER SKILLMAN: Mike, you didn't comment about Appendix B.

MR. BALAZIK: Appendix B does not apply to the Northwest facility. Our understanding it applies to fuel cycle and power reactors. But if we look at the -- I mentioned 15.8, the ANSI Standards 15.8, which quality assurance. If you look at some of the attributes of that guidance, it's similar to Appendix B. Not one for one, but it talks about document control. It talks about audits. It talks about change design.

MEMBER SKILLMAN: Thank you.

MR. BALAZIK: So as I mentioned on the last slide, we're looking at the regulatory basis for issuing a construction permit in 15.35. Basically, big picture, when are we going to decide that we can issue a construction permit? We have to come to these conclusions that we've got a good understanding of their principal design criteria, that technical or design information that Northwest has said can be left until later. Also identify research that needs to be completed. And also that the facility can be constructed without undue risk to the health and safety of the public.

And what we're trying to determine here is do we have enough information to let Northwest Medical Isotopes pour concrete -- well, I should say start digging a hole, install rebar, pour concrete and that they're applying this preliminary design that we have will inform their final design and licensing application. So it gets them started on construction.

There are a couple other standards that we need to -- that need to be met for issuance of a construction permit. I just want to touch on those really quick. Within 50.40 and 50.50 there's reasonable assurance that construction of the facility will not endanger public health and safety. There's financial. There's environmental requirements. And there's also issuance of a CPU will not be inimical to common defense and security of the public and it meets the standards and requirements of the Atomic Energy Act, our regulations and that outreach of other agencies have been conducted.

So we kind of talked about construction

permit. Big picture, it allows construction and that we had determined the applicant has given us enough information to say go ahead and get started. So in contrast to that I wanted to touch on operating license and when we issue an operating license that there is reasonable assurance that based on the final design of the facility that we believe it can be operated safely. So I just want to emphasize the difference in the two.

We're not making any -- we're not improving any safety of any design feature for the Northwest facility at this point. It's only at final design and operating license submission, but we expect to see -- so you have a preliminary design. That design will mature. We expect to see changes. We expect to see changes. We wouldn't be surprised. So just wanted to put that note out there.

MEMBER SKILLMAN: Michael, where do you touch on the issue of target and solution transport from Oregon to this facility and from the Missouri reactor to this facility? It would seem to me that part of this approval in your mind comes with the confidence that the logistics for the product and for the targets are fundamentally safe. I believe that's covered under Part 40, but I'm just curious how that factors into your decisions here.

MR. BALAZIK: Yes, sir. I see -- for transportation I don't see how -- I guess how it would impact the construction of the facility. That would be more of a operating license review that we would do for transportation.

MEMBER SKILLMAN: Let me explain why I asked the question. It's going to be hard to have a facility that has any relevance unless the facility can receive and dispatch the material essential for the facility's existence. And so in granting approval it seems to me there is the recognition that those transportation routes and the transportation of the products meet regulation at a sufficient level for the facility to be viable.

MR. ADAMS: You're correct. This breaks into a couple of places in the regulations. One part is within the facility itself do they have sufficient equipment to safely load/unload transportation packages, prepare them, respond to say --

MEMBER SKILLMAN: A spill?

MR. ADAMS: -- potential events, accidents. The sort of over-the-road transportation -- when you see the Environmental Impact Statement, you'll see some discussion of that, but once you're on the road, it's is your package approved? So it's an NRC-approved package. So the safety of the actual package is covered by that separate approval. And then there's all sorts of DOT and NRC regulations for moving uranium over the road: route approval, security. So all of those things are covered by the regulations, but they're not -- those are not specific to the construction of the facility.

MEMBER SKILLMAN: So your presumption on this license is simply that the other regulations will safely transport to and from and the cask licensing and all of the other details are for others?

MR. ADAMS: Right, that the certificate of compliance for the transportation package has to be such that it's allowed to carry these type of materials.

MEMBER SKILLMAN: Okay. Fair enough. Thanks.

VICE CHAIR CORRADINI: Just so I understand, I guess I assumed that the targets are solid going and coming from the irradiation facilities, right?

MR. ADAMS: Correct.

VICE CHAIR CORRADINI: Okay.

MR. TIKTINSKY: Okay. I'll talk a little

bit about the technical review that's being performed by the staff. So as I mentioned, Northwest Medical Isotopes has chosen to use an ISA methodology similar to fuel cycle facilities under Part 70 per the guidance of the ISG of NUREG-1537. The methodology is -- that they're using is to try and demonstrate that they can meet the performance requirements of 70.61, which again in the ISG as an acceptable approach.

The application provided a preliminary ISA summary. It talked about the events that were potentially credible. It identified items relied upon for safety. So it got into analyzing the events doing HAZOPs and other things to determine what those events were and determining that they have systems that -- for safety for those.

They've also evaluated credible chemical-related events including energetic reaction and direct releases of hazardous chemicals, minus the material. This is a focus of our review to make sure that those are adequate. Also the radiological hazards related to the separation of the molybdenum-99 as well as of uranium processing throughout the facility.

Then of course criticality events. Criticality is in this case uranium. In some portion of a facility it's in an aqueous solution and in others parts more of a solid. It is 19.9 percent enrichment, so that's different than other fuel cycle facilities. So that's other -- in terms of for criticality reviewers the benchmarking and validations of all the codes and things related to the use of that material is something that's a big focus.

So again, the staff in its review of this application -- is very similar to all the types of aspects we would do if this was a fuel cycle facility again even using the methodologies. And we have a cadré of technical experts in the various disciplines to do the review, as well as some contractor support for other areas which the staff -- the fuel cycle staff doesn't have -- currently have staff to do.

MEMBER BALLINGER: It's taken me a little while to catch up here, but I recall I did some work with TMI debris up where I am at MIT, and when they discovered that some of that debris contained plutonium, that meant we had to get a change in our special nuclear materials license. So are you going to -- you're going -- and this is recycled, so you're going to accumulate plutonium in the recycled fuel, right? Does that have an impact on the special nuclear materials license?

MR. TIKTINSKY: So at least with the

information we have they have discussed in the application the generation of plutonium in relatively small amounts. At least as of now what's in there is below the levels of what's called irradiated fuel, those standards. But that has to be demonstrated as part of the operating license application.

MEMBER BALLINGER: But there's an interim step where this is going to be dissolved.

MR. TIKTINSKY: So, yes, the targets are dissolved as they're separating it and running through the process and recycling it. And there is some buildup of plutonium over time that the staff will be evaluating just what those levels are, and they'll have to be maintained below the regulatory levels, or Northwest will have to do something to take it out or do something with it.

MEMBER MARCH-LEUBA: Yes, that's an excellent point to bring because that's not just plutonium, that's going to be weapons grade plutonium because is short evaluation. It's a lethal isotope. You have to look at that because even small amounts of weapons grade plutonium is problematic.

MR. TIKTINSKY: Yes, and that's part of our evaluation of the facility. I mean, that's one of the things that we sort of -- we look at it in the construction permit, but we certainly will look at it in the operating license application of exactly what those -- sort of the concentration as the facility is operating.

MEMBER MARCH-LEUBA: Yes, but the facility is concentrating it on the waste production and depending on how they separated it after it was into aqueous. It can become a serious problem.

MR. ADAMS: And that leads into the review of security at the facility, the security plan. As you're aware, the amount of S&M you have, the form of the S&M, the dose rates of the S&M all put you in certain places within the security.

MEMBER MARCH-LEUBA: Yes.

MR. ADAMS: And as more plutonium arrives at the facility that we and Northwest will have to make sure that they continue to stay in the right place in security, or else the security plan and the security requirements need to be adjusted to protect what is there.

MEMBER MARCH-LEUBA: Yes, just keep in mind when you do this review there won't be any plutonium-240 in there. It will be 239. And that is a different classification.

MEMBER BALLINGER: My comment that it was pretty much a red herring until the local population discovered that we had plutonium.

MR. TIKTINSKY: I'll just add one thing. There is a -- as part of the definition in 50.2 of a production facility it does have a limitation in terms of the plutonium. So that's another restriction that will have to be met by Northwest to sort of stay within the box.

MR. ADAMS: Okay. I'm going to wrap things up, at least for the staff's discussion today.

So this slide summarizes the status of the review. We're nearing to completion of the technical review of the PSAR. At this point in time Northwest has responded to our request for information, however, we are still in the process of evaluating the most recent responses. So we're still looking at that. So I can't guarantee you at this point that the staff will not have any more questions for Northwest.

Northwest has told us that they plan on revising the PSAR in its entirety to capture the responses and RAIs, which will allow one document to tell the story versus having to read an SAR and then read questions and put everything together.

CHAIRMAN BLEY: A timing question. Is that likely to occur before we start reviewing the documents?

MR. BALAZIK: This is Mike Balazik. I think that's the plan, but I'd have to --

CHAIRMAN BLEY: It would sure be really helpful if that's true.

MR. BALAZIK: I understand. And that was our intent with this in discussing with Northwest that that would be the best product to give the Committee is not a preliminary, lots of changes RAIs, but just kind of -- can I say a final PSAR? That was our intent.

(Laughter.)

CHAIRMAN BLEY: If you can deliver it, then you can --

(Simultaneous speaking.)

MR. ADAMS: But I think that would be an excellent question to ask Northwest when they're up here.

(Laughter.)

MR. ADAMS: Assuming a favorable review by you, we anticipate completing our safety evaluation by early October 2017 and then moving on and preparing for the mandatory hearing that we believe will be in front of the Commission.

So upcoming events, upcoming schedules of our interactions with the Subcommittee. Our next meeting is scheduled for June 19th. For the upcoming meetings it's our plan to present chapters to the greatest extent possible that are technically linked. For example, Chapter 7, Instrumentation and Control; and Chapter 8, Electric Power Systems, we'd like to discuss those at the same Subcommittee meeting. Likewise, we'd like to present radiation protection and accident analysis together.

Our goal with this approach obviously is to provide you the Committee with a well-organized presentation and well-organized information.

Last bullet on this slide is the list of the topics and the chapters that we're proposing to present at our -- at the next meeting in June.

With that, this completes the staff presentation. If you have anymore questions, we'll be happy to address them. And if not, we're ready to turn the front of the table here over to Northwest.

MR. BALAZIK: This is Mike Balazik. Professor, we'll send you the ISG.

MEMBER BALLINGER: Yes, I'm looking through 1537. I can't find it.

MR. BALAZIK: Yes, sir. We'll send that to you.

MR. ADAMS: It's a separate stand-alone document.

MEMBER BALLINGER: Yes.

MR. BALAZIK: I believe, Kathy, do you --

(Off microphone comment.)

MR. BALAZIK: And I can send that out again to you, Kathy, today.

(Off microphone comment.)

MR. BALAZIK: Yes, sir.

(Pause.)

MS. HAASS: So I'm Carolyn Haass. I'm the Chief Operating Officer of Northwest Medical Isotopes and I'm going to be introducing the team in just a moment. I'm going to go over real quickly kind of what our business model is. You've heard a little bit about what we're doing. I want to go a little bit more in depth. But I do want to talk about a couple questions that came up.

First of all, we have completed a preliminary design in our facility. When we did this preliminary design, we didn't look at it from a Part 50, Part 70 perspective because we had to do a total facility design. It didn't matter where the licensing came up. So when we talk target fabrication, we're at the same level of preliminary design as we are on our production facility. So I don't want you to think that we just left this over here and we haven't been considering that. We have.

Where the issue comes in is obviously -- with the licensing is that Part 50 requires you to do a construction permit application with an operating license application as Part 70 you just do an operating license application. But there are some requirements in there about that if -- when you put that application in, they want you to wait the nine months. So you can go in and look at it from a NEPA perspective.

One of the things that's already occurred by the NRC, we wrote an environmental report, which is Chapter 19. The Environmental Group of the NRC came in and they have written an Environmental Impact Statement. And it's imminent, when that's going to be released. We're hearing within the next several days or whatever, but that's going to be completed. That supports that nine-month action from a Part 70 perspective.

We are going be going in and asking for the waiver on the nine months because the target fabrication was considered a connected action to the production facility. So I want to kind of put that out there.

The other thing is when we did this design, we did look at -- we did use the ISA methodology, which means that we looked at the 70.61 performance requirements. We did a full criticality analysis which included doing a validation using 92 different experiments. We developed six different sets of calculations that support our criticality safety evaluations. We developed 13 qualitative risk assessments. We did a full-blown model for -- from a shielding perspective. And we also have done a lot of modeling both from at the -- based on the MURR reactor and that power and what would happen with our targets, as well as from the OSU reactor.

So we feel that we've done a full-blown evaluation and design of this facility. I just kind of wanted to get that out, because I didn't want you to have a misperception we haven't done anything on the target side because we have.

MEMBER STETKAR: Carolyn, did -- you mentioned you've done an ISA and you said 13 I think qualitative risk assessments.

MS. HAASS: Yes.

MEMBER STETKAR: Did you think at all about doing a quantitative risk assessment and whether that might actually provide more information in terms of relative ranking of risks and perhaps a smaller subset of IROFS and perhaps less effort overall than what you did with the ISA? I don't know how much effort you put into --

MS. HAASS: Do you mind if we -- we have a whole slide on that.

MEMBER STETKAR: You do? Okay. Fine.

MS. HAASS: I'd like to defer the --

MEMBER STETKAR: Fine. I didn't -- I haven't looked through your sides.

MS. HAASS: -- just defer the question --

MEMBER STETKAR: Fine. No problem at all.

MS. HAASS: -- when we get there, because I think --

MEMBER STETKAR: Sorry.

MS. HAASS: -- you'll have a better understanding.

MEMBER STETKAR: Thank you.

MS. HAASS: Let's see, one of the other items you did ask about was transportation and reactor license amendments. And the reason I wanted to bring that up is we have -- we do have a slide in here on transportation.

We have identified all the casks or

containers that we would need throughout the operations of this facility, and that means what container or cask you would use to bring in the low-enriched uranium, which would come from Y-12, the Department of Energy, what you would use to send un-irradiated targets out, what you use for irradiated targets back to our facility, and then what you would use for the moly product itself, as well as waste management.

So we have evaluated that and we've done that in depth. We know what we're going to be generating on an annual basis, where it would go, how hot it would be, how long it has to decay in our facility before it can even get on the road. I mean, because obviously that's got to occur from a waste perspective. So we have done those analyses and it's very detailed.

Unfortunately a lot of this information is not publicly available, so I will tell you if we need to go into a non-public session, we're willing to do that.

And, so I want to get through this first page and then I want to introduce --

MEMBER SKILLMAN: Carolyn, no, there will be opportunity for that discussion as we go through the chapters because --

MS. HAASS: Yes.

MEMBER SKILLMAN: -- the chapters --

MS. HAASS: Very much so.

MEMBER SKILLMAN: -- will invite this discussion. But I appreciate the tutorial up front. Great. Understand.

MS. HAASS: Yes.

MEMBER SKILLMAN: Thank you.

MS. HAASS: So on this -- on page 2 is our business model, and I think Mike, Al and Dave captured this fairly accurately, that one of -- what we're trying to do is -- our goal is to process moly-99. And to do that we knew that we needed to have a network of reactors, one, because of reliability and assurance that we were able to irradiate, but also if we needed to do multiple shipments a week, in case we have to deal with surge capacity.

So the first step is we identified our network of research reactors. They mentioned that we have the University of Missouri research reactor, as well as Oregon State. I'll tell you the thunder of the slide later on, but yes, we have selected a third one. We've not yet socialized it, so we don't put it out in the public yet.

VICE CHAIR CORRADINI: So just a question. Is Oregon State 24/7 operation?

MS. HAASS: No, they are not. So Steve Reese here, he is the director of the Oregon State reactor.

VICE CHAIR CORRADINI: Hi, Steve.

MR. REESE: Hello, sir.

MS. HAASS: You guys obviously know each other.

So they are not, but I'll let Steve answer that question.

MR. REESE: The answer is no.

(Laughter.)

MS. HAASS: No, but what we would do.

MR. REESE: Yes, this -- we have sort of -- I have two hats, to be honest with everybody or transparent with everybody. I'm the director of the Radiation Center at Oregon State University, which contains the TRIGA reactor, so I'm the licensing individual for that facility, as well as I am the source of neutrons for Northwest Medical Isotopes.

So at OSU we have plans -- sort of mapped out what's a transition from one shift to three shifts would look like. So, yes.

MS. HAASS: The next portion of our

business model shows that we're going to be constructing and operating a radioisotope production facility. One thing I want everyone to recognize here, we use the term "radioisotope production facility, or the RPF," as the total facility, so I'm not just saying it's the production of moly-99 that's Part 50. We call it one facility and it would include the target fabrication as well and uranium recycle and recovery.

The next big part of our business model is that our goal is to go sell this to domestic moly-99 generator distributors that already hold their FDA drug master file. The key thing is is our moly is not going to change anything with the generators. It's -- we're going to produce the exact same type of moly. And there would be no changes to that supply chain. That is very, very important from a generator manufacturer, that we can meet their standards.

So that's kind of the overall business model. We have the overall target processing facility or the production facility. Then we will use the network of university reactors for irradiation services.

The next page is our team. And so I think you guys have heard about our reactor team. We have the University of Missouri research reactor. And Ralph Butler, who is the director of MURR, is back there.

We also have Steve Reese, who is the director of the Oregon State Radiation Center. I'll give a little bit more credit. For Northwest Medical Isotopes -- he is the director for all irradiation services for Northwest Medical Isotopes. So that means he's going to be coordinating with all the university research reactors. And that means anywhere from actually doing the irradiation services to any upgrades that will be needed to do this irradiation and to support the license amendment applications at either of the reactors.

From an overall RPF perspective, who is on our team, I've -- there are -- I have two people here that support us. We have Atkins who does specialty engineering for us. Mike Corum. And that means shielding criticality, safety analysis, as well supporting in our AE.

Gary Dunford with AEM Consulting. He is a -- he is our process lead. He comes from the Hanford area where a lot of the PUREX UREX operations occurred. His team are all ex-operators, designers, engineers from those processes, so we feel very comfortable in what we're doing from that perspective.

The last item I wanted to talk about is I do have Roy Brown here. He is the Vice-President of Curium, or formerly Mallinckrodt Nuclear Services. And we brought him because I wanted him to explain why moly is important domestically to the U.S. and the world. So I'm going to turn it over to Roy.

MR. BROWN: Thanks, Carolyn.

As she said, my name is Roy Brown. I'm Vice-President of Government Affairs and Strategical Alliances for Curium. Curium is not a household name to you since it's only about a month old. Curium is the combination of the former Mallinckrodt nuclear medicine business and the IBA molecular business, largely run in Europe, and the CIS BIO radiopharmaceutical business in France. So that's a brand new company as of January. Curium is a new name as of beginning of April.

Curium operates a large radiopharmaceutical plant in Maryland Heights, Missouri. It's a large broad-scope licensee. And I wanted to spend a few minutes talking to you about nuclear medicine. I know some of you know nuclear medicine very well. Others may be new to it.

As Al mentioned this morning, molybdenum-

99 and technetium-99m, its daughter, are really the two most important -- technetium would be the most important radionuclide used in nuclear medicine. Technetium is used in over 35 million procedures each year and in more than 100 different types of medical procedures, mostly diagnostic.

Moly-99 has a very short three-day half-life, so this is something that you really can't make and put on the shelf. You have to make it typically several days a week with that short half-life.

Currently there's no domestic production of moly-99. All the moly that we use here in the U.S. comes from either Europe, South Africa or Australia, so we're enthusiastic about the potential for a domestic supply of moly-99.

VICE CHAIR CORRADINI: So just can I -- what's the current status in Canada, because they can start up the reactor if there's a shortage. They're allowed to by the CNSC's ruling.

MR. BROWN: Right.

VICE CHAIR CORRADINI: Is that correct?

MR. BROWN: Right. The NRU went out of moly production as of October 31st of last year. The CNSC and Health Canada have come to an arrangement where the NRU reactor could be put back into action if a certain set of criteria is met, and the criteria deals with how extensive a shortage may be of moly, how long that shortage may occur. Under those certain conditions working with the trade association in Europe by the name of IPEZ and the EU Observatory in Europe, they get together and demonstrate that that criteria is met. Then that would be the -- they're essentially the gatekeeper that would give the green light then to the CNSC and NRU to start making moly again.

VICE CHAIR CORRADINI: Okay.

MEMBER BALLINGER: But my understanding is that the NRU reactor will be shut down permanently in 2018.

MR. BROWN: That's right. Their plan is to start to decommissioning the NRU reactor in March of 2018.

MEMBER BALLINGER: Right.

MR. BROWN: So that will be off the board after that point.

Turning back to Curium just for a second, Curium is the largest technetium generator producer in the world. We have about 70 percent of the U.S. market. We have about 60 percent of the -- 70 percent of the global market. We have about 60 percent of the

U.S. market and about 75 percent of the European market. That makes us the largest consumer of moly-99. We're also the largest producer of moly-99. We currently have a moly production facility in Petten, which is about an hour north of Amsterdam where we make the majority of our own moly-99. So we know quite a bit about it. We produce moly five days a week, so we have quite a bit of experience. We've been doing this since the mid-1990s.

We see some significant advantages to what Northwest Medical Isotopes is proposing here. Some of the main advantages we see is the generation of radioactive waste. We're comparing their process to our process. In the Netherlands they generate quite a bit less radioactive waste.

There's a significant reduction in target cost. Our targets, all of our uranium targets are once-through targets. All the uranium -- we only burn up a couple percent of the uranium. The rest goes to radioactive waste. So our target cost is very, very significant. Northwest costs, the way we understand it, will be significantly less and they'll have the benefit of recycling the uranium as well.

And that's -- the third benefit is the recycling of the uranium, which we see as a huge advantage that currently we're not capable of doing, and frankly we probably never will be.

MEMBER KIRCHNER: Roy, are all your targets produced with HEU?

MR. BROWN: Currently all of our targets are produced by CERCA in France and using HEU, about 93.5 percent HEU, U-235. We've had a conversion process, a program underway since 2010. We've gone through and done all the process validation runs. We've submitted to the FDA, the European Medicine Agency, Health Canada and the Asian authorities. We have recently received FDA approval, European approval to start using that LEU moly. And we're waiting for Health Canada approval and we're waiting for approval in Asia. We expect to be fully converted by the end of this calendar year.

MEMBER KIRCHNER: That's an important step for the follow-on.

MR. BROWN: Sure.

MEMBER KIRCHNER: Yes.

MR. BROWN: Sure. So we anticipate being fully converted to LEU by the end of 2017. Northwest, as Carolyn has said, is of course all 100 percent LEU.

So that's my brief summary. We're basically here to support the efforts of Northwest

Medical. We've spent quite a bit of time reviewing their process and it is something we see has some very significant benefits to our current moly process.

MEMBER MARCH-LEUBA: Sorry to ask a technical question. You said two percent burnout rate?

MR. BROWN: I said a couple percent, right.

MEMBER MARCH-LEUBA: Per irradiation?

MR. BROWN: Right.

MEMBER MARCH-LEUBA: So really you will be depleted, you're starting at 20 percent and 18 percent and --

MR. BROWN: No, no. Yes, Mallinckrodt's current operation we're currently using HEU targets.

MEMBER MARCH-LEUBA: Yes, yes, but in the Northwest you will use 20 percent?

MS. HAASS: We use -- yes, 19.75, 19.9, yes.

MEMBER MARCH-LEUBA: And after once through it will go down to 19½ and then 19 and then 18½ and then 18?

MS. HAASS: It doesn't quite reduce that quickly, but --

MEMBER MARCH-LEUBA: But then it will be

two percent? Okay.

MS. HAASS: So the last thing I want to talk about on this slide is we have done a lot of technology demonstration, anywhere from producing our LEU target material to taking that material, irradiating it and processing it through hot cells. We have done the majority of this at MURR, but we are also in the process of working with the National Center for Nuclear Research in Poland. That means we're using the Ewa Reactor as well as their processing capabilities. The reason we're there is because we can do a lot more U-235, so we can produce more curies, so we can go in and do actual generator tests.

At MURR they were limited on the amount of U-235 that we could put into the reactor based on their tech specs, and so we knew that we wanted to produce more than that. And we're hoping within the next month we're going to be producing along the order at EOI about 400 curies. So it's a pretty significant maturation that we have done to date.

Next slide. The next slide is kind of a rehash of what we've already said, but it shows that Northwest Medical Isotopes is going to be constructed and operated and it's going to be in Columbia, Missouri. It's about five miles from MURR. It's about 2,300 miles from Oregon State, though. And we understand those transportation issues and those routes and understanding those logistics and those approvals that have to occur.

One thing for you guys to understand is MURR will be the base irradiation supplier. They have committed that they are going to be irradiating somewhere between 50 to 52 weeks per year, depending on what maintenance they have to do. If they have to go in and do a beryllium change-out, which is about every eight years, which they did about two years ago, they could be off line for about two weeks. And Ralph could go into great detail of how they were able to do it in such a short period of time, but they have a lot of research and development they do and other commercial customers that it had to be done very quickly, so that means it was managed very well to get it done.

As I said earlier, the third reactor has been chosen. We just are not socializing it at this point in time publicly.

The next --

CHAIRMAN BLEY: I'm just curious. How far away is the generating facility? And I guess that will be going through Curium.

MS. HAASS: Like for Curium in Maryland Heights, it's about 125 miles --

CHAIRMAN BLEY: That's close.

MS. HAASS: -- from Maryland Heights. The other generator facility is owned by Lantheus Medical Imaging and they're right outside of Boston.

Now the nice thing about the moly product is that can be transported by air. And that's what Curium does now from their Petten facility. They --

CHAIRMAN BLEY: They have to.

(Laughter.)

MS. HAASS: Yes, they would have to because obviously time is money. And so it is shipped over almost on a daily basis from Petten.

From a facility siting perspective we are working with the University of Missouri's system. They have a research park in Columbia, Missouri. It's about 550 acres. And we have signed our lease agreement with them, and we're going to be one of their anchor tenants to come in, because one of their goals in this research park is to broaden the whole isotope industry there because of the reactor and other technology activities that they are doing in the City of Columbia.

Our lot is about -- is 7.4 acres. And Discovery Ridge, the nice thing about it is it's donated land from an alumni and it was only used for agriculture in the last 150, 200 years. So it really is greenfield. And that's nice for us. As I said, it's about five miles from the University of Missouri research reactor. And so, it will be a fairly easy transport. They already do transports already for -- well, I can't talk about it, never mind, for certain items that go out, in and out of the facility. So we feel very comfortable with that.

You'll notice that there's a little picture there. You kind of see an outline of what our facility would look like. You see that the isotope facility is in the middle of the plot. If you go up to the left, you see some of the outbuildings. That's like an emergency diesel generator or a waste management outbuilding.

We may have to put in some type of water tank for fire. The City of Columbia is in the process of getting that water test done to understand whether we have to provide tankage or we don't need to have it, but that is up to the City of Columbia to go get that done, and it's on their docket to get done.

MEMBER SKILLMAN: Carolyn, just a

curiosity question. The idea that you've got really greenfield virgin land to build on, and a lot of area is very advantageous, but how do you prevent a botox facility or a cyanide facility from becoming your next door neighbor?

MS. HAASS: Well, remember the University of Missouri, the overall system owns this land. And they have covenants on what can and can't go there.

MEMBER SKILLMAN: Fair enough. Okay.

MS. HAASS: And there is a web site to that, if you ever really want to look into it. It's called Discovery Ridge Research Park, University of Missouri. You'll get right to it. And you'll see the covenants talk about what you can and can't do, what design codes you have to use, what's brought over from the university system, campus-wide, because we don't have the same design codes as the campus.

So what you'll see -- like in our design requirement document you'll see all the requirements that the NRC -- that we have to design to, you're going to see what the University of Missouri requires us to do, and then there are some city, county and state items as well.

Now a lot of those overlap; don't get me wrong, because the majority of the University of

Missouri is just typical IBC, but we still have to follow those things. And so, yes.

The next page is our licensing strategy. I know Dave and Mike went over this in detail, but the key thing is is we have submitted an application for the Part 50 activities. We understand that they got it for the whole facility, even the Part 70 side, because we really can't do one without the other. We had to design it at the same level all the way through. So that's the nice thing about this. When we went and did our preliminary hazards analysis, criticality shielding, it was all taken into account, the whole facility.

We are looking at that when we submit the operating license, we will be submitting one document, but there's going to be a very significant matrix that shows how Part 50 and Part 70 are both taken into account so that we can make sure all information is available, because they don't match either how they're set up. And so we're going to take the Part 50 and then we're going to have to kind of transplant in the Part 70. So we're in the process of developing those matrices. We have a good idea what it is, but we're finalizing that.

As we said before, the university reactors are going to have to do their license amendments for the commercial production. And then there is one cask that we're going to have to do a license amendment on, and it's for the irradiated targets that come from the university. And we plan on using -- it's called the Battelle -- what's -- it's -- now I can't even remember. Yes, Battelle Energy Alliance -- Battelle Research Reactor cask, the BRR cask. Sorry. I don't know why I can't remember that. But that's the one that we know that we're going to have to get a license amendment on.

The owners of the COC is AREVA. We have been working with them. We have just done some new modeling that will support that evaluation for that license amendment on whether or not we --

CHAIRMAN BLEY: Why do you need the amendment? What's different?

MS. HAASS: I'm going to let Steve talk to that.

MR. REESE: Yes, sure. The certificate of compliance for each cask is pretty specific to the type of material that goes in the cask. So as we talked about these targets, you will notice them -- if you have -- experience TRIGA reactors, these look remarkably simple to TRIGA fuel. However, just -- and the BRR cask is license currently for TRIGA fuel. But these -- they aren't specifically licensed for the targets, so --

CHAIRMAN BLEY: Okay. I understand. Thanks.

MS. HAASS: When you start looking at other transportation, casks and modes that we have to do, I mean, when you -- waste management, from a -- waste that would go maybe to WCS in Texas, whatever, we can meet those standards. And those casks are -- we can meet all of those requirements and get it on the road. We're not worried about that.

The primary assumptions for our facility, I think you guys all understand this, is that the RPF is going to include everything: target fabrication production and uranium recovery and recycle. We believe that the -- our --

CHAIRMAN BLEY: We'll get into the details later --

MS. HAASS: Yes.

CHAIRMAN BLEY: -- but just for now how small are the batches that you actually process?

MS. HAASS: We would have to discuss that later.

CHAIRMAN BLEY: Okay. I'd like to hear

about that if we go into session today, otherwise, when we get to this section.

MS. HAASS: Yes, the other thing -- assumption was is we believe that we're using the gold standard for the production of moly, which means it's a fission-based method. That's what everyone uses. Not that other methods: neutron capture, can't be done, but this is the gold standard. It's been used for 30, 40 years. So people understand it.

Our nominal capacity is going to be around 3,500 six-day curies on a weekly basis. We do have the capability of a surge capacity as well. And we are working with the universities that if we have to do a surge capacity how many targets would go into a reactor and what that configuration is. But that's obviously some of our proprietary information.

We -- you guys know that we have the network of university reactors. One thing to let you know, our target design is going to be the same no matter what reactor it goes in. We do have -- we have obtained our intellectual property and we're working through all the countries worldwide. We have already got it allowed in the U.S., Australia, Russia, South Africa, Korea. And India, Europe and China are pending. Obviously that's proprietary information for us, but we'd be more than happy to discuss what the target design is like.

The other -- a couple other things that I'll -- we -- it's very important for us that our -- all our fission product releases meet all environmental release criteria and that we're only going to generate Class A, B and C waste. We are not going to be generating any greater than Class C waste. That's important to us because there is nowhere to put it right now.

The Department of Energy, who has the only capability to deal with it, does not know what to do with it yet. And so they've got an environmental impact --

VICE CHAIR CORRADINI: I'm not sure what that means exactly. I thought the Medical Isotope Act said there would be a take-back clause.

MS. HAASS: Okay. So the Uranium Lease Take-Back Clause, you are very, very correct here. If you chose to do your uranium lease take-back, the Department of Energy, Environmental Management would have to take any waste that doesn't have a disposal pathway, which would be the greater than Class C waste. They don't have the capabilities to dispose of it yet, but they could take it and store it temporarily. So that's part of the problem with that.

Now there is -- we do have the ability to go purchase the low-enriched uranium outright. There's a lot of requirements in the ULTB process that may not be financially advantageous for a company, so your business model can't pencil out. So we've done a lot of evaluating whether you purchase or you go through the ULTB process. And if we want to talk about that offline, we can do that.

Okay. So we're going to get a little bit into the technology. I'm going to tell you up front unfortunately you're probably going to ask questions that have to go into an non-public session, but I'll try and answer as many as I can.

So what you're seeing here is that there are five major or primary steps to our process. And what you're going to see on the left hand side of this slide is you see target fabrication. Target fabrication consists of three steps, and I'll go into a bit more detail in some future slides, but we have to get the low-enriched uranium from the Department of Energy Y-12. Right now the Department of Energy says it's going to come in as broken metal. I can tell you that because they've told most people that.

We take that. We then produce our target material that will go inside the targets themselves. Once we have that material, we will encapsulate it into the target, which means you put it in, you weld it, you test it, you QA test it, you do all of those items. And then we package it to get it ready for the -- going to the university reactors. We -- it then is transported to the reactors. They will have the capability of storing so many weeks of targets there, so we're not actually transporting on a weekly basis these targets.

Once it gets put into the reactor, it is put in there somewhere between 150, 160 hours. It may depend on what the cycle is that week for the reactor or how long it has to go down. And Ralph could talk to this in a bit more detail, but like they go down I think on a Sunday night at 2:00 a.m. For the most part they're back up and operating about by 2:00 p.m. unless they've got to do some minor maintenance. So that's why I say it's a range of how many hours you get just based on how long you have to go down and you have to any minor maintenance.

The targets are the -- well, the reactor is turned off. Those targets are then held. They're pulled out of the reactor. They're going to be held in the pool how long?

MR. REESE: We're looking at about a day.

MS. HAASS: And then we air transport them into this BRR cask. I'll let you talk about that a bit more.

MR. REESE: Yes, so she's right. I mean, part of the business model here was to essentially make sure that the reactors or the source of the neutrons weren't the bottleneck anymore. Those of you who are familiar with the moly supply chain now, reactors tend to be a bottleneck for the process. So part of the original idea behind this whole concept is to take the -- make sure the reactors weren't to bottleneck anymore.

But she's absolutely right. All of the targets will be identical no matter which reactor we put it in. Northwest Medical is going to be responsible for the QA, so each of the university research reactors will obviously be watching that process fairly closely. We'll perform the irradiation nominally, 6-6½ days. Then it's pulled out of the reactor, it's left to cool for a certain amount of time. And we'll load it into the BRR cask.

We already understand what the sensitivity looks like on that in terms of radioactive decay, and also from the thermal-hydraulics point of view in terms of when can you actually pull it out in air? And then it's loaded in the BRR cask. QA is done in the BRR cask. Shipping for the transportation, which is substantial. And then it's shipped to the processing facility, the radioisotope processing facility that we're discussing today.

MEMBER KIRCHNER: Carolyn, can I back you up on the uranium supply? So is -- does the department -- you're getting it from DOE, right? So they're going to give you -- is it U-02 and to a certain standard?

MS. HAASS: No --

MEMBER KIRCHNER: And they're responsible for the QA?

MS. HAASS: Okay. So they have a specification of what they're going to give us. It will be as a broken metal, but we know what's in that. And then they will have to QA it and they will -- every shipment will have to have that --

MEMBER KIRCHNER: Very important that you --

MS. HAASS: Completely agree.

(Simultaneous speaking.)

MEMBER KIRCHNER: -- QA on that product --

MS. HAASS: Right. And so they already do this --

MEMBER KIRCHNER: -- that they provide.

MS. HAASS: -- whether it's sending it to CERCA for Curium purposes. Or even if you think of BWXT or NFS, they do these shipments all the time. And their level of quality assurance is -- it is very detailed, don't get me wrong. I don't really want to talk to them. Yes, I'm sure that they've made mistakes. But we have a QA program in our own facility. We just can't accept it as is. We've got to do some checks and balances as well.

CHAIRMAN BLEY: Dr. Chu, we're running way behind. We don't have a lot of flexibility on the back end, so I'd urge you to --

MS. HAASS: Well, I will -- what we can do is I'm kind of going through this flow diagram kind of in detail here. I'll try and jump a little bit through the technology slides, but the next major step is that we accept the irradiated targets. We bring them into the facility where we disassemble and then we dissolve the targets. I'd love to be able to tell you what the target material looks like and how we would do that, but it would have to be closed session. So I apologize.

But we dissolve this in nitric acid. Then once it is dissolved, we go into this moly production box where we talk about that we're going to go recover and purify the moly product so it can meet the specifications that Curium or Lantheus gives us, which are based on some FDA-type requirements, whether they're European or U.S.

Once we have recovered the moly; and remember, that is the critical path for us, then we go into the uranium recovery and recycle. And I'll tell you, uranium recovery and recycle, there's a lot of down time. There's a lot of decay that happens here, whether it's for U-237, or whatever it may need to be. The reason we do that is because this uranyl nitrate comes back into our target fabrication and we want to make sure that we can do it from a contact handled perspective. And so there is a lot of decay time there.

The next page I'm not going to go through. This is just a reagent, product and waste summary flow diagram. You can read that for yourself. You just see what kind of chemicals we're going to use, gas, the research reactors. We get the LEU. We are going to be sending our LEU product back to DOE. That is what -- we have been working with them. We believe because we're recycling that we're actually probably going to have it -- I mean, this isn't a very technical term, it's going to be more clean than when we got it because of the process we have to do. But the uranium isotopics will be less. But they have given us a draft spec for return, and we have no problems meeting that.

We're doing some additional analysis they've asked us to do, but that's what we plan on doing. And that's very important is that we're not going to generate greater than Class C waste and that Y-12 would take that back.

MEMBER MARCH-LEUBA: But you're returning it on a monthly basis or when you shut down the facility? When will you be reusing it?

MS. HAASS: That logistic hasn't been worked out because it's probably going to -- you wouldn't do it on a monthly basis, probably more on an annual basis. But it's going to take several years to even get to the point where we'd want to return anything --

MEMBER MARCH-LEUBA: So --

(Simultaneous speaking.)

MS. HAASS: -- because it's all based on the amount of uranium isotopics you have left.

MEMBER MARCH-LEUBA: DOE sends you LEU and you send them back LEU? Doesn't make much sense.

MS. HAASS: Well, it's still worth money, remember.

MEMBER MARCH-LEUBA: Yes, but --

MS. HAASS: Because the uranium isotopics are -- I mean, Steve, you can jump in, but we're not going from 19.5 down to 0.

MEMBER MARCH-LEUBA: Yes.

MS. HAASS: I mean, there's going to be a significant amount left that is still worth money to DOE like from a commercial nuclear perspective and maybe working with their fuel.

MR. REESE: So we do anticipate -- I mean, there's going to be process losses and they'll probably actually exceed the burnup that we're going to be doing, that this uranium is going to see. The burnup is pretty low, to be -- in all honesty.

The other thing is that along with sort of the paradigm for the lease take-back agreement with the Government is that you buy the uranium at a certain enrichment and you sell it back at a certain enrichment. Both have product specs. And so you end up -- or, I'm sorry, you buy it from the Government and then you sell it back to the Government at a lower enrichment. And so all of those numbers have been worked out such that you're essentially paying for the atoms that you burned up.

MS. HAASS: Right.

MEMBER CHU: Need to roll --

(Simultaneous speaking.)

MS. HAASS: Yes. The next page, this is the only publicly available graphic, so I apologize. And it was from a licensing perspective.

And so what you're seeing is where our target fabrication area is on the top. We have --

MEMBER MARCH-LEUBA: You need to talk into the microphone. Use the mouse to point.

MS. HAASS: Ah, sorry. I didn't know that existed.

MEMBER MARCH-LEUBA: That's the process.

MS. HAASS: Okay. So the target fabrication area, which is our initial step that we do, is up on the top. It -- then you ship it out here. When the targets are irradiated, they'll come in here through this target receipt area. The targets will go underground, up -- this is our hot cell processing area. This is where disassembly and dissolution occur. And that is -- and then down here we have the moly recovery and purification.

This whole tank hot cell has mostly to do with our uranium recovery and recycle. There are some pumps and some waste management tanks in there. But that's what that area is. We have a lab area, chemical addition, our admin and support area, utility. So I just wanted to give you that real quick.

Facility description. We're about 40 -- 50,000 square feet on the first level. We've got a basement level where the tank pit area is, and our HIC storage for waste management decay is. We have an admin building that's right now here. It's about 10,000 feet. Building height, I mean, you can go and read that, but kind of typical of a facility. You're going to go up and you're going to down. You're going to have both.

This I'm just trying to show you graphically what's going on. I mean, this is our tank pit area. You're seeing where our HIC storage area is, waste management. And it's just different facility cross-sections, if you'd like to look at it. I know they're not labeled, but there's a reason they're not labeled.

Just some more pictures that are more elevation-oriented.

So the next four or five slides have to do with each of the primary steps that I talked about. So you got target fabrication, which I'm just going to briefly say we're using an internal gelation process. If you know what that is, you can probably guess what we're almost doing, but make this material.

And then on the next page we show that we have an encapsulation step where we prefabricate our targets, we fill them -- we fill the targets with helium, we do the QA check. Once it's past the QA check, that meets the university reactor's requirements, we're able to send them to then -- if they fail, then we just disassemble them and we can redo it. We can remake -- encapsulate those -- that material. Then they're shipped off.

Then we have the target receipt, disassembly and dissolution that I briefly went over that we -- that they come into the facility. We pull the targets out of the inner basket of the transportation cask. We take the targets. We open them up. We get the material and we dissolve the material with hot nitric acid. And this is all done in a batch-wise fashion.

We know that we're going to have off-gas from this and we have developed a series of cleanup columns for whatever off-gas we're going to have, whether it's nitrogen oxides or fission gas or other gases.

MEMBER CHU: How many hot cells do you have?

MR. REESE: You want me to go back to the diagram?

MS. HAASS: No, because that's not going to really show us. I mean, it's how you want to define the hot cell, but we have two receipt and disassembly hot cells, two -- I mean, this is kind of general -- two dissolution, and then you have -- then you go into your moly recovery and purification. And all the uranium recovery and recycle is done over in the tanks -- in the hot cell pit. So that's not done in a hot cell.

I think I -- our moly recovery will be done with ion exchange media as well as our uranium recycle and recovery. We're not -- I know typical of a PUREX UREX-type process you'd use solvent extraction. We're using an ion exchange media. I'm not the expert on this; Gary is, but -- and we can go through it in much more depth at another time, but the whole point of the uranium recovery is we want to make sure that we decay it long enough so we are contact handled when we go back into target fabrication.

MEMBER CHU: So you have a lot of liquids going on --

MS. HAASS: Yes, that's --

MEMBER CHU: -- in the hot cells? All liquids?

MS. HAASS: That's one of the reasons you're going to see how much criticality analysis and shielding we've done to date. That's very, very important to us.

You can go one more. Just quickly on waste management, we understand we're going to generate liquid waste, solid waste, and then we have specialty waste. The specialty waste is going to be any solvent waste or silicone oil that we use in our internal gelation process or facility maintenance fluids. We have mapped that out. We understand how much we're going to generate. We know how we're going to treat it. We know how we're going to get it to a solid waste and where it's going to go for disposal.

Go down. I'll let you do that one.

MR. REESE: Sure.

MS. HAASS: I'm not the expert.

MR. REESE: Sure. So how much time do we have for the remaining?

MEMBER CHU: Until --

MR. REESE: Seven minutes?

MS. HAASS: Yes, because one of the things --

MR. REESE: We're in for a strobe light show.

MS. HAASS: Right.

MEMBER CHU: I'll give you 10.

MS. HAASS: One of the things I'd like to do is --

MEMBER CHU: I'll give you 10.

MS. HAASS: -- get to the criticality shielding and --

(Simultaneous speaking.)

MR. REESE: Yes. Yes.

So we have -- I mean, one of the radiological hazards we have off of this is catching all the off-gases. It's particularly tricky because you're dealing with a lot of noble gases, but we've got several systems set up to provide some redundancy and some diversity.

The other thing that this slide goes into is that you not only have to be cognizant of the gases that come off during the dissolution, but you also have to be cognizant of the iodine that grows in from later isotopes on the isobars that you're concerned with. So we've made sure that all the subsequent systems are also feeding to that and catching the iodine before it goes out. The idea is that we want to make the iodine and krypton signature and xenon signature as small as possible.

Ventilation. We've set up the ventilation system. Zone IV -- I'll start from the bottom and go up. Zone IV is your standard administrative offices, those kind of things. Those -- that will be positive to the environment and positive to the other zones and will be independent of the Zones III, II and I.

Then we're moving into the areas of the facility that are essentially floors and -- I'm sorry, hallways and those kinds of things where people are nominally walking around. That will be fed from the outside as will Zone II. Zone II will be negative to Zone III. Zone I will be negative to Zone II. Pretty standard situation. And of course the one that we're most concerned with is the actual hot cells, the gases coming off of the hot cells. So that will be independent.

MEMBER SKILLMAN: Steven, just a quick question.

MR. REESE: Yes, sir.

MEMBER SKILLMAN: As I did the review for what we have to date --

MR. REESE: Yes.

MEMBER SKILLMAN: -- it appears to me as though the ventilation system is your critical system in this facility. It is --

MR. REESE: It's one of them, yes.

MEMBER SKILLMAN: I mean, it's really at the top of your food chain in terms of importance.

MR. REESE: Yes, for both public and --

MEMBER SKILLMAN: Yes.

MR. REESE: -- occupational workers, yes.

MEMBER SKILLMAN: And so the reason I asked the question about Appendix B is because of what Appendix B would require in an important system such as this. The answer was: use a different standard of the -- whatever it was.

PARTICIPANT: You mean ANSI 15.8.

MEMBER SKILLMAN: I understand that. My question is how will the construction -- this is a question for later, but how will the construction assurance program ensure that this ventilation system does what it's intended to do because of this system's overarching importance?

MR. REESE: Yes, as you can imagine, later on we'll talk about IROFS and ultimately we want to convert the IROFS to tech specs because we'll be in Part 50 space, but many of the IROFS are essentially watching the ventilation system.

MEMBER SKILLMAN: We can talk about this later when we get into the design.

MR. REESE: Sure.

MEMBER SKILLMAN: Thanks.

MR. REESE: You bet. You bet, sir.

ISA. So ISA in 70 space, we have to do sort of a little bit of a -- what we've chosen to go forward with is we're essentially going to follow the ISA methodology on our application. There is -- essentially you're given two options. You either go down the Part 70 path or you down the Part 50 path. We've done calculations for both, but we -- we're going to go down the Part 70 space pathway, so the ISA methodology. We did that by doing a preliminary hazards analysis, identifying everything, setting up matrices in terms of risk, ranking the accidents.

The only thing that we'll point out is we will be -- we have identified the IROFS for these different systems and we know that we are going to have to convert these IROFS to tech specs.

So on the right you see the primary documents that we've created to address this part of this hazards analysis. We've tried to look at everything. We've got eight primary systems and we look at 107 nodes, so basically these are components that we anticipate having to fail in some fashion. We look at various accident sequences. It's many, many, many pages of the application. And in the end we did eight qualitative, not quantitative, risk assessments over the 75 accidents. Seventy. I'm sorry.

Shielding analysis very quickly. So we've done quite a bit of work between Oregon State and MURR on what the source term is going to look like. So once we get the source term, we can decay it off using SCALE, ORIGEN-S, and use that as the input decks for all of the shielding analysis which will be done with -- and is being done with MCNP.

It's -- at points in this facility, because of the thickness of the shield, it becomes a challenging MCNP problem because you're pushing -- you're transporting radiation through a fairly thick material. But we've got a pretty good handle on that.

In terms of criticality accidents, there's two things you probably want to worry about most in a facility like this. One that's already been pointed out is ventilation. The other one is criticality analysis. And we approached this as basically we can't -- this can't happen, period. I mean, that's how we have to view it.

So we've done a pretty thorough examination of all the things that we have to look for. You see the CSEs or criticality safety evaluation documents on the right of the things that we primarily hit on. We've done a pretty thorough code validation and verification. We've defined all of our -- what we consider are areas of applicability. We've identified our -- so our bias, our uncertainty and what our upper subcriticality limits will be for the facility. So we've got a pretty good handle on what that looks like.

This had to be done right off because this defines how -- what's your tank spacing, what's your tank size, what does that look like? So this was done actually very, very early on because it drives how you lay out the facility there on out.

I believe -- I think this is the last -- yes, the last slide. We've identified -- these are the different radioactive waste -- or I'm sorry, casks that will be required to ship or transport radioactive materials both to the facility using the ES -- we're anticipating using the ES-3100 cask, the BRR cask for irradiated targets, and then we have the MIDUS cask for the isotopics, or I'm sorry, the moly product itself. And then we have waste drums and HICs for the waste. So BRR cask is used now quite extensively. The MIDUS cask is used very extensively. HICs and drums are pretty well used and understood by the community. And the ES-3100 package is pretty well used these days, too, so --

And with that, I have tried to talk as fast as I can --

(Simultaneous speaking.)

MS. HAASS: Yes, so we appreciate the opportunity. We're looking forward to future opportunities. And we've kind of -- we've taken notes to understand maybe where -- some of the areas you'd like to go more in depth -- based on today's meeting. I know that there's going to be more.

But I know at the next meeting, Michael, we will be doing Chapter 4, which is the facility overview where we'll probably have a significant non-public portion of the meeting so we can go a bit more into detail on what we're doing.

MEMBER CHU: Thank you very much. It's very helpful. And then right on time.

(Laughter.)

MEMBER CHU: And now I would like to know if there are comments from the audience?

(No audible response.)

MEMBER CHU: Any comments from the public in the bridge line?

(No audible response.)

PARTICIPANT: It's open.

MEMBER CHU: Oh, it is open? Yes. Anybody in the public have a comment to make?

(No audible response.)

MEMBER CHU: No. Thank you.

Now any discussion from the Committee members?

MEMBER POWERS: Well, I'd just comment that in looking forward to our future meetings when we discuss things in detail I've flagged a few things that will I'm sure come up. I think you can count on of course some discussion of your ventilation system and what not, and especially the unfiltered portions and unfiltered leakage in the systems and how that's going to be controlled as the facility ages.

But I think you can count on a fairly detailed discussion of fires and fire suppression, especially in the hot cells. Flooding. I think you can count on a discussion of that. Material aging. And probably a fair discussion on ion exchange columns.

MEMBER REMPE: Actually one thing I would be interested in, too, is how the fabrication is done and how much automation is done with that, which I hope we will get into.

MEMBER CHU: Anything else?

MEMBER SKILLMAN: Yes, you've got two homeowners within 0.3 miles of this facility based on the information we have. Is there any special interaction for them?

MS. HAASS: So the Environmental Impact Statement was completed by the NRC. There are some homeowners near there. I know that they're -- and I may have to get back with you on this because I can't remember the timing, but I -- there's a trailer park fairly close as well and that they're trying to move everyone out of the trailer park because there's a research park there and there's already existing businesses. And so we're working through that. I may have to get back with you on exactly how that's going to be done because I don't remember.

MEMBER SKILLMAN: Just a curiosity question based on public sensitivity to living proximate --

MS. HAASS: Right.

MEMBER SKILLMAN; -- to a facility.

MS. HAASS: And when the public meetings occurred, everyone was very, very enthusiastic about this. There was only one person who was -- really wants this to occur, but he was worried about the bats in the caves.

MEMBER SKILLMAN: Okay. Thank you.

MEMBER BROWN: Margaret, just wanted to bring up -- I'm the instrumentation guy, supposedly. And I guess my primary interest was based on the other stuff that we'd looked at before was this is not like a power reactor that we have to have safety systems on, but you do have a considerable amount of computer-based manufacturing control, inventory control, what's where. And I guess the primary interest we expressed before is like the control of access to those systems via internal networks, automated systems, how much stuff is out -- you -- control you have out to the external Internet world, where do the -- in other words, the best answer is zero --

(Laughter.)

MEMBER BROWN: -- as well as how you control the internal access to those systems to ensure that their software processes aren't tampered with. So that's primarily where I'd be looking for on the instrumentation side.

MEMBER CHU: Okay.

MEMBER BROWN: Okay? Thank you.

MEMBER CHU: Carolyn, I just want to make a comment. There are a lot of proprietary information in the documents. When I was reading it, if I just read the non-public version, it's very hard for me to figure out which parts are proprietary unless I sort of compare with the public version.

So my caution is for the next few meetings we'll have to coordinate well so we don't accidentally trip, because it's very easy -- because when I read it, I had no idea what might be proprietary.

MS. HAASS: And we agree with you. I mean, I know that there's a process that you go through with the public and non-public. And when you have that much detail, I mean, it really is sitting down there and comparing and figuring it out. And we will --

(Simultaneous speaking.)

MS. HAASS: We'll have a presentation. We'll have kind of a top-level one. And then we kind of know where we need to go with the detail. And we have lots of detail that we can provide, and we have provided the NRC staff already. So a lot of times if you ask us a question, we can probably -- we probably have a slide already developed on it and I can go find it and I'll be able to put it up on the screen and we can walk through it. Because we have every part of our hot cells. Like every part of target fabrication is broken out and we can go through everything. We can go out through each part of the hot cell tank pit and tell you exactly what's going on or through each portion of every hot cell we have.

MEMBER CHU: Thank you.

Anybody else have comments?

(No audible response.)

MEMBER CHU: None. Okay. Meeting's adjourned. Thank you.

CHAIRMAN BLEY: No.

(Laughter.)

CHAIRMAN BLEY: You give it back to me.

MEMBER CHU: Oh, sorry.

CHAIRMAN BLEY: Thank you.

MEMBER CHU: I give it back --

(Laughter.)

MEMBER POWERS: It's a palace coup that she is attempting.

CHAIRMAN BLEY: Didn't take her long, did it?

MEMBER POWERS: No time at all.

CHAIRMAN BLEY: Okay. Thanks to everyone for the discussion and presentations. We are recessed until 10:45 when we'll begin P&P.

(Whereupon, the above-entitled matter went off the record at 10:26 a.m.)

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

+ + + + +

BIENNIAL REVIEW AND EVAL OF

NRC SAFETY RESEARCH PROGRAM

+ + + + +

FRIDAY

MAY 5, 2017

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ROCKVILLE, MARYLAND

+ + + + +

The Advisory Committee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B1, 11545 Rockville Pike, at 1:00 p.m., Dennis Bley, Chairman, presiding.

COMMITTEE MEMBERS:

DENNIS C. BLEY, Chairman

MICHAEL L. CORRADINI, Vice Chairman

PETER RICCARDELLA, Member-at-Large

RONALD G. BALLINGER, Member

CHARLES H. BROWN, JR. Member

MARGARET CHU, Member
WALTER L. KIRCHNER, Member
JOSE MARCH-LEUBA, Member
DANA A. POWERS, Member
JOY REMPE, Member
GORDON R. SKILLMAN, Member
JOHN W. STETKAR, Member
MATTHEW W. SUNSERI, Member

DESIGNATED FEDERAL OFFICIAL:

KATHY WEAVER

ALSO PRESENT:

JOHN NAKOSKI, RES
SEAN PETERS, RES
HAROLD SCOTT, RES
MARK TAGGARD, RES
KIMBERLY WEBBER, RES
MICHAEL WEBER, RES

CONTENTS

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

(12:59 p.m.)

CHAIRMAN BLEY: The meeting will come to order. And I turn this one over to Dr. Rempe.

MEMBER REMPE: Thank you. Okay, colleagues, just to give you a background here because I know some of us forget things after we sleep and there is a lot of people in the audience. So, I think it might be good to give them a brief history of why we're here today.

CHAIRMAN BLEY: Who has to go to sleep.

MEMBER REMPE: Anyhow, earlier this year, we agreed to revise not only the format of our Biennial Research Review but also the content of it. And these changes were motivated by a comment that now Chairman Svinicki made last October regarding our Research Review Report. And I was tasked to go through and investigate what we might do to improve the process, as well as the format. And I talked to the commissioners but I also talked to Mike Weber and Ed Hackett, at the time who was acting as his Deputy. And I was pleasantly surprised with their response because they not only appreciated our current review but they said additional changes would be helpful. But they also asked us for input on forward-looking topics. And so I reported back to you and there was some enthusiasm among us that we should try and do that. And actually looked at a notional schedule I provided on how we might accomplish it. And although we are still kind of iterating on the later task, all of us agreed in the meeting that Mike and some of the leaders of his organization might help us as a first step to understand how we can best help you.

And we also provided you in advance some questions and so we're going to be asking a lot of questions but this is a little different from our normal meetings. It's an information briefing and let's see where it goes but we are kind of in new territory here.

I'm hoping, after we're done, that we'll have some good ideas. We may want to have another brief discussion during our next P&P or something to talk about how we can implement this in the next steps. But my objective is to have the leads in each area -- we have identified leads that are going to be similar to your leads and they plan to meet with your division heads and their branch managers after this meeting is the general idea but what kind of things we're going to be looking for and the subsequent meetings will be shaped by what we discussed today.

And so with that, I'm going to turn it over to you, Mike.

MR. WEBER: Okay, thank you very much. It's a privilege to be with you this afternoon on a rainy day outside but it's nice and sunny here. I appreciate the background orientation to the presentation. We prepared some presentation materials to walk you through kind of from an orientation perspective what's research all about. We recognize that many of you are distinguished researchers on your own rights so, it's not a tutorial on what research, per se is, but really research at the Nuclear Regulatory Commission and how it supports the Agency's nuclear safety and security mission.

So I will begin the presentation and talk about some orienting questions that we received. That leads us into a review of what is NRC's need for research; how do we define the scope; what are the core capabilities of our Research Program; how do we plan and budget that research; and then looking forward from an anticipating perspective, you'll hear from each of the three technical divisions, the Division of Engineering, the Division of Risk Analysis, and the Division of Systems Analysis.

As it turns out on this Friday, all of the

Divisions' Directors are out so they're ably represented by the Deputy Division Directors. And they will proceed John Nakoski from the Division of Engineering; Mark Taggard, the Deputy Director of the Division of Risk Analysis; and then Kim Webber, who's the Deputy Director of the Division of Systems Analysis.

MEMBER POWERS: One wonders what the Division Heads are planning here.

(Laughter.)

MEMBER POWERS: A coupe may be afoot here.

MR. WEBER: And then they'll turn it back to me and we'll talk about ACRS assistance. And I should say you know I'm still relatively new in Research, having started there in November of 2015. It's been a real joy for me to serve in that capacity but it's made me go back and look up a lot of the history for Research because any organization is a product of what occurred in its past. And so it's illuminating and it's also a little frustrating because many of the issues that we've dealt with through the past 40 years we're refacing over and over again.

So, I think with that, we will launch right into it. So some of the focus questions that we understood from the committee is how does the Agency go about selecting its research projects and then how does the ACRS look at the Research Program. And then how can the committee best assist the NRC staff in your independent advisory role?

So, hopefully, by the end of our presentation, we'll give you some food for thought and then we'll be ready to engage on questions or however you want to proceed. We're here for you.

Of course the need for research was recognized at the very beginning of the Nuclear Regulatory Commission, back in the passage of the Energy Reorganization Act of 1974. It was the only one of the three program offices that was specifically called out in the Conference Committee Report that accompanied the Energy Reorganization Act. And if you read that language, which is about a page or so out of that report, the Congress recognized that research was clearly needed to ensure effective performance of licensing and other regulatory functions of the Agency and a heavy emphasis was placed by the Congress on ensuring professional competence and the means to evaluate the data and procedures to determine the adequacy of not only applications pending before the Commission at the time, but also the continued oversight of their safe and secure operations.

That's been affirmed on several occasions since then within the Commission and by the Congress. You may recall, back in 1997, the Agency was embarked on its initial development of a strategic plan. And out of that, in preparation for that, the Commission identified so-called direction-setting issues or DSIs for short. And DSI-22 was specifically focused on research, not dissimilar to where we find ourselves today. If you recall, at that time, operating plants were shutting down. The industry was viewed as quite sure that there weren't really burning issues pending before the Agency at the time. So why do we still need to have a Research Program?

And the Commission got input from a variety of sources. That input pretty much uniformly was of the view you definitely need an effective research program. Not all the issues are resolved; more to follow. And, therefore, it's important that the Agency conduct a balanced portfolio of both confirmatory and anticipatory research.

Now, anticipatory was quite controversial at the time and remains so today because you will see in a bit, we interact quite closely with our regulatory partner offices, primarily the Office of

Nuclear Reactor Regulation, Office of New Reactors, and the Office of Nuclear Material Safety and Safeguards and their focus tends to be on more of the here and now; what do we need to focus on to accomplish the Regulatory mission of the Agency, less so on the longer term issues like well what Research will we need out three, or four, or five, ten years from now, so that we can continue to ensure the Agency accomplishes its mission.

The Commission issued its decision in 1997 affirming the continued importance of the Research Program, directed that the staff focus that program on the issues of highest safety and regulatory significance. Another component of that was emphasis and direction to maintain the core capabilities of the Office of Nuclear Regulatory Research to support the entire Agency; prioritize the international research that we were doing and use that to the best of our ability to support the broader mission of the Agency, and then leverage cooperation with industry.

And we took a number of actions coming out of that, updating and signing memoranda of understandings with, for example, the Electric Power Research Institute, strengthening our collaboration with the Department of Energy, even outside the

National Laboratories but working agency to agency to align on what are the key issues that we need to address from a nuclear safety perspective and then how do we go about dividing up those responsibilities between ourselves and the Department of Energy.

And similar actions were taken on the international front, both multilaterally through the Nuclear Energy Agency, as well as the International Atomic Energy Agency, and then bilaterally with some of our largest, most-developed partners.

And then, of course, the Commission affirms this need on an ongoing basis, primarily through its approval and development of the Agency's budget, which then gets submitted to White House and then subsequently to the Congress. Research projects are specifically evaluated as part of that budget formulation process.

You may recall in the last couple years, the Congress, primarily through our Oversight Committee in the Senate, the Senate Environmental Public Works Committee put a lot of emphasis on the need to better report and track Research projects. The committee staff and committee asked a series of questions along this line. And the committee, at first, was frustrated and then the Commission became frustrated that we were not better able to answer those questions.

And out of that, we received direction from the EDO's Office to enhance how we go about planning, reporting, and tracking on those research projects. And I'm happy to report that we've made a lot of progress on that.

And then more recently, through Project Aim, which I previously visited with the Committee to seek your input on when we were formulating the recommendations as part of Project Aim, those recommendations went to the Commission in January 2015 and were approved by the Commission in June. And the staff has subsequently implemented all of those recommendations that were approved by the Commission and we just wrapped up the last of those providing the products back to the Commission.

But among those was one on common prioritization, taking all the work of the Agency and putting it into a common set of priorities that could be used to implement the Agency's program, including Research and then on re-baselining, which the Commission approved in April of 2016, specifically identifying projects that are of less value or lower priority that could, in fact, be shed or streamlined, or cut back in some way and would not have a substantial impact on the mission of the Agency.

And that reduced budget coming out of that process is, in fact, what's reflected in the Congress' approval just yesterday with the Senate's approval of the Consolidated Appropriations Act for 2017, which enabled the Agency to reduce its funding level.

VICE CHAIRMAN CORRADINI: So, can I ask a question about that, since you brought it up?

MR. WEBER: Certainly.

VICE CHAIRMAN CORRADINI: There were two adds to the NRC budget, $5 million for Advanced Reactors and $5 million for Universities. And as I understand it, the $5 million for Universities is moving out of Human Resources and moving into RES.

MR. WEBER: Yes.

VICE CHAIRMAN CORRADINI: And how much of the $5 million of the Advanced Reactors is available for RES for its use in Research initiatives to help for Advanced Reactors versus staffing for Advance Reactor criteria?

MR. WEBER: Right. So, if I could start with the first add, it wasn't an add. It was direction from the Congress to use the resources that have been appropriated specifically to address those functions.

VICE CHAIRMAN CORRADINI: It was not an add?

MR. WEBER: It was not an add. The Integrated University Program was transferred last fiscal year to the Office of Nuclear Regulatory Research.

VICE CHAIRMAN CORRADINI: Oh, I thought it was in this package.

MR. WEBER: No. So we've about that since last year. And in fact, we have a webinar that's coming up on June 3rd -- June 6th, sorry, where we're reaching out to would-be universities, trade schools, people who might be interested in applying for those grants. And the whole purpose of that is not only to broaden awareness of that program but also to better link at least some of those grant applications to the Agency's needs, specifically now in Research. So, we see the Integrated University Program as another opportunity to better leverage the resources that we're using to accomplish the work of the Agency.

VICE CHAIRMAN CORRADINI: Okay. Well, that's actually what I was going to -- I didn't realize that one wasn't new. But I was going to ask essentially what you said at the end, which is now that you have, excuse my English, control of it, instead of it just being an educational activity that is unconnected, it could be connected.

MR. WEBER: Right. We need to implement the law and so we will assure that we do that. But at least $10 million of the $15 million, as part of that program, can be used for mission-directed work.

VICE CHAIRMAN CORRADINI: Okay.

MR. WEBER: And so that's what need to look at and we would hope that we would get grant applications not only to develop the pipeline in nuclear science and related fields but then also to help support the Agency in addressing some of our key research needs.

VICE CHAIRMAN CORRADINI: Thank you.

MR. WEBER: And then on the Advanced Reactors, $5 million of the Agency's $905 million appropriation would be devoted to Advanced Reactor work and that's off the fee-base.

VICE CHAIRMAN CORRADINI: That's what I also wanted to ask.

MR. WEBER: Correct. And we are in the process of talking with the Office of New Reactors, which leaves that business line to discern okay, so the Congress has now appropriated the $5 million, how will we allocate that $5 million.

So, I don't have a firm percentage or number that I can give you today.

VICE CHAIRMAN CORRADINI: But when you brought it up, I thought this was a good time to ask about that because I was tracking those two things.

MEMBER SUNSERI: So Mike, I had a question for you regarding this common prioritization and maybe you answered it in the conversation you just had but let me restate it for understanding.

So when I've seen common prioritization systems applied to organizations with broad missions like the NRC, oftentimes you'll find that support groups like Information Technology or whatever have a hard time competing with the priority system against things like the Reactor Safety or Public Health and Safety directly, right? And so I kind of see Research is maybe one of those organizations that might, for lack of a better word I'll say, be impacted negatively by such a common prioritization system.

But I think you just answered it. It sounds like there are accounts where there is some money carved out specifically for Research activities. Did I -- so, can you just comment on that or explain maybe how this common prioritization has affected you positively or negatively?

MR. WEBER: I can do that now and I will also get to it later when I talk about how we plan to budget for our research.

So we don't have fenced money right now, except for the Integrated University Program under the appropriation. And you are correct that, as we develop that common prioritization, Research activities tended to fall lower in the pecking order than other activities that are, perhaps, more direct in supporting the Agency's mission like Licensing and Inspection.

There are some activities that are higher but most of our activities fell into the lowest of the categories, the so-called 4-B bin. And many of the 4-C activities were, in fact, shed as part of re-baselining decision that the Commission made.

That didn't surprise and it is for the reasons that you identified. We prioritized those activities based on the importance of the activities in fulfilling the Agency's statutory mission, as well as taking into consideration the principles of good regulation and the organizational values.

Now, I've also -- I was involved in formulating the recommendation. I've been involved in implementing the recommendation. I'm also an advocate for refining that prioritization system. I think it accomplished its initial objective. Now, we need to operationalize it. And I would like to see us get to the point where we can use those priorities on a day-to-day basis as we execute our programs.

And then within the Office of Research, you will probably hear later, we're also enhancing how we prioritize our own work so that, ideally, we could plug into the Agency common prioritization knowing how would we bin our activities. Probably not on a one-to-n basis, one being the highest, n being the lowest, but at least in a high, medium, and low and we're actively about that in the office.

MEMBER REMPE: So I have a question, too. I'm coming from a National Lab and yes, we have this structured process for most of the money but we recognize there is an emerging need that comes up. And so in our, I don't know, we call it LDRD, right, the slush fund that we use for new EDOs -- we always have a slush fund that is for a smaller amount of money for emerging needs. How does NRC, with all this prioritization and structure process, deal with an emerging need that needs immediate research? Do you have that capability?

MR. WEBER: We have that capability. We have no slush fund. So, I'll make that clear.

MEMBER REMPE: But it's not really a slush fund, as is a tax.

MR. WEBER: I understand. But the Agency does have an Agency-wide what we call an add/shed/defer process. And so as new needs emerge, if they are sufficiently high priority, we would reprogram resources to support those higher needs and it would come at the expense of lower priority activities, which may defer those activities or, in the extreme, would result in terminating those lower priority activities.

Okay.

MEMBER SKILLMAN: Mike, when you get to a point where you do make the decision to terminate, how is the embedded value of what you're terminating considered? You may have thrown out a single, apparently not important program, but the investment that has been made is worth keeping somehow. So how do you prevent something that's really valuable from being literally thrown away?

MR. WEBER: One thing that we specifically focus on is to ensure that we have fulfilled as much of the original objective as we had when we started that work. So you will see in a bit, many of our activities are driven by user need requests that we've received from the Regulatory offices. And to the extent we can, we attempt to fulfill those user need requests by ensuring that our Regulatory customers have the data, the tools, the information that they need to accomplish whatever they were trying to do -- licensing, inspection, event assessment, PRA.

We also try to do it in an orderly way. So, if we're going to terminate something, we try to get as much value out of that activity that we're terminating before we pull the plug on it. And you see that in how we implemented the re-baselining decisions. We didn't just stop work that was in progress but what we did was continue that work to a reasonable termination point so that we could extract as much value out of that as we could.

And then through our knowledge management, we try to ensure that we document enough of that so that the information will be available not just to today's Agency but for our successors, as well as for people outside that may have a need for that information.

MEMBER SKILLMAN: Thank you. Thanks.

MEMBER SUNSERI: I presume you consult

with the requester to figure out what that optimal point for cutting off is, right?

MR. WEBER: Yes.

MEMBER SUNSERI: Okay.

MR. WEBER: Absolutely. All right, thanks for those questions.

So that gets to how do we define the scope of our program. First and foremost, as you know, the Commission issues its decisions through documents called Staff Requirements Memoranda. So, the Commission may specifically task Research to do certain things. An example of that is the State-of-the-Art Reactor Consequences Assessment, which we've been embarked on for the last decade, more or less. And that originated through initial interactions with the offices, but then subsequently from the Commission.

Another example, the committee was briefed this week on the Level 3 PRA. That's another assignment that the Commission gave to the Office of Nuclear Regulatory Research. And so we factor that into planning and conducting the scope of our program.

Most of the work we do is in response to user needs. And I have on here 75 percent. That percentage changes with time. It might change on a weekly basis, as we complete user needs but it's hovered around this level for an extended period of time. It might be 70 percent. It might be 80 percent, 85 percent. But it does vary to some extent.

These are specific requests that we received, for example, from the Office of Nuclear Reactor Regulation, New Reactors, or Nuclear Material, Safety, and Safeguards, or even, in some cases, the Office of Nuclear Security and Incident Response, where they lay out a regulatory need; we need this information; we need this tool. We will typically work with that requester in advance so that we can help them kind of flesh out what might be reasonable that we could do within the time frame that they're asking for it. And then, ultimately, it gets formally transmitted to my office and then we coordinate it; review it; and then formally respond, saying here's what we can do with the resources available on this time scale. These are the products that we're going to deliver to you.

And then we continue, as we execute that work on an ongoing basis. And this goes all the way back to the founding of the Agency, perhaps not in as formal way as we do it today, but you'll see even later in one of the earliest reviews of the committee of the Safety Research Program, the committee recognized the importance of this close collaboration between the users of the research and the providers of the research to ensure that our program remains focused on what's important.

MEMBER MARCH-LEUBA: In that line, do you ever communicate with the regions?

MR. WEBER: Yes, we do.

MS. WEBBER: Yes, we support them directly.

MR. WEBER: We have people that are in Research that worked in the Regional Offices. We have people that go from Research to the Regional Offices, so they know of our capabilities. We have interfaces with the Regional Offices. We can get into that in more detail.

MEMBER MARCH-LEUBA: I always thought that most Regions will talk to NRR first and then NRO would talk to you.

MR. WEBER: There is that but that doesn't inhibit us from reaching out directly to the Regional Office. In fact, oftentimes, the Regions, knowing of our capabilities, will reach directly to the office to access the experts or the information that they need to support them.

CHAIRMAN BLEY: Do they go through the user need process or is it more informal?

MR. WEBER: It's more informal in that case.

We also have what we call Research Plans. These are area-based plans. For example, seismic, structural, it could be electrical, digital I&C, where we will, in the absence of specific user needs, identify here's what we think as an office we need to achieve over some period of time, three to five years. And that research plan will also be coordinated with our user offices.

That gives them a broader-based kind of umbrella for us to operate under, where perhaps they haven't identified specific user needs, per se, but they know, in general, they're going to need assistance and support from us by conducting research, and refining tools, and developing experimental results, working with code committees, for example, is another good example.

So, that's what we do and those research plans include both confirmatory and anticipatory research. And by anticipatory, I'm talking not basic research but I'm talking about perhaps we don't have an immediate need before the Agency for the information but, with the evolution and technology, with societal developments, we're anticipating that there is a need.

So, this gives us an opportunity to kind of look over the horizon and identify what research should we be doing today so that when and if that issue arises out in the future, we already have prepared the Agency to be responsive to that need. It's a less perfect system because sometimes we don't know what we don't know but this is part of what we do in Research, we try to anticipate what those needs are going to be and address them.

MEMBER CHU: Mike, are you --

MEMBER SKILLMAN: Will you --

MEMBER CHU: I'm sorry.

MEMBER SKILLMAN: Go ahead.

MEMBER CHU: Are you going to give us examples of anticipatory research?

MR. WEBER: Yes, we will.

MEMBER SKILLMAN: It sounds like we'll talk about it later, so I'll be -- okay, I'll be happy to wait. Thanks.

MR. WEBER: And then core capabilities, I mentioned this before in the Commission's previous approval of the core capabilities for the Office of

Nuclear Regulatory Research. So, we have to maintain those core capabilities and I'll talk about that in a little bit.

And then the last category I just labeled as regulatory support. You probably scratched your head. Well what, besides research, would you be doing to provide regulatory support? We actually provide a fair amount of licensing support to NRR, to the Office of New Reactors. We're involved right now in the NuScale review and we provide this kind of support to NMSS on the spent fuel storage areas. So --

MEMBER MARCH-LEUBA: What does that fit with the confirmatory calculations, for example, is that what you mean?

MR. WEBER: I can be confirmatory calculations but it could be other things, too.

So, for example --

MEMBER MARCH-LEUBA: Are you providing a hot body that can write on an SER or are you providing specific capabilities?

MR. WEBER: Yes and yes.

MEMBER MARCH-LEUBA: Okay.

MR. WEBER: In this case is something that what does the office need. They've reached out to Research for the expertise, for the information. How can we assist them?

The tricky part here is, in many cases, we don't have a line on a budget to do this. And so we always have to be balancing well how much licensing support are we doing and then what impact does that have on the Research Program because we don't want to find ourselves someday in a situation where most of our effort is devoted to this kind of confirmatory calculations, or Licensing support, or support to the Inspection and Assessment Program, and we're no longer doing research because that's not going to position the Agency well to meet our --

MEMBER MARCH-LEUBA: Well in that line, I mean and I know you are aware of this, there are superstars in Research that everybody wants.

MS. WEBBER: We have one.

MEMBER MARCH-LEUBA: Yes, and then there are the other guys that are the hot bodies that can type SERs.

So maybe you should have some planning ahead or something that those superstars, you know who they are.

MR. WEBER: I think most of our staff are superstars.

MEMBER MARCH-LEUBA: Yes, but there are

super superstars.

MR. WEBER: Yes.

MEMBER REMPE: So just so I understand, if you provide a warm body to help with Licensing support, it is not the fact -- because I assume would charge out of the licensing budget. It's not the money. It's just that you don't want to lose that warm body who could have been doing research.

MR. WEBER: Correct.

MEMBER REMPE: Is that what you're telling us?

MR. WEBER: Correct.

MEMBER REMPE: Okay.

MR. WEBER: Yes, so it's a balance that has to be struck because we want to provide that support. That support also helps us because it helps to ensure that the research we're conducting is, indeed, responsive to the needs of the Regulatory offices or to the Regional offices. But again, it can't be to the extent that it now undermines our ability to actually accomplish the research that we're here to do.

I'm not going to go through all these. I think you're going to hear these areas touched on in the look forward.

MEMBER SKILLMAN: Hey, Mike, just go back for a second to seven, please.

In defining your research scope, where have you tagged effort in research for your recon team? People who are not completely dedicated but who expend the bulk of their time going out and digging and finding out what it is you're not looking at that you should be looking at?

MR. WEBER: Yes, we don't have a lot --

MEMBER SKILLMAN: Where's your recon team, is what I'm saying.

MR. WEBER: We don't have a line item for our recon team. In fact what I've tried to do, since I've been in the office, is encourage all of our staff to be that recon team because I need them to channel their intellectual capabilities and their networks in the research community and broader to be looking out over the horizon. And we recently, through the last year, refined our what used to be called the Long-term Research Program so that we could make it much more operational in the sense that we don't incur long-term delays in moving forward on some of these shorter term recon initiatives. So, we've streamlined that process and we're in the process of now rolling out that refined approach. In fact, I think last week we briefed the Office of Nuclear Reactor Regulation on this new process. We got the Commission to approve this new process last year.

And so what it really is is it's a feeder process where, on an ongoing basis, we identify these emerging technologies, issues, needs. We channel that into a pool that then gets reviewed by our senior level service staff. We identify through that the need to do what we call feasibility studies. And then those feasibility studies are partnered with our Regulatory Program offices to identify the relative importance of that work and if it should be funded, to what extent. And then from that, we develop the research plan, which would then meet that need identified through that feasibility study.

MEMBER SKILLMAN: Let me follow-up with two more quick ones.

Do you have anybody who's really minding the OE out of INPO?

MR. WEBER: Yes.

MEMBER SKILLMAN: At a deep, thorough level?

MR. WEBER: Yes, John, you want to -- Mark.

MR. TAGGARD: Yes, so we have an agreement with INPO, where we get information from them, operationally, and that feeds into the updates that we use for our PRA models.

So I can go into that a little bit more but we regularly get information from them.

MEMBER SKILLMAN: How about IAEA, their event reports, particularly where something really peculiar happened and people are saying what in the world was that?

MR. WEBER: So I start my day, every day, by reviewing the event reports, including the IAEA event notifications that the Agency gets. And so I'm one of your miners identifying, looking for those sorts of things. And these divisions can tell you I routinely pulse them with hey, we're seeing this; what's the significance of this from the perspective of the NRC? Is this something that we need to look at, whether it's nanotechnology or its three dimensional printing or whatever?

MEMBER SKILLMAN: Thank you.

MEMBER POWERS: Mike, just to follow-up on that a little bit, one specific question is that we have seen, just recently, a lot of organizations coming in presenting some very nice work. Research was, of course, involved in it but it was a huge amount of effort to -- I mean it was conducted over five years. And it produced a risk-informed approach to getting the sump screen blockage issue. And other licensees anticipate using this but clearly, we cannot expend five years.

Do you look to see or do you get input from the line organizations about areas where they're spending huge amounts of resources that might be addressed by improved technology available to their staff?

MR. WEBER: I would say yes, we do but I'm not familiar with the specific example that you're citing.

MEMBER POWERS: Well, it was a South Texas project, risk-informed approach. And I mean, clearly, it cannot spend five years on each of ten plants and ED4 FTEs and things like that.

The question is, more generically, is line organizations have a horrible job. They have got tight time schedules, limited resources, lots and lots of innovation coming in that don't quite fit the way the regulations are written or the regulatory guidance. And so probably the worst people in the world looking and seeing do I need new technology to do this. I mean it is swamp and alligator problem that they've got here.

And it seems to me you're in a position to be able to do that, to look over these processes and say boy, we're spending -- it takes us forever to review a digital I&C system. Is there any technology that will -- that could, with a little bit of research, well maybe a lot of research, aid -- I mean you've had some little triumphs. The GALL Report for handling license renewal is one of the triumphs, where you provided I'll call it technology that made that whole thing possible; otherwise, it would be a nightmare continuing the examination, as kind of an outsider from the line organizations but intimately familiar with the mission to identify where technology would save on manpower and resources, which will be limiting.

MR. WEBER: Yes.

MEMBER POWERS: The added problem is, of course, you, like all of us, have an aging workforce and, consequently, the preservation of expert systems and things like that can be envisioned to integrate younger people into those places.

MR. WEBER: Yes, I think we do that. You know we defer to the Regulatory offices if it's a regulatory solution but we're not shy in sharing with them our views on where we think that there could be an alternative approach.

I'm fortunate to have Anne Boland, who is Acting for us as the Deputy Director of Research while Ed is up Acting for the Chairman. And Anne's normal job is as the Director of the Division of Operating Reactor Licensing in NRR. So, in fact, one of the benefits of having her in the office is to execute just what you're talking about, so that if there are frustrations, for example, from the South Texas project that we have the benefit of those insights.

MEMBER POWERS: Well don't get me wrong. They did a wonderful job, in my estimation. But you just can't spend that much resource on every licensee that comes in.

MR. WEBER: Right. It's a real partnership that I think is required.

Core capabilities, I alluded to this before, going back to '98, one of the things the Commission specifically directed us to do was identify. The staff, in responding to the Commission's direction considered two basic approaches.

One was a workload-based approach, where you would examine what might be a sustainable level of work that you would need to do to fulfill and maintain those core capabilities in support of the Regulatory Programs. And the other approach was an expertise-driven approach.

And the Commission, in light of the staff's assessment, agreed that an expertise-driven approach is the preferable approach because, in any given year or series of years, you may not find that you have enough actual requests from the Regulatory offices to sustain those core capabilities.

And in expertise-driven approach, no matter what the projected workload is, at least for that three- to five-year time frame, you have to maintain those core capabilities.

So we have been effective in achieving and maintaining those core capabilities. Back in '98, there were 29 capabilities identified and we looked at both staff capabilities and extramural capabilities, like National Laboratories, universities, and others, other agencies. And so it was 96 FTE and $34 million in that extramural support.

Most of those capabilities are as relevant now as they were back in 1998, interestingly enough, but that doesn't mean you've got to stop there. Right? We have to continue to be looking forward and anticipating what might be coming. And so in the last couple years, we've been reexamining those core capabilities and identifying what we need.

You may be aware that since January I've led a working group at the request of the EEO to look at strategic workforce planning, where you can take this same approach and scale it up for the entire agency. And so we provided our recommendations to the EDO on that back in April and he is now considering those, along with input from the offices in the regional --

CHAIRMAN BLEY: Is there an easy place to see your 29 core capabilities that you've identified?

MR. WEBER: We'd be happy to provide them to you.

CHAIRMAN BLEY: I think that would be interesting.

MR. WEBER: Yes.

CHAIRMAN BLEY: Have there been any significant changes? You said they're mostly the same. Anything you've added?

I remember a former commissioner, about eight years ago, saying we really are going to have a need for actinide chemists, for example, and we ought to start dumping money into the universities to make some.

MR. WEBER: Yes, I don't think we're developing actinide chemists today. That would be something where we'd be relying more on NNSA and DOE to develop those capabilities, under their attribution and forensics work.

But we did limited work in that area, related to reprocessing a couple years ago. And so there's some continuing work but I wouldn't say that that's one of the specific capabilities that we've identified.

We have made a transition during this period where today most of the research is actually performed by Research staff members. And so about two-thirds of our research is performed by Research staff members and the other one-third is performed by the extramural resources.

When the Agency stood up, it was just the opposite, where 90 percent of the work was done outside the Agency and mostly the remaining 10 percent was worked on by the Research staff and managing those projects.

So that's, I think, affecting how we would distribute those core capabilities today. We've also seen more recently interest in enhanced advanced technology fuel, EATF. And so that's making us recognize we need more capabilities in the fuels area. So, these are the kinds of shifts we're looking at.

There have been topics like polymer science and engineering that have come up since 1998 but that's a more tactical need. And in fact, we understand today that at least the licensee community is perhaps less interested in polymers than they were as recently as a year ago. But we're still looking at that from a long-term perspective where are we going and what capabilities do we need to have to have support for the Agency.

MEMBER REMPE: So, if I look at your management organization, there's a capability or perhaps a need for someone with a core capability related to fuel in several different areas. And I know that some people have matrix and home management ways to address that. How do you keep people that are doing fuel source term knowledgeable of other changes related to the fuel?

MR. WEBER: Yes, Kim, you want to address that?

MS. WEBBER: Yes, so I mean, Joy, you did touch on a hot topic of the Agency of late. And we do have a critical skill shortage in the fuels area. And it's more, you know it's the broad fuels area. It's fuel analysis, using some of our codes, but it's also sort of the materials aspect of fuel performance and some other analytical capabilities.

And so we recognize that this is a shortage. And as a matter of fact, we have, outside the Agency groups interested in our own people. And so we are trying to take steps to expand the knowledge base that we have across the Agency to include adding positions on our staffing plan and then starting to maybe recommend hiring outside of the Agency.

Because I think at this point, you know in order to train nuclear engineers, materials engineers, mechanical engineers who don't have that specific expertise, it's a long time in the making to really get someone who has that proficiency very quickly.

MR. WEBER: We also encourage teaming within the office so --

MEMBER REMPE: That's what I wondered.

MR. WEBER: -- we have multiple branches. For example on EATF, we have people in several branches within Kim's division, as well as in Mark's division that are working on how do you go about doing that assessment.

MEMBER REMPE: Yes, I want to know how you crosscut across different aspects of the fuel, whether it's the way the source term is or the materials, just how you communicate with the people. The people with that expertise have to communicate. So teaming would help, whatever you do.

PARTICIPANT: They have regular meetings.

MR. WEBER: Yes, and we have working groups. So for example, we're connected back to the Office of Nuclear Reactor Regulation, the other NRR, where they're more looking at people like Paul Clifford who were examining the Topical Report applications that are coming in, looking at it from a regulatory perspective. So, we'll connect Paul up with Michelle Bales and Ian in our office.

So, it's a lot of crosspollination that has to occur. You know collaboration across disciplines is key and I think it's only going to increase with time.

MS. WEBBER: Yes, I wasn't quite sure of the question but I do -- I can say that in a particular area, recently, there's interest in BWR stability analysis. And so we have created this kind of teaming team approach within NRR staff learning from some of our more skilled BWR stability analysts in the Office of Research. And so they help guiding the NRR staff on the technical reviews while also trying to help them learn some of the analytical techniques in order for them to do their licensing work.

MEMBER REMPE: Thank you.

MR. WEBER: Planning and budgeting. I'll be fast.

So most of our -- all of our work is planned and budgeted through what we call the planning, budgeting, and performance management process. It's the same process that ACRS participates in in planning and then obtaining the resources from the Commission through the budget.

About 80 percent of our resources, plus or minus, are funded by the Operating Reactor business line. Most of the remainder is funded under the New Reactor business line. And then we get dribs and drabs from the remaining business lines in the materials and waste areas.

We have a Research Operating Plan. We're trying to make that operating plan more effective in how we plan and execute our work and how we measure the success of our efforts. I mentioned earlier the enhanced reporting and tracking.

And then I wanted to make one brief point on control points. The committee may be aware of this. These control points were added to the Agency's budget in the 2016 appropriation that we got from the Congress. So these are -- we used to have a lot of flexibility to shift resources across the Agency, without having to necessarily have to go back to Congress and seek permission to do that.

Back in 2015 and into 2016, our Appropriations Committee started identifying hey, you know you have a lot more flexibility than many other departments and agencies. So, we think we need to control you better by imposing these control points.

And it's not an insurmountable barrier but what it requires is that we really be thoughtful and proactive in identifying when we need to shift resources. So, as you might well imagine, the Operating Reactor business line is the largest appropriation account. When you're in the materials and waste areas like decommissioning and low level waste, they're much smaller. So a small change in one of those small business lines could put you over the control point, which then would require the Agency to go back to the Congress and seek approval to make that transfer.

That's an arduous process, which takes

time. And so we try to forecast as best we can what the Agency's needs are going to be and then execute in accordance with that plan. And I think that's consistent with the original intent that the Congress had when they imposed those control points.

I only raise that because if, for example, you raised earlier the question of emerging needs, if we had a large emerging need, we would bump up, potentially, against those control points and, therefore, we would need to go through that approval process and seek approval by the Congress.

VICE CHAIRMAN CORRADINI: So is that both House and Senate or you have to go just to the Senate or the House or what is it?

MR. WEBER: Both. It's the Congress.

VICE CHAIRMAN CORRADINI: DOE is in this same boat?

MR. WEBER: Yes.

VICE CHAIRMAN CORRADINI: At the line item level? How fine detail do they control you?

MR. WEBER: I can't speak for DOE but the --

VICE CHAIRMAN CORRADINI: I meant you.

MR. WEBER: Yes, the control points are imposed on the business line. So, there's an overall control point for the business line and then there's a lower tier control point that covers the corporate expenditures within that business line.

So, we still have flexibility. But if there's large deviations, it requires appropriate planning and approvals.

On Research budgets, they have varied throughout NRC's history. This is part of the historical look that I was giving. A large percentage of the Agency budget was consumed in Research.

When NRC was created in 1975, half of the Agency's budget was devoted to Research. Today, it varies but we hover around four to five percent in looking at the program support budget. So, it's considerably less today than it was back when the Agency was established.

And of course it spiked through time, as the Agency responded to key events. The accident at TMI 2, the Chernobyl accident, and then the response to the terrorist attacks on 9/11 each prompted smaller spikes in spending. But once we refer that work, I think it properly demonstrated the Agency's ability to bring that work to fruition, to conclude it, and then to move on in addressing more longer term needs.

Because of the constraints we operate

under today, we're increasingly seeking opportunities to leverage the work done by others, such as EPRI, the Department of Energy, our international partners, our grants, as we mentioned previously. So, that's going to be key to our ability to continue to deliver the research in support of the Agency's mission.

And of course, we've benefitted by continued support by both the Commission and the Advisory Committee throughout the history of the Agency.

MEMBER POWERS: Do you attempt to -- does anyone attempt to benchmark this four or five percent of the budget going to Research against, well, say technological industries or other government agencies? Can you give me a feel for how that benchmarking is done?

MR. WEBER: Yes, I do that personally on an ongoing basis. So for example, I often will read the GAO audits. They recently came out with one on the DOE Nuclear Energy Program. So I was interested to compare and contrast.

It is challenging, I found, because you have to dive in and understand what's the mission of that organization and how does that organization accomplish its mission. So what I found is it is variable.

I recently read a review that the GAO did of the Research Program and Developmental Program of the Federal Aviation Administration. And their Research and Development budget is $450 million on an annual basis. So, considerably larger than our program but then you have got to take into account well, what does the country spend in the aviation industry and then how does FAA coordinate their research and development with NASA, which in that case picks up the longer term components of aviation.

So, it's a mix. I'd be happy to, if you have good insights on that, more benchmarks that we could compare against.

MEMBER POWERS: Well, my experience on that is I worked for Eastman Kodak. Fourteen percent of their annual budget went to research because they were a technological company. They make money off new products. So it's not a one-to-one comparison by any means.

Maybe a better comparison is comparing, say, France's regulatory structure or something like that.

MR. WEBER: Yes, although that's challenging as well.

MEMBER POWERS: It's different and has a different spin and things like that.

MR. WEBER: Yes. All right, and I think with that, I'll begin with John reviewing what we're doing on --

MEMBER POWERS: One question I did want to ask you. In formulating new research tasks I just question when they fall into your confirmatory -- or not confirmatory but exploratory kind of research, have you given consideration of, at the planning stage, presenting your ideas before learned societies, such as ANS, or something like that, and getting free consulting from the larger community and maybe even in your ongoing research providing updates to get that free consulting from the learned individuals?

I think, one, that would be welcomed by the society but it always struck me as that was an incredibly untapped source of free help and serves the function of public outreach to the public and this priority that Congress seems to give you on planning and whatnot.

MR. WEBER: We encourage our staff to make presentations before such organizations. We do benefit from the feedback that we get from those organizations. It's got to be folded in with everything else that we're doing. We have constraints on travel and certainly constraints on time. I think --

MEMBER POWERS: Well, it would be interesting to do a cost-benefit analysis on that. And you know whether a presentation is one thing but actually setting up a workshop at one of the learned society meetings. It doesn't have to be ANS. I just happen to know something about them. But an appropriate learned society might give you feedback and contribute to your interest in academics, for instance, looking at your grant program. A lot of unquantifiable benefits it strikes me there and the costs, of course, in doing that, are not zero by any means, but it's a thought.

MR. WEBER: As an example, in the health physics area I know we participated actively at the ICRP workshop that was held here several years ago. We also participated most recently in the mid-year meeting that was held across the street. And Cindy Jones is going to be representing the Agency at a joint workshop that's being sponsored under the auspices of the Health Physics Society and other organizations coming up the beginning of June down in Oak Ridge to specifically compare and contrast what are our needs; what do we perceive the key issues to be; and how does that compare with what industry views and other professional societies. So, just as an example.

MEMBER POWERS: The professional societies may offer you an untapped resource. I don't know.

MR. WEBER: Okay, thanks.

John.

MR. NAKOSKI: I appreciate the opportunity to discuss the activities of the Division of Engineering. As the slide shows, I'm John Nakoski. I'm the Acting Deputy Director of the Division.

In the Division of Engineering, there are four major areas of research, as outlined on the slide. This slide also provides the current level of resources and points of contact in each of these areas.

In the area of digital instrumentation and control, the research supports both operating and new reactors and deals with the challenges using new digital systems and safety applications in response to component obsolescence and the use of new technologies.

A prime driver for the electrical engineering area is support for subsequent license renewal with regard to cable aging and degradation.

Drivers in the area of materials include subsequent license renewal, advanced non-light water reactors, and to a more limited extent, long-term spent fuel storage, primarily with casks and bore hole panel degradation.

And the structural area is also driven by subsequent license renewal with other drivers, including reducing the uncertainty in current methods for seismic analysis and applying risk-informed performance-based approaches and conducting seismic analyses and evaluation of soil liquefaction.

The main drivers related to reg guides is to assure that technically sound bases for issue resolution and guidance on acceptable methods to meet requirements is thoroughly vetted and documented, including soliciting feedback from ACRS.

In the area of digital I&C, research is currently involved in supporting the integrated action plan following Commission direction. The Commission directed the staff to modernize the I&C regulatory infrastructure. We created a Steering Committee and several working groups. And on May 17th, the staff will be in front of the ACRS to provide additional information on the activities of this digital I&C

Steering Committee and the working groups.

Of our currently ongoing activities, our focus is primarily on the modernization plan, in the areas of protection against common cause failure, impacts of digital I&C on licensing bases, acceptance of commercial off-the-shelf digital equipment, and modernization of the I&C regulatory infrastructure.

Research is being done to meet both the industry short-term needs and also to address the modernization of the regulatory infrastructure in the longer term.

As we execute the integrated action plan, we expect to identify areas that require research to develop strategies and technical bases to support decisionmaking, in developing a simplified streamlined, more technology-neutral and performance-based regulatory infrastructure meeting the Commissions directions.

In addition, we anticipate the need for research on cybersecurity-related issues with the intent to develop the technological or technical basis for improving the effectiveness and efficiency of regulatory programs and practices in this dynamic area, as we develop lessons learned and gain insights from various activity in the domestic and the international arena.

In the area of electrical engineering, our focus is currently to support the Agency's subsequent license renewal, focusing primarily on electrical cable, qualification and condition monitoring assessment.

Specifically, one research activity of note is cable aging to support subsequent license renewal by investigating cable degradation mechanisms and testing various condition monitoring techniques for low and medium voltage cables, as well as wet cables.

MEMBER POWERS: I want to ask a question about that specific item. Just an anecdote. I was speaking to someone from EPRI on exactly this subject, exactly that, and he said we've invested, he said millions -- I kind of doubt that -- but millions of dollars into this and nothing seems to work out. And so he said he'd thrown up his hands at the whole area.

Is there a promise here or is this just a sinkhole?

MR. NAKOSKI: I don't know that it's a sinkhole. I think there is a -- we are looking at this. We do have hold points to determine whether or not more research is needed as we go forward to see if there are gaps that perhaps we can bridge.

So if you need a more specific answer, I could probably ask Ian Jung to come up.

MEMBER POWERS: Well, I mean it is something we can go on later.

MR. NAKOSKI: Okay.

MEMBER POWERS: Something that is of enduring interest to this committee because we have to worry about these things for license renewal.

His discussion with me was that things look beautiful in the lab and as soon as you take them out to the field, they just get nonsense out of them.

And I was shocked when he told me that. You know I thought there were ways to do these things.

MR. NAKOSKI: Well that's why I think our focus is on what can we do for in situ monitoring or how can we translate the lab to the field and where are the gaps. And I think that's a prime driver for looking at degradation in the long-term.

MEMBER POWERS: Because it is a major headache for life beyond 60 and things like that.

MR. NAKOSKI: Exactly.

MEMBER MARCH-LEUBA: A different topic on this slide, cybersecurity. Do you guys leverage the knowledge of all the IT guys across the hall? They have to fight every day, I guess, intrusions and attacks and they probably have more expertise and higher budget than you do.

MR. NAKOSKI: That could very well be. At the point we're at right now, this is -- we anticipate -- I don't know that we fully understand the scope of what we need to do. We're working with NSIR in the cybersecurity area to define that scope. Again, looking forward, this is an area we anticipate where we'll be in front of the ACRS talking in much more detail.

MEMBER MARCH-LEUBA: We were just reviewing this morning this new isotope facility and we were telling them that they should just use a pair of scissors and cut the cable but they won't do it. But when they come in, I would get a couple of those guys who know exactly what you have to face day-to-day and review with them. I would use that resource.

MR. WEBER: We do participate as part of the Cyber Assessment Team. That's a multi-office, including the security folks from our Office of Achieved Information Officer. But at this point, we're not doing anything, any research on cybersecurity. It's just been a need that's been identified to us by NSIR to prepare.

MEMBER MARCH-LEUBA: So maybe this wasn't a research question, it was more of an NRO, NRR question.

MEMBER BROWN: I'll make one comment on the cyber thing. Most of that stuff you're all working on, I would think, I hypothesize or speculate, I'm not sure which is the word I should use here, is probably not focused on the most relevant part that's associated without fully installing or the utilization of I&C equipment in power reactor plants with digital I&C. The primary focus there is really keeping access out, compared access, not the programmatic part of it where you're to do this top level umbrella. It's just you never want a door that can be open or you can only open it one way and nobody can ever get back in the other way, which you have probably heard me say 500 million times so far.

MR. WEBER: Not that many.

MEMBER BROWN: All right, I exaggerate a little bit every now and then.

VICE CHAIRMAN CORRADINI: They are counting, though, Charlie.

MEMBER BROWN: They do in balls and strikes. I think most of mine are -- I guess my point is that one of the things I keep missing in all the stuff as we go through this, there's still a lot of push back because everybody keeps pointing at our comments as being oh, that's all programmatic. And if you don't have a set of hardware that allows you to protect yourself, then you can have all the programmatic stuff you want to and it's just like -- well, there's some terminology I won't use here in the public forum. I don't know how you get that into your overall whatever you all do with them to get those points for yourself.

MR. NAKOSKI: Well, I think you know you're looking at improving the regulatory framework for I&C.

MEMBER BROWN: Yes, but what is that?

MR. NAKOSKI: Exactly. And that's one of the challenges in front of us is understanding not just what the hardware is intended to do but what it can do beyond what we think it can do or want it to do.

MEMBER BROWN: Yes, but some places I don't want it to do anything except open a door going outwards.

MR. NAKOSKI: Exactly.

MEMBER BROWN: I mean if everybody -- it's like a stork dance that everybody's doing around this stuff. It's very, very frustrating because we certainly don't want plants having to spend 100 man-years a year trying to fight every different hacker that could possibly defeat their software that they've got with their software based bidirectional firewall, which will never work. It's always defeatable by probably a 12-year-old, if they really work at it.

So, anyway, I had to get up on my soapbox now that you brought it up.

MEMBER REMPE: So we've gotten several comments from members and, although this is occurring during a full committee meeting, I guess it is worth mentioning a point I'm sure you already know, that these are member comments and we speak --

MEMBER BROWN: Thank you very much, Joy.

MEMBER REMPE: -- through our letters. But I just want to make sure I emphasize that point in public.

MEMBER BROWN: I appreciate that. There is very little of my proselytizing.

MEMBER REMPE: But we really appreciate the opportunity to convey your comments in person today. Right?

MEMBER BROWN: It's an opportunity. I never try to miss an opportunity.

MEMBER REMPE: I know.

MR. NAKOSKI: And another area -- I'm going to move on past cyber now. Another area in the electrical engineering arena is we're looking at to what extent other electrical components like batteries need further research, particularly in light of new and advanced reactor applications.

In the materials degradation aging and component integrity arena, we're conducting research to develop probabilistic fracture mechanic tools to assess the structural integrity and safety of the primary circuit.

The focus of our research is primarily on two tools: The FAVOR Code, which is the fracture analysis of vessels prepared by Oak Ridge. That's for reactor pressure vessel analysis. And the xLPR, extreme low probability of rupture for piping.

For the FAVOR Code, research will be performed to independently verify and validate the code, given some recent unanticipated outcomes from the use of the code that have the potential to challenge vessel integrity.

Research on the xLPR Code will be performed on how to apply these tools to develop more risk-informed guidance on leak before break analysis.

And finally, the staff has started the development of regulatory guidance on these tools to help guide the industry and the staff on their use.

In the area of primary water stress corrosion cracking, we're performing independent testing and in coordination with EPRI to gather information on crack growth data and reactor pressure boundary components. Future research is going to be focused on crack growth rate testing in the well dilution zones, heat-affected zones, and partial penetration welds.

In irradiation-assisted stress corrosion cracking, current efforts are focused on testing reactor pressure vessel internal materials, for example, materials harvested from Zorita, a reactor in Spain. Cooperative testing with ERPI is being conducted on plate samples and welds.

Additional irradiation and testing of the welds will be done at Halden is also planned.

And the NRC will conduct a limited independent testing of the Zorita materials later this year and next year.

Future research in this area will focus on obtaining experimental data for void swelling of stainless steel in reactor pressure vessel internals.

In the area of reactor pressure vessel embrittlement, our efforts are focused on assuring the adequacy of the NRC's guidance in the Reg Guide 1.99, which deals with radiation embrittlement of RPV materials. The research uses an extensive database that was recently compiled by the American Society for Testing and Materials with support from the staff.

The results of this research will support continued operation of commercial reactors throughout their operating life, including the renewal and subsequent license renewal periods.

In the area of steam generator tube integrity, the research is an ongoing research activity that is being done in cooperation with our international partners from France, Korea, and Canada, and domestically with EPRI. We're trying to leverage our resources. And the research is being performed to evaluate advances in and the effectiveness of any current inspection techniques, tube performance and integrity, and industry techniques and standards.

This is an area where our level of effort is trending downward, just as a side note.

MR. WEBER: And we know the consequential steam tube generator briefing, which occurred this week, there was some discussion by the committee or the subcommittee on this topic.

VICE CHAIRMAN CORRADINI: We have no opinion. We have no letter.

MEMBER REMPE: But we're going to have one, I hope.

VICE CHAIRMAN CORRADINI: Yet, I should say.

MEMBER REMPE: Yet, yes.

MR. NAKOSKI: In the area of non-destruction evaluation techniques and tools, research is being conducted to better understand the accuracy and reliability of the methods for use in in-service inspections, specifically at detecting degradation and safety-related components. This includes advanced and emerging NDE methods, such as phased array UT, considering its capabilities and limitations relative to conventional UT.

Other areas of research include assessing the use of modeling and simulation tools for analyzing UT methods and the influence of human performance on NDE reliability.

In the area of spent fuel cask degradation, research is focused on aging management of dry cask storage systems. We've prepared some aging management tables that provide the technical basis for dry storage, license aging management, as guidance has provided in the MAPS report. That's the Managing and Aging Process and Storage report.

Future work will focus on chloride-induced stress corrosion cracking of stainless steel canisters to support evaluation of canister inspections, to assess the effectiveness of NDE methods used for in-service inspection, and potentially doing research to collect data on CISCC crack growth rate.

In the area of the Neutron-absorbing Materials Program, we're working collaboratively with EPRI in materials testing to ensure neutron-absorbing materials used in spent fuel pool meets subcriticality margin requirements.

The research is currently being performed to evaluate the performance of boral under varied water chemistry conditions to determine the corrosion kinetics and potential degradation.

Efforts are also underway --

MEMBER POWERS: Why would that be a --

MR. NAKOSKI: I'm sorry?

MEMBER POWERS: Why would that be an NRC concern? I mean isn't that a licensee's concern?

MR. NAKOSKI: Well, it's I think both. I think we need to understand what they're doing to assure that the criticality, subcriticality margins are maintained. So this would support the views of license submittals or amendments.

MEMBER POWERS: Yes, I mean you just say have enough and go make sure you have enough. I mean I don't know how much understanding you need.

MR. NAKOSKI: Well, when you're looking over the long-term, we need to I think have an understanding of what the degradation mechanisms are and whether or not the programs in place and the technical basis is sufficient to conclude that it will meet its needs in the longer term.

MR. WEBER: This recently arose, as the committee might know, in cask uses of boral and other materials.

MEMBER POWERS: Yes.

MR. WEBER: And so if you're going to seal the spent fuel in the cask with the intention not to reopen that cask, you'd want to have some confidence that it's going to do what you think it's going to do.

MEMBER POWERS: I understand.

MR. WEBER: To me, it's a classic application of confirmatory research.

MEMBER POWERS: Right.

MR. WEBER: Yes, it is the licensee's and the vendor's obligation to demonstrate safety but going all the way back to the founding of research, it's also our obligation to ensure that we've got the information necessary to confirm.

MEMBER POWERS: I mean cask I can understand but you just seal it up and nobody can go look so, you have got to know. But the spent fuel pool, I can look anytime I want to.

MR. WEBER: Yes, and we want to ensure that those spent fuel pools don't go critical.

MEMBER POWERS: That's always a good idea.

MR. WEBER: Yes.

MEMBER BALLINGER: I have a question. Do any of these projects have what I would call a sunset clause on them, which force you to make a grounds up reevaluation of where you are, what the benefit has been, and what needs to be done going forward so you don't just -- I mean we've looked at projects where the user need -- when you chase it back to the user need, there's absolutely no connection between the user need and what we see in a lot of cases. I'm exaggerating a little bit but it's tenuous. Let's put it that way.

MEMBER RICCARDELLA: I guess it has to do with the time constant. You know the user need and a lot of these things were written in 2008, 2007. Is there any periodic updating of that user need, and how the research is going, and is it still current?

MR. NAKOSKI: The user needs are typically reviewed on about a five-year basis.

MEMBER RICCARDELLA: The research.

MR. NAKOSKI: No, user needs and research plans. I mean the work requests that we receive are typically reviewed on a five-year basis to see whether or not the work needs to continue.

In some instances, these are long-term programs that develop codes that we apply and maintain and keep state of practice. So those types of things probably you won't have a sunset clause on.

In other instances, for example, on like I mentioned earlier on cable degradation, there's going to be a point where we stop and reassess the research that we're doing to see do we need to do more after this. Are there gaps that we still have to close before we proceed?

And if the answer to that is no, we're done. We document the results and draw the conclusion that on this topic there's no more research we need to do based on our current state of knowledge.

MR. TAGGARD: Well, can I add one thing?

So one thing we are also doing, we are meeting regularly with our partner offices. So, we meet regularly, almost like a quarterly basis with the Office of Nuclear -- NRR. And we go over all the user needs and how we're addressing them. And we do the same thing with NRO.

So, I think there's less opportunity now than in the past for things to kind of just drag out because they have no interest in us doing that.

CHAIRMAN BLEY: So when John says these are revisited on a five-year basis, that's by a coordinated effort between your office and the office that generated the user need.

MR. NAKOSKI: That's correct. The idea is that we would sunset the older user need and prepare a new one to make sure that the research that we're doing is still valid, still driving towards the program office need, and they understand what we're doing.

CHAIRMAN BLEY: Okay. Some we get the impression just kind of sit there forever but I don't know. If we're really getting reviews, that's good.

MR. NAKOSKI: Some of them are older than five years and we recognize that.

MEMBER RICCARDELLA: Do you think five

years is frequent enough? Should now all these things be looked at on a more frequent basis, all of the programs?

MR. WEBER: I think Mark's point was that we are looking at them on a more frequent basis. I think John's talking about at the office level. But you've got at least quarterly meetings going on with counterparts in the regulatory user offices.

This was at the heart of that congressional concern by the Senate Environment and Public Works Committee that we were just going on and on and on on some of these projects. And in an era of constrained resources, we don't have the resources to keep spending on work that's not going to be needed. We need to focus our resources in the areas where it is needed.

So, we have a built-in incentive to ensure that we're staying on top of those user needs and developing the information necessary.

MEMBER SKILLMAN: I would like to ask a question about this image. This, to me, is a Davis-Besse piece. This is May 14th of 2002 at 10:40 in the morning, after the head was removed and this section was removed. But this, to me, is the poster for why we should be talking about international operating experience.

If I go back to 1995 to 2000, the French knew that this phenomenon was occurring. They knew the A182 weld situation. And Davis-Besse was tolerating the weep from the cracking that was occurring in this hole. The rest of the B&W fleet was not responding. There might have been an info notice or an info bulletin but it certainly was not one that had bells, lights, and whistles. It wasn't one that would cause the plant staff to go and take a thick magnifying glass and look. And it wasn't one that would have had the residents come into the head of engineering and say you had better get out there and take a look. But the French were experiencing this.

And so, as I ended my term at Three Mile Island, we had a B&W head, 69 control rods identical to this one. I said to myself why didn't we know about that. Why weren't we looking? And then I spent months out at David-Besse because they went right into O350. They had their keys taken away. And then we did the post-mortem and we learned everybody knew that they weren't doing anything about it; that there was information that was six or eight years old from Europe that should have told us you had better be looking for this.

That, to me, is a guiding principle in what we ought to be doing now in mining the OE from whatever because that OE might prevent and event similar to this, maybe a different area of technology, but one that could really cause trauma.

So I think this idea of recon, having your people looking. Some of the best recon team members you have are the residents because they know. I mean they're looking at stuff and they're saying, hey, you ought to take a look at this. There's something really funny here.

How to make that information actionable and kind of get it on one 8.5 x 11 piece of paper with a couple of bullets that simply says this is flagged, this is for attention, at the every minimum let's do a little bit of digging. Because if there had been just a smidgen of that back in 1999, 2000, 2001, I don't think this would have occurred or if it had occurred, it would have been at a level of significance that it would have become a maintenance item but not a near small break LOCA.

MR. WEBER: Well said. I think we agree.

MR. NAKOSKI: Absolutely.

MEMBER SKILLMAN: Thank you.

MR. NAKOSKI: Okay, the last area on this slide is advanced non-light water reactor materials. And these materials will be unique to the specific design. And the assessment will require that the specific materials, the environmental conditions, and the loading specific to each design be considered.

The technologies we're currently looking at are gas-cooled reactors, sodium fast reactors, and molten salt reactors, and with the potential for other designs that will have unique materials and may subject familiar light water materials to new environment conditions.

MEMBER REMPE: So that's one I'd also ask why don't you make the applicant deal with this as their research and they just have to justify that they've done due diligence? Why is NRC doing this?

MR. NAKOSKI: Again, I think we have an obligation to independently verify or review and at least understand the proposals they're submitting. So, we will typically work in collaboration with EPRI and other people that are doing research in this area to understand what's being done up front so that when we do get those applications in-house, we at least understand what we're looking at.

MEMBER REMPE: So you're not really doing materials testing. You're just reviewing what other people have done to gain the knowledge. Is that a better way of characterizing it?

MR. NAKOSKI: Well, where we're focusing our initial research on, and I'll touch on that, is to look at the material and structural and the integrity issues that need to be addressed during licensing. So, that's one of the areas we'll be looking at in the short-term or in the near-term.

Then, looking at what confirmatory research is needed to be done to validate the industry's approach to addressing these issues, which I think goes directly to the question you raised. Also, to access the capabilities and needs of the current tools that we have, to see how they need to be updated. And then looking at gaps in staff and contractor expertise and knowledge to develop the approach to efficiently address those gaps.

So it's not necessarily going out and doing our own independent confirmatory research but it's making sure we have the tools in-house to do the assessments when they come in.

MEMBER REMPE: Sounds good. Thank you.

MR. NAKOSKI: Okay.

MS. WEBBER: Can I just add one thing on that? So more broadly across the office, we're looking at a lot of technical areas to support future license applications for advanced reactors. And this, to Dr. Chu's question earlier about anticipatory research, what we're trying to do right now is understand where we have knowledge, analytical and gaps, basically, gaps in knowledge so that we could probably maybe lean a little bit forward and try to determine if there's value added in doing some anticipatory research in certain areas.

So, the current phase upon us is assessing where we have the gaps and then we'll try to determine where it makes sense to do some kind of anticipatory research.

MR. WEBER: And we'll do material testing, if it's needed to confirm safety.

MEMBER REMPE: I'd wait until we had an application, I think.

MR. WEBER: Oh, yes.

MEMBER REMPE: With 80 plus vendors --

MEMBER BALLINGER: You probably ought to wait until they know what materials they're going to use.

MEMBER REMPE: Go ahead. Thank you.

MR. NAKOSKI: Okay, going to the next slide. In the structural seismic and geotechnical area, we're doing research on concrete degradations with alkali-silica reactions or ASR. And it's being done to assess the structural performance of affected concrete structures, to support the technical basis for generic regulatory guidance to evaluate the potential effects of ASR. And that's through current operating, through license renewal period, and subsequent license renewal.

And the NRC and the National Institute of Standards and Technology are working jointly to address both material degradation aspects and structural performance of ASR-affected concrete.

MEMBER BALLINGER: I'll keep coming back to this reviewing process and I'll pick -- we can pick concrete, if you want. But is there an ongoing review process where you look at what's going on and then you make an assessment? I thought this was going to happen but we're not seeing it happening. So, therefore, we need to cut this off.

MR. NAKOSKI: I think yes, we will do that. I think that's part of what we do routinely with our program offices but then more from a research perspective I think it gets back to do we have gaps that we need to fill to meet a regulatory need.

MEMBER BALLINGER: But it comes back to

what people are saying about five-year reviews is just a long time.

MR. NAKOSKI: Well in specific programs, we do have hold points identified, where it's we will -- whether it's two years down the road or five years down the road, it's really dependent on achieving a specific point in the research activity that then decide do we stop now and suspend research in this area or do we have to continue.

VICE CHAIRMAN CORRADINI: So let me --

MEMBER BALLINGER: If I might just kind of comeback -- I'm sorry, Pete, did you want to -- go ahead.

VICE CHAIRMAN CORRADINI: I guess the one area that I think is within your is and for light water reactor sustainability, there is a lot of work that is being done by DOE. And I know NRC is following it.

So a way of asking of Ron's question differently is if you said okay, all the things in terms of materials aging and degradation, there are certain things that agencies like DOE do or EPRI do simply because either A) they should do it, or they should be on top of it and you check it versus you do it. And then other things you want to confirm, you might want to anticipate. But at least in that area, there's ongoing conversation because I know I think Brian Thomas attends some of the review meetings.

So I guess another way of asking Ron's question is there a continual conversation? So you decide we have a limited budget; we can only do this much. Is that happening in all the areas? I know it's happening a LWRS because I've been at the meetings.

MR. NAKOSKI: I would never make an absolute claim but I believe it's happening in all -- most of the areas, if not all.

VICE CHAIRMAN CORRADINI: Okay.

MR. NAKOSKI: There's a continual dialogue, not just internally with our program offices but externally with key industry players, other federal agencies that might be doing research, and the international community.

VICE CHAIRMAN CORRADINI: Eventually, I was going to ask you about that, about international collaboration.

MEMBER RICCARDELLA: Is the bulk of this ASCR effort, is there work being done at NIST, the big experimental program that they're doing?

MR. NAKOSKI: It's being done at NIST.

MEMBER RICCARDELLA: And are we funding that?

MR. WEBER: Yes, we are funding that.

MEMBER RICCARDELLA: But also is DOE funding part of it?

MR. WEBER: We're funding it 100 percent. We also participate in the DOE-funded work down at University of Tennessee. In fact, we just had people down there from Research that participated in the project review for that project, and we're working with an international cooperative research project, and we're doing bilateral work with our French counterparts at IRSN.

MR. NAKOSKI: And that's again, we're trying to leverage more of our domestic and international efforts.

VICE CHAIRMAN CORRADINI: Right but the only reason I just jumped in is I think that's kind of where I think Ron's coming from is that with limited resources you want to know what EPRI's doing, what DOE's doing, what utilities are doing individually, owners' groups internationally, or if you collaborate so that you can get more bang for your input.

MR. NAKOSKI: I think all of the above. Where we -- one, first, we understand what work is being done, try to understand what work is being done by other -- in research by other organizations. And where we can best leverage our limited funds to maximize our return on investment, I think we're looking at that more thoroughly than we have, perhaps, in the past.

MEMBER RICCARDELLA: Moving on to that second bullet, I mean as I understand, there's maybe a total of three inches of concrete in some plants that receive enough irradiation to see any damage at all.

MEMBER BALLINGER: So I wasn't trying to be that blunt but I'm an academic and I've never met a research program that I didn't like but you guys only have a certain amount of money to spend.

MR. NAKOSKI: That's right.

Well and I think at this point in the irradiated-related degradation of concrete structures, I think what we're looking at is do we have a problem that needs to be addressed. Do we fully understand the impact of the degradation mechanisms on the concrete structures before we dive off the deep end and do I think much more detailed research in that area?

So we're at the investigation phase to

see, I think, how far we should go.

MEMBER BALLINGER: But you do have a critical review process on these things.

MR. NAKOSKI: That's correct.

MEMBER BALLINGER: Yes.

MR. NAKOSKI: I'll continue on. And then another area is on the aging of pre-stressed concrete structures and we're doing research to assess the complex stress conditions from post-tension concrete that may lead to degradation of the structure, looking in a couple of areas, for example, creep-induced split cracking and the potential for primary creep reactivation from re-tensioning operations. And this research is done to --

MEMBER BALLINGER: Have you been down to Farley, lately?

MR. NAKOSKI: No, I have not -- to either confirm the guidance provided in the GALL Report or to identify the need for updates to the information in the GALL Report.

MR. WEBER: Is there an issue we should be aware of?

MEMBER BALLINGER: There's a guy down there who's probably, I'm sure, keeping track.

MR. NAKOSKI: Okay. In the seismic

hazards area, research is being conducted to update the NRC-approved models used to conduct seismic hazards assessment for both operating and new reactors. The research is focused on models, for example, the seismic source or ground motion models. They're not well characterized. The intent is to update the models to reduce uncertainties and establish more robust seismic hazard calculations to take advantage of advances and state of knowledge.

And the risk-informed performance-based seismic study or seismic safety research is being done to evaluate the current status, develop a path forward, and explore long-term possibilities, including the development of approaches by other organizations.

In the area of probabilistic soil liquefaction analysis, the research is being done to address the issue that current evaluation methods rely on deterministic approaches that may not be consistent with performance target goals used during design. This research will develop the technical basis for assessing liquefaction hazards and consequences using probabilistic models and then we'll update Reg Guide 1.198 that provides guidance to the industry and staff on an acceptable method.

Finally, the last slide for DE is related to regulatory guides, generic issues, and codes and standards. We have about 360 reg guides that are currently issue at the NRC. About 100 of these reg guides are on some state of review at any time and we issue about -- new or revised guides about 10 to 20 a year that are provided to ACRS for review.

In the Generic Issues Program, in March, recently, we just briefed the ACRS on the program. And currently you have GSI-191 at the subcommittee on thermohydraulic phenomenon.

And then as part of the review of the Commission papers prepared by JLD, ACRS has reviewed GI-199 on seismic hazards and GI-204 on flooding and we'll continue to have interactions with the ACRS' progress as made.

An issue that is emerging and is a potential generic issue is on high-energy arc faults, where aluminum is present and Mark may touch on this more later. And ACRS has expressed interest in keeping abreast of this and we'll do that.

In codes and standards, you typically get engaged or ACRS would typically get engaged with reviewing specific standards where it's related to a larger regulatory process, preparing reg guides, new rules, or issuing new updates to the standard review plan.

And there's an area where you might likely want to get engaged and that's in the development of long lead time standards for non-light water reactors. And we'll be looking at that.

And then as a side note, in the codes and standards, we're looking at strengthening our oversight of NRC staff participation in codes and standards and make sure that we have better records of the interactions that we have.

And finally, the question was asked looking out over the horizon, what are we doing to recon, and Mike mentioned this earlier, the feasibility study requests. It's a new process to identify and assess areas for future research.

The ideas will be collected and then reviewed to determine whether to conduct a feasibility study. So, it's put the idea in. Let's not discard anything. Let's review it. Let's do a feasibility study to see if we can do research or need to do research in this area to meet a regulatory need. And then we would engage ACRS as those research topics are identified and we move forward.

MEMBER REMPE: Is there something that

documents this process you're talking about? Because I'm not sure I'm aware of it. Is there some memo or something?

MR. NAKOSKI: We can provide it. It's TRM-001.

MEMBER REMPE: Okay.

MR. NAKOSKI: It's in the process of being updated and revised.

MEMBER REMPE: Also, I just wanted to mention we would be interested if you have any thoughts of areas in your division that you'd like us to focus upon.

Dick Skillman is going to be leading the team that meets with your organization and I'm sure he'll have thoughts, as you can tell from his comments and questions today. But if there is some area where you think you know we'd really, really like you to focus on because, again, we're not going to do the 80-page report anymore. We're going to be highlighting topics of interest, even though we're interested in the whole area. So, let us know.

MR. NAKOSKI: Okay.

MEMBER SKILLMAN: So let me ask one final question, based on Joy's comment.

Has consideration been given to doors that are going to close? Worldwide, what, around 400-450 reactors. Did you ever think of going to the cheapest, most highly irradiated carbon steel plant and somewhere in catch as catch as can and taking a sample, knowing that it was local concrete; it had no QA; there was no Appendix B; this thing operated for four decades; it's got 10 to the 21 NVT; and here's a piece of concrete from the inside of that?

I'm making up a story, clearly, but what I'm suggesting is doors are closing and there might be stuff out there that we would say boy, we don't want to miss that. That could be cool. We could really learn something from that.

MR. NAKOSKI: And we have been engaged in a harvesting workshop. I forget exactly when it was. It was not that long ago when we were working with -- okay, a couple months ago. So, we are trying to identify those instances where the doors are still open but may be shut soon. They are in active decommissioning. Can we go and harvest material?

It is a cooperative effort, I think, with DOE and EPRI and I am looking to folks in the DE that might have more information on that. But we are trying to, again, leverage limited resources to maximize industry-wide efforts to harvest material.

MEMBER RICCARDELLA: And the overall message from that workshop was harvesting is very expensive.

MR. NAKOSKI: Yes.

MEMBER RICCARDELLA: And you have to be very, very selective in how much you could do.

VICE CHAIRMAN CORRADINI: But if I understand it, you're participating in the harvesting of design that DOE is doing, right?

MR. WEBER: Yes.

MR. NAKOSKI: That's correct. That's correct.

Okay and I'll turn it over to Mark.

MR. TAGGARD: Okay, and I will try to be as brief as I can.

MR. NAKOSKI: Well, hopefully they asked all their questions already.

MR. WEBER: I don't think so.

MR. TAGGARD: So this first slide provides an overview of the Division of Risk Assessment. In terms of resources, our key program areas, and also some of the key contacts. You will notice that one of the contacts is John. He actually works in my division but he's on loan to DE right now. So we should have him back in a couple of weeks.

MR. NAKOSKI: My replacement has been picked.

MR. TAGGARD: So in the Division of Risk Analysis, we're involved in four primary research areas. These are not the only areas that we are involved in but these are the ones that most of our resources are tied up in. These are development of PRA methods and models, human factors, and human reliability analysis, fire PRA and flooding assessment.

And so I'm going to walk through each of those four areas and talk a little bit about we anticipate our research needs or where our research is going in those four areas.

So we begin with the PRA area. The key activity here is maintaining the computer codes used by the Agency for conducting probabilistic risk assessment. These codes are regularly updated, based on operational experience. We have a staff member that participates with NRR and looks at the licensee event report. We also get input from INPO. So, that information is regularly looked at.

Some of the areas that we're focusing on right now is adding the capabilities for assessing all hazards. This would include seismic, fire, flooding, and high winds. We're also hoping, at some point, to incorporate insights that we gain from the Level 3 PRA work. One of the areas that we're going to be probably looking at in the future is assessing risk from multi-units.

In terms of new reactors, we are developing SPAR models, which is our main computer code for the Vogtle and the Summer sites.

There are some advanced PRA methods that we are starting to look into. We're not actually doing any research in these areas but we are keeping an eye on them. They're primarily work that's been done by the universities. We're looking at these areas primarily from the context of the applicability in terms of some of the work that we do and this would include dynamic PRA methods, use of advanced statistical methods, such as Bayesian belief networks, global sensitivity analysis and cost analysis. And we are also looking at the new technologies, such as knowledge engineering and how that might be used in some of our PRA work.

And one of the last areas that I wanted to mention in PRA, we're looking at a means of using industry -- developing an industry-wide precursor-based evaluation for assessing the effectiveness of our Reactor Oversight Program.

Right now, when we do risk analysis for a particular plant, some people, particularly some of the members of the public, they tend to add up those risks from the various plants and try to get an idea of what the overall risk is to the industry. And obviously, there are some limitations to that and we recognize that. So we're trying to look at how that information came to use or if there is some other technique that can be used to make those kinds of assessments.

In the area of human factors and human reliability, we expect to continue developing human factor guidance in several areas, including advanced control room technologies for new and advanced nuclear power plants, nondestructive examination techniques, and drug and alcohol testing.

We are also working to develop a human reliability analyses methodology. We did a briefing to the subcommittee on this earlier this week. This work was actually directed by the Commission with the idea of improving our HRA capabilities so that work in that area is going to continue.

One of the things that we are hoping that this is going to give us is a better means of addressing issues such as the licensees that want to take credit for the use of FLEX equipment, which seems to be a high priority for the industry right now.

And lastly, we have an effort on the way to collect data on reactor operator errors. This project is called the SCADA Project. It is voluntary activity. It's not mandatory for licensees, plants to participate but it provides us information that we use -- that can be used to provide better estimates on human error probabilities. So we see a lot of potential promise in this particular area.

What we're working on right now is trying to increase the number of licensees that we can get to volunteer to participate in this program, as well as we have some international utilities that have signed up --

MEMBER POWERS: That must be a challenge getting the licensees to report when they screwed up.

MR. TAGGARD: Well, there are actually some benefits to them. Sean Peters, who runs that branch, he maybe can touch on it a little bit.

MR. PETERS: Yes, it's a collaborative effort. This is Sean Peters. I'm the Chief of Human Factors and Reliability Branch in Office of Research.

That effort is actually a collaborative

effort that we worked with the South Texas Project Nuclear Operating Company and we developed this SCADA software as a way for them to manage their operator training program. So for them, it helped them manage their operator training program better. For us, it allowed us to capture all the operational data from that training program into our database.

So we worked with them to develop it and we rolled it out internationally. Taiwan right now is implementing this in their nuclear power plants and we are also looking at signing at least trial agreements with a couple other utilities here in the United States. So we recently issued a regulatory issue summary, where we told everybody about this particular program and we had a RIC session on this program also in March. And so based upon that outreach, we've gotten significant feedback from the industry that there are other utilities that would like to sign up.

MR. TAGGARD: Okay, just moving on to my last slide, so one of the areas that we're working on in the fire PRA area is trying to improve the realism of our fire PRAs. This is a big focus for NRR because fire tends to be one of the drivers in PRA analysis.

So we recently had meetings with NRR as well as EPRI and we have come up with general alignment on where we think additional research is needed in this area. This includes determining heat release rates, emission frequencies, and circuit analysis.

So we're going to work with the industry -- work with EPRI in terms of laying out a program in terms of who is going to do what research and that type of thing.

We're also looking to continue our cooperative effort with the international community, looking at a high energy arc faults. As John alluded to, one of the areas that has a lot of interest right now is these high energy arc faults associated with aluminum. That issue right now is being looked at in our Generic Issues Program. So we're going to continue research in that particular area.

VICE CHAIRMAN CORRADINI: So can I -- I'm not an expert in this but I seem to remember as part of the refocusing of the Agency and Research that some of this work was going to considered to be curtailed. Am I misremembering?

MR. TAGGARD: No, you're actually correct. So --

VICE CHAIRMAN CORRADINI: And I think we wrote something in the last report --

MEMBER SKILLMAN: To save this one.

VICE CHAIRMAN CORRADINI: -- to please don't do that.

MR. TAGGARD: Yes, actually so --

VICE CHAIRMAN CORRADINI: Maybe it was just don't do that.

MR. TAGGARD: Yes, so this was one of the areas that -- the fire research area was one of the areas that got hit pretty hard in the re-baselining effort, including this particular program. But the Commission actually singled this particular program out and told us to not -- to remove it. So we'll continue working it because of that.

MEMBER SKILLMAN: The Commission heeded your advice.

MR. TAGGARD: Yes.

VICE CHAIRMAN CORRADINI: That's a nice way of putting it. Maybe so.

MEMBER SKILLMAN: I recall we debated this and said let's go back and tell them keep it. Since Mark Sally is here, there is some irony in this image. There's a little fire extinguisher down in the lower left corner.

(Laughter.)

PARTICIPANT: I thought that maybe you

missed that, Mark.

(Simultaneous speaking.)

MR. TAGGARD: Okay so lastly, we have a significant effort underway to develop an approach for assessing the risk from low probability flooding events. And we're hoping to develop what we call a PRA methodology for assessing flooding.

And this was work that came out of the Fukushima effort. Licensees are required to go back and do a flooding reassessment. So we are thinking that a lot of licensees are going to actually use a methodology similar to this. And so we want to be in a position to be able to evaluate what they are going to provide to us.

So I hope that was brief. I'll turn it over to Kim.

MEMBER REMPE: Before I let you start, though, Matt Sunseri is going to be leading the effort in interacting with your division. And so are there comments in areas that you want him to focus on?

MEMBER SUNSERI: Yes, Mark, thanks for that briefing. I was wondering, maybe it is embedded in there, but is your division doing some work on human reliability with respect to decisionmaking and performance in like I call them these extreme cases?

I mean you mentioned FLEX. And when we get down to FLEX, I mean we're talking about people protecting the plant now, right? They've got to make decisions on how to use the equipment and whatever.

So what kind of research is being done in that area of severe core massive environmental destruction? I mean these are things that affect how people perform, right?

MR. TAGGARD: Yes. And I don't know --

MR. PETERS: Yes, I would like to weigh in, if possible, on that.

MR. TAGGARD: Oh, okay.

MR. PETERS: We developed the general ideas methodology and you guys have got to sit in on that presentation on Monday. In the methodology, we've actually applied this general method to extreme conditions, as in the Fukushima accident. So we have developed that Fukushima accident into an example that we've shown the capabilities of modeling those human decisionmaking aspects.

The concept with that general methodology is that if we want to model areas outside of main control environments, we can. And so we have that capability in that method.

MR. TAGGARD: Thank you.

MR. WEBER: The committee may also recall we looked at human reliability aspects in the spent fuel pool consequence study, which --

MEMBER STETKAR: Oh, I wouldn't advertise that one.

MR. WEBER: Don't go there? Okay. All right. But we did.

(Laughter.)

MS. WEBBER: Good afternoon. My name is Kim Webber. I'm the Deputy Director of the Division of Systems Analysis and I know we only have about five minutes or so until the formal end of the meeting. I'm going to try to be brief.

VICE CHAIRMAN CORRADINI: Your area is the most important. I'm waiting.

MS. WEBBER: Okay, I'm going to try to be brief.

What I wanted to give you a flavor of, really, what my case and I wanted to do is give you a flavor of some of the hot topics. We're not going to exhaustively go over everything that we do in the Division.

Also to give you a sense of where we have challenges for critical skills, some drivers for future research. And then something that we do in the office that maybe goes unnoticed at times is leveraging other organizations' resources to do our work. And so I'll touch on that a little bit.

So in this slide you can see in the left-hand column the span of the technical research areas that are important to our division and then you can also see the FY17 resource levels in the primary point of contacts.

As you also notice in the column called key tools, DSA maintains a significant number of nuclear codes which are used for a wide range of regulatory applications. Additionally, we have reimbursable code sharing programs. Those programs are called CAMP, which is Code Applications and Maintenance Program; CSARP, which is Cooperative Severe Accident Research Program; and RAMP, which is the Radiation Protection Computer Code Assessment and Maintenance Program. And through these programs, we actually get monetary reimbursements for maintaining the codes and in-kind contributions which go to maintaining the codes and developing new correlations and models for those codes.

So other regulators and technical support organizations are involved in these reimbursable code-sharing programs. Thus, we have a strong obligation to verify, and validate, and maintain the codes. And that's a big emphasis for our division. And as you know, it takes quite a lot of resources in terms of skilled staff and contract support to do that.

So a key challenge for us and one that we're actively working on is to try to ensure we have enough resources to maintain the codes, while still trying to deliver high-quality analytical and user need-driven work products to the customer offices, who are NRR, NRO, and NMSS.

I'll touch briefly on thermal-hydraulics. I know this is a hot area for many of you. Do know that if there are specific topics that you are interested in that I'm not going to cover, I'd be happy to meet with you and get you hooked up with the right folks, including Steve Bajorek and Chris Hoxie, who are the leads in those areas.

So our thermal-hydraulics and computational fluid dynamic staff are involved quite a lot with confirmatory analysis, including support to NRR to develop trace decks, input decks for evaluating reactor transients under MELLLA+ operating conditions and to perform LOCA analysis in support of the potential new 50.46 rule if the Commission supports that.

We're also significantly involved with supporting the NuScale design certification application review. And in there, to the question about do we write SERs, and RAIs, and so forth, our staff's going to be involved with writing RAIs and we'll be writing something akin to an SER called a Technical Evaluation Report that NRO staff can then include in their Safety Evaluation Reports.

You know this is beneficial. This level of engagement with the licensing offices is beneficial to our staff because they get a better appreciation for the design criteria that the staff in the licensing offices use to evaluate these reactor designs.

One of the key drivers for changes to our Thermal-Hydraulics Research Program is the yearly reductions in funding to participate in international and domestic research programs. I think we touched on this a little bit earlier. An example or for example, this year we may be faced with a decision to not fund two Nuclear Energy Agency Integral Effects Test facilities, ATWS and PKL facilities, and we're having difficulty obtaining funds for experimental programs at some of the domestic research facilities, such as at the Rod Bundle Heat Transfer facility. And as you know, all of these facilities support verification and validation of these codes in our CFD models.

Additionally, and we touched on this a little bit earlier, you know key drivers in this area for us are advanced technology fuels, or enhanced advanced technology fuels, whatever the term is today.

VICE CHAIRMAN CORRADINI: Is that the new word?

MS. WEBBER: I can't keep up with the terminology changes, quite frankly.

VICE CHAIRMAN CORRADINI: Nice to know. I didn't what ATF meant.

MS. WEBBER: Yes, advanced technology fuels, formerly known as accident-tolerant fuels.

MEMBER REMPE: They pay people to come up with the new acronyms.

MS. WEBBER: Yes. Another key driver for us, as I mentioned earlier, is heightened interest on behalf of the industry and Congress on non-light water reactor technologies. And you know there is -- I think I heard a statistic that there is 51 vendors who are interested in designing these non-light water reactor technologies. And that presents some unique challenges trying to target and focus on what are the materials issues or what are the designs that are going to be most prevalent. And so you know at some point, we have to make some determination on how to focus our precious resources.

VICE CHAIRMAN CORRADINI: So I have a question that's probably off in left field. But the DOE is investing heavily on some of this work and they have a program where they bring in the universities. It's called the Nuclear Energy Universities Program, where they're spending something like 20 percent of the budget.

Does NRC participate in any of the discussions about directions or do staff members are asked to review some of the proposals?

MS. WEBBER: I don't --

MR. WEBER: Yes.

VICE CHAIRMAN CORRADINI: Okay because I think that's a way to get into the mix in terms of what is going on and how things fit or don't fit. So I mean this is -- you kind of mentioned it when you started talking about advanced somewhere in non-LWR technologies but I do think this is a way to do it.

The other thing, too, is is that DOE's normal programs are such that I think NRC, since you don't necessarily want to pay for it but you could evaluate or at least participate in the direction of it, this would be another way in which you can get it, particularly for the advanced non-light water reactor technologies, where that seems to be the major expenditures within the DOE.

MS. WEBBER: Right.

MEMBER REMPE: Well, to even go further, there's different types of flavors of NEAPs. There's the Integrated Research Program, which are multi-year, larger efforts. And if you're participating in the selection process, that could be a way to leverage even more of your resources than the little one- or three-year ones to a single university.

VICE CHAIRMAN CORRADINI: Yes, I wanted not to use the word selection but at least in the review, to the extent that you can give your feedback as to the relevance because they have a number of criteria in terms of this and, as Joy said, with the IRPs, they are large enough they demand multi-teams which mainly times are industry people as well -- industry folks as well as university folks, and lab participants. So that's another way to --

MS. WEBBER: Great thought. Yes, great thought.

Let's see, I'm going to move on to fuels and neutronics.

So our fuels experts have been heavily involved in guiding International Fuel Performance Research Programs to support regulatory applications, including the 50.46 rulemaking and evaluations of performance of high burnup fuel under dry cask storage and transportation conditions, which is work that we do for NMSS.

Our neutronic experts have been performing analysis of the effects of high neutron fluences on structural materials outside the beltline of reactors in support of subsequent license renewal and they are developing technical bases for BWR burnup credit that could help mitigate design limitations on spent fuel storage and transportation casks.

So, additionally, one of the areas that we've been moving into over the last several months is collaborating with the Department of Energy to make TRACE and the FRAPCON, FRAPTRAN fuel codes interoperable with the DOE CASL and NEAMS codes to leverage DOE's multimillion dollar -- hundreds of millions of dollars' investment in those codes.

So we think this will provide us with greater flexibility, analytical flexibility to support future licensing actions involving advanced technology fuels and the non-light water reactor programs.

And I see a question that you have. And It will help us be more cost-effective for the NRC.

MEMBER REMPE: Tell me what you mean by interoperable. What does that mean?

MS. WEBBER: So this is an area that I am definitely not an expert but I will try my best and I do have an expert if I need to call on Chris Hoxie.

My understanding of interoperable is that, for example, our FRAPCON, FRAPTRAN codes will be inked to, for example, MOOSE code and a BISON code so that they can exchange calculations and information back and forth so that we can leverage some of the correlations in some of the DOE codes for which our codes do not have currently have the capability to address.

MR. WEBER: If I could add, you know one of the key issues that we would benefit from the committee's perspective on is to what extent do we need to develop our own codes for reactors or to what extent can we rely on other people's codes, other countries' codes, other industry codes.

And if you look at the history of what we've done in light water reactors, we spent of hundreds of millions, billions of dollars to develop the current fleet of codes that we rely on and not just we, but many other parts of the world rely on to ensure nuclear safety.

We don't have the time, nor do we have the resources to replicate that same capability, that same approach for consideration of advanced reactors.

VICE CHAIRMAN CORRADINI: But in some sense though, I'm not -- let's leave the advanced reactors off the table for a minute. What I think you are talking about, I just think about FRAPCON versus BISON, both fuels codes coupled into a reactor physics calculation or a thermal-hydraulics calculation. To the extent that you have at least participate and can demand certain levels of -- I don't want to use the word QA -- rigor, pick the word you want, so that you actually, even though you're not developing it, you at least can put it through its paces and learn how to use it appropriately. That, I think, is a benefit.

I mean just like in the past you have chosen not to do experiments just to duplicate the experiments that the vendors are doing. You essentially observe and look at the data and determine its reliability. In some case, these are just kind of big experiments or numerical experiments such that you need --

MEMBER POWERS: There's a dissenting view on that.

VICE CHAIRMAN CORRADINI: But I don't think -- I figured there would be a dissenting view. I'm just not sure you want to necessarily invest in this.

Let me give you an example that came to us with GSI, since we finished that letter. I thought staff here did an excellent job of using RELAP5-3D and looking for the simplest way to use it to help address an issue, or at least to evaluate the issue that the licensee came up with.

To me, that was not doing alternative audit calculations but essentially looking very closely as to what the applicant was doing. I thought that was a very inventive way of doing it. And instead of making it more complex, they chose to find out -- the staff members chose to find out the simplest way to do it, to make sure that they were happy with the calculations and then did side calculations by themselves.

So now, I want to the dissenting view.

MEMBER REMPE: Before you do that, getting back to the answer to your question because my understanding is BISON is being benchmarked using results from FRAPCON. So to me, what I think you're doing is you're just linking it and getting nice graphics out with FRAPCON or something.

I'd like to hear more about that when you come and talk to the people in the division and understand what's being done.

MS. WEBBER: I'd be happy to because I'm clearly not the expert in these codes.

MEMBER REMPE: Yes, we don't have to go through it here but I'm just curious on it.

MS. WEBBER: Sure, okay.

MEMBER KIRCHNER: Maybe -- could I mention I mention the CASL code?

MS. WEBBER: Uh-huh.

MEMBER KIRCHNER: Are you involved at all with that or I can't mention it?

CHAIRMAN BLEY: No, no, I was just going to say don't mention it.

MEMBER KIRCHNER: Well, the U.S. Government is investing a lot of money in that.

MEMBER REMPE: Yes.

MS. WEBBER: So we are actually engaged in meetings with Department of Energy to learn more about the CASL codes, to understand what they are, to figure out where we might be able to utilize some of the work that they've done to either enhance our own codes, or to use their capabilities.

MEMBER KIRCHNER: But we're into a problem like since RELAP was mentioned, it's not the latest and greatest edition. I forget what it is RELAP5-3D, I think.

MEMBER REMPE: Yes.

MEMBER MARCH-LEUBA: It was mentioned in error, by the way. It was mistakenly.

MEMBER KIRCHNER: Okay. Some version of RELAP, whatever, advanced is not approved by the NRC. Is that correct?

MEMBER REMPE: It was developed in Idaho and when they separated it, it became RELAP5-3D.

MEMBER MARCH-LEUBA: I'm not aware of any LTR that approves RELAP generically.

MEMBER KIRCHNER: Generically.

MEMBER REMPE: We're going to run out of time, guys. So why don't we let --

(Simultaneous speaking.)

MEMBER KIRCHNER: Well, let me just put it on the table for when we meet going down the road.

MEMBER REMPE: For later on, yes. And by the way, Walt will be leading the interactions with this area.

MS. WEBBER: Okay, great.

MEMBER KIRCHNER: I'm concerned about QA and your use of these codes.

MS. WEBBER: Okay, sure. I think we are, too. But sure, we'll talk some more about that.

In terms of critical skills, I think I mentioned you know we feel like we have the right number of nuclear mechanical engineers to perform thermal-hydraulics and computational fluid dynamics analysis but in the fuels area, that's where we see some gaps across the Agency and will likely need to hire.

In the accident progression and source term analysis, yes, so this is an area where we think it's one of the strongest international experimental research programs, in terms of leveraging international resources to benefit NRC's regulatory applications. And I'll just mention a few of the key areas. And if you want more information on the details of the experiments, you know we'd be happy to provide them.

So key research topics and programs include iodine absorption, desorption experiments on paint surfaces. I'm sure Dana's probably very familiar with that one.

MEMBER POWERS: No, I've never heard of

it, myself.

MS. WEBBER: Sour term evaluation experiments --

MEMBER POWERS: Where?

MS. WEBBER: Source term evaluation experiments to include assessment of stability aerosols in site containment.

MEMBER POWERS: I've never heard of that either.

MS. WEBBER: Right. And you probably never heard of this one, too, analysis and characterization of Fukushima fuel debris and water characterization.

MEMBER POWERS: Never heard of that one, by the way.

MS. WEBBER: So NRC actually contributes a very small fraction of the total cost of these kind of research programs and, in return, obtains multiple millions of dollars' worth of data.

One small and fruitful example of this is NRC's participation in the Nuclear Energy Agency Senior Expert Group on Safety Research Opportunities Post-Fukushima, known as SAREF, where our participation costs are $50,000 for four years and we'll obtain about a million dollars in data from that kind of work.

In the consequence analysis area, as you know, the staff is working diligently on the Sequoyah SORCA Study and they're getting ready to brief you on June 6th. They're also working hard to finish the Surry uncertainty analysis and have been providing a significant amount of support to NRR on the development of the cost-benefit analysis guidance.

We're also involved in the Level 3 PRA. And that really has been a fruitful activity in terms of helping to maintain and build consequence analysis skills with our staff and also we'll apply the results to other areas like emergency protection atmospheric deposition.

And we're going to make some enhancements to the MACCS code in terms of economic and atmospheric models. And a challenge area for us here is to better market the use of this code internationally with our regulatory counterparts internationally.

In the radiation protection area, and this is my last slide -- so in this area, it says a much stronger than desirable program management or program oversight focus. We have very few requests for analytical work coming from our regulatory partners. This makes it difficult to maintain critical skills in the radiation protection and health physics area and it's compounded by the loss of health physics experts to include our own Sami Sherbini, who retired a few months ago. He was the only one who had advanced dosimetry expertise. So this is a key area for us to coordinate and collaborate with the regulatory offices.

And then as I mentioned, RAMP has been in existence about two years and its membership in the program is growing steadily. And like CAMP and CSARP, the purpose of RAMP is to develop, maintain, and distribute NRC's many radiation protection dose assessment in emergency response computer codes, both domestically and abroad.

And we're also undergoing collaborations with DOE to try to bring in new codes into RAMP so that we could offer a suite of assessment analysis tools that span the whole fuel cycle.

MR. WEBER: So, if we bring this presentation to a close and then get into your comments and questions, we continue to seek ACRS assistance in conducting the reviews, the quality of our research. That includes the scope, the approach, the necessity of that research, and how we're developing the research results to apply to support the mission of the Agency.

It would also be of benefit to the staff if the committee continues to highlight emerging technology trends that are of importance to nuclear safety and security in your ongoing reviews.

And then monitor the technical competencies of the staff and the core capabilities. I know we frequently hear feedback from the committee, especially if you see declining trends in the capabilities of the staff. And we appreciate your calling those to our attention.

So to prepare for this, we went back and reviewed the history of the ACRS reviews and we pulled this first review, which I am not sure is as well-known as some of the other ones. But as you may recall, back in 1977, the Atomic Energy Act was revised to specifically require the committee to do reviews.

The legislation passed on December -- or was signed by the President on December 13th and the committee provided its first review to the Congress by December 30th. So I thought that was a remarkable accomplishment in rapid sequence.

The committee established six what were then called working groups to review the program. The working groups, not unlike what's been considered, aligned around the organizational structure of the Office of Nuclear Regulatory Research. You see those groups depicted here. So there were six of those to support this review. I just about the rapidity with which the committee formulated its recommendations back to the Congress but in truth, the House had passed the legislation in May. So the committee used the time between June and December to conduct its work, in fact conducted 26 days' worth of meetings on that research review.

By the following year, the committee had set up 11 subcommittees, which were focused on the 11 principle components of the Nuclear Safety Research Program. And, again, submitted its research recommendations to the Congress by December.

And then, ultimately, this activity was sunset at some point by subsequent congressional legislation. But I thought it was telling with how the committee conducted its review activities back then. That was in NUREG-0392.

MEMBER BALLINGER: I don't see Dana's name up there.

MR. WEBER: This is not the committee. This is the Office of Research at the time.

MEMBER POWERS: I've got to admit that I got to appear as a supplicant before the ACRS three times in the period from May to December.

CHAIRMAN BLEY: It's only ten times what it is now.

PARTICIPANT: Yes, was that when it was 50 percent of the total budget?

MR. WEBER: Yes, that was, I think, on the order of $140 million and that work was managed by on the order of 70 people; 62 of whom were professional staff and the others were system administrators, program support. So interesting changes that have ensued. And yet when you read this first report, many of the issues that we're still working on remain relevant and important to the country in terms of nuclear safety and security. And of course, at that time, the program included safeguards, research, and other aspects, environmental research.

So with that, we're happy to answer --

MS. WEBBER: Can I just add one plug? I don't know if any of you have seen this NUREG. This is NUREG-1925 called Research Activities FY2015 to FY2017. It is a very good reference. I'm a new person to Office of Research and it's a very good reference that talks about our research program. So

I just wanted to note that for those of you who have not seen it before, 1925. I'll give you this copy if you want it and we can get you other copies.

MR. WEBER: NUREG-1925, Volume 3 and you note the end date on that is 2017. So, we're already working on the next installment of that publication.

What we attempted to do here is write it a high level in plainer language so that some of our stakeholders would at least understand what we're embarked on and why it's important from the safety and security perspective.

MEMBER POWERS: That citation, of course, is useful but I will have to say sometimes you guys are pretty bad at selling yourselves. You do some marvelous things and act like it was just another day in the park. And whereas I have to admire your modesty, you might think about advertising yourself just a little more.

MEMBER CHU: You said you leverage your research with like DOE, EPRI and all this. I'm actually thinking of a longer time horizon. You know the work is getting more and more dangerous and the threats are becoming more and more sophisticated. I've been wondering if you leverage your work with DHS. You do.

MR. WEBER: We have no ongoing cooperation with DHS, other than through interagency functions. We do participate on a variety of those that are coordinated through the Office of Science of Technology Policy. So but beyond that, I would say today most of the work that you and I might look at and say well, that's research, it's actually being done in the Office of Nuclear Security and Instant Response.

When the 9/11 attacks occurred, our office largely had very little expertise remaining that could support security and safeguards work. And so we've continued to build up those capabilities and, of course, we did a lot on aircraft impact analysis after the 9/11 attacks. But it is an area that we're discussing with the Office of Nuclear Security and Instant Response to get the research into Research and also to then build on that, leveraging the other organizations like DHS and other parts of the Federal Government.

MEMBER CHU: I want to make sure the right organization is doing the right stuff you know so it's not bureaucratically separated and actually there are gaps. Okay, thank you.

CHAIRMAN BLEY: I want to follow-up on

what Dana said. And I'll give a plug. I see Mark Henry Salley in the back. Out of the whole organization, he's done a lot with publishing in small easy to read form what's going on in the fire area that's very useful and I think that some of that in the other areas would go a long way to letting people know more about what goes on.

MEMBER KIRCHNER: I wanted to ask a question, not well formulated I think. I'm going over the history you shared that more and more of your research is being done internally versus contracted. Fine but by its very nature, it probably becomes more and more, I don't want to say theoretical, but paper-bound, more -- less experimental, more code-heavy oriented, understandably.

How do you -- do you see challenges in maintaining your core competency as a practitioning organization because of not just the budget constraints but the changes that you're facing?

CHAIRMAN BLEY: Can I add on to Walt's before you answer? I don't know if you do this but when you do have these cooperative efforts and you find things like out at NIST and at other labs do your people get out and participate in that kind of -- I think that's what you were after in those real experiments hands-on things?

MEMBER KIRCHNER: With travel budgets and --

CHAIRMAN BLEY: Yes, to do it.

MR. WEBER: Well, I appreciate the question. It is an area that we do focus on quite a bit because you're right, if we don't get out and do those things, then we do tend to do more of the code work and analytical work in-house and less and less experimental work.

MEMBER KIRCHNER: You don't believe your codes after a while. I was a code developer.

MR. WEBER: I started at the Agency as a code user doing performance assessment way back. So, I know the value of validating and verifying codes.

So you mentioned Mark Salley. Mark's staff have access to NIST and, in fact, go out and do hands-on research on fire safety at NIST. The recent work we were talking about with the alkali-silica reaction, Jake Phillip, our principle investigator, was out at NIST participating in the design of the experiment, the pour of the concrete, the establishment of the instrumentation. So, to the extent we can, we do try to leverage those capabilities.

There are certain areas where we just can't replicate the capabilities of organizations like the National Laboratories. For example, if you have alpha-contaminated material, you're going to need hot cells. It would be prohibitively expensive for the NRC to maintain our own capabilities.

And that's what Kim was mentioning with Rod Bundle Heat Transfer facility and other unique facilities, not just here in the United States but also abroad. So, we've conducted experiments abroad as part of these cooperative activities and we've sent our researchers so they could be there as part of the team, doing the actual hands-on --

VICE CHAIRMAN CORRADINI: I was going to say the Kathy (phonetic) test that Peter Yarsky just went with --

MR. WEBER: Correct.

VICE CHAIRMAN CORRADINI: -- I can't remember, Tarek?

MS. WEBBER: Tarek Zaki.

VICE CHAIRMAN CORRADINI: Yes.

MR. WEBER: Right.

MEMBER POWERS: It's a firm lesson learned from a long history of being involved in foreign research. When you just give them the money and tell them to go off, you get nothing back. When you're actually involved in the planning and conduct of the experiment, then you oftentimes get a lot back.

MS. WEBBER: Yes.

MR. WEBER: If I could just build on that, that's been our experience and it's key to maintaining the core capabilities. If we don't do the research, we would not be able to maintain those capabilities and that would not be what we've been asked by the Commission to do.

MEMBER REMPE: So with that, there aren't any more -- Pete, it looks like you really want to say something.

MEMBER RICCARDELLA: Well, I just wanted to maybe seek some input. Joy mentioned in the beginning that we're considering revising the nature of our report and the way we go about doing our biennial review and I just wanted to -- what would you like to see in that report? What do you think would be the most productive way for us to --

MR. WEBER: The high quality advice we continue to get from the ACRS on the adequacy of our research program.

I don't think we're particular with how we get it. What matters more is that we get it. And you all are experts. That's why you're on the ACRS. You've got a diversity of experience. We would ask you to harness in providing feedback to us.

We're not in the business of just looking for positive feedback. Now, hopefully, we will get positive feedback. But if, at times, your view as a body is no, you need the tough love. You need the feedback because we're going off in the wrong direction. That's what we need to hear from the ACRS.

MEMBER REMPE: Well, I hope, as we go forward, that you will continue to help us focus our attention where it needs to be focused but, as you can tell, we also have our own ideas we want to pound on.

Anyway, I want to thank each of you for coming and giving these presentations and I want to thank my colleagues for their active participation in this meeting. And I don't think we need to have public comments in an information briefing, or do we, Mr. Chairman?

CHAIRMAN BLEY: Yes, I think we probably ought to ask if there are any.

MEMBER REMPE: Okay, is there anyone in the audience? It looks like it's maybe staff but is there anyone who has a desire to make a comment at this time?

And I'm not sure if the phone lines are open.

CHAIRMAN BLEY: I believe there's a phone line. There should be a phone line.

MEMBER REMPE: Okay, so we'll get the phone line open. But sure, go ahead. You need to state your name, by the way.

MR. SCOTT: This is Harold Scott, Research. Could I mention the document number about the capabilities you asked about, the 29 and 39 capabilities that SECY-97-075, S-E-C-Y dash 9-7 dash 0-7-5, you can probably look it up. Does that sound right, Mike?

MR. WEBER: That's right.

MEMBER REMPE: Okay, anyone else in the audience?

Is the phone line open?

CHAIRMAN BLEY: There's no comments.

MEMBER REMPE: Thank you. Is there anyone out there who wants to make a comment at this time?

And with that, I'll turn it back over to you, Mr. Chairman.

CHAIRMAN BLEY: Thank you very much.

MEMBER POWERS: I just have to inject. You need to make me Nathan and Sue work harder.

(Laughter.)

CHAIRMAN BLEY: We're recessed until 3:45.

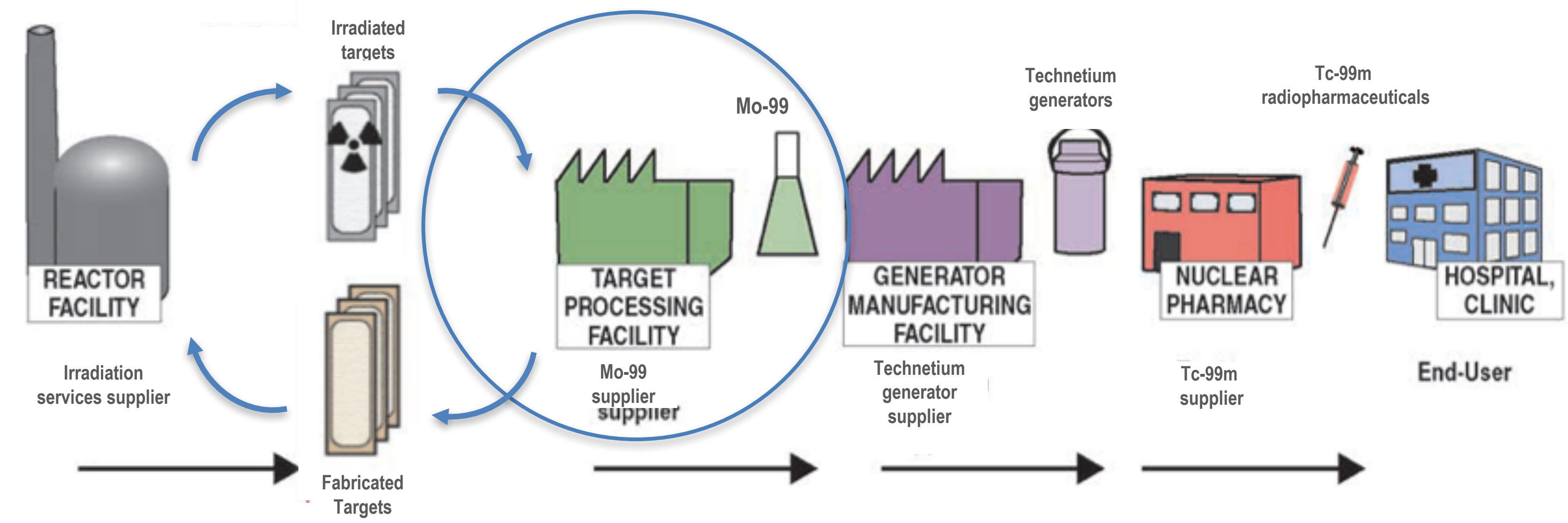
(Whereupon, the above-entitled matter went off the record.)

Northwest Medical Isotopes, LLC
Overview

Advisory Reactor Safeguards Committee (Full)
Public Meeting

May 5, 2017

Business Model



- Captive Network of University Research Reactors
  - Reliability/assurance of supply
  - Multiple shipments/week
- Radioisotope Production Facility (RPF)
  - Fabrication of LEU targets
  - Mo-99 production
  - Uranium recycle and recovery
- Domestic Mo-99 Generator Distributors
  - Hold FDA Drug Master File
  - No changes to generators
  - No changes to supply chain

OSU Oregon State University

MISSOURI

Lantheus Medical Imaging

CURIUM LIFE FORWARD

GE Healthcare

NWMI Team

Commercial Irradiation Services University Reactors

MURR® Matters...

OSU Oregon State University

Radioisotope Production Facility

Engineering Design

ATKINS

AEM Consulting

MERRICK® & COMPANY

Nuclear Criticality, Shielding, and Safety Analysis

ATKINS

Preconstruction/Construction

McCARTHY®

Environmental Assessments and Permitting

PORTAGE

Technology Demonstration

MURR® Matters...

Narodowe Centrum Badań Jądrowych
National Centre for Nuclear Research
Świerk

OSU Oregon State University

Oak Ridge National Laboratory

MCL Inc
Materials and Chemistry Laboratory, Inc.
"Linking Technology to Solutions"

University Reactor Network and NWMI Location

Third reactor selection complete; not yet socialized

Facility Siting – Discovery Ridge Research Park

- University system-owned 550-acre research park
- NWMI "anchor" for radioisotope ecosystem; two existing companies
- RPF would be located in Lot 15 of the Discover Ridge Phase II section (54.9 acres)
- Lot 15 is 7.4 acres and contains no existing structures

Source: MU, 2011, "Phasing Overview," Maps and Roads, Research Parks & Incubators, Discovery Ridge, www.umsystem.edu/umrpi/discoveryridge/maps, University of Missouri, Columbia, Missouri, accessed July 2013.

Facility Site Layout – Lot 15

NRC Licensing Strategy

- Submit one (1) application that meets all applicable regulations for construction/operation for RPF

10 CFR 50 Activities

- Irradiated target receipt
- Irradiated target disassembly
- Target dissolution
- Mo-99 separations, purification, and packaging
- Uranium (U) recycle and recovery
- Waste management
- Associated laboratory and support

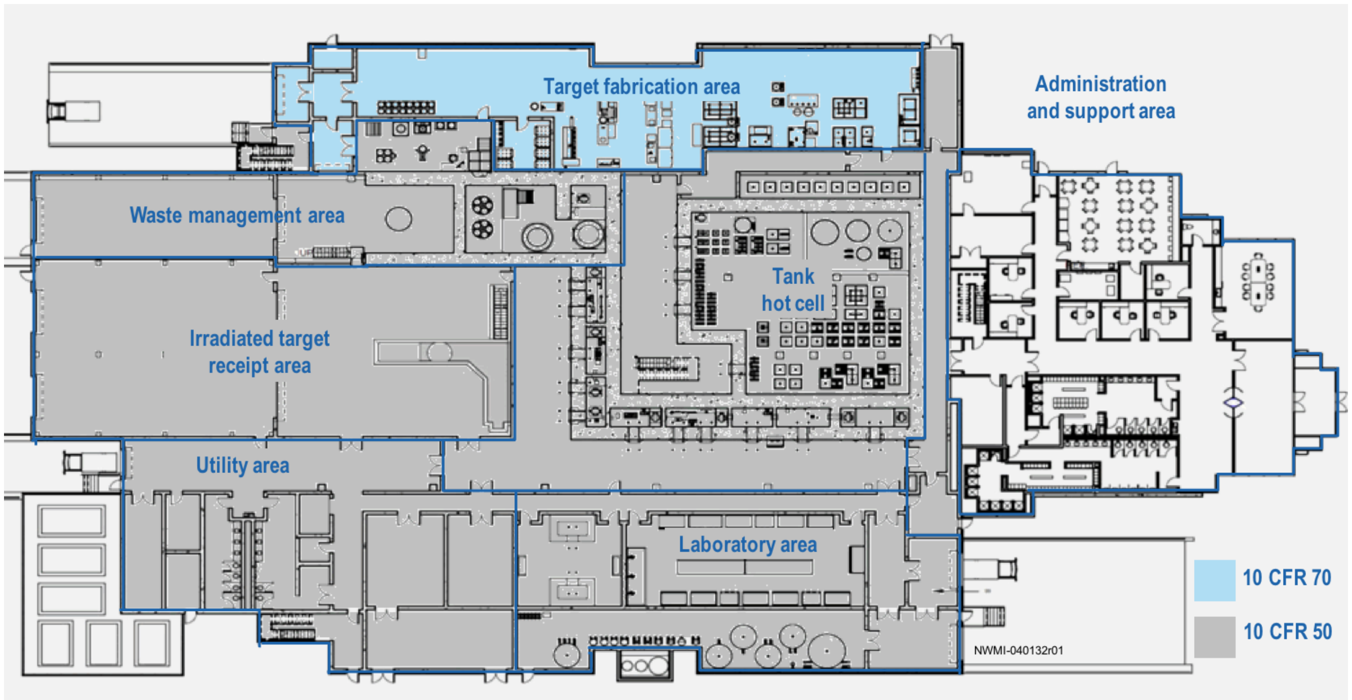
10 CFR 70 Activities

- Receipt of LEU (from DOE)
- Production of LEU target material
- Target fabrication and testing
- Shipping/loading of fabricated targets
- Laboratory and support areas

10 CFR 30 Activities

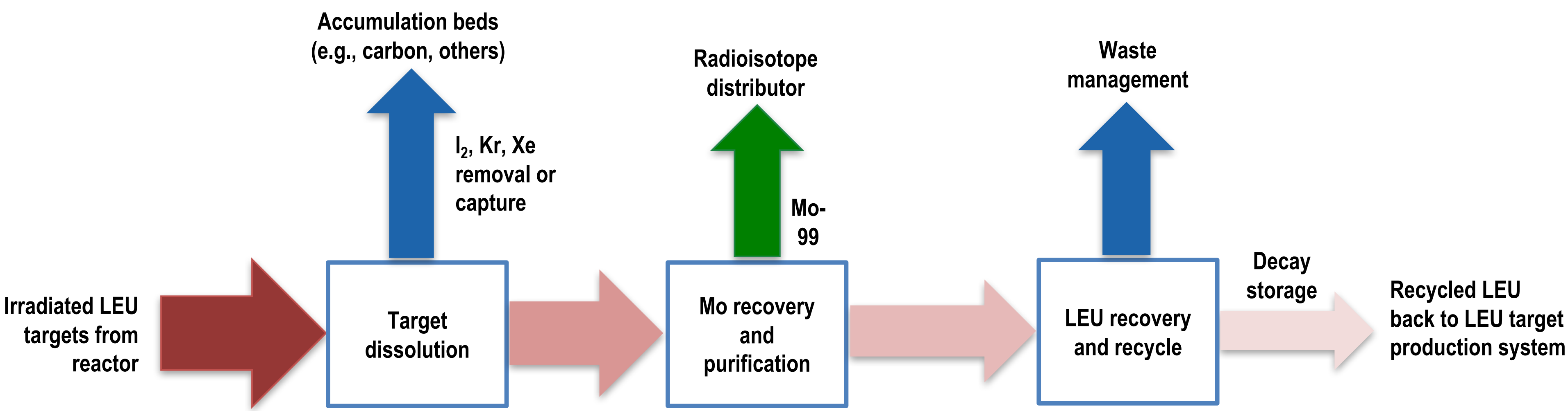
- Handling of byproduct material

- University reactor(s) and cask licensee(s) will amend their current operating licenses

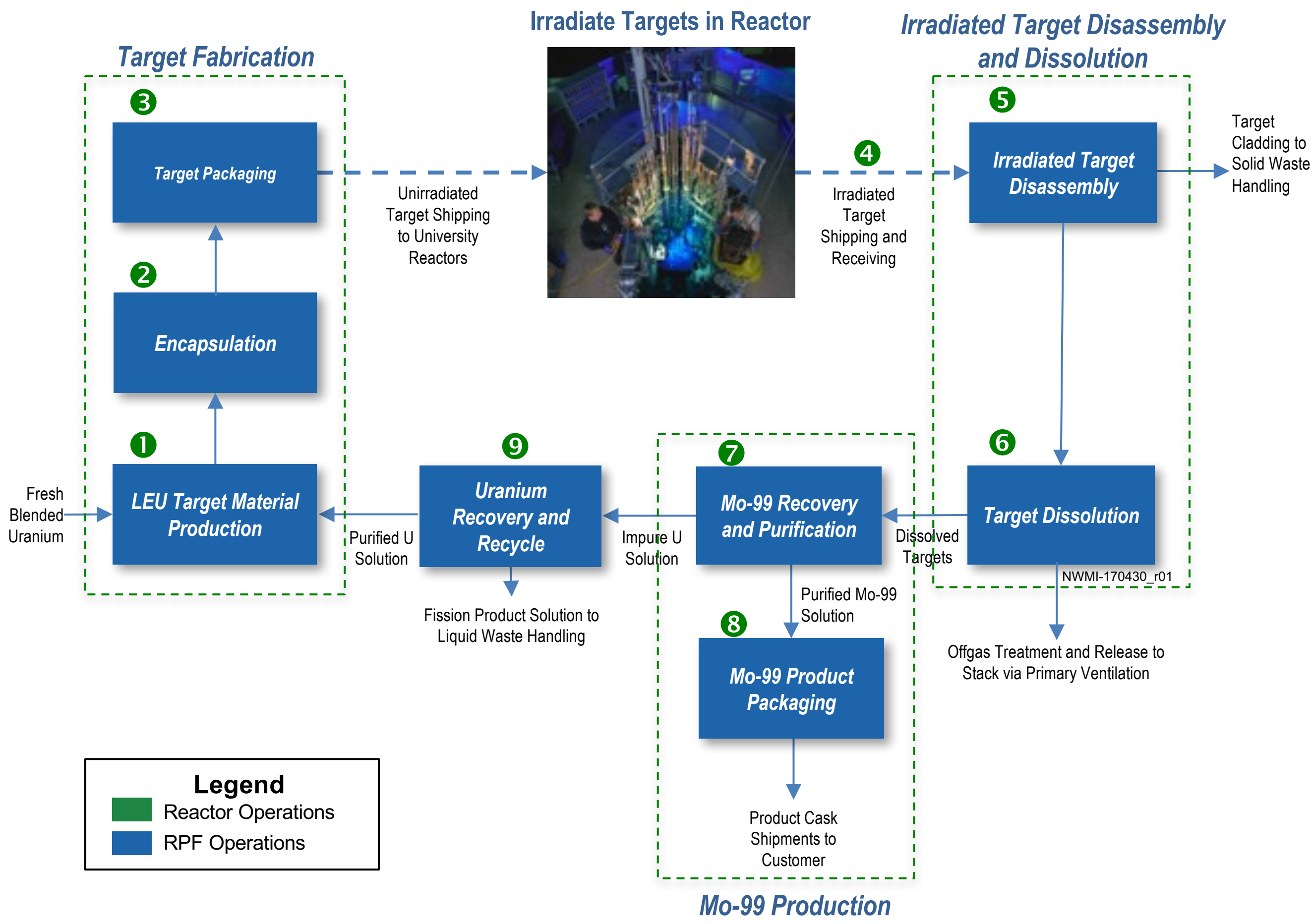


Primary Assumptions

- Single radioisotope production facility → RPF
  - RPF includes target fabrication, Mo-99 production, and uranium recycle and recovery
    - Simple/straightforward chemistry processes
  - Mo-99 produced using a fission-based method – "Gold Standard" using LEU
  - Nominal capacity 3,500 6-day Ci; surge capacity of 1,500 6-day Ci
- Use network of university reactors
  - Use same target design for all reactors
  - Intellectual Property obtained
    - U.S., Australia, Russia, South Africa, Korea → Allowed
    - India, Europe, China → Pending
- Fission product releases will comply with environmental release criteria
- Generate Class A, B, and C wastes; no greater than Class C (GTCC) waste



RPF Process Flow Diagram



❶ LEU target material is fabricated (both fresh LEU and recycled U)

❷ LEU target material encapsulated using metal cladding → LEU target

❸ LEU targets are packaged and shipped to university reactors for irradiation

❹ After irradiation, targets are shipped back to RPF

❺ Irradiated LEU targets disassembled

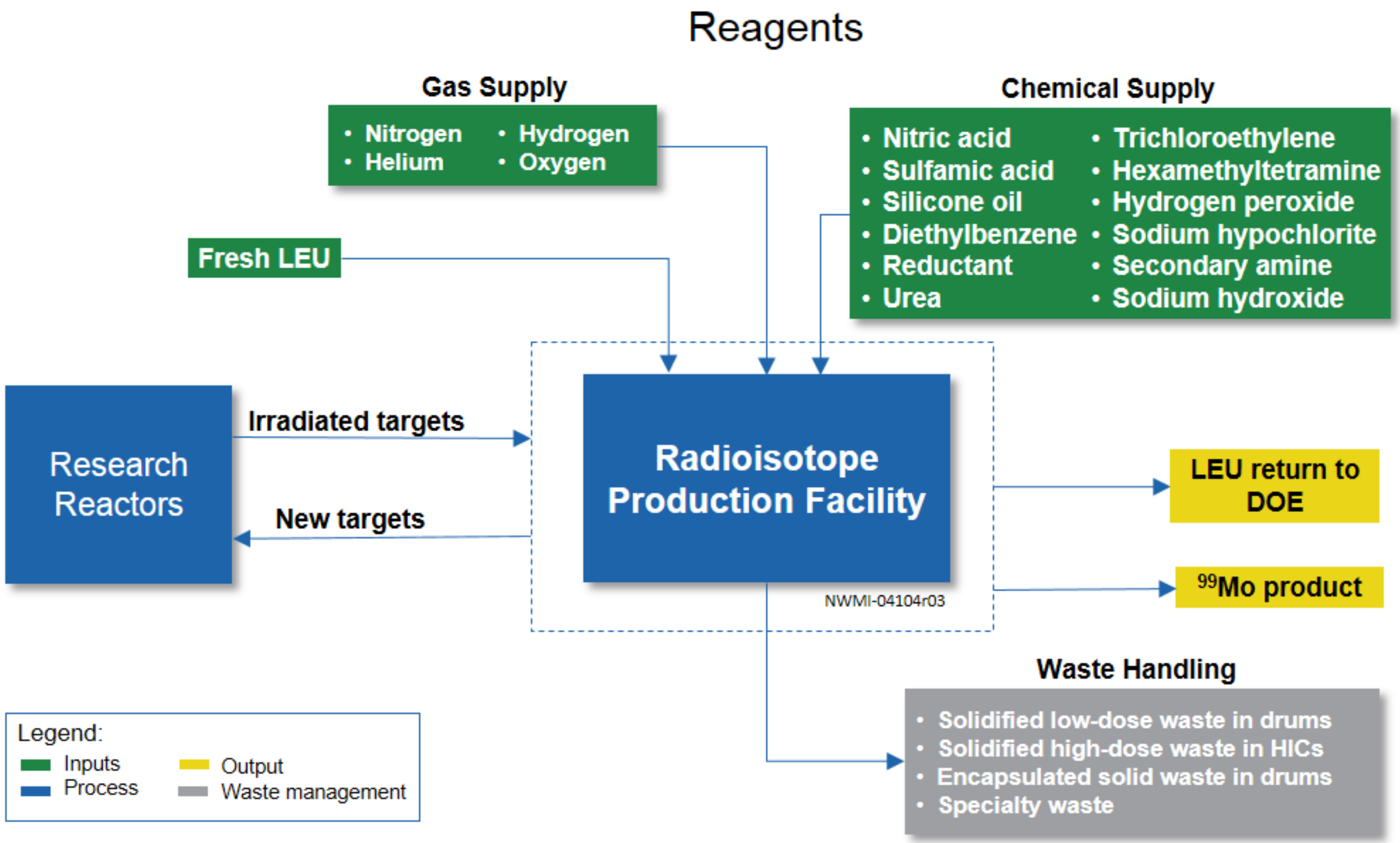
❻ Irradiated LEU targets dissolved into a solution for processing

❼ Dissolved LEU solution is processed to recover and purify Mo-99

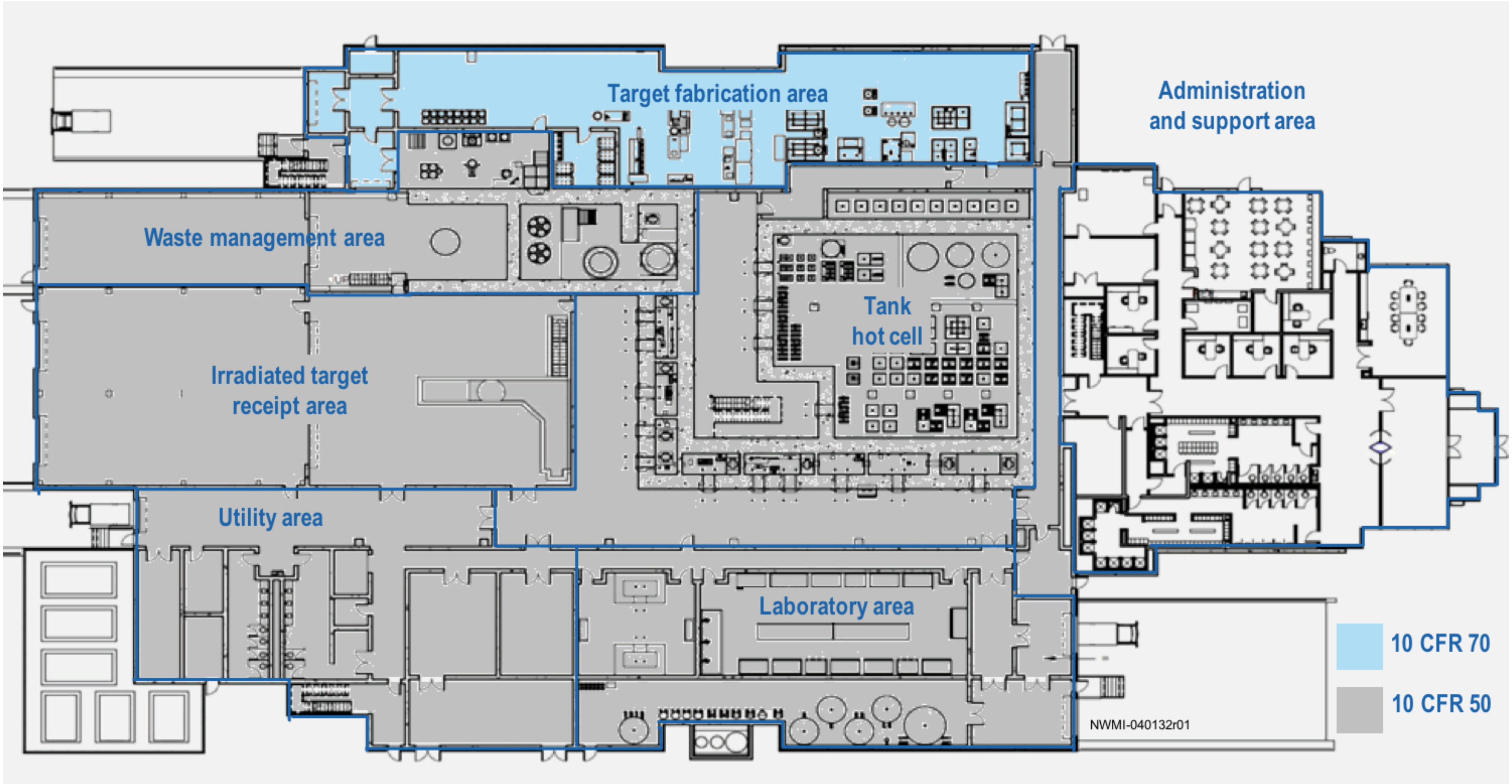
❽ Purified Mo-99 is packaged/shipped to a radiopharmaceutical distributor

❾ LEU solution is treated to recover U and is recycled back to Step 1

Reagent, Product, and Waste Summary Flow Diagram



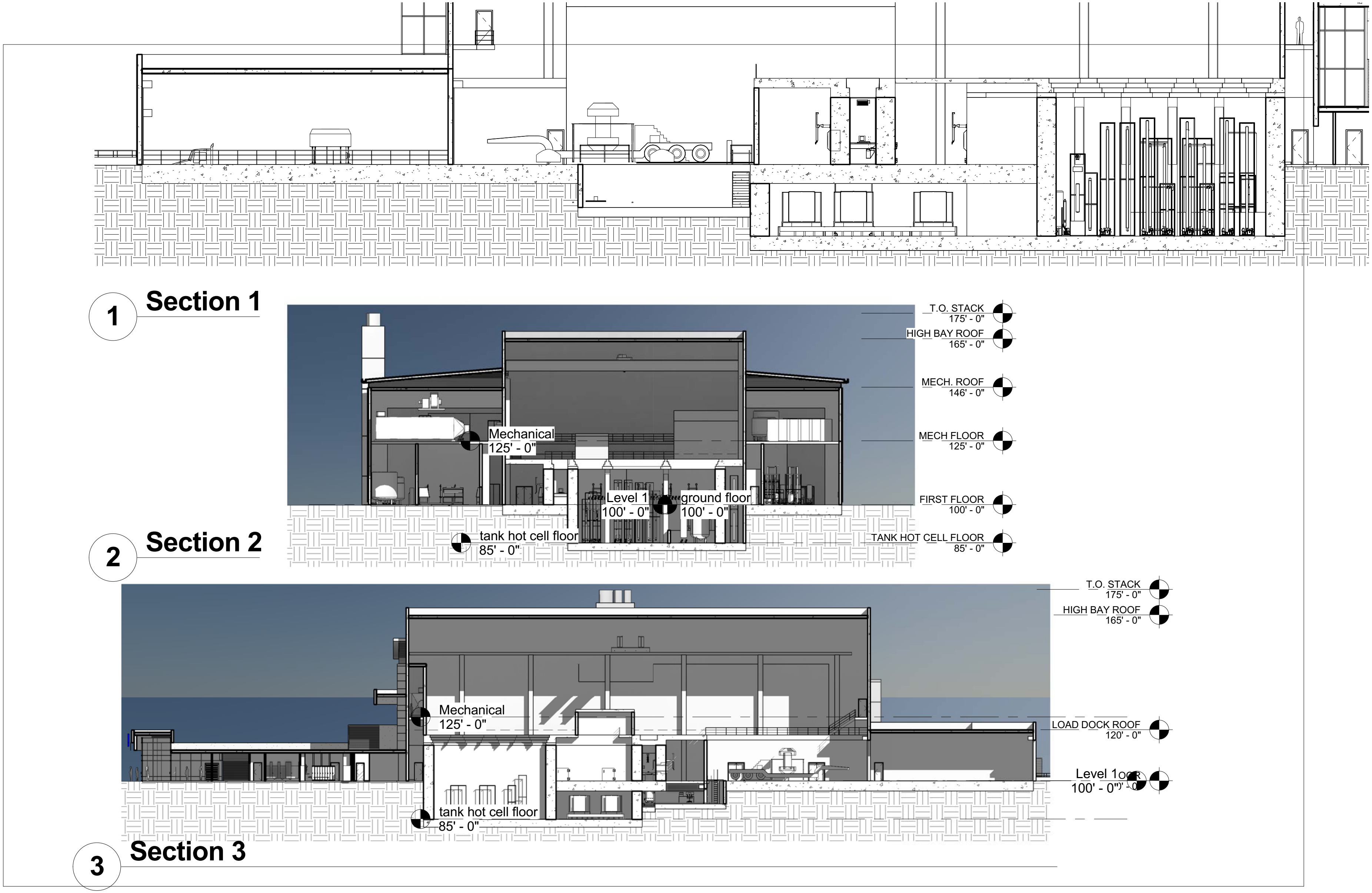
Radioisotope Production Facility Layout



Facility Description

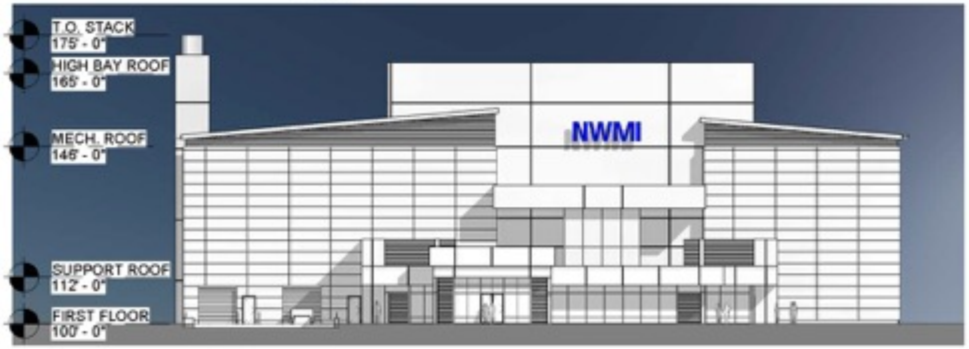
- RPF size → ~350 ft x 185 ft
- First and second level footprint ~46,000 ft^2
  - First level → Target fabrication, hot cell processing, waste management, laboratory, utilities, and ops administration
  - Second level → (utility, ventilation, offgas equipment)
- Basement ~5,800 ft^2 (tank hot cell, waste management decay area)
- Administration Building (outside of secured RPF area) ~10,000 ft^2
- Building height – 65 ft
- Top of exhaust stack – 75 ft
- Mechanical area, second floor – 46 ft
- Loading dock (back) roof – 20 ft
- Support and admin (front) roof – 12 ft
- Depth below-grade – 15 ft

Facility Cross-Sections



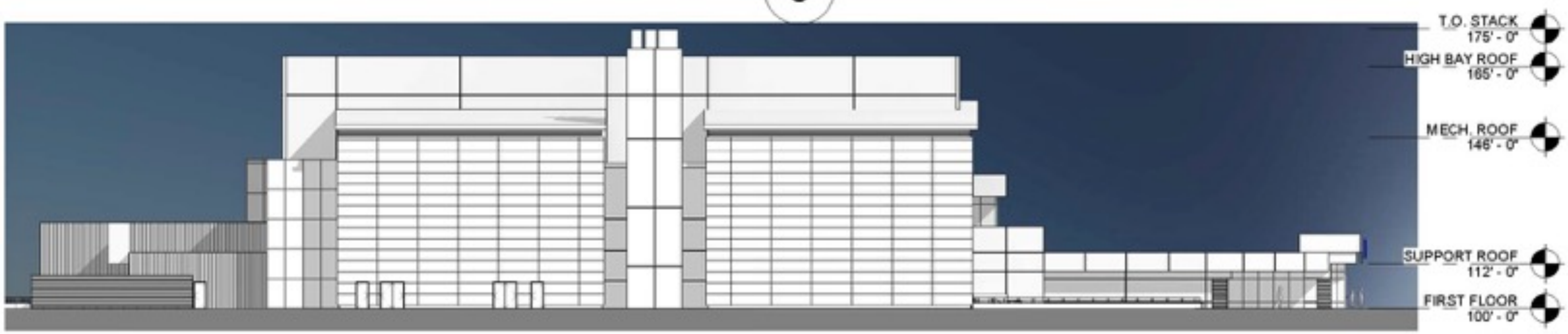
Facility Cross-Sections

1 East Elevation



2 South Elevation

3 North Elevation



4 West Elevation

Target Fabrication Summary – Steps ❶, ❷, and ❸

- LEU Target Material Production (Step ❶) (internal gelation process)
  1. Recycled uranyl nitrate is mixed with uranyl nitrate produced by dissolution of fresh U metal and is converted to ADUN using a solvent extraction process (selectively removes nitrate ions from the solution)
  2. Resulting ADUN is evaporated to achieve desired uranium concentration and chilled before mixing with urea and HMTA to form a gelation broth
  3. Broth is then injected into a column of heated silicone oil
  4. LEU target material is filtered out from silicon oil (at column base) and washed with a solvent, ammonium hydroxide, and water
  5. LEU target material is then reduced in a stream of dilute hydrogen within a furnace at a high temperature
  6. Finally, LEU target material is sampled and analyzed to ensure that it meets all quality requirements

Acronyms
ADUN – acid-deficient uranyl nitrate
HMTA – hydroxymethyltetramine

Target Fabrication Summary – Steps ❶, ❷, and ❸ (cont.)

- Encapsulation (Step ❷)
  1. Target hardware is prefabricated and cleaned before entering RPF
  2. Targets are filled with LEU target materials and helium cover gas
  3. Once targets have been loaded and welded, they undergo inspection and quality assurance (QA) checks, including leak testing
  4. Targets that pass QA checks are shipped to University reactors for irradiation
  5. Targets that fail QA checks are disassembled and LEU target material is recycled, and hardware is cleaned and disposed of as nonradioactive scrap
- Target packaging and shipment (Step ❸)
  1. Assembled targets are loaded into shipping casks for transport to University reactors
  2. Transport will be via ground transportation

Convert fresh and recycled uranium into LEU target material and then load into target hardware for shipping to university reactors for irradiation

Requires no shielding; all equipment is contact-handled

Target Receipt, Disassembly, and Dissolution – Steps ❹, ❺, and ❻

- Target receipt and disassembly (Steps ❹ and ❺)
  1. Irradiated targets are received in shielded shipping casks
  2. Irradiated LEU targets are moved into hot cell via a below-grade tunnel to hot cell access point that mates up with either shipping cask or a transfer cask
  3. Targets are disassembled by puncturing target, collecting any fission product gases, opening target, and transferring irradiated LEU target material into a transfer container

  Spent target hardware is inspected and disposed of as solid waste

- Target dissolution (Step ❻)
  1. Irradiated LEU target material is transferred into a dissolver and dissolved in hot nitric acid → operated in a "batch" fashion
  2. Dissolver solution is diluted, cooled, filtered, and pumped to Mo-99 system feed tank
  3. Offgas will go through a series of cleanup columns
     - Nitrogen oxides (NO_x) is removed by a reflux condenser and several NO_x absorbers
     - Fission product gases (noble and iodine) are captured on absorbers
     - Remaining offgas is discharged into process ventilation header

NWMI NORTHWEST MEDICAL ISOTOPES

Mo-99 Product Recovery and Purification System (Steps ❼ and ❽)

- Mo-99 recovery and purification (Step ❼)
  1. Dissolver solution is pumped through 1st IX column (Mo-99 recovery)
     - Mo-99 and trace components are absorbed onto IX media
     - U and most of fission products contaminants flow through column and are sent to U lag storage tanks
  2. Mo-99 is eluted from first column and purified in 2nd and 3rd IX column
     - Product purification process primarily consists of a series of chemical adjustments and IX columns to remove unwanted isotopes from Mo-99 product solution
     - Remaining waste solutions will be sampled and sent to low- or high-dose waste storage tanks
- Mo-99 product packaging and shipping (Step ❽)
  1. Product solution is sampled to verify compliance with radiopharmaceutical acceptance criteria
  2. Product solution is put in clean vials and then placed into shipping container liner in hot cell then transferred outside hot cell and loaded in to shipping containers
  3. Shipping containers are surveyed and manifested for transport Mo-99 product is transported via air or ground transportation depending on which radiopharmaceutical distributor is receiving shipment

Uranium Recovery and Recycle Summary (Step ⑨)

- 1st Stage U Recovery
  1. 1st stage Mo-99 IX column LEU stream is held in lag storage tanks to allow decay of select radionuclides
  2. Decayed U solution is diluted and pumped through 1st stage IX columns to separate bulk fission product contaminants
  3. U is eluted from IX columns, and concentrator/condenser is then used to concentrate eluate for 2nd stage IX U recovery

     Waste (from step 2) is sampled and sent to high-dose liquid waste accumulation tank
     Condensate is sent to low-dose liquid waste accumulation tank
- 2nd Stage U Recovery
  1. Interim U product solution is processed through a 2nd stage IX column to remove trace contaminants
  2. U is eluted from the IX columns, and a concentrator/condenser is used to control volume of recycled U product
  3. Final U product solution is sampled to confirm that it meets recycle specifications

     Waste is sampled and sent to the high-dose liquid waste accumulation tank
     Condensate is sent to low-dose liquid waste accumulation tank
- Product U lag storage → Allows for ^{237}U decay in U product solutions to contact-handled levels, then returned to target fabrication system

Waste Management System (3 Subsystems)

1. Liquid Waste System
   - Consists of storage tanks for accumulating waste liquids and adjusting waste composition
   - Split into high-dose and low-dose streams by concentration
     - High-dose fraction is further concentrated, adjusted, and mixed with adsorbent material
     - Portion of low-dose fraction is expected to be suitable for recycle to selected systems as process water
     - Water that is not recycled is adjusted and then mixed with an adsorbent material
     - Both solidified streams are held for decay and then shipped to a disposal facility
2. Solid Waste System
   - Consists of an area for collection and staging of solid wastes
   - Solids placed in waste drums and encapsulated by adding cement material to fill any voids
   - Will be held for decay and then shipped to a disposal facility
3. Specialty Waste System
   - Addresses small quantities of unique wastes generated (e.g., solvent waste, silicone oil, facility maintenance fluids, spent batteries/fluorescent lighting tubes, personal protective equipment)
   - Waste streams are containerized, stabilized, and shipped offsite for treatment and disposal
   - Goal is to reuse specialized waste to reduce waste and operational costs

Process Offgas Systems

- Dissolver offgas subsystem
  - Connected directly to process vessels associated with irradiated target dissolution process and is located in hot cell tank pit
  - Two primary features
    1. Recover NO_x from the nitric acid dissolution of irradiated targets
    2. Capture fission product gases released from irradiated targets
- Iodine potential offgas subsystem
  - Connected directly to process vessels or equipment that contain tellurium isotopes that decay and form iodine isotopes
  - Iodine capture system is included to ensure that any iodine evolving from the process is captured on treatment media
- LEU target/target fabrication offgas subsystem
  - Connected directly to process vessels and equipment that are associated with LEU material production of target fabrication process → primary process is general offgas filtration
  - Controls/design features are required to maintain reducing gas within flammability limits

All offgas systems are connected directly to process vessels and maintains a negative pressure
All subsystems merge together at process offgas filter train

Ventilation – Four Confinement Zones

- **Zone I** – Initial confinement barrier
  - Includes gloveboxes, fume hoods, open front gloveboxes, vessels, tanks, piping, hot cells and Zone I exhaust subsystem
- **Zone II** – Secondary confinement subsystem
  - Includes walls, floors, ceilings, and doors of laboratories containing gloveboxes, high-efficiency particulate air (HEPA) filter rooms, and Zone II ventilation exhaust subsystem
- **Zone III** – Tertiary confinement barrier
  - Includes walls floor, ceilings and doors of corridor that surrounds operating galleries and mechanical mezzanine
- **Zone IV** – Traditional confinement zone and is reserved for characterizing positively pressurized areas, served by unitary, non-safety, and commercial-grade equipment
  - Includes administration support area, truck bays, and maintenance utility areas

Integrated Safety Analysis Methodology

- RPF was evaluated using the integrated safety analysis (ISA) process
  - Preliminary hazards analysis (PHA)
  - Follow-on development and completion of quantitative risk assessments (QRA) to address events and hazards identified in the PHA as requiring further evaluation
- Accident sequences were evaluated qualitatively to identify likelihood and severity using event frequencies and consequence categories consistent with regulatory guidelines
- Each event with an adverse consequence (involving licensed material or its byproducts) was evaluated for risk using a risk matrix that enables user(s) to identify unacceptable intermediate- and high-consequence risks
  - Items relied on for safety (IROFS) were developed to prevent or mitigate consequences of events
  - Risks were reduced to acceptable frequencies through preventive or mitigative IROFS
- Event trees analysis was used (certain circumstances)
  - Provided quantitative failure analysis data (failure frequencies)
  - Quantitatively analyzed an event from its basic initiators to demonstrate that quantitative failure frequencies are highly unlikely under normal standard industrial conditions (i.e., no IROFS required)
- Management measures were identified to ensure that IROFS failure frequency used in analysis was preserved and IROFS are able to perform intended function when needed
- Translation of IROFS (10 CFR Part 70) to technical specifications (10 CFR Part 50) will be developed

Preliminary Hazard Analysis

- Completed PHA on eight “systems”; 107 nodes were evaluated (PHA tables ~300 pages)
- ~140 accident sequences were identified for additional evaluation; 75 accident sequences were evaluated in QRAs
- 8 QRAs were completed, covering 75 accidents; 1 QRA addressed chemical accidents

Qualitative Risk Assessment Documents
Radioisotope Production Facility Preliminary Hazards Analysis
Radioisotope Production Facility Integrated Safety Analysis Summary
Chemical Safety Process Upsets
Process Upsets Associated with Passive Engineering Controls Leading to Accidental Criticality Accident Sequences
Criticality Accident Sequences that Involve Uranium Entering a System Not Intended for Uranium Service
Criticality Accident Sequences that Involve High Uranium Content in Side Waste Stream
Facility Fires and Explosions Leading to Uncontrolled Release of Fissile Material, High- and Low-Dose Radionuclides
Radiological Accident Sequences in Confinement Boundaries (including Ventilation Systems)
Administratively Controlled Enrichment, Mass, Container Volume, and Interaction Limit Process Upsets Leading to Accidental Criticality Accident Sequences
Receipt and Shipping Events
Natural Phenomenon and Man-Made Events on Safety Features and Items Relied on for Safety

Shielding Analysis

- Source terms were calculated based on radionuclide inventory for various process streams
- SCALE v6.1.3 version of ORIGEN-S code was used to decay the stream radionuclide inventories and generate photon source spectra
- Dose rates were computed using ICRP 74 flux-to-dose conversion factors in rotational geometry
- Shielding process
  - Monte Carlo N-Particle (MCNP) model was used to evaluate process components
    - Materials, geometry, source term
    - Tallies, variance reduction
    - Calculation, post-process
    - Five process areas considered
- Shield wall design was completed
  - Deep penetration problem requiring advanced variance reduction, elaborate source description
  - Hot cell penetrations analyzed

Criticality Analysis

- "First principles" were used as bases for equipment design and process area layouts
  - Geometry constraints (e.g., pencil tank diameters)
  - Tank array spacing (conservative)
  - Transition from "safe-geometry" process equipment to less-restricted waste staging and processing equipment was considered
- Evaluations and analysis
  - MCNP code validation and upper subcritical limits for all areas of applicability
    - Defined operation/process to identify range of parameters t
    - 92 criticality safety experiments
    - Defined area of applicability (AoA)
  - Project-specific single-parameter criticality limits for U enrichment, forms, and basic geometries
- Criticality safety evaluations (CSE)
  - Normal operating conditions described
  - Criticality hazard evaluation
  - Contingency analysis
  - Double contingency controls

Criticality Safety Evaluation Documents
Irradiated Target Handling and Disassembly
Irradiated LEU Target Dissolution
Mo-99 Recovery and Purification
LEU Target Material Production
Target Fabrication Uranium Solution Processes (Wet)
Target Fabrication (Dry)
Target/Can Storage and Cart
Uranium Recovery and Recycle
Liquid Waste Processing
Solid Waste Collection, Encapsulation, and Staging
Offgas and Ventilation
Target Transport Cask and Drum Handling
Analytical Laboratory
Calculations • *Single Parameter Subcritical Limits for 20 wt% ^{235}U - Uranium Metal, Uranium Oxide, and Homogenous Water Mixtures* • *Irradiated Target LEU Material Dissolution* • *55-Gallon Drum Arrays* • *Single Parameter Subcritical Limits for 20 wt% ^{235}U - LEU Target Material* • *Target Fabrication Tanks, Wet Processes, and Storage* • *Hot Cell Tank Pit*

Transportation

- Fresh LEU and unirradiated targets
  - ES-3100 Package (Certificate of Compliance No. 9315) (NRC, 2005)
- Irradiated targets
  - BEA Research Reactor cask or similar (Certificate of Compliance No. 9341)
    - Irradiated targets will be contained in basket structures that are specifically designed for NWMI's target and provide for optimum heat rejection and criticality control
- Mo-99 product
  - Medical Isotope Depleted Uranium Shielded (MIDUS) Type B(U) container (Certificate of Compliance USA/9320/B(U)-96)
- Radioactive waste
  - High-dose radioactive waste
    - High-integrity containers (e.g., Model 10-160B cask)
  - Low-dose radioactive waste
    - Waste drums (208 L [55-gal])

Questions?

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Technology and Licensing Overview of the Northwest Medical Isotopes Radioisotope Production Facility

Office of Nuclear Reactor Regulation
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
May 5, 2017

Introductions

- **Michael Balazik** - Project Manger, Research and Test Reactors Licensing Branch, Division of Policy and Rulemaking, Office of Nuclear Reactor Regulation

- **David Tiktinsky** - Senior Project Manager, Fuel Manufacturing Branch, Division of Fuel Cycle Safety, Safeguards, and Environmental Review, Office of Nuclear Material Safety and Safeguards

- **Alexander Adams, Jr.** - Chief, Research and Test Reactors Licensing Branch, Division of Policy and Rulemaking, Office of Nuclear Reactor Regulation

Purpose

- To provide an overview of the Northwest Medical Isotopes (NWMI) construction permit (CP) application
- To provide an overview of the NWMI proposed facility activities/technologies
- To provide an overview of the licensing approach of NWMI's proposed facility

Overview of the NWMI Process

- NWMI proposes to produce ^{99}Mo from irradiating low-enriched uranium targets at existing research reactors
  - University of Missouri - Columbia (10 Megawatts)
  - Oregon State University (1.1 Megawatts)
- Proposes to fabricate targets at the radioisotope production facility (RPF) using new and recycled uranium enriched to 19.9 weight percent
- Processes, activities, and hazards similar to fuel-cycle facility

Overview of the NWMI Application

- NWMI has submitted a 10 CFR Part 50 construction permit application, for a RPF to:
  - Disassemble and dissolve uranium targets
  - Recover and purify molybdenum-99 (^{99}Mo)
  - Recover and recycle uranium
- Two-part construction permit application
  - Environmental Report docketed (May 2015)
  - Preliminary Safety Analysis Report (PSAR) docketed (Dec 2015)
- Future 10 CFR Part 70 information or application for possession and use of special nuclear material (SNM) to be submitted (safety evaluation of target fabrication to be conducted prior to facility operation)
- Proposes to construct facility in Columbia, Missouri

Overview of NWMI Activities

- Target processing - 10 CFR Part 50 (CP and OL)
  - Disassembly, dissolve, and concentrate
  - ^{99}Mo recovery and purification
  - Product packaged and shipped to radiopharmaceutical distributor
- Uranium recovery & recycle - 10 CFR Part 50 (CP and OL)
  - Separation, concentration, and purification
  - Recycle into new targets
- Waste management - 10 CFR Part 50 (CP and OL)
  - Encapsulation
  - Storage for decay
  - Waste shipments

Overview of NWMI Activities (cont.)

- Target fabrication - 10 CFR Part 70 (Future application)
  - Preparation of low enriched uranium targets for irradiation
  - Target encapsulation
  - Target transportation to research reactors
- Target irradiation -10 CFR Part 50 (License Amendment)
  - By research reactors (MURR and OSU)
- Byproduct material licensing - 10 CFR Part 30

NRC Licensing Approach

- RPF consists of several hot cell structures, which meet the 10 CFR 50.2 definition of *production facility*
- 10 CFR 50.2 defines *production facility* as:
  - Any facility designed or used for the processing of irradiated materials containing special nuclear material…
  - Based on batch size (i.e., greater than 100 grams)
- While NRC has historically licensed production facilities, no such facilities currently operating
  - Issuance of SHINE construction permit (*utilization* and *production* facilities)

NRC Licensing Approach (cont.)

- Technology involved in target fabrication activity similar to fuel-cycle technology
  - Does not meet the definition of either a *utilization* or *production facility* (10 CFR Part 50)
- Applicability of 10 CFR Part 70 to target fabrication
  - Receive title to, own, acquire, deliver, receive, possess, use, and transfer SNM
  - Scrap recovery of SNM
  - 10 CFR Part 70, Subpart H requirements apply
  - Possess greater than critical mass of SNM
  - Processes to prepare targets and associated hazards similar to fuel-cycle facilities

Regulatory Guidance and Acceptance Criteria

- NUREG-1537, “Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors”

- Interim Staff Guidance Augmenting NUREG-1537
  - Radioisotope production facilities
  - Aqueous homogeneous reactors
  - Incorporates relevant non-reactor guidance from NUREG-1520, “Standard Review Plan for the Review of a License Application for a Fuel Cycle Facility, Rev. 1”

- Other guidance (e.g., regulatory guides and ANSI/ANS standards) and engineering judgment used, as appropriate, to make construction permit findings

NUREG-1537 Review Areas

1. **The Facility/Introduction**
2. **Site Characteristics**
3. **Design of Structures, Systems, and Components**
4. **Facility Description**
5. **Coolant Systems**
6. **Engineered Safety Features**
7. **Instrumentation and Control**
8. **Electrical Power Systems**
9. **Auxiliary Systems**
10. Experimental Facilities*
11. **Radiation Protection and Waste Management**
12. **Conduct of Operations**
13. **Accident Analysis**
14. **Technical Specifications**
15. Financial Qualifications
16. Other License Considerations*
17. Decommissioning*
18. Uranium Conversions*
19. Environmental Review

*Not applicable to the NWMI construction permit application

BOLD – Chapters presented to ACRS Subcommittee

Construction Permit Requirements

- Some regulations applicable to NWMI construction permit:
  - 10 CFR 50.22, Commercial and industrial facility licenses
  - 10 CFR 50.30, Environmental Report
  - 10 CFR 50.34(a), Preliminary safety analysis report
  - 10 CFR 20.1201, Occupational dose requirements
  - 10 CFR 20.1301, Public and accident dose requirements
  - 10 CFR 50.35, Issuance of construction permits
- Note: 10 CFR 70.61, Performance Requirements
- 10 CFR Part 50, Appendices A, “General Design Criteria….,” and B, “Quality Assurance Criteria…,” are only applicable to nuclear power.
- 10 CFR Part 100, “Reactor Site Criteria,” siting and accident dose criteria are only applicable to nuclear power reactors and testing facilities.

Construction Permit Findings

- A construction permit may be issued per 10 CFR 50.35, if:
  - The applicant has described the proposed design, including the principal architectural and engineering criteria for the design and identified major features or components for the protection of the public health and safety
  - Further technical or design information that completes the safety analysis, and which can reasonably be left for later consideration, will be supplied in the FSAR
  - Safety features or components requiring research and development have been identified and the applicant will conduct a research and development program reasonably designed to resolve associated safety questions
  - There is reasonable assurance that safety questions will be resolved prior to the completion of construction and the proposed facility can be constructed without undue risk to the health and safety of the public

Construction Permit Findings (cont.)

- Issuance of a construction permit considers whether the following standards in 10 CFR 50.40 and 50.50 have been met:
  - There is reasonable assurance: (i) that construction of the facility will not endanger the health and safety of the public, and (ii) that construction activities can be conducted in compliance with the Commission's regulations
  - The applicant is technically and financially qualified to engage in the proposed activity
  - The issuance of a construction permit would not be inimical to the common defense and security or to the health and safety of the public
  - The applicable environmental requirements of subpart A of 10 CFR Part 51 have been satisfied
  - The application meets the standards and requirements of the AEA and the Commission's regulations, and that notifications, if any, to other agencies or bodies have been duly made

Construction Permit vs. Operating License

- Construction permit (10 CFR 50.35)
  - Allows licensee to proceed with construction based on preliminary design information
  - Does not approve of the safety of any design feature or specification unless specifically requested by the applicant
- Operating license (10 CFR 50.57)
  - Allows licensee to operate the facility based on final design
  - Issued when, among other things, construction of the facility is substantially completed in accordance with NRC requirements and there is reasonable assurance that the activities authorized by the license will not endanger the public health and safety

Technical Review Focus Areas

- Accident analyses as presented in PSAR and Integrated Safety Analyses Summary
- Chemical and Radiological hazards
- Prevention of Criticality

Status of Safety Evaluation Report

- Staff is nearing completion of technical review of NWMI PSAR
- All NWMI's responses to requests for information (RAI) received to this point
- NWMI plans on submitting revised PSAR incorporating all RAI responses to date
- Completion of Safety Evaluation Report by October 2017

ACRS Subcommittee Meetings

- ACRS Subcommittee scheduled meeting dates
  - June 19, 2017
  - July 11, 2017
  - August 22, 2017
  - August 23, 2017

- Presenting selected Safety Evaluation (SE) chapters that are technically linked and complete

- SE chapters for discussion on June 19:
  - Chapter 1 - The Facility/Introduction
  - Chapter 2 - Site Characteristics
  - Chapter 4 - Facility Description
  - Chapter 5 - Coolant Systems

Enhancing Research Oversight

Presentation to the Advisory Committee on Reactor Safeguards
May 5, 2017

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Overview

- Overview
  - Selecting Research Projects
  - ACRS Assistance
- Need for Research
- Defining the Scope of NRC Research
- Core Capabilities
- Planning and Budgeting Research
- Anticipating Research Needs
  - Engineering
  - Risk Analysis
  - Systems Analysis
- ACRS Assistance
- Discussion

Focus Questions

- How does NRC select research projects?
- How can ACRS best assist the NRC staff?

Need for Research

- Authorized by Congress in 1974
  – Highlighted in Conference Committee Report
  – Needed for effective performance of licensing and related regulatory functions
  – Ensured professional competence and means to evaluate data and procedures to determine adequacy of applications and operation

Need for Research

- Affirmed in 1997 by Commission in Direction Setting Issue 22
  - Conduct balanced portfolio of confirmatory and anticipatory research
  - Focus on issues of highest safety and regulatory significance
  - Maintain technical core capabilities
  - Prioritize international research and integrate into program
  - Leverage cooperation with industry research

Need for Research

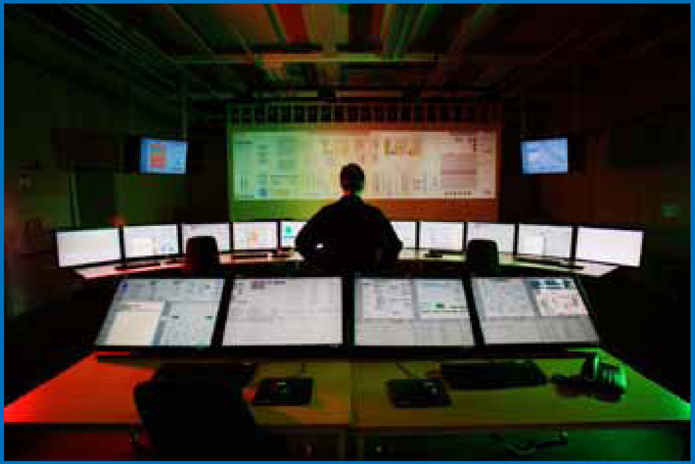
- Commission affirms the need
  - Establishing agency budget (annually)
  - Reporting and tracking research projects (October 2015)
  - Project Aim (June 2015)
    - Common Prioritization (November 2015)
    - Rebaselining (April 2016)

Defining Research Scope

- Staff Requirements Memoranda
- Research User Needs ~ 75%
- Research Assistance Requests
- Research Plans
  - Confirmatory research
  - Anticipatory research
- Core Capabilities
- Regulatory Support

Key Research Areas

- Thermal Hydraulics
- Fuel and reactor core behavior
- Severe accidents and accident consequences
- Radiation effects and environmental protection
- Risk analysis
- Human Reliability and human factors
- Fire protection and fire safety
- External events
- Materials performance and degradation
- Structural performance
- Digital instrumentation and controls and electrical systems



Core Capabilities

- Approved by the Commission in SECY 98-076, April 1998
- Considered “workload based” and “expertise driven” approaches
- 29 capabilities for NRC (96 FTE) and Contractor Support ($34M)
- Most capabilities as relevant now as back in 1998
- Challenging to forecast emerging needs

Planning and Budgeting

- Research planning and budgeting developed through NRC Planning, Budgeting, and Performance Management (PBPM) process
  - Operating Reactors (~ 80%)
  - New Reactors (~ 20%)
  - Remaining business lines
- Research Operating Plan
- Enhanced Reporting and Tracking
- Control Points

Research Budgets

- Varied throughout NRC history
- Large percentage of agency budget in early years
- Declined throughout agency history
- Spiked following key events
- Leveraged domestic and international partnerships and grants
- Supported by Commission and ACRS

Anticipating Research Needs

- Engineering – John Nakoski
- Risk Analysis – Mark Thaggard
- Systems Analysis – Kimberly Webber

Division of Engineering – Landscape

Research Areas	FY17 Estimated Contracts (K)	FY17 Estimated FTE	Contacts
Digital I&C and Electrical Engineering	$2,500	13	Ian Jung Kenn Miller
Materials Degradation, Aging, and Component Integrity	$9,500	20	Istvan Frankl Raj Iyengar
Structural, Seismic, and Geotechnical Engineering	$1,700	11	Dogan Seber
Regulatory Guides, Generic Issues, and Codes and Standards	$500	9	Tom Boyce

Digital I&C and Electrical Engineering

- Protection Against Common Cause Failure in Digital I&C Systems
- Impact of Digital I&C on Licensing Basis Changes
- Acceptance of Commercial Off-The-Shelf Digital Equipment
- Modernization of the I&C Regulatory Infrastructure
- Cyber Security
- Electrical Component Qualification
  - Cable Degradation Mechanisms

Materials Degradation, Aging, and Component Integrity

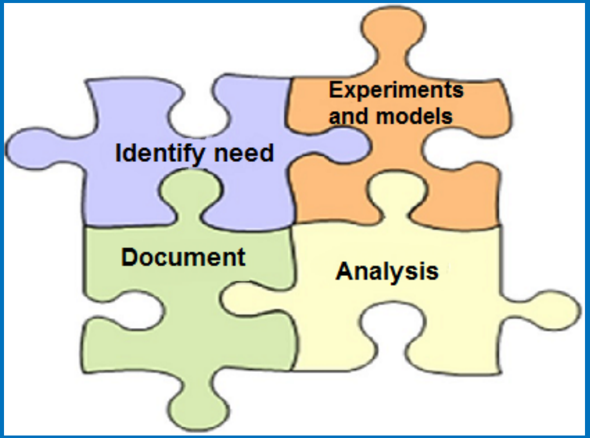
- Probabilistic Fracture Mechanics Assessment Tools
- Primary Water and Irradiation Assisted Stress Corrosion Cracking
- Reactor Pressure Vessel Embrittlement
- Steam Generator Tube Integrity
- Non-Destructive Examination (NDE) Evaluation Techniques and Tools
- Spent Fuel Storage Cask Degradation and NDE
- Neutron Absorbing Materials Degradation
- Advanced Non-Light Water Reactor Materials

Structural, Seismic, and Geotechnical Engineering

- Concrete Degradation Through Alkali-Silica Reaction
- Irradiation Related Degradation of Concrete Structures
- Aging of Pre-Stressed Concrete Structures
- Seismic Hazards, Including Source Ground Motion and Site Response
- Risk-Informed Performance-Based Seismic Safety
- Probabilistic Soil Liquefaction Analysis

Regulatory Guides, Generic Issues, and Codes and Standards

- Review and Update of Regulatory Guides
- Generic Issues
  - Debris Accumulation Assessment (GI-191)
  - Implication of Seismic Hazards Estimates (GI-199)
  - Flooding of Nuclear Power Plant Sites (GI-204)
  - High Energy Arc Faults (HEAFs) with Aluminum (Pre-GI)
- NRC Participation in Standards Development Organizations
- Feasibility Study Requests to incubate new areas of potential research



Division of Risk Assessment - Landscape

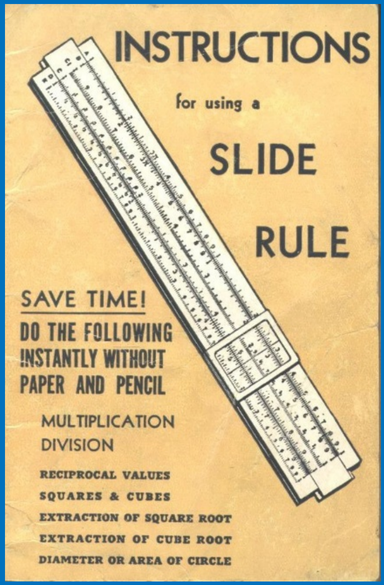
Program Area	FY17 Est. Contracts (K)	FY17 Est. (FTE)	Key Tools/Programs	Contacts
Probabilistic Risk Assessment (PRA) Methods and Tools	$5,600	23	SPAR, SAPHIRE, RASP Handbook, ASP Program	Kevin Coyne, John Nakoski, Nathan Siu
Human Factors & Human Reliability Analysis (HRA)	$1,100	10	IDHEAS, SACADA	Sean Peters
Fire Research	$1,200	8	Fire PRA guidance, National Fire Protection Assn. (NFPA)-805	Mark Henry Salley
Flooding & External Hazards	$1,500	6	Probabilistic Flood Hazard Assessment	Mark Henry Salley, Tom Nicholson

DRA – Primary Research Areas

- Development of Probabilistic Risk Assessment (PRA) methods and models
- Human Factors and Human Reliability Analysis
- Fire assessment
- Flooding assessment

Anticipated Research - PRA

- Continue updating models (SPAR/SAPHIRE)
- Greater emphasis on realism in modeling
  - Addition of all hazards, FLEX equipment, RCP seals
  - Insights from Level 3 PRA project
  - Development of new reactor design SPAR models
- Potential advanced PRA methods
  - dynamic PRA
  - use of advanced statistical methods
  - use of knowledge engineering
- Development of a precursor-based index to support agency decision making



Anticipated Research – HF/HRA

- Human factors guidance development
  - Advanced control room technologies
  - non-destructive examination techniques
  - drug and alcohol testing

- Improved HRA methods - IDHEAS (*Integrated Human Event Analysis System*)
- Use of SACADA (*Scenario Authoring Characterization & Debriefing Application*) for updating human error probabilities

Anticipated Research - Fire/Flooding

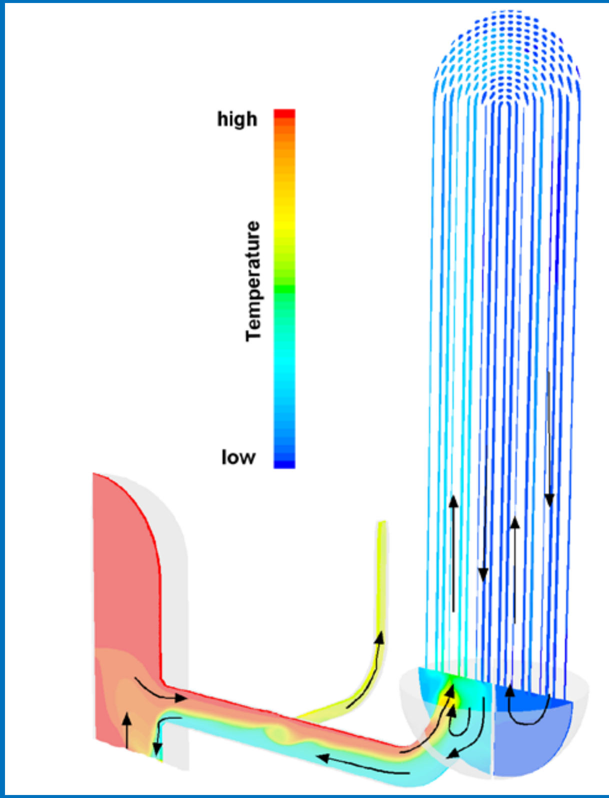
- Fire PRA
  - Continued focus on improving realism in fire PRAs
  - High Energy Arc Faults (HEAF)
    - Entered into the Generic Issues Program (GI-205)
    - OECD/NEA Testing Program
- Probabilistic Flood Hazard Assessment

Division of Safety Systems and Analysis - Landscape

Research Areas	FY17 Est. Contracts (K)	FY17 Est. FTE	Key Tools	Contacts
Thermal-Hydraulics Analysis	$2,265	15.3	TRACE, SNAP, and CFD	Chris Hoxie, Steve Bajorek, Chris Boyd, Ghani Zigh
Fuels and Neutronics Analysis	$1,729	6.8	PARCS, SCALE, FRAPCON/FRAPTRAN	Richard Lee
Accident Progression and Source Term Analysis	$1,716	6.7	MELCOR	Richard Lee, Ed Fuller
Consequence Analysis	$1,340	5.0	MACCS, WINMACCS, and SecPop	Pat Santiago
Radiation Protection Analysis	$1,477	7.8	RADTRAD, RASCAL, Gale, Pimal, Radiological Toolbox, VARSKIN, HABIT, DandD, VSP, Mildos, and RESRAD	Rebecca Tadesse

Thermal-Hydraulic and CFD Analysis

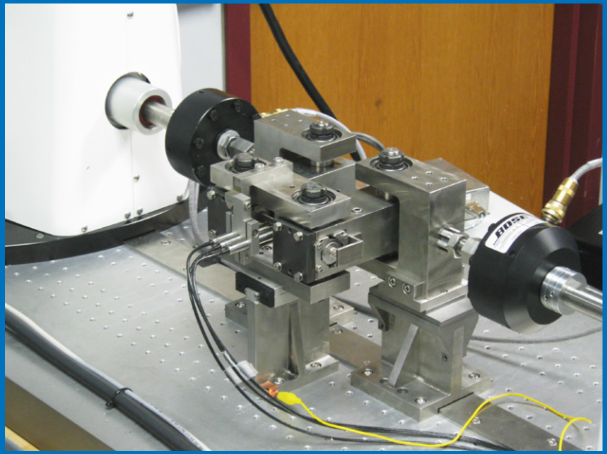
- Recent Key Items:
  - NuScale Confirmatory Calculations
  - BWR ATWS Licensing Support
  - 50.46c Preparations
  - NuScale Thermal Mixing
- Future Drivers and Issues:
  - International Leverage
  - Advanced Technology Fuels
  - Non-LWR Technologies
  - Uncertainty Methods



Hot Gases during a Postulated Severe Accident using CFD

Fuel and Neutronic Analysis

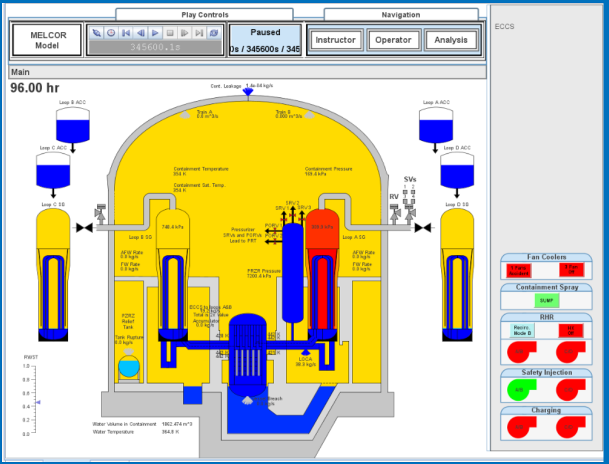
- Recent Key Items:
  - – 50.46c Rulemaking
  - – Concrete Fluence
  - – BWR Burnup Credit
- Future Drivers and Issues:
  - – Advanced Technology Fuels
  - – Non-LWR Technologies
  - – Interoperability with DOE Codes



Testing of Irradiated Materials

Accident Progression and Source Term Analysis

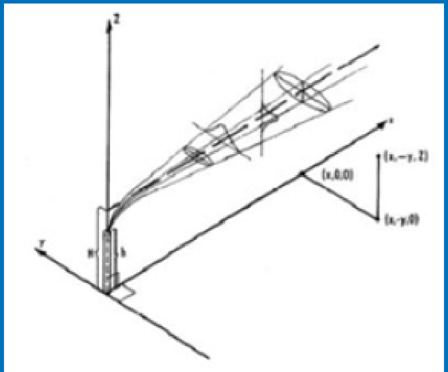
- Recent Key Items:
  - Fukushima NTTF
  - Application of Alternate Source Term (RG 1.183)
  - International Collaborations
- Future Drivers and Issues:
  - Advanced Technology Fuels
  - Non-LWR Technologies
  - MELCOR 3.0
  - Long-Term Fukushima Activity

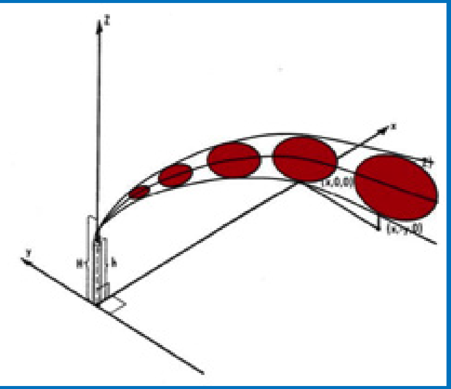


Severe Accident Progression using MELCOR and SNAP

Consequence Analysis

- Recent Key Items:
  - Sequoyah SOARCA
  - SOARCA Uncertainty Analysis
  - Regulatory Analysis Support
- Future Drivers and Issues:
  - Level 3 PRA
  - MACCS Enhancement
  - Emergency Planning Issues
  - Increased Resource Leverage





MACCS Plume and Puff Modeling

Radiation Protection Analysis

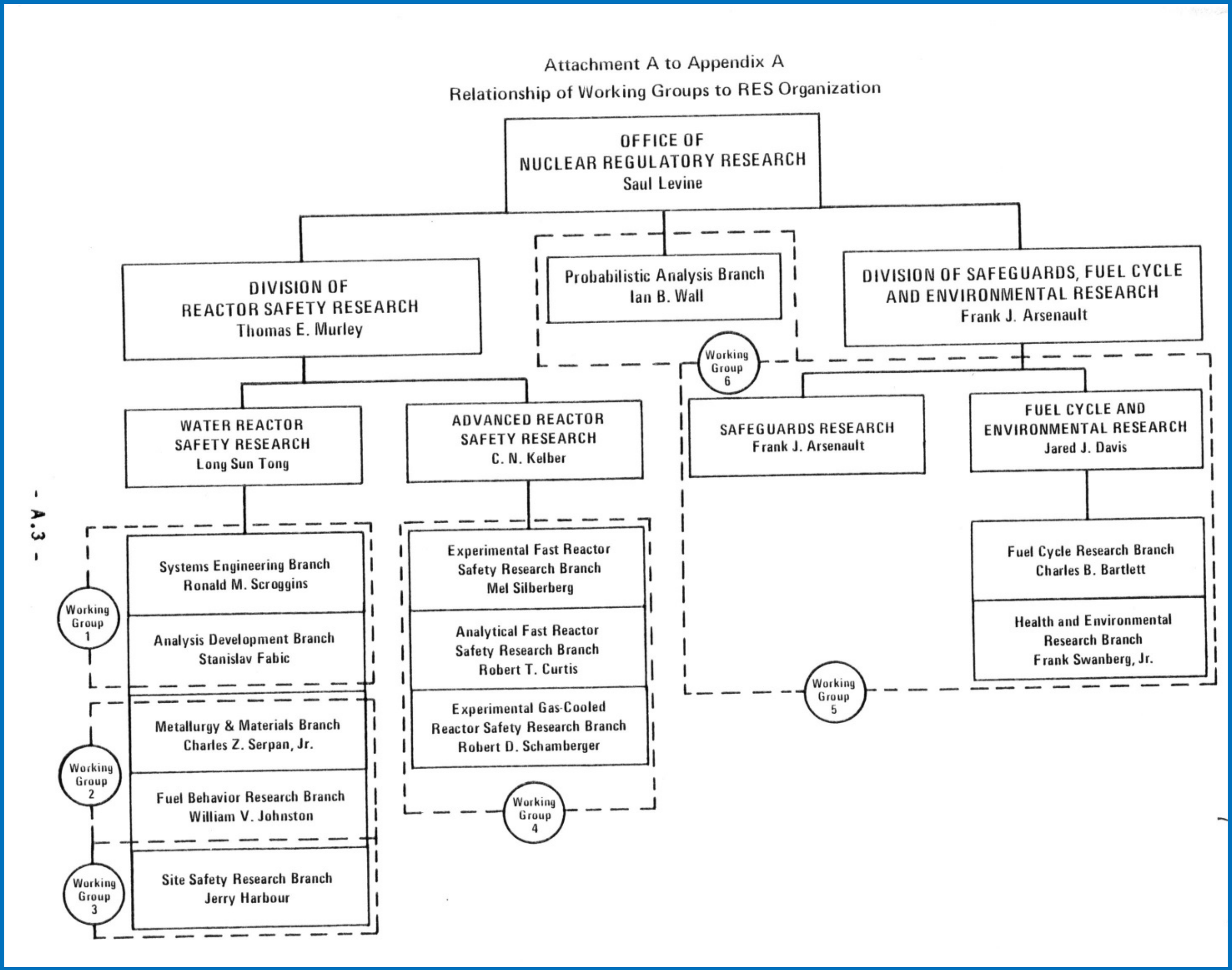
- Recent Key Items:
  - Initiation of RAMP
  - NCRP Report on Dose to the Lens of the Eye
  - Dose and Abnormal Occurrence Reporting
- Future Drivers and Issues:
  - Increasing RAMP Participation
  - Stabilizing Code Development and Maintenance
  - Stimulating Analysis Work
  - Skill Erosion
  - Non-LWR Technologies

Radiation Worker Taking Measurements

ACRS Assistance

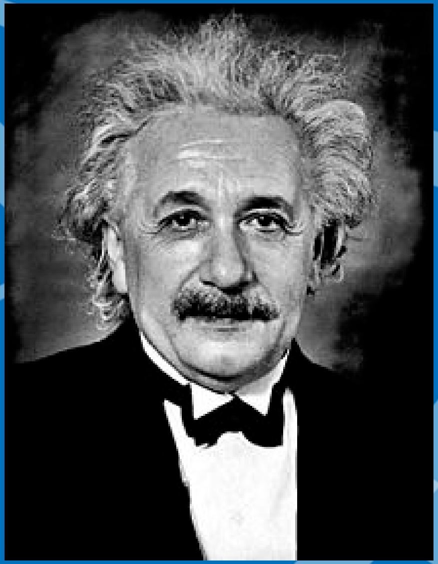
- Conduct reviews of the quality of research
- Highlight emerging technology trends of importance to nuclear safety and security
- Monitor technical competencies and core capabilities

First ACRS Research Review



Discussion

"Equations are much more important to me, because politics is for the present, while … an equation is for eternity"



Albert Einstein

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Protecting People and the Environment