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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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METALLURGY AND REACTOR FUELS SUBCOMMITTEE

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FRIDAY

FEBRUARY 23, 2018

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ROCKVILLE, MARYLAND

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The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B3, 11545 Rockville Pike, at 8:30 a.m., Matthew W. Sunseri, Chairman, presiding.

COMMITTEE MEMBERS:

MATTHEW W. SUNSERI, Chairman

RONALD G. BALLINGER, Member

DENNIS C. BLEY, Member

MICHAEL L. CORRADINI, Member*

WALTER L. KIRCHNER, Member

JOSE MARCH-LEUBA, Member

DANA A. POWERS, Member

JOY L. REMPE, Member

PETER RICCARDELLA, Member*

GORDON R. SKILLMAN, Member

DESIGNATED FEDERAL OFFICIAL:

KENT HOWARD

ALSO PRESENT:

TAE AHN, NMSS/DSFM

SHAWN ANDERSON, NRR/DSS/SNPB

MICHELLE BALES, RES/DSA

ANDREW BIELEN, RES

JON CARMACK, INL

PAUL CLIFFORD, NRR

KEVIN COYNE, NRO/DSRA

AL CSONTOS, EPRI

ELIJAH DICKSON, NRR/DRA

RICK ENNIS, NRR/DORL

HOSSEIN ESMAILI, RES/FSCB

MIRELA GAVRILAS, NRR/DSS

JOE GILLESPIE, OGC/OR

MICHELLE GONZALEZ, RES

JIM HAMMELMAN, NMSS

DON HELTON, RES/DRA

MATTHEW HISER, RES/DE

BEN HOLTZMAN, NEI

NATHANAEL HUDSON, RES/CRAB

ANDREA KEIM, NRO/DCIP/QVIB-2

ROBERT KISEK, OCM/JMB

M.J. ROSS LEE, NRR/DLP

MIKE MARKLEY, NRR/DORC/LPL2-1

ANDREW MAUER, NEI

WILLIAM MCCAUGHEY, U.S. DOE

CHRIS MURRAY, RES

TONY NAZARIO, NRC

JOHN PARILLO, NRR/DRA

GARY PETERS, Framatome

ANDREW PROFFITT, NRR/DLP/DLPB

MERES RAHIMI, NMSS/DSFM

BRIAN SMITH, NMSS

JOSEPH STAUDENMEIER, RES/DSA

NAN VALLIERE, OCM/COMMSB

JENNIFER WHITMAN, NRR/DSS/SRXB

JOSH WHITMAN, NRR/DSS/SNDB

*Present via telephone

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P R O C E E D I N G S

8:32 a.m.

CHAIRMAN SUNSERI: Good morning. We now call this meeting to order. My name is Matthew Sunseri, Chairman of Metallurgy and Reactor Fuel Subcommittee on Accident Tolerant Fuel. This morning, the Subcommittee will review the draft project plan to prepare the U.S. Nuclear Regulatory Commission to license and regulate accident tolerant fuel.

ACRS members in attendance are Ron Ballinger, Dennis Bley, Jose March-Leuba, Dick Skillman, Dana Powers, Walt Kirchner, and Joy Rempe. On the phone line, we have Peter Riccardella and Michael Corradini. Kent Howard of the ACRS staff is the Designated Federal Official for this meeting.

This morning, to aid our understanding of the draft project plan, we will hear presentations from the Office of Nuclear Reactor Regulation, the Department of Energy, Idaho National Laboratory, the Nuclear Energy Institute, and EPRI.

The ACRS was established by statute and is governed by the Federal Advisory Committee Act, FACA. As such, this meeting is conducted in accordance with the provisions of FACA. The ACRS can only speak through its published letter reports. Therefore, any feedback

you hear today from individual members of this subcommittee are not representative of the full ACRS.

The ACRS will meet on this topic during our full committee meeting during the week of March 8th through 10th. At that time, we will decide if a letter report is warranted. We hold meetings like this to gather information to support our full Committee deliberations. Interested parties who wish to provide comments can contact our office requesting time after the Federal Register notice describing a meeting is published. That said, we set aside time at the end for spare-of-the-moment comments from members of the public attending or listening to our meeting. Written comments are also welcome. We have not received any written comments or requests for time. Nonetheless, I encourage anyone in the room that is listening or anyone listening on the phone to make comments during the public comment period. The entire meeting is open for public attendance.

The ACRS section of the U.S. NRC public website provides our charter, bylaws, letter reports, and full transcripts of full and subcommittee meetings, including all slides presented at the meeting. The rules for participation in today's meeting have been announced as part of the notice of this meeting

previously published in the Federal Register. There is a public phone bridge line in use. To preclude interruption of the meeting, the phone will be placed in a listen-in mode only during the presentations and subcommittee discussion. A transcript of this meeting is being kept and will be made available as stated in the Federal Register notice. Therefore, I request that participants in this meeting use the microphones located throughout the meeting room when addressing the subcommittee.

The participants are requested to please identify themselves and speak with sufficient clarity and volume so they can be readily heard. For the presenters, you have your own microphone that is switched on and off using a push button at the base of the microphone. Please familiarize yourself with this feature and only turn on your microphone while speaking and avoid shuffling paper with a microphone while it's on.

I'll now turn to Mirela --

MEMBER REMPE: Matt, before you do that, please, I need to, in order to comply with Section 10.1 of the bylaws of ACRS, I need to acknowledge that I have reviewed material on this topic for the Department of Energy and believe, before I retired, I actually,

my group did some, provided some sensors for a drop-in capsule many years ago. Thanks.

CHAIRMAN SUNSERI: Thanks for that declaration.

MEMBER POWERS: Did it actually help? Just curious.

CHAIRMAN SUNSERI: Okay. Thank you, Joy, for that declaration. Now, I'll turn to Mirela Gavrilas to make introductory remarks.

MS. GAVRILAS: Thank you very much. So I'm going to be brief. I just want to mention that the project plan that we will be presenting this morning is a collaborative work of several offices that include NRR, the Office of Research, NMSS, and NRO. It provides a comprehensive look at the totality of issues that may develop in licensing accident-tolerant fuel.

I would like to recognize the working group staff, many of whom you will meet today, for their exceptional effort in pulling together a strong document in less than six months. I want to also thank the folks who reviewed the plan and provided comments, great substantive comments. This is exactly what we wanted, and we think that those comments will help us ratify areas where we weren't clear enough in the graphs that we put out and it will also, they also brought

up issues that we need to consider as we finalize the plans.

So before I end my remarks, I want to preview one thing, that when we started work on this plan, we were talking about, there was talk about down-selecting and it became clear that there won't be down-selecting. In fact, the number of concepts may grow and vary as time progresses. So what you see in the plan is high-level and it's intended to be comprehensive and capture all kinds of concepts that may evolve. There's no attempt made to focus in on any concepts. We can't do that before we actually do some sort of significant expert elicitation to find out what individual concepts actually need, where we need to focus our efforts as a regulator.

So with that, I'm going to yield it back and you'll hear more about this during the presentation. Thank you.

CHAIRMAN SUNSERI: Thank you. And just one thing, as we get started here, there are many stakeholders involved in this, I'll call it program, and there's a lot of technological advancements being pursued. I just want to emphasize that why we will hear technical information today, our main focus is to review the strategy and plan that the NRC is putting

in place to review and regulate these fuels.

So while it's important that we understand the technology, today's focus will be on the plan. So with that, I'll turn it over to William McCaughey. All right.

MR. MCCAUGHEY: Thank you very much. Yes, thanks. It's a pleasure to be here, happy to start things off with an overview of what the Department of Energy's research and development program is. I will start off with some history and overview and then turn it over to Jon Carmack for some of the details on the R&D program.

So I am Bill McCaughey. I am one of three directors in the Office of Nuclear Energy's Research and Development Office. We also have Advanced Reactor Technologies as one of the three offices and also Materials and Chemical Technologies. And I have Advanced Fuels Technologies. And that includes, that includes our TRISO fuel qualification for high-temperature gas reactors which is ongoing; advanced light water reactor fuels which accident-tolerant fuel is a part of; and also advanced reactor fuels, which is primarily focused right now on metallic fuel for sodium fast reactors in a continuous recycle.

So let me get started. I'll be covering the first portion here, the congressional direction after Fukushima in our development plan. And Jon will take the national laboratory R&D support, which we organized along those lines you see there.

So following the accident at Fukushima, we seek direction from Congress through the fiscal year 2012 appropriations to start a program on developing fuel with enhanced accident tolerance. It also asked for a development plan which we provided some years later. But the development plan is about 14 pages long. It consists of a vision, mission, and scope for the program, and noteworthy there is that the scope is for primarily existing reactors. That's what this program was geared for, not future reactors but fuel that could be used in the existing fleet. And it's also focusing on the fuel. There are many aspects of accident tolerance, and there were many steps were taken post Fukushima. But with this program, it's focusing on the fuel.

The ultimate goal in this plan was to develop, well, to insert a lead fuel assembly or lead fuel rod in a commercial reactor by 2022. It also goes on, the plan goes on and defines what we mean by accident-tolerant fuel. It talks about the attributes

of the fuel: reduced hydrogen generation, fission product retention, cladding reaction with the steam, fuel cladding interactions. And it describes also our considerations for the development program and also what capability needs we have in the department or had at that time for conducting the necessary research and development.

MEMBER POWERS: Have you, in thinking about accident-tolerant fuel, do your confine your attention solely to DBAs?

MR. MCCAUGHEY: No. In assessing the fuel concepts, it's from normal operations through beyond-design-basis accidents.

MEMBER POWERS: The whole spectrum?

MR. MCCAUGHEY: Excuse me?

MEMBER POWERS: The whole spectrum?

MR. MCCAUGHEY: Yes. So the development plan has three phases to it. The first is complete. This was the feasibility assessment and screening many, many fuel concepts. We formed partnerships with fuel vendors through a competitive process. They proposed concepts. We started a radiation test program at Idaho Lab, and this culminated in a down-selection at the end of phase one at the end of fiscal year 2016 to the concepts that we are now pursuing in phase two.

Phase two is now, we're two years in. We're in the second year here. We are progressing to do more testing, more focused testing safety assessments. The vendors are working closely with the utilities. They've scheduled a series of lead fuel rods being inserted into commercial reactors using their concepts. And then we will have, phase two will lead to what we hope is a commercialization phase where these concepts are commercialized, the fabrication ramps up, they get commitments from utilities to insert one or more of these fuel concepts that's under development right now, insert that in batch reloads in the commercial reactors.

So we are updating the development plan. One of the main reasons we're doing that is because, as I said earlier, our goal in the first development plan was to have one concept in lead fuel rod or lead fuel assembly and one reactor by 2022. What's happened since we began phase two is we had, well, first we realized that we had multiple concepts that looked promising and we wanted to proceed in phase two with them. We actually have three concepts, three fuel vendors who are further developing those concepts. We'll be talking about those in a minute.

And the second is that for the utilities,

an interest in the accident-tolerant fuel concepts, that they are greatly accelerating the pace of development in inserting these concepts into these reactors. The first is going in right now into a reactor and two more are coming up and scheduled for the spring of 2019.

MEMBER REMPE: So, Bill, ACRS usually doesn't care about money, but because some of the interactions and discussion topics we'll be talking about, the SPAR models and things like that, issues have come up, I think I'd like to make sure everyone understands here what's the belief, is accident-tolerant fuel going to cost more money than the current fuel?

MR. MCCAUGHEY: That's under study. That's being studied right now. In fact, you'll hear from NEI and EPRI who are leading studies on that to answer that question.

MEMBER REMPE: Because if it does cost more, the Commission has said reactors are safe enough, we've got flex, and so the motivation for this commercialization would be different in how they would implement it. And so I think that that's a question we'd like to better understand so we can understand some of the comments that have been going back and forth

about this.

MEMBER BALLINGER: Along those lines, do any of these fuel concepts require you to go above 5-percent enrichment?

MR. MCCAUGHEY: That was one of the premises at the beginning of the program. I said was we wanted this fuel in existing reactors. And, also, this is a very fast-paced fuel qualification program. For that reason, we said, no, we did not want to take that on to exceed 5-percent enrichment. However, things now are developing and the industry is looking into that, and we would support that if that's something that is for, you know, many reasons. If it's advantageous, we would support that through R&D.

MEMBER BALLINGER: So this is not a deal-breaker going above 5 percent?

MR. MCCAUGHEY: All of these fuel concepts are being pursued with the understanding that they need to work at the existing enrichment.

MEMBER BALLINGER: So 5 percent or less?

MR. MCCAUGHEY: Five percent or less, right.

MEMBER BALLINGER: Thank you.

MEMBER SKILLMAN: Let me build on Dr. Rempe's question. You said that the utilities are,

the impression I got are enthusiastic or very supportive. What have you heard from them from the perspective what's in it for them? What do they perceive they are going to gain in this?

MR. MCCAUGHEY: Well, they would gain the same, the same advantages for this fuel for performing in a beyond-design-basis event also have advantages under normal operations. You will have more robust, more robust fuel, and that could lead to operational flexibility in operating the reactor. It could lead to higher, it could lead to higher burn-ups. It could help with issues such as fuel failures due to fretting. They're looking at a whole range of possible advantages that would help with under normal operations.

MEMBER SKILLMAN: Thank you.

CHAIRMAN SUNSERI: Perhaps that would be a great question to ask NEI when they show up.

MR. MCCAUGHEY: Okay. Moving on. So this plan is under development. It's in review and concurrence within the Department right now.

In updating the development plan, we met with the stakeholders in the program, the fuel vendors, the utilities, the NRC, at a workshop in September. This slide best summarizes what was discussed in that meeting. It's a fairly busy slide, and I know we want

to move on to other things here. But the way this is laid out is for listing the activities that belong, that would be a part of phase two of the program and then phase three below. The culmination of phase two is to introduce reload quantities of accident-tolerant fuel in commercial reactors in 2025 - 2026 time frame. I believe that the utilities would like to beat that.

And you can see those three columns point out the three areas of activities that we need to pursue in order to achieve that: the evaluation of the fuel performance, the regulatory licensing structure in the middle and those are the activities that need to be pursued there, and then the affirming safety benefits for using this new fuel which goes to Joy's question earlier about the, you know, the economics of this fuel.

MEMBER REMPE: You're almost implying that you're hoping to get some regulatory relief in return for the use of this fuel, right?

MR. MCCAUGHEY: The extent of the regulatory relief is not certain right now. There's a lot of discussions. It all depends on how the fuel, you know, it depends on the R&D and the testing and it depends on the analyses that are taking place now. It also depends on not just the fuel itself but what

else can be done supporting the fuel, credit for flex, credit for other ways of operating to get cooling to the core after an accident. So that's what's going on in that, and that's going to lead or inform the benefits, part of it.

Okay. Let me turn it over to, let me turn it over to Jon now, who will discuss the R&D support that we provide to the fuel vendors and the Nuclear Regulatory Commission.

MR. CARMACK: Good morning. I'm Jon Carmack. For about five years, I was the national technical director for the Advanced Fuels Campaign that has the responsibility for managing the technical work underneath this program for DOE. I've since, at the end of September, I've now moved to a different position at DOE Headquarters, but I'm here in a temporary fashion. I've turn the national technical director position over to a gentleman named Dr. Steve Hayes. Steve was in Texas this week and was unable to make it to this meeting, so, hence, I'm here in my historical name, I think. So you should be seeing more of Steve in the future at these types of meetings.

I'm going to try to focus on the testing and assessment capabilities and resources that the Department has established under this program beginning

at the beginnings of the program. But, first, you know, I think I heard that we didn't want to focus on the details of the individual concepts that are being proposed and brought forth by our vendor teams, but this slide provides an overview and summary of their concepts and some of their ideas.

I would agree with Mirela that these concepts are still fairly varied. There's competition, and the vendors, as we always know, are very competitive in their technology development. So you will see them now being pretty communicative in the open press about their ideas for accident-tolerant fuel, and our intent in the Department was to provide the resources and technical experimental capabilities to develop the large quantity of data that we know is needed to make full assessment and, ultimately, qualification and licensing of new fuel technologies.

MEMBER KIRCHNER: Jon, before you go on, could you just summarize what -- I assume this is the down-selection as far as you are at this point in 2016?

MR. CARMACK: So Framatome is currently pursuing a coating on a fuel concept that is taking their M5 cladding, coating it with chromium metal on the outside for a corrosive, a protection of oxidation and corrosion, as well as improvement to fretting and

wear issues. They are using a standard uranium dioxide fuel pellet but adding a chromium oxide additive to it to improve the fuel pellet properties, material properties, I guess, is the best word and we'll stick with that.

They do have, as you will see, Westinghouse has a similar concept that they're bringing forward. They have been trying to replace the uranium oxide fuel pellet with a uranium silicide, a uranium, U3Si2 we refer to it in that composition set.

But Westinghouse wants to convert from the chromium-coated Zircaloy, which would be their Zirlo-based zirconium cladding, to a silicon carbide cladding fueled with uranium silicide. The question about enrichment is important because their idea is to improve fissile density in the fuel system by going to a higher-density fuel, and that is their offsetting to economics idea.

AREVA has the same idea as to ultimately move to silicon carbide, but they're not currently pursuing it under the DOE program. They have some internal research that I believe they're still pursuing that under. But I don't believe they have been approaching the staff at the Commission with such ideas.

GE, as we know, is primarily focused on

the BWR system, and so they have been pursuing a direct conversion of the Zircaloy-based cladding to an iron-based cladding in the iron chrome aluminum system, still fueled with standard UO2 pellets. They are pursuing a couple of different compositions within that iron chrome aluminum system. We have had a few commercially-available compositions of that allow in the test reactor test series, and I think they're still working through some of the selection of that exact composition set. They would like to have, it would be great if there was a commercially-available alloy that they could directly procure that performs well in pile, but I think they want a little bit refinement of the commercial grades to something that is better suited for the reactor environment.

MEMBER KIRCHNER: And there they would compensate with a higher enrichment or it's the same nominal pellet?

MR. CARMACK: We've asked that question, also. I think they say that they can thin the cladding down to the point that their enrichment increase is still below the 5 percent current limit. So I think that's their challenge is to try to gain a balance between thinning the clad down to the point that it's still performance based but that they can still stay

under the 5-percent enrichment limit. Good question.

MEMBER KIRCHNER: Thank you.

MEMBER CORRADINI: -- your calculation of how much thinning and what experiments they're doing to show the thinning is doable.

MR. CARMACK: Mike, what I've seen is that they are within the capabilities of being able to achieve that. We have some of their fuel concepts directly going into the events test reactors soon later this spring in that composition set with that diameter and thickness of cladding. So I think they're within the range. The question will be whether it can still meet all of the stress and mechanical capabilities required.

MEMBER CORRADINI: Okay. All right. Thank you.

MEMBER POWERS: Most of your program, as I see it, is looking at how the fuel behaves during irradiation. Anybody look at the handling fueling and de-fueling storage and things like that? You're not going to be the first to have put a stainless clad on fuel, and it was a nightmare. True enough, it was austenitic. But the problems that arose have nothing to do with the phase. They had to do with things like

activation and the like.

MR. CARMACK: So all of the vendor teams have been looking at all the aspects of fuel handling, fuel condition, up to fuel storage. Each of the portions of the Nuclear Regulatory Commission that govern those activities and functions in the plants have been engaged in this plan, in Mirela's team's plan, so that they will be engaged at the Commission level with our vendor teams to answer those questions directly, also.

I know that they've been investigating these specifically on some very specific case-by-case basis recently. In fact, GE has gone through some of their submittals and reviews for transport of fuel with the FeCrAl cladding in their existing fuel boxes, as well as long-term storage in the pools and monitoring storage on the pads. So all of those aspects are being looked at as part of the program activities.

MEMBER BALLINGER: With the FeCrAl cladding, are they also going to have to use FeCrAl channel boxes?

MR. CARMACK: I have not seen them actually propose that, Ron. I have seen them possibly --

MEMBER BALLINGER: They better.

MR. CARMACK: I have seen them possibly

looking at coatings of other components in the reactor system, but that's outside of the scope of four program in DOE.

MEMBER BALLINGER: It goes to the economics, which is one of your top feasibility things.

MR. CARMACK: So let me move on off of the individual topics and move into a little bit the test series and the resources that have been established in the DOE system and across the program to provide data and testing of these fuel systems. Early in 2012, we established an experimental plan that crossed steady-state operation all the way through transient operation.

The first experiment test was the ATF-1 steady-state irradiation test to be conducted in the advanced test reactor. We refer to it as a simple drop-in capsule test. It's not fully prototypic because it is not in a flowing coolant that is prototypic of what we would see in PWRs or BWRs. But we looked at it as more of a screening and separate effects generation of data capability. I have a little bit more on that, each of the individual tests, as we go forward.

At the same time, we were working to establish a PWR condition loop in the advanced test

reactor. We refer to that as the ATF-2 test. That test will come online later in sort of the middle part of this year. It was actually initiated this last year with flowing PWR coolant with some of Joy's thermocouples in it. You knew that, right?

MEMBER REMPE: I'd say yes right now. But I do have a question about your Halden test. I was in OECD in January, and in both of the meetings I started off, and they were international meetings, the OECD guy said, hey, you know, the future of Halden is uncertain.

MR. CARMACK: That is true. We've heard the same thing. Over the last year, we have been pursuing a bilateral relationship with them which allows for protection of IT information, as opposed to being in the international program.

MEMBER REMPE: But they're talking about shutting it down. If there's not more money going to Halden, the folks at Halden are not going to ask Norway to subsidize it as much is what I'm talking about.

MR. CARMACK: That's true, and I actually can't control that. I don't think DOE can control that either. But we have still been working with them on establishing two loops, one PWR based and one BWR based, for initiating testing in Halden possibly later this

year if funding on our side is available. But I don't think that they've actually taken a decision either way. They've been funded through, as far as I understand, through the end of 2018 and, at the end of 2018, the Norwegian government makes a further decision to fund them further into 2019 and 2020.

I think you're correct. I think Halden is in, is threatened definitely. They've been losing people. In fact, we've hired some of their people.

Okay. So let me move on to TREAT. Probably in 2009 - 2010, the Department initiated activities to consider the re-establishment of transient testing capabilities in the United States for full fueled systems and in 2014 made the decision to refurbish and restart the TREAT transient test reactor facility. That reactor actually came online in November of this last year with at-steady state levels and has been progressing through doing some initial transient pulse testing, not with fuel yet. We plan to get to the fuel test system starting later this year, I believe. But that was a major decision by the Department to re-establish transient testing capabilities primarily to provide data in the off-normal conditions that we know is needed for some of these fuel systems in the design-basis and

beyond-design-basis accident machines.

We knew in 2012 that we wanted to start putting leads into, lead rods and lead assemblies into commercial nuclear power plants. We expected that that might happen in the 2018 to 2019 time frame and, in fact, I believe there will be some GE-installed cladding tubes early this year, maybe in the next couple of months. And the other two vendors are planning fuel insertions in the early part of 2019.

We fully expected that after commercial irradiation of leads that we would bring those fuel systems, those fuel pins and tests, back to the TREAT transient test reactor and put them through transient testing in an interval fashion following their steady-state irradiation.

The ATF-1 test series, which is the first dropped-in capsule experiment series, was established in 2014 and has now seen upwards of 30, a little bit beyond 30 different fuel pins installed in the reactor for separate effects, data, generation and testing. It's been doing pretty well. We have fuels out of that experiment and undergoing post-radiation examination. Some things have finished, some things are still under irradiation, and some things are still under post-irradiation examination. That data, in the

general sense, is pretty open to release to multiple entities who need it for assessment of some of these fuel systems.

We expect that -- let's see. Earlier last year, in about August of 2017, we established a PWR condition loop in the center flux trap of the advanced test reactor in Idaho, established PWR condition and chemistry in this loop l, and installed some non-fueled samples and had instrumentation in it for assessment. Later this year, probably in the June - July time frame, a full fuel test train will be installed in the center flux trap that has fuel from each, fuel concepts and technology from each of our vendors installed with it. And so we'll start a very specific PWR condition irradiation test series in the center flux trap, start in the middle of this year.

Your Halden question, Joy. There's actually at least two different ways you can put material into the Halden. Under the joint program that's open to international collaboration, we have provided separate effect samples of this iron chrome aluminum alloy, as well as silicon carbide creep tests. Those are in-pile creep data generation tests. Those tests have been generating data since the end of 2015 and we're still obtaining some data off of those

experiments that are ongoing in Halden. We are also providing fueled tests under the joint program fabricated at Oak Ridge National Laboratory for open public use in the international program.

We have large activity in DOE referred to as the NEAMS advanced fuel modeling and simulation capability, and there was a joint experiment that was designed to qualify a fuel performance code, the Moose-Bison-Marmot fuel performance code environment in a 3D experiment. And so there were some experiments that were provided to Halden and modeling simulation capabilities that are undergoing V&V in the reactor today.

And then, as I mentioned before, we are currently working with Halden to establish a BWR and PWR condition loop experiment capability in Halden. I see those as synergistic with the PWR condition loop in the ATR. One thing we cannot do in ATR is void in the loop, and so we cannot establish BWR conditions in the 2A lop, but we can have PWR condition experiments between Halden, comparable experiments between Halden and ATR. And so we see it as a synergistic irradiation test capability that provide much more data to the community for assessment of these concepts.

MEMBER POWERS: It has been a long time

since I've looked at the Kanthal phase diagram, but somehow I remember those in epsilon prime phase that shows up that embrittles. What do you do about that? Does it disappear under --

MR. CARMACK: I don't think we'll actually use Kanthal, but Kanthal has been in the reactor --

MEMBER POWERS: Chromium aluminum phase diagram.

MR. CARMACK: It's really difficult to weld going into the reactor, I agree with you. So I think it's been, we've been using that as a surrogate example of the iron chrome aluminum system. I think there is embrittlement. There is a heat treatment process that can be used. I think the vendors are going to have to come through some R&D to --

MEMBER POWERS: Well, I mean, the question seems to be does irradiation destroy the epsilon prime phase or does it precipitate it?

MR. CARMACK: I think we'll learn that in some of the irradiations that are coming out of the reactor today.

MEMBER POWERS: You will not from creep tests.

MR. CARMACK: Well, that's not the only place that we have iron chrome aluminum material in

a separate effects test. There's material in the advanced test reactor also that's just undergoing steady-state irradiation, not creep.

MEMBER POWERS: And that will tell us about epsilon prime?

MR. CARMACK: I'll have to come back to you with a definitive technical answer to that, Dana. I'm not prepared to answer that today, but if you need a definitive answer on epsilon --

MEMBER POWERS: Well, I mean, embrittlement of the alloy is a big problem for us because under DBAs we go to great lengths to assure that the cladding retains a certain amount of ductility once it's cooled down because of the requirement that the core is cool-able and retains its geometry for 30 days. And so embrittled clad is a problem.

MR. CARMACK: So I don't think we've actually done that test, but it would be done after we obtained some of the steady-state irradiated material back out of the reactor and made it available to those types of tests and --

MEMBER POWERS: Do you see --

MR. CARMACK: -- the transient --

MEMBER POWERS: -- Appendix A as being your licensing authority on these issues or are you going

to take exception to Appendix A?

MR. CARMACK: I think the licensing authority would ask that question of the data and the vendors as it's presented.

MEMBER POWERS: Because the entire strategy is to make sure there's residual ductility after you've gone through a DBA transient. Like I say, it's been forever since I've looked at the iron chromium aluminum phase diagram, but I do know that Kanthal heating elements embrittle as you age them.

MR. CARMACK: So some of the alloys that are in the iron chromium aluminum system, I think they're hoping to alleviate that embrittlement feature in. So --

MEMBER POWERS: Well, you make them ductile under lots of conditions.

MR. CARMACK: So I think it's a question to answer from some of the data that's being generated out of the --

MEMBER POWERS: Maybe it amorphizes the epsilon prime phase, maybe it precipitates it. I just don't know.

MR. CARMACK: And so I think those are still data that needs to be generated to answer your questions.

CHAIRMAN SUNSERI: So after the Halden reactor becomes unavailable and you're unable to complete your research plans for that facility, what's your alternate plans for completing the research? Do you have an alternate facility?

MR. CARMACK: We'll have to generate all the data here in the United States out of ATR --

MEMBER REMPE: But you just pointed out you can't boil an ATR. I think the MIT reactor can handle boiling, but I don't know how much fuel they can put --

MEMBER POWERS: We're going to shut that one down, too.

MR. CARMACK: So there is no BWR loop that can handle fuel that we know of. So, yes, I think that's an issue for generating data for the BWR systems in these tests.

CHAIRMAN SUNSERI: So that would be something that we would need to consider in a plan to assess how the research and results are going to be produced. Okay. I understand.

MEMBER REMPE: But it's not the NRC's problem, it's the vendor to supply the --

CHAIRMAN SUNSERI: Well, if the NRC is relying on research outside the agency to support their

--

MEMBER REMPE: But the vendor should provide that data to the agency so they can render a decision, right? It's not the NRC's --

CHAIRMAN SUNSERI: I'm just asking if the only place in the world that can produce that has not been able to produce it, how are we going to get it? That's my question.

MR. CARMACK: I think there are ways you can do it. It might not be the most ideal routes. I think it will be a combination of lead fuel assemblies and lead fuel rods tested in the boiling water condition, but it might take us longer and a little bit slower in generation of the data. We were hoping that Halden would provide us with more data faster, basically, and try to support the acceleration of the program. I think with Halden possibly going down in 2020, it will make things slower and more lethargic, but I don't think it's a showstopper for generating data and routes generating data.

CHAIRMAN SUNSERI: Thank you.

MEMBER MARCH-LEUBA: Have you considered separate effects test, like what sees the BWR conditions, just like cladding? The pellet doesn't care that you are possibly boiling and different

chemistry. So the pellet only gets about a spectrum of the flux.

MR. CARMACK: Right. So that's the point of this next slide is that one of the things that, one of the types of data you need is test in LOCA condition, and so we've established an interval LOCA test facility at the Oak Ridge National Laboratory. It's a facility similar to a facility that's been used by many years by the Nuclear Regulatory Commission at Argonne National Laboratory, but this one handles fuel alpha contamination, as well as beta gamma contamination. So you can test the --

MEMBER MARCH-LEUBA: Well, my point was you can test the cladding material without the pellet inside as long as you maintain the pressure inside and you don't need to have uranium to test it and to obtain all that brittle and --

MR. CARMACK: And I think those tests are going on today. I just don't have them highlighted in this test series of irradiations.

MEMBER MARCH-LEUBA: But you might need a plan to pass it through the stuff but separate effects is sufficient. On principle --

MR. CARMACK: And that's true, and I think that's the type of test that GE is currently installing

in an operating commercial reactor in the next month is a pressurized tube welded on both ends with pressure, and so it will generate the data that they need in that regime, I think. You are correct. But I don't have those, I don't have some of those, that level of detail of the test series and the data generation.

MEMBER MARCH-LEUBA: But you don't have an agreement or at least a nod from the regulators that that would be acceptable because, in principle, it looks terrible until you start thinking about it and say, hey, I get all of it I need.

MR. CARMACK: And I think that's an important thing for all the commissioner, committee, and program to look at and to communicate with each of our vendors on these individual concepts because I think it will also vary between the concepts that are being brought forward.

I think we talked about TREAT quite a bit. If you have more questions on TREAT, I think we can probably get you a tour.

The Department has invested a large amount of money and effort into a new facility to generate separate effect data at the microstructure level called the Irradiated Material Characterization Laboratory. It's located at the Idaho National Laboratory. It

has significant capabilities for microstructural studies and is currently working on establishing formal property characterizations and having that capability available for highly-irradiated fuel samples. So we see that as being able to generate the data, much of the data needed to inform decisions on these fuel systems.

We've also established in the program what we call fuel system handbooks. We know that there's a large appetite for data in the open literature that can be tracked to experiments and well-defined experiments and then, ultimately, qualification data. So we've established a uniform handbook guide and established the first editions of many fuel system overview handbooks. We intend to make these handbooks available to the public, but we also consider that each of our vendors will have proprietary data on their individual fuel systems that they provide to the Commission separately.

I mentioned the advanced modeling simulation activities in DOE. These have been very extensive and, I think, been very fruitful in terms of providing the capability to model, simulate, and analyze new and alternative fuel systems to the standard UO2 Zircaloy system. The program, over the last couple

of years, has pursued what we refer to as a high-impact problem specific to the accident-tolerant fuel system. They've been looking to make sure that the tools and structures that they've been establishing in their analytical capabilities are relevant to the accident-tolerant fuel systems that are being brought forward by the vendors.

Go ahead, Joy.

MEMBER REMPE: Well, go ahead and finish that slide. I have some questions on it.

MR. CARMACK: They're currently working together with the Nuclear Regulatory Commission and established a working meeting between NEAMS, CASL, which is a separate piece of the modeling and simulation capabilities, and the Nuclear Regulatory teams.

MEMBER REMPE: So here's where I'd like to stop you here, and it's not on this slide exactly, but, if I look at some of the information that we were asked to review, there's a lot of back and forth about just rely on the DOE codes, don't use your own NRC codes. And so I'd like to make sure everyone understands a few points here. Do you know what temperature you start seeing controlled material liquefy? Silver indium cadmium, or the interaction with B4C and stainless steel?

MR. CARMACK: Between 300 and 400 degrees Centigrade, correct?

MEMBER REMPE: That's a little low, actually, but we're talking around, Dana can correct me -- actually, I brought a little figure along here, but for silver indium cadmium, you start seeing liquefaction occurring around 1073. B4C starts liquefying around -- oh, excuse me, K. Excuse me. 1073 K. And B4C stainless steel starts liquefying around 1500 K, so 1200 C. And I did a little extra homework here and I have a publication that was issued last August, I believe, from Oak Ridge where they're looking at one of the vendor designs and they're predicting for a station blackout event up to around 2500 K.

So what you will have, and Ron and several of us have gone to various vendors to visit and they sometimes use MAP, but these guys used MELCOR for the DOE program, by the way. But you typically have these scenarios the controlled media will liquefy and then relocate before the fuel does with accident-tolerant fuel. And a lot of times I'd ask the question, and I believe you've been at some of these meetings, what are you going to do about re-flood if your controlled materials are gone, and sometimes someone will pop up

and say, oh, we're going to do accident-tolerant control rods, Joy. But all of the material I read for this meeting didn't mention accident-tolerant control rods, and so I'm kind of wondering how are we going to analyze that time frame when you have no control material but I guess it's still in the design-basis accident region because the fuel is still in a cool-able geometry. I mean, you could have like an atlas, right?

And so what tool does DOE have that -- I mean, first of all, you're using MELCOR, you're not using anything in NEAMS to analyze this. What tool does DOE have that can be used in that scenario?

MR. CARMACK: So I think it's still the standard codes for, say, RELAP and those kinds of codes --

MEMBER REMPE: So I saw RELAP7. Was it well water yet? When I retired from INL, they couldn't even get it to boil water. Does it boil water yet? Can it analyze -- are you going to have a whole trigger and say once you reach this temperature the control rods go but you still have the fuel in the core and you're going to try and connect it to some sort of reactor physics model that will help you analyze an atlas?

MR. CARMACK: So I think that's part of

the NEAMS program is to develop those capabilities and needs as the industry brings them forward and informs the NEAMS and CASL programs.

MEMBER REMPE: So they don't exist today is what I think your answer is.

MR. CARMACK: I think they exist today in complete entirety.

MEMBER REMPE: They're about to allocate it, and they don't even exist probably. I mean, I don't know if you put a trigger in yet to consider when the control materials go in RELAP. And by the way, RELAP, does it do boiling water reactors very well?

MR. CARMACK: I'm not sure. I'd have to get you that answer. But it sounds like you know better than I do.

MEMBER REMPE: But, anyway, those questions, because I know industry will be coming up and I think it's better since you've been involved in the CASL, NEAMS, Moose-Bison, the critter codes, I think it's better to do it with you up there instead of them because I think you'd probably be the one that would have to go find the answer out.

MR. CARMACK: So modeling simulation, people that can answer that question are not here today. So we'll have to have them back at a future --

MEMBER REMPE: And as we discussed, what industry is going to be suggesting, I think that's a good point to be raising here.

MR. CARMACK: So if you want to learn more about the details of what the DOE program has accomplished in the last year, there are two open literature reports, the 2016 Accomplishments report and the 2017 Accomplishments report. Both are available online and open to the public at nuclearfuel.inl.gov.

So first, in summary, we believe that we have defined an original phase three feasibility assessment and down selection. We believe that we've passed through that and have focused on a few concepts that the vendors are working on and will bring forward through phase two development and qualification. I don't want to predict which ones will make it through development and qualification, but I think there's still some questions that are out there that will lead to more of these concepts.

The national laboratories in the DOE system are fully supporting the industry teams and the Nuclear Regulatory Commission, as needed, through irradiation testing, post-radiation examination, safety testing, and advanced modeling simulation. I'm sure we'll get

there with RELAP7.

MEMBER CORRADINI: Jon, this is Corradini. Maybe you said it in your discussion, but I view this as a short-term and a long-term issue. So is DOE going to be further down-selecting or are there going to be what I count to be essentially two to three short-term fuel clad forms to have to be addressed by the NRC and, unless I'm mistaken, you tell me, two or three long-term? Because I can see how one can, how the agency can potentially with the short-term ones which are not a big leap, but the long-term ones will require a significant amount of data. I think that's where Joy and Dana were getting at. So is there a long-term plan that the DOE has on this, or is it still under development?

MR. MCCAUGHEY: We don't have, we don't have a plan that's the way you just described it yet. But that could be shaking out here soon with when we assess when we're at after here at the beginning of the first two years of phase two and where the industry might want to go with utilizing the fuels. So that is certainly something that could be shaking out, but we don't have, we at DOE have not established a two-part program at this point.

MEMBER CORRADINI: Then a follow-on that

I don't think deserves an answer now but just to think about from the staff's standpoint, it seems to me that they also need a plan as to, if I understand it correctly there are single pins or parts of assemblies that are going in reactors now under, and I can't remember the right regulation that doesn't require additional justification because it's such a small inventory, but, eventually, I'm curious on the staff side when that cannot be supported because there's simply not enough data to feel comfortable that you can do it in a current reactor. But I think that's something I want to bring up with the staff because I don't understand this transition point, as well as the short-term/long-term issue.

MR. CARMACK: So, Mike, I see him writing furiously in the back of the room. I think they're ready for you to ask that question when staff is out. I think it's a planning exercise. I mean, right now, if you look at the lead fuel rods that are going in and the utilities and the industry believes those are fully within their licensing set of 50, Part 52 insertions for --

MR. MCCAUGHEY: I don't want to pretend to be a regulatory, I just want to --

MR. CARMACK: Exactly. But where that

split takes place or where you have to go to other things, I think that's a question for the Commission.

MEMBER CORRADINI: That's fine. Thank you.

CHAIRMAN SUNSERI: Any other questions for these gentlemen before they step down?

MEMBER POWERS: I think I don't quite understand in this panoply of tests that you've outlined for us where we look at high-pressure flowing steam.

MR. CARMACK: I didn't show you the capabilities of the LOCA test system specifically, but I would refer to them as separate effect tests that are furnish driven. But we do have, let's see if I have the -- it is high pressure, it is high temperature, but I have to get you the -- oh, here we go. I don't have the test capabilities of the system on it, and there are some other autoclave type testing and separate effects tests that have been done and are available for high-pressure steam, but there's nothing, say, in-pile capability. You'd have to be separate effects and out of pile.

MEMBER POWERS: The issues that I'm aware of may not require in-pile if I'm only aware of a finite number of issues. There may be things that do require

in-pile testing, but, for instance, we have had troubles with chromium-coated articles in high-pressure form of flowing steam because we generate chromic acid vapor. A strong oxidant like that usually does grievous things to ion exchange columns and the like. Interesting. Not catastrophic, I suppose.

Where we do have real problems is in silica systems where we form silicic acid, and that tends to clog up everything. And the problem is that you'll never see it in an autoclave system, but you will run into the problem in high-pressure flowing steams or even in high-pressure flowing water you'll find that you get silicic acid coming off. And those are things I would think you would want to know about a lot.

MR. CARMACK: So I think we have those capabilities, Dana. I just don't have them in the slides for all of the large number of material property characterization capabilities. They're both at Oak Ridge, PNNL, and Los Alamos National Laboratory, as well as within some of the vendor resources themselves. We'll have to get you that exact data --

MEMBER POWERS: Well, I mean, it has to show up in your plan. Those things are interesting, providing the fuel. I mean, I'd worry about it if I -- my real trouble, however, is worry about public

health and safety, and that deals with the primarily the fission product release under accident conditions. Your presentation today and, indeed, your planning, you haven't laid out anything on fission product release here. Do you have people planning that, thinking about what it is you're going to need? You're not going to be able to use any of the Regulatory Guide source terms for any of these fuels.

MR. CARMACK: So I think we intend to get that from the transient testing capabilities in TREAT. We have scheduled meetings later this year with R&D to try and get some of those types of issues with fission product source term laid out directly with --

MEMBER POWERS: Well, certainly, the TREAT tests that were done in the past in response to the TMI accident were wholly unsatisfactory and they simply are not used for fission product release modeling.

MR. CARMACK: I thought we used a combination of out-of-pile tests and high-temperature furnaces, as well as some of the integral tests performed in PBF, as well as TMI, to generate some of that knowledge base.

MEMBER POWERS: I don't know that, I mean, PBF, does PBF even exist anymore?

MR. CARMACK: No. And so that's the point

of transient testing in TREAT is to provide source term --

MEMBER POWERS: Well, I don't know what, I don't know what the upgraded capabilities of TREAT are, but the experiments they did in the aftermath of the TMI accident were uninterpretable.

MR. CARMACK: At TREAT or at --

MEMBER POWERS: At TREAT.

MR. CARMACK: Yes. So we're designing new test loops for TREAT, not the original, I mean, because TREAT was primarily focused in the past on fast reactor fuel testing, as opposed to light water reactor fuel testing --

MEMBER POWERS: Well, those things are all, I mean, you can do that. I'm sure, I mean, there are very capable at all the facilities you mentioned. The real question is strategy. How much can I live off looking at things like put a furnace in a laboratory in a hot cell versus looking at the integrated effect of a large bundle? We do see substantial differences in fission product release from a single pellet to a set of control rods, and that suite of data, you have to make some sort of strategy on how much you do with each one and what you're looking for. I mean, some fuels, chromium-doped UO2 is not going to be that

different from ordinary fuel. But some of them could really get fairly exotic, and the clad interactions with fuel aren't going to behave anything like in a certain way as far as its effect on fission product release. I have no idea what fission product release occurred from uranium silicide fuel, and I've never even seen a microstructure on uranium silicide fuel after irradiation, so I have no idea. That strategy needs some thought because you hate spending now, wait until you get into the fission product world. Then you're going to spend some money.

MR. CARMACK: So I think Bill understands that. I think those, we're going to have to do the best we can out of some of the transient testing capabilities that we're building with TREAT --

MEMBER POWERS: Well, there's, I mean, best you can may not be adequate for the regulatory process.

MR. CARMACK: Well, I hope we'd be able to fairly well define what tests are needed for the regulatory process and make those testing capabilities available. That's been our sort of challenge from the very beginning is anticipating what the regulatory data needs are going to be, and I think we'll get there later this year as we have specific meetings set up with staff

to get them directly involved in some of the planning and experiment design that we have underway for the beyond-design-basis and design-basis accident scenarios.

MEMBER REMPE: One of the things I've been puzzling about is what is a design-basis versus a severe accident because of what I mentioned earlier. And that's -- pardon?

MEMBER POWERS: 1200 degrees Centigrade.

MEMBER REMPE: Okay. I mean, really, we used to talk about a cool-able core geometry, but we never think about the control materials might be gone in that cool-able -- this is more the question I was going to --

MEMBER POWERS: We think about them all the time. That's when we put borated water into these systems.

MEMBER REMPE: That's true, but then we aren't analyzing it with the --

MEMBER POWERS: We've analyzed all of these things at one time or another. The problem is that life gets very complicated in these situations.

MEMBER REMPE: Yes, and I think we're going to have to think about how we --

MEMBER POWERS: I mean, there's, to be

sure, the PWRs, one of the biggest concerns we had about TMI, TMI we thought was getting these re-criticality --

MEMBER REMPE: And the same concern happened at Fukushima, too.

MEMBER POWERS: -- and now we've got Fukushima, and guess what? We don't seem to have a lot of re-criticality.

MEMBER REMPE: But that was the concern during the initial days of the accident.

MEMBER POWERS: They thought they were going after spent fuel pools.

MEMBER REMPE: I remember that, too, yes. But, again, I think it's something that we're going to have to think about differently when you design the fuel to be -- what's the benefit of going 400 degrees higher with accident-tolerant fuel when you don't have the control materials?

MEMBER POWERS: I think they're avoiding -- I don't think they're changing to 1200 degrees Centigrade. I think we're just saying you're not going to get there.

MEMBER REMPE: Say that again. You don't think they're --

MEMBER POWERS: You're just not going to

get there.

MEMBER REMPE: Oh, I thought they've done an analyses they will get there.

MEMBER POWERS: No, no, they're not going to go over 1200 degrees Centigrade with Kanthal, I guarantee you.

MEMBER REMPE: Well, their analyses that they did, they're going to much higher temperatures.

MEMBER POWERS: They can try. The Kanthal will give up before then.

MR. CARMACK: Question?

MEMBER REMPE: No, I'm done.

CHAIRMAN SUNSERI: All right. Well, thank you, gentlemen, for the presentation. As we think about the plan, it's important to know what you're doing from a research and technologies perspective so that we make sure the plan can cover that, but we appreciate that. And so now we'll transition. We'll get the staff up here.

All right. Whenever you're ready, you can introduce your team and get started.

MR. PROFFITT: Good morning. I'm Andrew Proffitt. I'm the lead project manager for ATF at the NRC, and I work with the steering committee and the working group who are preparing this project plan to

get the agency ready to license ATF.

You've heard from Mirela this morning. She's the head of the ATF steering committee here at the NRC, and, as she mentioned, it's comprised of division directors and deputy division directors across the agency, including the NRR, the Office of Research, NMSS, and NRO.

The working group under that steering committee has staff experts from all those divisions, including fuels, reactor systems, PRA, source term and dose experts, and NRR and research. In NRO, we had fuels, reactor systems, and now vendor inspections and expertise. In NMSS, fuel cycle, transportation, and storage experts, and we get legal expertise from our office of general counsel.

We were invited here today to share an overview of our plan and to get your insights and feedback early in the process before we finalize our first version of that plan. It's currently in draft form. It was published for public comment in December, and we shared that document and the public comments with you guys prior to the meeting.

That public comment period ended at the beginning of this month. We plan to address all those comments and the feedback that we get here today by

either adding or altering language in the plan where appropriate and to finalize the first version by the middle of the year.

We'll begin here today with a quick background on ATF and the current concepts that we considered when we were developing the plan. Paul Clifford will then go through our process for licensing fuel at NRC. These presentations will help align us on the same starting point as we get into discussing the plan, and then we'll have our working group leads go through each section of the plan and walk through that at a high level. I'll then close the presentation with brief details on the public comments we received and our preliminary thoughts on addressing those.

So DOE just gave us a good segue into this presentation. So industry, along with DOE, are looking to develop fuel with advanced enhanced accident tolerance, and the main goal there is to have a longer coping time during loss of active cooling conditions. As they mentioned, all three major U.S. vendors are participating, and there are also concepts that other entities and the vendors and other entities are pursuing outside of that DOE program, so it is larger than just the DOE program.

MEMBER MARCH-LEUBA: I see you said

something really good I liked, the main goal is. Is it that clear that that is the goal of what we're trying to achieve? Is it written somewhere? Does everybody know that we have one goal, or do we have multiple effort?

MR. PROFFITT: So I will say that goal, and I don't want to misspeak, DOE can correct me if I'm wrong, but I think that is in the DOE documentation. They may be revisiting that a little bit in the coming months or years? No? I'm getting a no. So that's the main goal of the DOE program. But outside of that, I think there may be some other objectives --

MEMBER MARCH-LEUBA: During the DOE presentation, I tried not to talk too much, but I was thinking that it would be worthwhile to develop some metrics for characterizing these new fuels with respect to the goals of what you're trying to achieve. I mean, this fuel is 23 percent better than another.

MEMBER REMPE: They actually do have, I don't know if we were provided it for this meeting, but when they started the program and, if Jon is still here, he can speak up and confirm this or maybe Bill, but they do have a metrics document that they developed at the beginning. Right, Bill?

MR. MCCAUGHEY: I'm sorry. I missed --

MEMBER REMPE: Shannon Brennan developed some sort of metrics document for accident-tolerant fuel and what was considered to be done, right?

MR. MCCAUGHEY: Yes. So this is Bill McCaughey at the U.S. Department of Energy. So, yes, we have one goal, and that is the goal that was stated. But in order to implement that goal, there are other considerations; and, of course, economics is a major one. And that's why we need to see how this will perform not just in a severe accident but in normal operation and also what -- so we're not developing a fuel that's impossible to commercialize.

MEMBER MARCH-LEUBA: So it's a complex problem.

MR. MCCAUGHEY: It's a complex problem, but that is our goal. Our goal is longer coping time during loss of active cooling in severe accidents. That is certainly the goal. As far as the metrics go, yes, that was one of the first things we did in phase one was to establish the metric so that we can evaluate these fuel concepts from the vendor fuels. There were multiple fuel concepts, and we got to the point where we're at now because we developed metrics for evaluating them and applied them to all of the ideas that are out there.

MR. PROFFITT: As I mentioned before, we're working across the agency here to prepare for licensing ATF. And then, finally, we have signed MOUs with the DOE and EPRI to facilitate coordination and transfer of data and getting that data earlier in the process from the DOE program.

I'll turn it over to Josh to take us through the concepts we considered.

MR. WHITMAN: Hi, I'm Josh Whitman. I'm in NRR, Division of Safety Systems in the Nuclear Performance and Code Review Branch, and I'm the ATF working group technical lead.

I shouldn't have too much stuff here. Jon covered a lot of it in his presentation, but I want to touch on two important points. First off, I wanted to talk about how the project plan sort of divides up the different ATF concepts into two groups. In the plan you reviewed, we refer to them as evolutionary for the near-term concepts and revolutionary for the more long-term concepts. And we've received some feedback in the public comment period that there's some sensitivities to those terms, so we're working through maybe changing those terms in a future revision.

So up here we've got a slide of near-term and long-term concepts. I'm not sure if that's going

to be the final or not, but just to clarify.

MEMBER POWERS: You're being run by form over substance here.

MR. WHITMAN: I didn't say that. The other important point I want to touch on is that the NRC's project plan isn't limited to those products supported by DOE's project, DOE's ATF project. So there's coated claddings that are one of the near-term ATF concepts, and I believe Framatome is the vendor that is doing that through the DOE program. But the other two vendors have also expressed the desire to use some sort of coating on a cladding for similar purposes. And so we need to be prepared to review that regardless of whether it's part of the DOE-funded effort or not.

And so I'm not going to go through each of these because Jon already did. But if we can go to the next slide --

MEMBER POWERS: Well, in thinking about things as modest as putting a coating on the outside of cladding, is it really an issue that the NRC needs to delve into or is this kind of an operational thing? I mean, does it take a lot of work to say that? If fuel works in the reactor and you're talking about ten microns or less coating, is there a consequence that

you can identify for public health and safety here?

MR. CLIFFORD: Okay. So I think the industry is still researching, you know, not only the most optimum thickness but also the most optimum compounds to use and also the best manufacturing process for adhering it to --

MEMBER POWERS: Yes, that's their business. Happy to have them do that.

MR. CLIFFORD: And, certainly, like you said, it is the least significant departure from the existing proven method because you're still using UO2 standard fuel, you still have an approved cladding alloy that you're adhering this 15 to 20 microns of chromium to, but you still have to look at its stability and whether it will, maybe it would be abrasive or, you know, the opposite of having interactions with the grid steps. You could imagine that you would ensure that it would be adherent to the cladding under all conditions and that it wouldn't flake off and form a new form, a new source of debris.

MEMBER KIRCHNER: Is it implicit in the DOE program that the burn-up would push to where the vendors are with some of the, what should I say, the more modern fuel that's being already deployed? Is that a given that you're going to go to the same burn-up?

MR. CLIFFORD: I don't think any of that is a given. I think the industry right now would like to pursue higher burn-ups. They feel they have come up with better zirconium alloys that can achieve higher burn-ups, more corrosion resistant, and they would like to push burn-ups today with or without ATF. The same would go for enrichments and cycle length. I think you're going to see a push to more aggressive utilization of fuel to try to improve economics. If you added chromium coating to it, I think that would give them more ammunition to come in and to seek longer cycles and higher burn-ups, maybe even higher power wells.

MEMBER POWERS: Do we have the database to support higher enrichments?

MR. CLIFFORD: Higher enrichments? No, there's not a lot of data out there to support higher enrichments.

MEMBER POWERS: It's burn-up we can tolerate but --

MR. CLIFFORD: There is a lot of data out there to 70 - 75 gigawatt-days, but there's not a lot of data out there for 7 - 8 percent enrichment.

MEMBER SKILLMAN: I've been holding this

question really for NEI, but I introduced it with the first speaker. I think you might be able to shed some light on this. As you just said, the vendors would like longer cycle lengths. That's higher enrichment, higher burn-ups. That's going to push the LOCA heat right in the pins.

So my real question, as this program proceeds, what consideration is being given to changing because I'm thinking I'm going to decide I'm going to put in an LTA and I've got a do a core operating limits report and I recognize if I'm going to exceed by 50 degrees my currently-analyzed temperatures, I've got to consider whether or not I've got to do a license amendment application. So I see division for accident-tolerant fuel bumping into not only Appendix K because you talk about enrichment, I think the Louisiana Energy Service has popped out a 5-percent regulation topped at 5 percent, so there is a domino effect that is rather large and really begins with the notion, hey, you know, we can just squeak the enrichment a little bit and, you know, go a little higher burn-up, but the house of cards collapsed with our current licensing framework, at least my opinion.

MS. WHITMAN: Jennifer Whitman also at NRR and DSS with the Reactor Systems Branch. So one of

our later slides, we talk about that's the first task in the plan is to address the inter-reactor regulatory framework. So we can cover that --

MEMBER SKILLMAN: Let's wait until then. Okay, thank you.

MR. CLIFFORD: But you did bring up a good point. I mean, the stated goal here is to increase coping time under loss of coolant in an accident type or station blackout scenario, but, as you know, there's no free lunch. So if you start pushing these designs, you may find that other accidents become more limiting, like steam line break or loss of flow. There may be other accidents that become even more limiting than they currently are.

MEMBER SKILLMAN: Well, my first reaction is do I have high-pressure injection, do I have enough cooling, are all the analyses we've done with the turbine-driven emergency feed water pump sufficient to take care of the first hours of cooling if I've lost power? I mean, there's just a whole host of things that weave into this, and it really begins with the heating of the fuel, and if you push the fuel too hard you just run out of gas in your systems in the current design. That might say this is really hooked to future design, but the mission from Congress is current fleet.

And so that seems to me to create an appropriate tension that we're going to have to resolve.

MR. CLIFFORD: Absolutely.

MEMBER SKILLMAN: Thank you.

MR. WHITMAN: So the next slide is sort of fuels that are listed as revolutionary in the plan right now, but we're calling it longer term for now. Again, you know, Jon talked about the first two. Another one that I just wanted to highlight that we're also sort of anticipating potentially having to deal with is Lightbridge, which is a helical cruciform metallic fuel that I think they just joined with AREVA to begin promoting the concept.

MEMBER CORRADINI: So this is Corradini. Can you repeat that? They joined who?

MR. WHITMAN: Well, with Framatome, I guess. They have a joint venture with Framatome that was just recently announced.

MEMBER CORRADINI: Okay. But I just want to connect back. I thought you said early on that your intent was to stick with those concepts that DOE is funding, for want of a better word, because there's going to be a need for data. So is this something you're intending to expect to get an application of that you have to then respond to? I guess I was unfamiliar.

MR. WHITMAN: Maybe I wasn't clear. The ATF plan is also sort of anticipating potential other new fuel designs, and so it's preparing us to be ready to license new fuel designs, whether or not they're included in the DOE plan or not.

MEMBER CORRADINI: Okay, all right. Thank you. Got it now.

MR. PETERS: This is Gary Peters from Framatome. I can add a little bit of information on that one. Lightbridge and Framatome, as you mentioned, recently announced a new joint venture. The company is called Enfission, so that will be a new name that you'll be hearing, and they're working together to develop this metallic fuel. So, again, the NRC is aware of it and we'll start kicking off some more formal discussions later this year to give more information.

MEMBER BALLINGER: On that point, what's the connection, if any, between Lightbridge and Twel? The last time I was in Minsk, I saw this fuel.

MR. PETERS: I don't know that there's a formal connection between Lightbridge and them.

CHAIRMAN SUNSERI: And I noticed that the speakers in the audience are kind of looking for the microphone. There is an open mike right behind me.

It's hidden by this column, so anybody in the room can use this mike and you don't have to shuffle.

MR. CLIFFORD: Okay. So right now I'm just going to walk through at a very high level the major steps that are required to license any new fuel design for unrestrictive badge application and then we'll kind of see how this all unfolds or how the NRC envisions how it will unfold for the ATF designs.

So the first step would be to conduct research to fully characterize the material, mechanical, chemical, thermal, nuclear properties of the new fuel material and the evolution of these properties with time in reactor and burn-up. The next step would be to conduct separate effects and integral testing to fully characterize the performance of the new design features under a wide range of accident conditions as defined in the FSR, identify degradation mechanisms, establish performance objectives, and define design requirements and analytical limits that ensure acceptable performance. And these, because of potentially new degradation mechanisms, you then potentially have new performance metrics, and that's something you always have to consider. The existing regulatory framework with respect to how it's defining acceptable performance may be different for a new fuel

design.

The next step would be to conduct similar type of testing, separate effects and integral testing for more of the beyond-design-basis type scenarios and define your fission product release, core melt progression, core relocation, mechanical-chemical interactions that ultimately feed into your SAMGs and your beyond-design-basis type scenarios.

Based upon the previous slide, we then have to identify any existing regulatory requirements, for example the GDCs, which are not satisfied or where this unique performance characteristics of the new design require new regulatory requirements. And then you're looking into something like developing new guidance, rulemaking, etcetera.

The fifth step would be to develop, calibrate, and validate your analytical models which are used to simulate the performance of the new design features, undergo normal accident conditions, to quantify the uncertainties of those models based upon the extent of your empirical database and define an application methodology. Next, on a plant-specific basis, you need to define tech spec, LSSSs and LCOs which ensure acceptable performance under normal operation AOOs and postulated accidents.

The final step would be on a plant-specific basis to then document and demonstrate that all of these design or regulatory requirements are satisfied. And at a high level, for normal operation, you have to maintain geometric stability, integrity, compatibility with reactor internals, co-resident fuel, and the handling equipment. For AOOs, you would need to maintain your geometry integrity and the ability to perform your intended safety functions. And, finally, for postulated design-basis accidents, including safe shutdown earthquake, you would need to maintain geometry and integrity to the extent required to perform the intended safety functions. And that would be, at a very high level, the ability to insert control rods, the ability to achieve safe shutdown or long-term cooling, to maintain a known cool-able geometry, and to limit fuel damage to the extent required to satisfy your on-site and off-site radiological limits.

MEMBER POWERS: You've put together a great list. I wouldn't have expected anything less. But, you know, this list that you got here, the prospect of regulating an existing fleet of reactors for several decades. Is this not now an opportunity to go through and see is there anything on this list that we don't need to do anymore? I mean, it's just not limiting

as to really affect public health and safety. Is this an opportunity to identify things that we just don't need to do?

MR. CLIFFORD: That's a difficult question to answer.

MEMBER POWERS: I know it's a tough question, but you're the man to do it. I've got confidence in you.

MEMBER BALLINGER: But he's going on rotation.

MEMBER POWERS: Some poor organization's getting you for --

(Laughter.)

MEMBER POWERS: -- six weeks? They wanted to get their program planned for handling Paul.

(Laughter.)

MS. GAVRILAS: So this Mirela Gavrilas. Let me give the short answer. It's definitely an opportunity to look at it again. So I think we're going to do that continuously as --

(Simultaneous speaking.)

MEMBER POWERS: Yes, I know, Mirela that --

MS. GAVRILAS: -- different concepts.

MEMBER POWERS: -- I -- we say that, and I think we actually try to do that, but now is -- when we've got these new concepts in there, you cannot persuade me there isn't some wheat and chaff built into the regulations that could be pruned out to the benefit of all concerned. I mean, it's not just something to the benefit of the licensee. It's one of those infinite number of niggly things that the staff has to go over and collect all the documentation and clog up their computer with. It's just not having an impact on the primary mission.

And as long as you've got people -- I mean, they're going to have to look at the whole suite, because I mean, if you're going to use cladding, handling of fuel is just going to become a different world that what we're used to right now. Storing the fuel, transporting the fuel. Everything is going to have to be looked at.

Can we just flag and say if there's stuff that we've been doing that we don't need to do? Let's at least flag it and then maybe specialists can look at it more carefully or something like that. I mean, they don't have to make a final decision if they look -- if they flag things. I think it's a great

opportunity to see if there's stuff that we just don't need to do.

MS. GAVRILAS: Agreed.

MEMBER REMPE: So I'm down in the weeds still and I'm thinking how you're going to analyze the ATF fuel with your suite of codes. And so basically you'll use TRACE. Maybe you'll put a flag when you reach a temperature where the control materials will go. And then you re-flood and you kind of monitor it until you finally reach the temperature where the fuel degrades and you flip to MELCOR. Is that the staff plan on how you're going to predict this stuff?

MR. CLIFFORD: I think we have upcoming presentations which will get into how we plan on updating our codes, and I think that might be the best time to answer that question.

MEMBER REMPE: Okay. In today's, because I didn't notice it in the slides at all, but I'll look.

MS. WHITMAN: Yes, so Task 4 is all of the analysis: capability, development.

MEMBER REMPE: Okay.

MS. WHITMAN: We're going to switch presenters.

MEMBER REMPE: Okay. That sound good

then. Thanks.

MEMBER POWERS: It's also useful, Joy, to understand that the nice pictures that we tend to draw on cores when they degrade portray for instance silver indium cadmium melting and falling out of the core. That's not the way it actually happens. The rods over-pressurize and it blows all the control material out through the PWR last. So it doesn't really drop out. Similarly in the quench test we have done kind of what I colorfully describe as half-assed simulations of channel boxes. And we find that the nice picture we tend to draw of things liquefying and slumping down is not quite actually what happens. It gets all distorted and crumpled around in the fuel and things like that.

So you don't -- you probably never get a situation where the control rod -- controlled material is all on the bottom and the core is sitting there nice pristine in its optimal configuration with no control material. I mean, that just never happens. Things are complicated and ugly and whatnot.

MEMBER REMPE: Instrumentation could help perhaps.

MEMBER POWERS: Instrumentation dies

quicker than the control rod materials.

(Laughter.)

MEMBER REMPE: But if you've still got fuel up there it might be good to have some neutron detectors.

MEMBER BALLINGER: Just go from a 12-compartment system to a 14-component system.

(Laughter.)

MR. CLIFFORD: Okay. So you all should have gotten a handout so you can read it. Difficult to see on this slide.

So here's how the staff envisions the overall process working for ATF based upon the information we've gathered from talking to INL, EPRI and NEI and the fuel vendors. And here's just kind of a flow chart which I think is good because it really illustrates that there are many parallel an in-series programs that need to be completed on a very aggressive schedule in order to meet the goals and objectives of the DOE program. I mean, we're already through Phase 1, which is the feasibility study. And that was completed a year or so ago. And that's really the top portion of this.

But then you get into multiple parallel

programs involving long-term irradiation that are really critical path items for the success of this program. Jon mentioned that we're in the process of the ATR base irradiation with the drop in capsules. And that will then move into the ATF-2 PWR loop. Then we're starting some Halden irradiations. And probably just as important is we're starting some commercial LTA irradiation programs. So those are three parallel irradiation programs that are all necessary.

And then we get down to evaluating the -- doing -- performing the PIE, post-irradiation examinations and then developing specimens for further research where you get into more separate effects and more integral testing where you're going back to and developing specimens for TREAT or looking at some various long-term irradiation programs, and halting and then going back and revamping them, re-instrumenting them and changing the types of examinations you're performing.

And then there's a feedback loop with the LTAs. The LTAs need to go through several years of commercial irradiation. You need to have segments removed and prepared, pulled and shipped to different hot cells, prepared further and then sent to some

irradiation programs at say Halden or TREAT to then gather further information to fully characterize performance of the fuel, the new fuel under various accident conditions.

So there's a lot of feedback that occurs in this flowchart that I'm trying to capture --

(Laughter.)

MR. CLIFFORD: -- to really show you that there's a lot of work that needs to be done and there's a lot of critical path items. And if any of them get delayed, I think they'll have subsequent effects that will --

(Simultaneous speaking.)

MEMBER POWERS: Well, things -- all plans work right up until you start working on them and --

MR. CLIFFORD: Yes.

(Laughter.)

MEMBER POWERS: Some of the issues that I wondered is they've laid out a lot of experimental facilities, no TREAT and ATR and things like that. Are you going to have somebody look at these experiments ahead of time and say can this facility actually deliver data of sufficient volume and sufficient precision that I can use it in the regulatory process?

MR. CLIFFORD: I think that is the most -- utmost important --

MEMBER POWERS: Yes, I think so.

MR. CLIFFORD: -- that we do that. And we've established these Memorandums of Understanding with DOE and EPRI. And I think it's important that we're involved in the design of the experiments, how it's being conducted, how it's being instrumented, what sort of material they're using, what level of radiation they're targeting, what programs they're running. And we're --

MEMBER POWERS: Well, I think --

MR. CLIFFORD: -- going to need to be involved with every aspect of it, because if we just sit back and wait, we're going to get something that's not going to be sufficient and then that's going to through another 5 or 10 years onto the program.

MEMBER POWERS: Yes, and I think you need to look early at this with a jaundiced eye to say this is just never going. I mean, I've seen the data this facility has generated in the past. I can't use it. So is there any hope of getting it out of this particular kind of test?

MR. CLIFFORD: Yes.

MEMBER POWERS: And we have these problems of high-pressure flow systems that are just very, very difficult and rare. Some people don't like to do them, but sometimes that's just the only data that's going to count. I mean, you can give me 1,000 autoclave experiments and I just don't care because that's not the data that works.

MR. CLIFFORD: Right, and people don't want to put 250 calories per gram into a fuel rod --

MEMBER POWERS: Yes.

MR. CLIFFORD: -- a high burn-up fuel rod under riot conditions because they don't --

MEMBER POWERS: Yes.

(Laughter.)

MR. CLIFFORD: -- that level of --

MEMBER POWERS: Exactly.

(Laughter.)

MR. CLIFFORD: -- decontamination effort to clean up after. So we need to be involved from the beginning.

MEMBER CORRADINI: Paul, can I just ask another question? So let me just pick and example. Let's take the Framatome where I have; I don't know what the amounts are, you said 10 or 20 microns of

coating and some sort of small percentage of chromium doping, chromium oxy doping in the fuel. Does this flowchart have to be followed for something which seems to me to be -- I think Dana called it an incremental change?

MR. CLIFFORD: Right, so the way I envision it is the -- each of the -- you would follow each of the steps. You'd go through each of the blocks. You would enter each of them, but depending on the level of departure it would really dictate how long, how much effort is required to then exit that block. You're correct. If you're putting just chromium coating on it, then you don't have to go to TREAT to run riot-type tests because the fuel pellet is going to respond the same, you're going to have the same level of swelling under certain calories per gram. So you know that that -- you can enter then exit that block --

(Simultaneous speaking.)

MEMBER CORRADINI: Okay. Okay. So you view this with what I think you guys call the short-term grouping as potentially something they've got to at least consider and dispose of, but may not need to test?

MR. CLIFFORD: Correct.

MEMBER CORRADINI: Okay. Let me ask a

different question: Dana earlier was asking about source term testing. Where if the absence -- where is one going to do the source term testing at the appropriate prototypical conditions? I'm missing that, because some of this is not transient testing. A lot of this is heat up and hold for time at temperature testing.

MR. CLIFFORD: Right. So if you're looking at like -- there would need to be a lot of the lead test assemblies, something that was irradiated under prototypical conditions. You would need to do a lot of rod puncture tests on those to gather the amount of fission product release to use to validate your models.

MEMBER CORRADINI: Oh, so let me --

MR. CLIFFORD: And then --

MEMBER CORRADINI: Right, if I might just make sure I understand your point. So you would do a lead rod or a lead fuel rod, take it out of the reactor, then take it back under simulated conditions and then -- and do additional testing? Am I understanding that correctly?

MR. CLIFFORD: Correct. So you can gather end-of-life cumulative fission release from doing rod

puncture tests of lead test assemblies, but you can also do online fission release measurements at a facility like Halden.

MEMBER CORRADINI: Okay. All right. So that kind of circles me back to Joy's question. In the absence of Halden what options does one have?

MR. CLIFFORD: That's a good question.

MEMBER CORRADINI: Okay.

MR. CLIFFORD: Right now we may not have an option.

MEMBER CORRADINI: Okay. So that leads me to my final question: Is NRC working with DOE since it seems to me not one or both need to identify needed experimental facilities to actually make this happen? Because I think Dana said it, Dana or Joy said it, but I would agree that if you don't have the data, you can't move forward.

MR. CLIFFORD: I agree. And I think when we're looking towards ATF designs that include non-UO2 pellets, then I think it will be difficult to license those should facilities like Halden not be available.

MEMBER CORRADINI: Okay. Thank you.

MR. CLIFFORD: But for the UO2-based systems it may be easier because now you're dealing

with only the performance of the cladding.

MEMBER CORRADINI: Okay. All right. Thank you.

MEMBER REMPE: I had the same question Mike had at the beginning, and I see post-irradiation examinations, hot cell is that fission gas release, but I guess it wasn't obvious to me when I was looking at that you've got a furnace that you're going to be doing in those tests. And it might be good to clearly identify source term or something in this chart just to make sure everybody understands that.

MR. CLIFFORD: Right. Sure. And as I mentioned, it would be a lot more difficult when you're dealing with non-UO2 because now you're getting into not just fission gas release during normal operation, which is well understood, but now you're getting into a melt progression and release of different products at different temperatures, etcetera.

MEMBER POWERS: Don't forget iodine that way.

MS. GAVRILAS: This is Mirela Gavrilas and I've just got a couple of comments. One is not only are we and DOE looking at experimental facilities that can support fuel qualification into the future, but

so is the Nuclear Energy Agency. There was a workshop in January and one of the activities that came out of that is a survey of what's available and what's needed for the various fuel concepts that are emerging. For example, the staff is going to go to Joel Horwitz and see what their capabilities are. We have that tripped planned in the near future.

MEMBER REMPE: But there is -- when is it scheduled to go critical? Isn't it like 20 -- it varies. I hear, what -- like was is it up to 2025, 2027 or something when --

MS. GAVRILAS: That is true, but we're looking what's out there as is the entire community, basically surveying. But I think everybody emphasizes -- has emphasized in the discussions I've had with both the importance of the Halden facility when nobody dismisses them.

The other point I wanted to make is, this -- the focus is the fuel, the qualification of fuel, but there will be -- in Task 4 there will be a presentation that's broader going to other areas that will support fuel. And Jen's presentation about the licensing approach is going to sort of set the stage. So there's more to come on source term,

thermal-hydraulics, severe accidents later in the presentation.

MR. CLIFFORD: And so, yes, that's good to mention. We're going to be talking about a lot of aspects that I think this flowchart will help. You can look back at this as we're going forward later on this morning and see how it all fits together.

But I think I want to leave you with here from this spreadsheet is I think there are certain critical path items that are important regarding long-term irradiation programs, the integral testing and the vendor is developing their analytical models and methods. I don't believe that the NRC review is in any way a critical path for the success of this program just because if you look at how everything falls back, there are so many things that need to be done before the NRC review action starts.

CHAIRMAN SUNSERI: I'd like to interrupt here and take a 15-minute break. So let's come back at 20 to on that clock up there.

(Whereupon, the above-entitled matter went off the record at 10:20 a.m. and resumed at 10:38 a.m.)

CHAIRMAN SUNSERI: Okay. We're back in session. Andrew, I'll turn it back to your team.

MR. PROFFITT: All right. Thank you, Matt.

I'm Andrew Proffitt again, the project manager for the ATF project plan. We do have -- somewhat changed the cast of characters up here. So we have Jen Whitman in NRR, Jim Hammelman in NMSS and Don Helton from Research. These are some of the leads as we move from the plan and then we'll do one more change as we move through.

MEMBER BALLINGER: I might add that having somebody named Proffitt is probably a good thing here.

MR. PROFFITT: It's always a good thing. Always a good thing.

(Laughter.)

MR. PROFFITT: Okay. So the draft project plan, it outlines the activities associated with preparing the agency to conduct efficient and effective reviews of ATF designs. It really lays out the strategy to prepare us for licensing and is not tech-specific. And then one of the big things it does, especially in this right now is helps focus our limited resources and where it makes sense.

It also includes a preliminary estimate of lead time necessary to complete activities in each

area. And right now we believe our timeline will not hinder industry schedules.

And it's intended to be a living document. As we learn more our industry plans change. We will maintain the document.

One of the first main sections of it is the assumptions, and the biggest of all probably is that the NRC will not perform independent confirmatory testing. So in lieu of doing our own independent confirmatory testing we need the next two things to be met, that the data will be available for DOE, industry or others for the vendors when they submit, and the data will be sufficient scope and quality to allow the staff to perform code assessments and confirmatory analysis where needed. And also aside from that also sufficient scope and quality for us to make our safety finding.

MEMBER BLEY: Where in your plan do you describe what it will take to be of sufficient scope and quality to let you do all these things?

MR. PROFFITT: So I'll say that --

MEMBER BLEY: Are you going to wait until they bring it to you and then say, nah, that's not it?

MR. PROFFITT: Well, no, I think we want

-- what our current plan is; and then we do need to elaborate it in the current plan is to use the profile system for our next steps and to inform sort of a licensing road map that kind of follows what Paul presented but for each concept and what --

MEMBER BLEY: Are we still up in the top box of that? Have you got a preliminary PIRT now?

MR. PROFFITT: We have not conducted PIRTs yet.

MEMBER BLEY: Of any sort yet? Okay.

MR. PROFFITT: No. So you -- we planned -- we've engaged industry on that at a couple meetings recently and we have a public meeting this upcoming Tuesday where we're really going to kick that discussion into the next year, I would say.

MEMBER BLEY: Okay. Now you're -- what you just told me is you're looking for that PIRT to do some things that maybe not all PIRTs do. You're looking for it to kind of scope these data requirements from your point of view?

MR. PROFFITT: Yes.

MEMBER BLEY: I hope that's clear to everybody.

MR. PROFFITT: We'll -- and we plan to make

that clear and our expectations clear. Jen will talk a little bit more about the PIRTs and then we'll have a full discussion on Tuesday that really goes into all the details and all the expectations that go along with them.

MEMBER BLEY: Okay.

MR. PROFFITT: The next thing is that interaction with DOE, EPRI, vendors and other organizations will take place in real time and in advance of experiments when possible. Paul alluded to this and the importance of that. And we do have MOUs in place with DOE and EPRI to help facilitate this.

And then last, the interactions with external stakeholders will keep us informed about developments that can affect the activities in the plan. This is obviously extremely important to keep us using our resources in the right manner and applying ourselves where we need to be. And one of the things I'd highlight here is we -- many of us here were just down in Texas actually at an EPRI-DOE-INL workshop earlier this week. Flew in yesterday to make it back here. But that's part of that engagement and keeping informed.

Stakeholder Interactions. This is to highlight that communication is really key as we move

through the plan, and we think we are doing a solid job in that regard and we plan to continue and expand on that where we can, just really to be informed of where industry is going so that we're ready.

I'll turn it over to Jen to talk about the in-reactor regulatory framework.

MS. WHITMAN: So I'm Jen Whitman. I'm in NRR DSS Reactor Systems.

So the first section of the ATF plan is Task 1 and it talks about the in-reactor regulatory framework. And so we've identified that there's really two different sets of changes that we might be looking at implementing. So the changes that would support the batch loading of ATF, and then separate and different from that would be changes to the regulatory framework that would allow crediting the benefits of ATF. And so --

MEMBER BLEY: I haven't been up on this along the way. I know people have thought about accident-tolerant fuel for years and -- but I haven't really been keeping us as we've come along. And I'm sitting here trying to think. And this -- the benefits of ATF is the thing I'm hanging on -- is this was introduced; it was at Daiichi, led to the excitement

to get this done.

What kind of -- well, it kind of goes back to the question about the PIRT. What kind of gains and coping time, I guess is the easiest way to say, are being expected by this, or has that been defined?

MS. WHITMAN: No. So part of what we identify in the plan is that we are waiting for industry to tell us what they're expecting to get out of ATF.

MEMBER BLEY: Okay. I mean, if we had great ATF fuel in Daiichi and had the same sequence of events, this would have helped.

MEMBER POWERS: No.

MEMBER BLEY: No?

(Laughter.)

MEMBER BLEY: No, no, no.

(Laughter.)

MEMBER BLEY: So what are we looking for to help? Are we looking to be able to get a little more power out of the reactors? Are we looking -- I'm not sure what the goal is of this whole big program. Is it well-defined anywhere? I probably should have asked DOE because -- but I've been stewing on this for a while here and --

MEMBER REMPE: But to give you some

insights, there was this report that Oak Ridge produced looking at FeCrAl alloys and they got five hours.

Now that report though has to make a lot of assumptions because they don't have all the data. But they used MELCOR and that's what they got.

MEMBER BLEY: I'm really interested in what the staff sees as where are you headed with this? What do you want to get out of it?

MS. GAVRILAS: Let me try to take this one. So we distinctly put two sub-bullets there because we think the two have different sort of drivers. So the top one is clearly the vendors come to us, engage us and we evaluate the safety case that they make, right, and in a topical report process and write the safety evaluation. And then it goes to licensing to --

MEMBER BLEY: Okay. And that's your job, and I understand that.

MS. GAVRILAS: But the second one we say specifically in the plan; and by the way, it's a draft plan so it's subject to comment, but we say if the vendors or the industry want some benefit out of it, they need to come to the staff and explain to us where that benefit is coming from.

So let me give an example. We can think

perhaps that there can be some 50.69 benefit that one type of fuel might lend. It would -- we would -- the staff expectation is that the vendors would come and engage us with what is needed for that benefit to be materialized. We do not take it on as our job to try to identify the -- how the agency can credit the benefit of ATF. That's when we say basically --

(Simultaneous speaking.)

MEMBER BLEY: So I should have brought this up with the DOE, but I'm really struggling with this. And before you define your project plan, before you do a PIRT you need to know where this all is headed and why and what's driving it or the PIRT won't be meaningful. You have to do the PIRT against some requirement, some goal. Where's Al?

MR. CSONTOS: So, yes --

MEMBER BLEY: Welcome back.

MR. CSONTOS: Thank you.

(Laughter.)

MR. CSONTOS: Al Csontos, EPRI now. And we spent the last better part of a year and two months looking at this, both EPRI and NEI, and we've been doing the safety analysis that you've said and you've asked about. And we've looked at all the different concepts

that are out there.

We've worked with the vendors. We've had what we call reconciliation meetings to look into where -- all the different codes that are out there: MAP, MELCOR. We've worked with DOE. We've worked with National Labs that use MELCOR. We worked with Mike Corradini, others who have used MELCOR as well. And we've all come to a consensus set of what we call those safety benefits you're talking about.

I can say that part, but the rest of it is all -- that's all proprietary. And it's in the reports, both ourselves and NEI's reports, but we have said in the public domain. And there's a lot of other -- there's consensus reports that we can give you references to that are out there in the literature. But roughly about a one to two-hour coping time benefit for these ATF coping -- for coping times for these ATF concepts.

But it -- I'll have to just say that you have to be careful because it's all related to the performance metrics that you choose.

So I think, Joy, you brought up the metrics that Shannon Brennan said in the report -- talked about. And that's actually true, because if you choose one

type of metric -- like we used 10 kilograms of hydrogen generation. If you use 25, if you use 50 kilograms, it'll change those coping times significantly.

MEMBER BLEY; Yes.

MR. CSONTOS: So the key there is you need to come to a consensus on the performance metrics that you're looking at for whatever key safety metric you're looking for. And then back it up and then take a look at how those safety metrics could impact other areas of regulatory possible benefits and things along those lines, which then can be placed in economic goods.

What EPRI did was look at the safety benefits. What NEI did is compel how -- and NEI and the industry of how you convert those safety benefits into possible economic or regulatory benefits.

MEMBER REMPE: But if you are going to do that, it seems like this PIRT that Dennis mentioned -- you need to interact with the regulator, because if you're planning to get regulatory relief, the data that might be needed might be much more rigorous than if you just want to do good for the world and produce less hydrogen. Right?

MR. CSONTOS: That's absolutely the perfect statement because that is exactly where we were

going last year as well, looking into developing PIRTs. We were already working on PIRTs with some of the vendors and looking into -- now we're looking into bringing everybody into the fold. And I think when I was a -- has been a champion of it, and I think that's where -- if we could work -- and you'll see a slide of ours. We'll talk about the PIRTs and where the vision is. You're actually --

(Simultaneous speaking.)

MEMBER BLEY: Matt, it sounded to me like by the time they get on those chart to where the PIRTs are going on, we ought to have had a closed meeting to find out where this is really headed.

MEMBER MARCH-LEUBA: Yes, can you give us an example of where those cost savings are coming from? Are you reducing FLEX material? Are you cutting down ECCS requirements? Are you -- what --

MEMBER BLEY: That's proprietary and you need a closed meeting.

MEMBER MARCH-LEUBA: Because that --

MR. CSONTOS: The specifics are proprietary we -- generally I can tell you that -- and I'm also going to go into it a little bit in my slides. You're looking at rod reliability increases. You're

looking at fuel cycle optimization possibilities. There's also flexible operations, or operational flexibilities I call it. And also just fuel performance.

So there are many, many, many pieces underneath those four big sub-bullets.

MEMBER MARCH-LEUBA: I just want to emphasize what I think we're saying subconsciously is vendors are always improving their fuel. I mean, they're always making better fuel and sending to the operators and the margin gets reduced all the time because the operator takes advantage of this margin. You never get more margin in the plant.

(Laughter.)

MEMBER MARCH-LEUBA: So we need to know where we're going with this.

MEMBER BLEY: Well, yes, and I see some PRA slides coming up, and the PRA slides -- well, the PRA gains aren't going to come from margin. They're going to come from some longer times to --

MR. CSONTOS: And that's deliberations.

MEMBER BLEY: -- recover from some of these events before you'd wipe out the --

(Simultaneous speaking.)

MR. CSONTOS: Those are the deliberations. It's all about margin exchange. It's really -- it's going to come down to the deliberations with the staff and the utilities and seeing where that margin exchange occurs, whether it's in -- where NRC controls it or where the utilities -- there's a lot of pieces to this.

MEMBER REMPE: So has your effort gone far enough that you've clearly identified what regulatory relief is needed to even make this economically worth considering?

MR. CSONTOS: It's a presumptive to think that there's a regulatory -- you can get regulatory relief. There may not be. Okay?

MEMBER REMPE: Right. But I mean but I'm wondering have you gone -- and this is a curiosity question. It doesn't affect safety, but do --

MR. CSONTOS: We call it --

MEMBER REMPE: -- you know really what's -- how much is needed to really make this worth the effort?

MR. CSONTOS; We call what we did before ATF Evaluation 1.0.

MEMBER REMPE: Yes.

MR. CSONTOS: We're embarking on

Evaluation 2.0 now to get to more in-depth answers to what you just asked. So I -- it just --

MEMBER REMPE: You don't know yet is the bottom line?

MR. CSONTOS: Yes. We're -- we have ideas, but we need to flesh out those specific areas to the level that we did before on 1.0.

MEMBER BALLINGER: I'm a little surprised that you only get one-and-a-half hours on coping time, but that's another question. But I'm assuming that you've done -- somebody has said, okay, with this much coping time I get this big hitter in terms of benefit. I'm presuming that's --

(Simultaneous speaking.)

MEMBER BALLINGER: You think it's burn-up? Not getting rid of diesels or something like that? EPZ?

CHAIRMAN SUNSERI: So let me step in for just a second and ask this question: I mean, I don't want to turn off this dialogue if it's leading towards comments that we would make on their plan for regulating ATF fuel. If these are questions relative to approval of a specific design, then I'd like to steer away from that because that's not the purpose of today's meeting.

Today's meeting is is there information that needs to be included in their strategy such as the quality of the PIRTs or whatever, not --

MEMBER BLEY: Well, you can't do a PIRT unless you know what you're doing it for.

CHAIRMAN SUNSERI: Okay.

MEMBER REMPE: And furthermore, their plan discusses the need for SPAR models. Industry has commented you guys don't need this. And again, if you now where the end game is, you can understand what you need to do. So I guess I would offer that as a reason to explore this.

CHAIRMAN SUNSERI: But do we need to go into a closed session on proprietary data, then make that decision?

MEMBER BLEY: Well, I don't think you need to do that today, but somewhere soon.

CHAIRMAN SUNSERI: Okay.

MEMBER REMPE: Maybe before we provide comments on the plan.

MEMBER BLEY: Perhaps. But they might be -- without that they might be critical comments, yes.

MEMBER SKILLMAN: Jennifer, may I please ask a question?

MS. WHITMAN: Yes.

MEMBER SKILLMAN: On your slide --

MS. WHITMAN: Yes.

MEMBER SKILLMAN: -- on your first bullet; excuse me, the first indent under your first bullet there, changes to allow batch loading of ATF. Is there an item that precedes that particular item that is changes to allow LTAs at a higher enrichment or with a different design?

MS. WHITMAN: So --

MEMBER SKILLMAN: It would seem that there needs to be some relief, otherwise it would be difficult to install an LTA that was outside the bounds of the current regulatory framework.

MS. WHITMAN: Yes. So as I think the DOE folks were saying earlier, the DOE-targeted programs are looking at staying within the bounds of the current regulation for enrichment. And so right now in front of us we don't have anything to indicate something is solidly coming in to go beyond those. So right now we don't have that as part of the plan, but if plans develop such that something like that is going to be coming in, we would need to consider that.

MEMBER SKILLMAN: Thank you.

MS. WHITMAN: So there's -- we've talked about kind of the two different types of changes. And it might be necessary to have two different PIRTs. The initial batch loading of ATF, the -- it would be nice for the world to have more margin. And then the accrediting of the margin could be two different paths and we might be more ready for one now and be able to complete the first one now and have to revisit the second one later.

But so we've kind of gone through this. We want to identify the hazards and failure mechanisms of the different ATF concepts individually, because as we've talked about before, some of them are very similar to existing designs and may not require a lot of additional effort to understand the safety attributes and see how they fit into the current regulatory infrastructure.

There may not be any additional changes other than some guidance or individual topical reports or license amendments that would fit within the existing regulatory infrastructure, but for something like the silica cladding or the silica fuel, one example that you guys have dealt a lot with is 50.46. As it exists today, it's applicable to the zirconium-based clads

and the UO2-based fuel. So moving to something like 50.46(c) to have the codified demonstration of compliance with GDC 35 would be necessary for something like that.

So as we do the nearer term designs or ATF concepts, we envision less work needs to be done in this area than for the longer-term ATF concepts.

And so as we've been talking about the PIRT process, we really see the PIRT process being the foundation of building the safety case. It's NRC's responsibility to independently verify the safety case, but we need to take advantage of all of the experts in industry and DOE in order to ensure safety.

So go to the next slide.

MEMBER BLEY: I just want to toss in -- I'm being repetitive, but it's really important to get everything defined before you do these PIRTs. Fair and simple example: If you're interested in a little margin on critical heat flux in particular accidents, you'd get one set of results out of a PIRT. If you want five hours coping time, as I heard somebody say, there's a lot more issues to dig into including the ones that are already there and a lot more areas that you'll have to question more critically. So it's

really important to know what you're looking for.

MS. WHITMAN: Yes. And so as we talk about level of effort for these activities is going to be proportional to the departure of the ATF concept from the current fuel designs. And so to minimize everybody's expenditure of resources it's going to be very desirable for NRC, DOE and industry to work together and coordinate the various PIRT exercises that are going to go on.

So for example, we could have one PIRT that feeds the needs of NRC, DOE and industry. The PIRT could be informing NRC's regulatory requirements, helping DOE to prioritize their research and then helping industry to develop the safety case.

We're also aware that the Commission had directed a white paper on expert elicitation, and so we're going to be coordinating internally at the agency to make sure we're utilizing all of those best practices as we move through the PIRT process.

MR. HAMMELMAN: My name is Jim Hammelman. I'm the low person here on -- I'm the NMSS point of contact, so I work about or NMSS worries about getting fuel to the reactor, the fabrication of it and the storage afterwards. We're focusing on what we need

to think about to support both LTAs as well as down the road these batch or commercial implementation, if that does occur.

Initially we've taken a look at our existing regulations: Parts 71, 70 -- 70, 71, 72, and they appear to be adequate. We have and experience of licensing a spectrum of fuel fabrication facilities, various levels of enrichment, various material forms, so we have some confidence those basic regulations will work as we move into the ATF area.

Simply, there's been a spectrum of spent fuel storage facilities that have been licensed. There are pretty versatile regulations, so we've got wet storage, dry storage, canisters and a variety of things. So we think we're comfortable on that front, too.

We do recognize that there might be some particular issues that come up with a new material or a new way the fuel is being fabricated. There may be some regulatory guidance that's required, but the basic regulations appear to be in place.

We are in fact -- like the reactor people, we are continuing to stay in contact with the fuel fabrication people to make sure we're understanding where they're going so that we can make sure we're

focusing our resources on those issues that need to be addressed.

MR. HELTON: Hi, my name is Don Helton. I work in the Office of Nuclear Regulatory Research and I'm representing the staff working on the PRA aspects of the ATF plan. So that includes C.J. Fong and Mehdi Reisi-Fard, who are both in the Office of Nuclear Reactor Regulation.

The PRA parts of the ATF plan talk about four basic areas where PRA and ATF intersect, and I outline those here on the slide. They involve the maintenance of risk-informed programs at the plant, those programs that are already in place at the time the ATF is loaded. They involve the review of licensee PRAs for risk-informed licensing applications that occur after ATF has been loaded. They involve the use of the NRC's PRA models in the reactor oversight process after ATF has been loaded. And finally, they involve the questions that we'll inevitably be asked to answer such as some of the ones that you all are starting to ask yourselves today about developing perspectives on the change in risk associated with loading ATF.

So the caveat to all that is that the role of PRA in the actual licensing of ATF is to be

determined. That's something that's obviously going to have to develop as we understand better the approach that industry is taking and the details of that. And we know in your comments so far today have already alluded to the fact that PRA staff involvement throughout this process is important so that we are asking the right questions at the right time so that we're prepared to do the work that we need to do down the road.

And finally, the ATF plan outlines several ways in which very specifically PRAs can be impacted by changes in fuel design. So things like system success criteria, sequence timing and the line.

Next slide.

MEMBER MARCH-LEUBA: Going back to the discussion; I'm also repeating myself, you said you emphasize the risk impact of loading ATF fuel, which we're all going to have to agree that it better be positive, there is no risk increase by loading the ATF fuel, because you will demonstrate that it's good for severe accidents. There might be some normal operation that ends up be negative, and if it's very bad, we'll remove them and put the other fuel in. So it won't have a negative impact.

But the likely scenario is the operators will come back with offsetting operating procedures, reduction in emergency systems. And so compensatory procedures to getting -- to use that margin. Will that be part of your analysis?

MR. HELTON: So the key here in that regard is really the first line on that slide. The PRAs, both the NRC and the licensee's, need to model the as-built/as-operated plant to the extent necessary for their application. So in the sense that ATF is a change in the plan, to the extent that has an important or a change to the as-built/as-operated plant that's important in quantifying the risk for the plant, then that needs to be incorporated.

Likewise, downstream changes, it's the same thing. It's more of a process question than trying to have a presumption that there's going to be a net increase -- or a net decrease in risk that's immediately going to be compensated for by other changes. It boils down to the PRAs modeling the as-built/as-operated plant, whatever that as-built/as-operated plant looks like.

MEMBER MARCH-LEUBA: Okay.

MEMBER POWERS: Don, one of the issues that

weighs heavily on my mind is I can see how some of these new fuel designs could help one in the DBA land, but I see them as being catastrophic when I move into severe accident land, which is just much worse. If our focus gets so focused down and we're looking at just design-basis impacts and don't have PRAs with the deterministic modeling to tell us is there a cliff edge effect here if we go a little bit beyond the DBA region, we have just a terrible situation.

Are we sure that we're not going to get trapped into looking too narrowly with our PRAs?

MR. HELTON: Okay. Sorry, could I -- I just missed the last word of that.

MEMBER POWERS: Looking to narrowly with our PRAs.

MR. HELTON: So the PRAs, as you know, by definition are looking at beyond-design-basis conditions, even if they're design-basis accidents --

MEMBER POWERS: Well --

MR. HELTON: -- with additional failures.

MEMBER POWERS: -- let me say that I have seen some analyses of some ferritic stainless steel clad fuels done in which the core degradation modeling was laughable. I mean, it simply did not reflect the

way the ferritic stainless steels behave when you get up to the melting point. And that's not the fault of the people. They didn't have any models of that. But they come to a set of conclusions out of those that cannot possibly be correct because of the crudity with which they had available to them the tools to model the severe accident land.

MR. HELTON: So then answering at a different -- on a different level, I would paraphrase what you just said to be you sure are glad that these folks had the foresight to invite the PRA people to the table at the beginning rather than waiting until it was too late.

MEMBER POWERS: Absolutely. I'm always happy with that.

(Laughter.)

MR. HELTON: So I mean, that's the bottom line here for us is that's why we're here. We're here to try to keep -- to be a voice for those concerns such that when a strong design-basis understanding is extended to the modeling of the plant response in beyond-design-basis space there is technical credibility to how that's done.

MEMBER POWERS: Okay. Very good.

MEMBER CORRADINI: Don, I guess I think what Dana's asking; he can correct, but I think is there's going to have to be experimental data; he picked ferritic steel as the example, such that you might get a benefit in terms of delay of oxidation, but once you get to certain levels of temperature, the cladding will behave totally differently. And without data one could make the wrong assumption of what you'd expect to occur.

MR. HELTON: Yes, I mean, that's certainly true. There's going to have to be a technical basis for how these things are modeled, or how the fuel modeled under beyond-design-basis conditions. And part of that technical basis is going to come from some of the work that has to be done for source term development, but some of it's going to go beyond that. And like the current generation of zirc oxide UO2 fuel, that's going to be an evolving state of knowledge.

So what we can do at this point is to make sure that the right questions are being asked and that the people running the experiments and doing analysis have these questions in mind to lead up to having a credible technical basis at the time that ATF is loaded and to then thereafter try to continually evolve that state of knowledge just as we've done since WASH-1400

for zirc oxide UO2 fuel.

MEMBER CORRADINI: Okay. Thank you.

MR. HELTON: Okay. And then just real quickly, the second slide here for PRA, the plan itself talks about a series of activities that involve continual engagement like what we were just talking about: licensing review support, as needed; SPAR model pilots; licensing and oversight guidance updates; and finally the update of the agency PRA models.

Joy earlier brought up the point about the public comment about why do we need SPAR? And I just want to make the point there that we can clarify the language in the plan. The point we were trying to make was not one of, well, we need SPAR in order to license ATF. That's not the point. The point is SPAR are our PRAs of record for the reactor oversight process and they need to reflect the as-built/as-operated plant.

And then finally, just two caveats to what the plan does not contain at present. One is consideration of changes in regulations that would be designed specifically to allow different types of credit than what is currently built into those. And the second one is treatment of -- graded treatment if we were going to have periods of time with six

substantially mixed cores. So right now we're viewing this more as sort of a binary situation. That's all I have.

MR. PROFFITT: We'll do a little shift change. Don and Jim, I think you guys are good. And we'll ask Michelle Bales to come up.

MS. BALES: Hello, I'm going to speak a little bit about analysis capability development. So I'm Michelle Bales, from the Office of Research, and that's where staff were looking at what's required to update NRC's analysis capabilities in the disciplines of fuel performance, thermal-hydraulics, neutronics and source term.

And in each of these disciplines the staff experts really see a process as following the same four steps: So first, examining what's needed in the analysis capability development, taking information from -- coming out of PIRTs to look at which models are going to change with these new technologies and making sure that we have identified the information gaps that require the data. We'll need to update codes.

The second step is examining the architecture of the codes to look for ways to make them more flexible. So a lot of the codes were developed

for uranium dioxide fuels and they have some of the assumptions about those fuel types imbedded in the code language, so the developers are looking to address that and make the codes more modular or flexible and so that they can more easily evolve to a variety of accident-tolerant fuel concepts.

And then all of the codes will need to be updated with new material properties and models relevant for the new technologies and then be assessed and validated for integral performance once those materials have been updated.

And the experts have looked at what's required kind of at a high level and tried to estimate how long it would take to have the codes ready to make assessment of ATF. And for the near-term designs they range from one to three years. For some of the longer-term designs they range from about three to six years, depending on the code and the technology.

And one of the things that you'll see in the timeline is that we assume and take the benefit of a lot of interactions with DOE and industry. You heard earlier that one of the assumptions in the project plan is that NRC won't be running any independent confirmatory testing. We're really trying to work with

industry and DOE to identify the data needs and provide feedback as programs are being run so that we can ensure the product of those programs are going to meet the data needs for code updates. And a lot of the property and models as they're being integrated into the codes, we may identify that there's other gaps. They'll be back and forth. So that's why you see arrows going in both directions for a lot of these programs. And as test programs are being conducted we're also looking to do code updates in parallel so that these programs can feed back to each other.

MEMBER POWERS: I applaud your interactions here, but you're still interacting with a very narrow part of a technical community, or a peer community here. You're interacting with the industry and there are various EPRI and whatnot. These are all advocates for these things. And so where do you go about interacting with informed technical community that's not an advocate?

MS. BALES: I think a lot of that is going to be in the PIRT process. We really have to build the PIRT exercises to include folks from academia who have been studying these materials for a long time. They know their vulnerabilities, they know their fire

modes, or they ask the right questions so that people become aware of the vulnerabilities.

And so my short answer would be in developing a PIRT panel we need to really be conscious of getting outside of the advocate community.

MEMBER POWERS: And that's a good answer, I mean, a plausible answer certainly and --

(Laughter.)

MEMBER POWERS: -- an approach, but that's something I would give some more thought. I mean, I would give a lot of thought to it, because any community quickly becomes a closed community. You're aware of this. I'm not telling you anything that you don't know. But I would seek out -- and you -- the NRC has the advantages that it has some international peers in this world that they can draw upon that maybe have an independence.

I'm thinking of course of IRSN, maybe some Korean or Japanese organizations that you could bounce some of your thoughts and thinking about things off. Similarly, you could try to draw upon the American Nuclear Society by presenting your plans and whatnot and say here's what I'm fixing to do. What do you guys think?

I mean, I would think broadly in this to assure that I wasn't getting focused in what I was looking at too much.

MS. BALES: Yes.

MEMBER POWERS: I mean, you have to be a little bit focused or you never get anything done. But to get a breadth of opinion that may not be available just because you're working on a schedule against a budget and whatnot -- I mean, it's nobody's fault. It's just the way life is and you need -- but yours was a good answer and --

(Simultaneous speaking.)

MS. BALES: No, but I think that also in some of the joint programs; like for example, the Halden Program, you get that peer community together, and they're a skeptical audience. As Halden presents some of the results from their tests, there are people from Japan, Korea, France who are asking different types of questions because their context is different.

And so I think that a lot of the -- well, historically in the integral effects area where you're looking at reactor programs and you have a large peer community coming together to fund those, you get some of that feedback as well. So I think this slide is

pretty over-simplified, but besides the PIRT process I think ongoing in some of the experimental programs there is an opportunity to get external peer community --

(Simultaneous speaking.)

MEMBER POWERS: Yes, you're thinking about it and it's good. And I would -- when I talked about it, I would reflect that thinking --

MS. BALES: Yes.

MEMBER POWERS: -- a little more than saying, yes, I'm just going to work with the advocates on this thing.

MS. BALES: Yes.

MEMBER POWERS: That may not give you full credit for what the breadth of your thinking was.

MS. GAVRILAS: This is Mirela Gavrilas of the staff. I think your recommendation is a wonderful one. There's -- we mentioned in passive -- in passing those good practices for eliciting expert opinion, and those cover how to go about making sure that you minimize biases.

But in addition to that I think your suggestions about subjecting the plan to a broad peer review and engaging with entities that have no incentive

to sugarcoat is great advice. Thank you.

MEMBER REMPE: So I had a different question. It's the question I keep asking from the beginning of this meeting. What's your plan with the -- how to do this with TRACE versus MELCOR when the control materials relocate? Are you going put some sort of trigger in TRACE and use it for considering reactivity feedback or are you -- on the record can you say, are you going to use MELCOR?

MS. BALES: I heard your question and was talking in the margin to Joe so that he could come and help me, because I think he's going to be able to give you a much more satisfying answer.

MR. STAUDENMEIER: Joe Staudenmeier, Office of Research, DSA.

Right now we don't have any idea of all the sequences we're going to need to analyze. We haven't seen anything specifically from the industry, but if that arose that they proposed limiting or moving peak temperatures up in that range where control materials melted, we'd -- certainly could put something into TRACE to say either stop the calculation and we need to do a MELCOR calculation or put in some model assuming some melt rate of the control materials and

put in reactivity insertions that corresponded to that. We don't really know yet what we would do, but those are possibilities that we could consider, yes.

MEMBER REMPE: Yes, there's -- when I think about -- again, I'm more in the weeds I guess than other members, but when I think about how I'm going to analyze this, that was the concern. I know you probably are well aware that in MELCOR the channel boxes and I believe that the way that the core is modeled that you have to break out separate components. And so there's a lot of things that you're going to have to do. From what I know about MAP, industry's going to have to do that. And I'm not so sure of what's in the CRIDR codes as I mentioned earlier.

MEMBER MARCH-LEUBA: Yea, but, Joe, help me on this one. I mean, if you're melting the control rods, it's because you don't have any water in the core. So you run it, you melt it. And then when you put the water in, you remove the control rods from the model. It's not a complicated calculation.

MEMBER REMPE: It's not, but then there's -- what will you do in design-basis accidents? Is it normally going to consider those kind of temperatures?

MR. STAUDENMEIER: We don't --

MEMBER REMPE: And then the dividing line to go over to MELCOR. It's just I think something that I haven't seen. And I think you've confirmed there's not a --

(Simultaneous speaking.)

MEMBER MARCH-LEUBA: Joe is the number one expert in the world in TRACE. I don't think you've ever had a model that had a control rod modeled in TRACE.

MR. STAUDENMEIER: We don't have any plans to put any SCDAP-like or MELCOR-like models into TRACE for melting out control rods.

MEMBER REMPE: So you'll have to --

MEMBER MARCH-LEUBA: So you --

(Simultaneous speaking.)

MR. STAUDENMEIER: So we would have to model it with some sort of --

MEMBER REMPE: Reactivity?

MR. STAUDENMEIER: Yes.

MEMBER REMPE: It -- yes, it -- just it's not clear to me how you're going to do it and I just am bringing it up now because I --

MR. STAUDENMEIER: Yes, it's not clear to us either.

MEMBER MARCH-LEUBA: And for us it is

terribly important, because we could -- this is one of those cliffs that Don is talking about, that you forget because you never put control rods in TRACE.

MR. STAUDENMEIER: Right.

MEMBER MARCH-LEUBA: I mean, you just don't put them in there.

MEMBER REMPE: Yes, but --

(Simultaneous speaking.)

MEMBER MARCH-LEUBA: -- forget about it.

MEMBER REMPE: Yes, and I don't think the CRIDR codes have thought that through yet, too. And so I just -- I think probably your better suited to try and figure out with your tools on what should be done, which is why I think industry is using MELCOR on some of -- or the DOE was at least.

MEMBER MARCH-LEUBA: And it's not a simple calculation, because the control rod is mostly hitting up by radiation.

MR. STAUDENMEIER: Yes, and --

MEMBER REMPE: Yes, it's just --

MR. STAUDENMEIER: -- the plant may not be able to meet GDC criteria anymore of being able to shut down the reactor if you get into --

(Simultaneous speaking.)

MEMBER REMPE: Two diverse things. And that's why when you mentioned earlier about, oh, it will be safer, it's not clear in my mind yet. I want to understand better if it's safer with these accident-tolerant fuels without making some other changes.

MEMBER MARCH-LEUBA: My claim before is if it's not safe, then we wouldn't insert it in the core. We would not load it in the core.

MEMBER REMPE: Yes. Well, I think that that's something we'll have to learn. But anyway --

MEMBER MARCH-LEUBA: And my concern is that as long as we keep the reactor operating plans and the strategies and the equipment the same as it is now, then it will be more safer. The problem is when you start getting a little safety from the core and then you start removing equipment because you don't need it anymore. Say that you only need now two diesel generators instead of three or things like that. That result worries me because we don't have the experience of the last 50 years of operation in this fuel.

MEMBER POWERS: We definitely have experience operating with fewer diesel generators, because we've had them --

(Laughter.)

MR. PROFFITT: Okay. Thank you, Michelle.

Getting into the public comments, I'll try to gloss over some of this, but the plan was issued for public comment for 45 days. We received nearly 80 comments from those organizations listed there, 10 organizations and individuals. The bulk of the comments came from NEI and their members.

So a quick breakdown of those comments to help you visualize what topics they were on. The biggest chunk of them were on the licensing process and how we may be able to have some transformation or innovation in our process for licensing. Thirteen percent on our codes and whether or not we use our codes, use other codes, don't use codes at all. Coordination and communication. Just emphasizing the importance of that. Ten percent on PRA, ten percent on the evolutionary/revolutionary vetting of the designs, some general and then LTAs and timeline.

Just slides from the public comments. We wanted to just give you an overview of what those were and our initial thoughts on addressing those.

Concerns that the regulatory requirements

associated with lead test assemblies. While we recognize that's important to ATF and the development of that, we considered outside the scope of the plant is it's normal operating -- normal licensing process at the NRC and we are working on that. NRR set up a steering committee to address the concerns with LTA programs.

Emphasize the importance of communication and coordination. Again, the staff is committed to continue that and enhance where we can. We are fully on board.

The "evolutionary" versus "revolutionary" language. We plan to remove that and replace with "near term" and "longer term." Again, we're still open to any other terms that someone may want to suggest. That was originally put in as a term of convenience just to have a qualifier on the differences in the state of knowledge and the departure from the current technologies.

Opportunity to transform the fuel licensing process. Dana, you mentioned this. The staff is always looking for efficiencies and we're always open to specific suggestions where that could be done. And I will get into a little bit more on that,

some of the considerations we're looking into.

The plan does not support the industry's deployment schedule and we're not employing a graded approach. So again, as we stated I think a few times through this presentation, we believe that the timelines we put together to prepare ourselves are consistent with and will not delay the industry's schedules that have been shared with us so far.

We're committed to minimizing the lag between the time that the industry would be developing the technical basis and the licensing of that activity. I think a lot of those things we've discussed here today and Paul mentioned kind of right in the beginning about the importance of being plugged into the experimental programs and making sure that they will be successful in providing the data that we need to make our safety conclusions.

MEMBER POWERS: So what happens when you say, gee, you submitted it and we don't have this data and you need this data to make a licensing decision and they say, ah, you're delaying our schedule?

MR. PROFFITT: I think that would be a fact of live at that point. We hope the plan and the communication prevent that from happening. I mean,

that's certainly the goal of this whole exercise is to make sure that the products that we get will be able to meet our needs.

MR. CLIFFORD: I mean, one option, Dana, would be -- for instance if they were lacking sufficient high burn-up data, one option would be to grant them a limited approval --

MEMBER POWERS: Sure.

MR. CLIFFORD: -- some lower burn-up level --

MEMBER POWERS: Sure. Sure.

MR. CLIFFORD: -- and allow them time to gather high burn-up data.

MEMBER POWERS: Yes. Yes, sure.

MR. CLIFFORD: Essentially that's what we've done historically. Then you started --

(Simultaneous speaking.)

MEMBER POWERS: We've done that many times, yes.

MR. CLIFFORD: They start at something smaller and they've worked their way up through time.

MEMBER POWERS: Yes. Well, we've done that several times.

MR. CLIFFORD: Or it could be a limited

approval.

MEMBER POWERS: Yes. The more difficult one is where they don't have any data at all.

(Laughter.)

MR. PROFFITT: You make a good point.

And so the PIRTs we believe will inform the licensing road maps and how each concept kind of progresses through the chart that Paul presented earlier. Again, some concepts will be able to easily exit a lot of those boxes. Others will stay in each box for quite some time.

The PIRTs will help facilitate this tailored approach for each concept and essentially make it a graded approach.

So this is sort of an illustration of what I was just saying, and one thing that may be missing there in between the project plan and the road map is the PIRT. So for the project plan, it lays out the overall strategy. And then as we conduct the PIRTs and we can really lay out what the licensing road map looks like for each concept. And then even below that would be if there's multiple vendors for a concept how they choose to proceed. That could be different and acceptable.

MEMBER CORRADINI: If I might just jump in, I think that figure is good because if you proceed from left to right, you're going to need to plan ahead about data as necessary. Just even take your second box in terms of ferritic steels. There's going to be needed for experimentation -- or they may have a long lead time. Otherwise, you're not going to be able to answer some of the questions that Dana for example has been raising.

MR. PROFFITT: Absolutely. So some of the licensing efficiencies we have under consideration. Again, the staff is continually looking to improve on our processes where we can while maintaining safety. So expediting the regulatory guidance, being able to enhance our internal processes to make that a quicker process.

Exploring the use of vendor inspection to verify the data intended to support licensing activities. So, this not only -- with the staff being involved with the design of the experiment and understanding the capabilities of the experiment, but having vendor inspection actually be able to lead credibility to that so that we don't have to go back and question that data as we're doing our review.

Potentially a change process for topical reports. This goes to kind of Paul's last comment and, Dana, your consideration there where as they gain more data they could feed that back into their topical report and not have to come to us for another review and putting in some type of process like that in place before --

MEMBER POWERS: That's a good idea.

MR. PROFFITT: -- we get to the submission of topical reports.

And then leveraging the use of DOE codes. I have another slide on that a little bit further.

This graphic just goes to show kind of what this plan does. It allows for a lot more events to happen in parallel while we maintain our independence and our ability to come to a safety conclusion as opposed to us doing the work for the regulatory infrastructure up front then the industry going off for 10, 15 years, developing the technical basis and then us questioning it along the way. We can have touch points where we interact so that more can happen in parallel.

So on the leveraging of DOE or advance computational capabilities, first we start off with the need for confirmatory calculations. We don't always do confirmatory calculations as the staff. I

mean, obviously this is informed by the margins that there are, the uncertainties that exist, and it really depends on the strength of the technical basis presented by the applicant. And also sometimes it's very easy for us to run a confirmatory calculation, so we go ahead and do it and that helps the review go quicker.

The use of non-NRC codes. Again, this is something that we're very comfortable with as a staff. We've done this in many instances where we've used either the same code as the license or a commercial code or a DOE code.

And then the effectiveness and efficiency of using non-NRC codes depends on a lot of factors. One good thing about the NRC codes is most of the staff are very fluent in their use and can easily perform the calculations they need to do.

MEMBER POWERS: In the previous era we would have had an academic sitting here and in language that's far more eloquent than I can generate just excoriate you over the use of "fluent" for a licensing activity because you don't -- there's so many things in commercial codes you don't have access to. He would call attention to convergence forcing in fluent. He would call attention to the two-phased flow

correlations that are built-in to fluent and things like that and say you don't know how those are behaving.

MR. PROFFITT: Yes.

MEMBER POWERS: And you don't know that you're avoiding compensating errors in the commercial codes.

MR. PROFFITT: Yes.

MEMBER POWERS: I think he's in fact -- would be in fact correct when he raised those objections. And my recollection is we tend to use things like commercial codes when we're looking for the qualitative behavior of a system. Then when we actually come down to the licensing we use something that we know and love, even if it's cruder.

MR. PROFFITT: Well, it depends. It's case-specific certainly and depends on what the need is that the particular reviewer is looking to -- what itch they're trying to scratch and then what tool they need to use.

MS. GAVRILAS: This is Mirela Gavrilas of the staff, and I specifically called my colleagues in Research yesterday to talk about this. And the example we put here is the work that's done in support of heat rejection in dry storage casks, single-phased that

-- where the staff feels that there is ample V&V done that now has qualified the code sufficiently for our use. that's the specific example on this slide.

MEMBER POWERS: Well, I also knew or have read things where the Department of Energy is encouraging you to use codes that are not static; that is, the calculation I run today will be on a code that's quite different than the code I have available to me tomorrow. What do you do about that? I mean, they've been very insistent that you take advantage of -- well, let's say CASL or something like that. That code is never static. It's always changing. You can't keep the computer science people from not changing it.

MR. PROFFITT: That's a valid concern and it's something that we're -- part of the plan we're really trying to engage more with DOE, understand the capabilities, understand what we could use and what would make sense for us to use, but obviously we are very comfortable with our -- the tools that we have in house.

MEMBER POWERS: Well, in house you've -- I mean, you've looked at them and everybody else has looked at them and you have some idea what they're good for.

MR. PROFFITT: Yes. Yes, absolutely.

So our next bullet is about the simulations in lieu of experimental testing. And at this time the staff is not currently aware of computational tools that could obviate the need for experimentation to support licensing decisions. Certainly some of these more modern and advanced computational capabilities can help inform the experimental testing programs, and hopefully expedite that process by preventing failed tests or tests that don't get you the data that you need, but we don't think they could replace it at this point. But obviously we're always receptive to addressing that and continuing that conversation. That's all we have.

CHAIRMAN SUNSERI: Okay. Andrew, there was one comment that I read in the public -- or in the comments you received, and I'm going to paraphrase this because I don't have it before me. So if I don't have it right, correct me. But it was something to the effect that the NRC is obligated to do independent research to support the licensing activities. How do you plan to address that comment in light of the fact that your stated objective is not to do independent research?

MR. PROFFITT: Yes, we don't feel that's the case. We certainly have an obligation to independently confirm the technical and the safety basis in front of us, but doing our own confirmatory testing, we don't feel that we have the need to do that.

CHAIRMAN SUNSERI: And the basis for that feeling is?

MR. CLIFFORD: Well, I mean, I wouldn't say independent. It's really how you define "independent." In other words, just because you work with the industry to design the experiment to gain hours at the facility and to pick the parent rods, it's really the breakdown of the data, the manipulation of the data that results and how you interpret the data and how you then use that data to inform a regulatory decision where it can be different.

I mean, a good example was we conducted a very extensive high burn-up LOCA research program at Argonne National Labs, which was the basis of revising 50.46(c). That research was a joint research effort with the industry being involved. So it's something we've done in the past.

MEMBER POWERS: And that's something the Commission has effectively agreed to with your Memos

of Understanding. The data are the data.

MR. PROFFITT: Right.

MEMBER POWERS: And what we know from experience of course is that if you simply allow people to generate data, they will generate data as they see fit which may not match your requirements. And what you've attested to us here is the now you're going to be an active participant in the collaborative effort. And that works. I mean, it's a good idea.

CHAIRMAN SUNSERI: All right. Thank you.

Any other comments from the Committee for this group?

(No audible response.)

CHAIRMAN SUNSERI: All right. Well, thank you very much.

MR. PROFFITT: Thanks for having us.

CHAIRMAN SUNSERI: Thanks, Andrew and your team. And we'll move onto the NEI-EPRI group now.

And due to the robust nature of the questions we're running a little over time here, so -- and robust answers that were provided.

So we can run a little over 12:00, but I'd like to really finish up by 12:30.

MR. MAUER: Welcome, good morning. And

thank you to the subcommittee for inviting the industry and EPRI to participate in the discussion this morning. We will be sensitive to the time and the schedule today. And I think a lot of the stuff that we are going to cover, you know, has been touched on to some extent. So we -- we will be as efficient as we can going through.

I am Andrew Mauer with the Nuclear Energy Institute and along with me Ben Holtzman from NEI and Al Csontos from EPRI -- he doesn't need an introduction to this group. Before we get into the presentation I just want to, you know, just emphasize up front -- and I think it's -- its's stating the obvious, but ATF is really a key innovation for the industry. It's one of our top priorities. And we have a lot of significant industry engagement, momentum and interest. And outside of the industry we obviously have -- in the U.S. we have a lot of interest internationally. And we've got strong support from the NRC and the Department of Energy and the National Labs which has been very valuable and will continue to be for us. Next slide, please.

So this slide -- and I think you have hard copies. It might be difficult to read on the screen. Sort of as a high-level picture of -- of the path

forward that see in some of the areas that we're actively engaged in. So our overall objective is to enable initial deployment of ATF technologies in the commercial reactor in the early to mid-2020s. I am just going to briefly step through the collective efforts needed to get there. We've essentially already touched on those in the previous presentations this morning.

So starting on the right side here where it says safety benefits -- you know, we have made significant progress to analyze the safety benefits of the technologies and begin to articulate the economic case to move forward. Al talked about that a little bit earlier. We are impressed with the initial results. There are clear safety and economic benefits. But as Al also stated, we have additional evaluation activities going on this year and we're very much working hard on that front. On the left -- oh, go ahead. Sure.

MEMBER MARCH-LEUBA: Let me re-ask the question we asked earlier this morning. Nobody is considering going over to five percent, correct?

(No audible response.)

MEMBER MARCH-LEUBA: Because if you do,

then there is an awful lot of stuff that needs to be done.

MR. MAUER: So let me -- let me pause on that question until we get into the technologies on the next slide.

MEMBER MARCH-LEUBA: If you go over five percent transportation casks, you need to do it for UF6 --

MR. MAUER: Got it.

MEMBER MARCH-LEUBA: And then you have to re-license all of them.

MR. MAUER: Certainly -- certainly. Understood, understood. So on the next -- going to the blue column here on the left -- and I categorized it by -- by R&D -- we did recently celebrate the initial load of lead test assemblies at Plant Hatch in Georgia. They're loaded so that's -- that's great. We do have additional stations planning to load in 2019. And we'll talk about that in the future slide here.

These activities are really an essential piece in providing us the key data we need to study the performance of the technologies. The LTAs are obviously just one piece of a very large volume of efforts planned and underway across the industry and

government that we're actively involved in. And you -- you heard a lot from the Department of Energy this morning on that front.

MEMBER SKILLMAN: Andrew, the -- what I understand as loaded really isn't the fuel rod. What you have is the rod that has a different exterior coating. And so what you're really looking at is the clad that is supplement as opposed to a difference in fuel. Is that accurate?

MR. MAUER: Is that -- I believe that is accurate, yes. Do you want --

MEMBER SKILLMAN: Okay, so -- so with your LTA what you're really doing is not -- not exploring fuel burn-up, that type of thing. What you're really looking at is clad corrosion, robustness of clad coating.

MR. MAUER: So we broadly categorized this category of lead test assemblies, you know, in that broad header, but when you get into the specifics for each of the plants, you know, whether it's lead test rods, assemblies and the fuel there are differences there. The next slide we're going to get into some of that in particular.

MEMBER SKILLMAN: Okay, thank you.

MR. CSONTOS: But I believe it was iron for a little bit of -- it was the iron clad, not -- not a coating.

MEMBER SKILLMAN: What I am trying to get to is you didn't change pellets, you didn't change enrichment, you didn't change densities --

(Simultaneous speaking.)

MR. CSONTOS: Correct.

MEMBER SKILLMAN: You're working on the outside of the cladding at this point.

MR. CSONTOS: Correct, and we'll -- and as Andrew mentioned, in like -- I think in two slides we go into a little more detail in terms of what actually are in those LTAs.

MEMBER SKILLMAN: Thank you.

MR. MAUER: Actually -- but before we go there -- if you could -- so on licensing, I want to say that, up front before we get into the comments and we discuss some of those -- the staff did. We very much appreciate the staff efforts to develop the licensing plan and allow for stakeholder input. I'd say it's a little unique, maybe awkward, in that we have not yet had a public meeting to review the comments and have the dialogue with the staff before we come

here to the ACRS subcommittee, which we usually have and benefitted from some of those interactions. So I just want to point that out. You know, we're still working through this. We literally just submitted the comments a few weeks ago on February 5th. So we're still working through that. It's a work in progress.

But certainly, as we look at the presentation this morning, I think, you know, there's certainly a strong willingness to look at the comments and address them in a positive way. And it's -- it's very promising to us as we go through that and hear that discussion. So we'll look forward to further discussion next Tuesday at the public meeting. With that, let me stop there and go to the next slide and turn it to Ben.

MR. HOLTZMAN: So this is a very high-level summary of kind of what you already saw at the DOE presentation. So we're not really going to dwell too much on this. But this is just meant to kind of highlight some of the overall technologies that are in development by some of the different vendors under consideration. So this slide is kind of talking through the lead test assembly that are planned for the United States so far.

And as you can see under the first bullet -- which was Southern's Hatch -- so the -- what I think you're alluding to, the -- the iron chromium aluminum clad fuel is a non-fuel rod. And that -- and you are correct in that these LTA -- the -- the rods as part of these LTA are not changing the fundamental structure of the pellets or enrichment or anything like that. The near-term LTA programs are all primarily focused on the claddings. These are things that -- that in the future we will be looking at in terms of -- as those technologies get more developed in terms of also having their own LTA programs.

MEMBER BALLINGER: Have any of these licensees incorporated any -- any of this stuff in their PRA?

MR. HOLTZMAN: Yes, we're not -- we're not certain on that. So what you can see in this slide, though, is the general, high-level interest again in terms of cladding -- coated claddings as being kind of the near-term -- the near-term ATF concept that our industry members are looking into implementing.

MEMBER SKILLMAN: Let me ask this. When Exelon or Southern Nuclear choose to make this change, do they do this under 50.59 and determine that they

need a licensed amendment request? Or -- or is there some other process that they are using? I would expect they are doing some form of a COLR -- Core Operating Limits Report -- update or change, informing the commission of what they're doing. I'm just curious -- it gets back to the question I asked early on, which is what -- what's in it for them? At least, my experience is this is not a small undertaking for the licensee. So -- so -- you know, how does this work?

MR. MAUER: Well -- and I don't -- I will tell you, this is -- there are certainly ongoing dialogue with the staff, and in particular with some of the individual licensees as they chart their licensing strategy out for -- for the lead test assemblies for -- for Southern -- and I don't want to speak to each of the -- each of our members here, but there's a -- you know, a publically documented -- give me an occasion from the NRC, for example, to the Congress that -- that stated the agency was comfortable with the use of 50.59 for -- for Southern. So --

MEMBER MARCH-LEUBA: So this is an LTA -

MR. MAUER: It's an LTA licensing question. I don't -- and -- and, you know, we were really prepared to talk about the project pending this

morning and we quickly get into individual members and licensees, which we don't want to --

(Simultaneous speaking.)

MEMBER MARCH-LEUBA: It's probably just one bundle, at most four.

MR. MAUER: Right.

MEMBER MARCH-LEUBA: And located in non-limiting conditions --

MR. MAUER: Correct. But unlimited --

(Simultaneous speaking.)

MEMBER MARCH-LEUBA: The LTA-approved procedure --

MR. MAUER: Correct.

(Simultaneous speaking.)

MR. MAUER: Yes, this hasn't been done historically and regularly -- that's right.

MEMBER MARCH-LEUBA: Almost every plant has an LTA law --

MR. MAUER: Exactly. Exactly.

MR. CSONTOS: Okay, so you've heard a lot about the PIRTs and the discussion about the PIRTs. And so the rationale for the PIRTs and to why EPRI and utilities and industry are supportive of the PIRTs has been that we believe that when you have a lack of

regulatory guidance -- especially for some of the more exotic or the more longer-term concepts -- silicon carbide, metallic fuels, uranium silicide -- that getting NRC engagement early on the process would be highly beneficial -- highly beneficial to provide that type of structure that we talked about to the -- informing the R&D priorities. And that's the key there is that -- are there key tests that need to be run? Are there key information that we need to know so that we can either get a value statement out of it or a safety consideration out of it? And to see whether or not there are critical path, critical tests that can provide us the information that we need to make certain decisions -- either business or safety decisions in the future.

And so we are under discussions right now with Mirela and the Office of Research and also DOE and Bill -- and as well as OECD/NEA. There was a discussion earlier about international participation. I would love to not duplicate. I would love to not triplicate and quadruplicate -- if that's a word -- to this type of expert elicitation -- and do it only at one time with all -- as many international experts as -- and domestic experts that are specific to these

cases. And we had a lot of discussion about that. I think Josh alluded to the meeting that we had down in Fort Worth, Texas -- the seventh annual EPRI-DOE-INL-ATF workshop. And there was a lot of discussion about the PIRTs and making sure we have --

MEMBER MARCH-LEUBA: Would people see that -- keeping technology -- do a PIRT for one technology and then --

MR. CSONTOS: Yes.

MEMBER MARCH-LEUBA: Another one for another technology? Or all of them together?

MR. CSONTOS: No, no. Definitely separate. Because they're all very, very different. And so you need to have it specific to the technology that you're looking at. And so silicon carbide would a silicon carbide PIRT because there are multiple vendors that are looking at that. And so -- and looking at the fuels -- things along those lines that we're looking at. Because, like I said, when you're changing the fuel there's a lot of data that you need to collect -- a lot of testing that needs to be done, both static and dynamic as -- and -- and, you know, all sorts of tests.

So getting that and documenting that with

-- especially with NRC participation in that to help us prioritize the data needs and the testing needs is really critical for that. And how we do that is through the NRC-EPRI-MOU as well as the NRC-DOE-MOU that is looking at these cooperative efforts that we could do to -- on these expert elicitations. It's explicitly in there in the MOU agenda.

And so that is -- we talked about earlier about some of the things between what can be done independently. Well, the data -- identifying the gaps, if you want to call it -- that's what the PIRT's there for. And identifying those gaps is -- is the first priority.

But then how we resolve the gaps, that's a separate item that the NRC could have a separate report on, DOE could have a separate report on, we could have a separate report on as the industry. To look at how are we going to resolve those gaps? And in what priority that we -- we call it? Okay?

And so that's where -- I use these examples on the right-hand side. Many of this -- on this subcommittee know about the work that was done for long-term operations, second -- subsequent licensing rules, licensing rule. We already looked at that PNBA

was the was the -- Mirela worked on the PNBA for -- for NRC. The industry looked at the -- this material degradation matrix. And then we all developed an issue resolution report, which was called the Issue Management Tables. And so that was our way of how do we address all of those technical issues to get to licensed removal and subsequent licensed removal? And that's just the example.

So this is the vision -- what we're looking at. And -- and I would love to put NRC and DOE and OECD on this, but I -- but before -- but we're still in negotiation or discussions about this. But the goal here is to foster the ATF-stakeholder engagement that addresses those technical and regulatory issues. It's the phased approach. It's something that we can leverage the global resources to identify, prioritize -- create that structure for the R&D needs and tackling the R&D needs going forward. And it -- also in a time frame that meets the industry's goals. Okay?

And so this also goes to resources and how do we get those resources to attack these issues? So going through the phases -- Phase 1 is what we talked about -- you heard a lot of discussion here about, you know, how many PIRTs? What kind of PIRTs? What

different phenomena are we going to be looking at?

That's the first step, is we need to create the steering committee that address -- that creates charters, identifies the structure, creates the charters for each subcommittee and also the goals -- the common goals, the common needs and the focus areas that we need to go after. Then we establish those technical groups, find the experts out there, fill those gaps -- or, fill those -- the -- the -- the teams. And then we go and develop those PIRTs in a systematic way over probably the next -- for each different concept, it -- some of them may take much longer than others just because of the issues, especially in the fuel area. So -- and I think that's it, right? Then back to you.

MS. GAVRILAS: Chime in for just a moment for clarity. So the general construct of conducting PIRTs that are concept-specific has been discussed in these meetings. But this goes beyond what's been discussed so far. So I just wanted to say that the agency has not as far as Al portrays on those slides. Those are details that you haven't discussed yet?

MR. CSONTOS: Yes, that's correct.

MR. HOLTZMAN: So, our overall -- and this

is going to go through some of our comments and implementation that -- suggestions on the project plan. And I know the NRC before us talked through some of this as well and not only for our comments, but over -- some of the other comments. So we'll try to move through this as well fairly quickly. Our main ideas, feedback, is, you know, we want to try to break the sequence that we see as a series of licensing actions into more parallel processes.

We want to try to move forward in a timely fashion in terms of licensing of extant tolerant fuel technologies. Part of this is that we see that we can do some of the nearer-term concepts faster under the existing framework -- the coatings, things like that, whereas we recognize that the long-term concepts that need additional research and development as Al is going to -- was just talking through the PIRT process. You know, it has more -- has more details and more things that need additional flushed out.

We fully recognize that our own public timelines that we've put out there need additional details. And we look forward to working with the NRC in terms of -- having those timelines come into alignment so that we can really work together to drive

those things forward. We see this processes -- in terms of implementation -- you know, iterative, working back-and-forth, working with the NRC, working with our different member organizations -- partner organizations such as EPRI as you know, in order to really get these things licensed and have a positive benefit to the industry.

So one of the -- and one of the points that the NRC made as well, we believe that the level of effort should be commiserate with the safety significant with the design changes. So again, going to things that are, you know, coated claddings, couple -- tens of micrometers of -- of coatings on the existing cladding structure -- you know, we view this path forward as something where, you know, we did -- straight -- that there isn't a degradation of safety. And then we can get this into reactors.

And then once we can start getting more data and start trying to go for benefits, that's when we really see this being a change forward. But it's -- fundamentally, that's essentially the same process. What we want to ensure, though, is that there is regulatory stability going forward for everything that there is -- we don't start down the path and have a

question of well, how are we actually going to get there? How are we going to do the implementation for the different ATF concepts?

So one of the things that we want to make sure is that each ATF concept is evaluated, that we've clearly identified what are the regulatory hurdles? What are the gaps in research? What -- how do we get from A to B and really make sure that we don't, you know, move forward and then realize, oh, no one looked at, you know, X, Y, Z aspect -- and we need to come grinding to a halt while we look at that.

So again we want -- we support NRC's position that independent testing is -- is not required. One of our comments was that we believe that through close collaboration between the NRC, DOE and National Labs -- that we can really eliminate or mitigate the need for NRC's independent code development work. We think the modeling and simulation techniques don't remove the need for experimental data, but that, you know, we can really speed up the timeline of implementation for ATF technologies -- for the longer-term concepts if we not looking at doing multiple -- updates and remodeling work.

So -- and I know that DOE, and you know,

Al, we had a lot of discussions earlier about what exactly would be done in terms of that. So I won't try to go into that.

MS. GAVRILES: Can I -- I am sorry, this is Mirela Gavriles, again. I just wanted to clarify one of the bullets on -- on these slides. The fact that the staff is not going to do any testing is a plan assumption. And it's assumes that we will get all the data that we need for our confirmatory analyses from efforts that the industry, DOE and others have ongoing. Should we not get all the data that we need for our confirmatory analyses, we will do testing. So again, it's a -- it's a plan assumption, but it's not carved in stone.

MR. HOLTZMAN: Yes, one of the -- and one of the ways in which that we see that we can, you know, ensure that we meet that is, you know, we were discussing insuring that we have alignment through the PIRT process and then identifying where the gaps are, what are the needs? And then once we come to agreement in terms of what those experimental gaps are, go out and do that -- do what we agreed to and provide that data. And that would kind of be the check and the reassurance that we are planning to have all the data that NRC is

needing and meet the requirements in terms of having that -- providing that to the NRC and in a timely -- timely time frame that was under the agreed-upon framework as part of the PIRT.

MEMBER SKILLMAN: Mirela, when you say that if the data does not come in that is sufficient or is of an adequate quality, and that the NRC will do testing, does that communicate that there must be some funding waiting in the wings in order to accomplish that? And a plan for execution for that work?

MS. GAVRILAS: So I think you -- you got exactly the concept. For our plan right now the assumption is that no testing will be necessary. Should that assumption change at any time, the plan will have to be revisited to account both for resource changes and timeline changes.

MEMBER SKILLMAN: Okay, thank you.

(Simultaneous speaking.)

MEMBER BALLINGER: I would think -- I would think that if we get to that -- a catastrophic change in terms of timeline.

MEMBER SKILLMAN: That could be a show-stopper, yes.

MEMBER BALLINGER: I mean -- yes.

MEMBER SKILLMAN: But I'm glad that she's identified that.

(Simultaneous speaking.)

MEMBER MARCH-LEUBA: Will it look like this in nine years that you will return the application and ask them to collect it?

MEMBER SKILLMAN: Right.

MS. GAVRILAS: So basically the staff -- that's -- that's also a possibility. We don't do things, you know, without communicating. We don't start a program without communicating with them. But I just wanted to clarify that the fact that we say that we're not going to do confirmatory testing is a plan assumption. If the staff feels that the technical basis would benefit from -- or requires confirmatory testing, then we'll deal with it when -- when that scenario arises.

MR. HOLTZMAN: Advanced modeling and simulation is -- is used -- we feel across the board in other industries to reduce the time and cost for developing new, innovative technologies. We think that this ATF program gives us -- gives us a nuclear opportunity to also leverage that sort of innovation techniques. So we -- we believe that again the

near-term concepts -- which are again mostly coated claddings -- don't really need new code development works, things like that. They're going to be using existing codes and methods. It's really the longer-term concepts that we're looking to leverage in order to -- you know, to have a faster timeline for implementation for that.

MR. CSONTOS: I think it goes to what Dana said earlier, which is that maybe there's some testing that we have to think about what the what and the chaff are when it comes to another new concepts. And in that way, maybe advanced modeling and simulation can provide us that map that maybe can, I don't want to say risk-informed -- but more in terms of -- what was the other terms we used? Great approach or something -- kind of prioritize our research a little bit. So maybe there's ways where advanced modeling and simulation can help us with prioritization as well. And that can come out in the PIRT process as well.

MEMBER MARCH-LEUBA: And that has to come out of the PIRT, but like -- I'm in the thermo-hydraulics field, so whether it's zirconium -- so you see it's have correlation works well with -- whether you have zirconium or stainless steel. But maybe it doesn't

with the carbine. Okay, so if it doesn't weld then you'll see it's a provision doesn't work and you have to go into a whole new testing process.

MR. CSONTOS: Right -- that's right.

MEMBER MARCH-LEUBA: And that's the thing that the PIRT has to identify.

MR. CSONTOS: And that's where the modelers -- when you do the PIRT, I really want to -- instead of keeping people separate, we need to bring the modeling teams together with that.

MEMBER MARCH-LEUBA: Yes -- and don't get only metallurgical people --

(Simultaneous speaking.)

MR. CSONTOS: Exactly, exactly.

MEMBER MARCH-LEUBA: We need associate shift guys.

MR. CSONTOS: Right.

MR. HOLTZMAN: And we see this as a process that we can use to have -- you know, reduce some of the series and iterative process that's involved in doing fuel licensing work. So.

MEMBER BALLINGER: Have you thought about literally separating the chromium coating path from everything else? Because that's a cliff. In other

words, the chromium plating path is a much simpler path, requires much, much less data -- and if you get it tied up into a -- this overall PIRT process as a -- as an element --

(Simultaneous speaking.)

MEMBER BALLINGER: You just end up wasting a whole bunch of time.

MR. CSONTOS: Ron, that's a good question, because --

(Simultaneous speaking.)

MEMBER MARCH-LEUBA: If you look at the licensee, all three vendors have common chrome because that's the --

(Simultaneous speaking.)

MEMBER BALLINGER: Right. They started out with one and the other two copied, okay?

MR. CSONTOS: When you look at the PIRT discussion it's focusing on the silicon carbides and advanced fuels. And the -- and that's specific because of what you just talked about, Ron. And that's -- that -- and that's where I -- it's kind of -- it's mentioned here is that the near-term concepts, which the coatings are -- can leverage the existing approved codes both at NRC and the vendors and everybody else. Because

it's just a iterative step. So in terms of needing to do a whole PIRT, or to do all these other activities, I think it's overkill. That's -- that's killing a fly with a sledgehammer. And so it's -- it's -- it's probably unnecessary at this point.

MEMBER BALLINGER: It's separation from Halden.

MR. CSONTOS: Well, the -- I think all the vendors have testing being done at Halden right now for the coatings. And so -- so, you know, it is -- there are tests that still need to be run. I think, you know, Paul mentioned about what would happen -- you know, there's delamination -- there's the things that they have thought about that are out there.

MR. HOLTZMAN: But we fundamentally agree that we want to evaluate each concept independently on its own merits and have its own timeline for implementation that's not tied up with every other concept. So the things like the coated claddings, near-term -- near-term ATF concepts, we -- we don't see a lot of inter -- inter-connectivity between that and the other concepts in terms of implementation going forward. And that's one of the things we are looking forward to working with the NRC in terms of firming

up and getting the agreement on those implementation timelines for the very reason you mentioned.

MEMBER MARCH-LEUBA: Since you have a tie-in to the developers, are you following that? I'm changing the topic.

MEMBER BALLINGER: Have you defined what -- what is good enough?

MR. CSONTOS: Good enough for?

MEMBER BALLINGER: The coatings. In other words, have you decided that 100-percent adherence all the time is the -- is the point where you have to meet? Or have you incorporated into a PRA or some kind of analysis what's good enough? In other words, how much can you --

MEMBER MARCH-LEUBA: Ninety-seven-percent is good enough?

MEMBER BALLINGER: Yes, it's --

(Simultaneous speaking.)

MEMBER BALLINGER: In order to get your coping time -- coming back to the coping time --

MR. CSONTOS: There are areas that we need to still get data on. And the vendors are getting that data and doing the testing to -- to address those comments and those issues. But in terms of the modeling

that was done, you have to make certain assumptions. And you look for the oxidation resistance so then you have to make a decision on when can you just say that we can't -- we can't go that far?

And so when you look at the modeling, let's say for coatings, the work that we did is we looked at the oxidation resistance up to 75 percent for thickness. And then after that you just couldn't -- we just felt that you just could not make the case that you wouldn't -- you could go for the next 25 percent. So we just made an assumption in that kind of an analysis. That's what Joy was mentioning is that your assumptions run -- really can run what the safety case is and the benefits are. But I think fundamentally that question is really between the vendors and NRC and not the utility groups.

MEMBER MARCH-LEUBA: But see you have access to the developers. Let me -- ask them a question from my -- for me. Have they considered using enriched chromium. When we had a presentation by Dana, AREVA, they told us that the impact of those 10 micros of chromium on K effective was not insignificant. Indeed, it was very significant.

And I did want to check all the isotopes

and has four -- chromium has four stable isotopes and only one -- I don't know if it's 50 or 54 -- has a high-absorption cross section and a stable isotope enrichment is of the -- one thing you can -- you only need a kilo. It may be worthwhile to see how much a kilo of chromium-52 costs.

MR. CSONTOS: And that's the fuel cycle optimization work that we're working with.

MEMBER MARCH-LEUBA: Yes. And it wouldn't change any of the testing you've done because this is isotopic enrichment. But it would be worthwhile to just check what the price of -- of chromium-52 is.

CHAIRMAN SUNSERI: All right, as we wrap up this meeting, can we focus our comments on the plan versus designing of ATF?

MEMBER BALLINGER: You know we can't do that.

(Laughter.)

MR. HOLTZMAN: One of the -- so, at NEI we have working group and different task forces. The -- specifically the licensing task force has been looking into the -- NRC's project plan and putting together a lot of the comments for it. We have been

developing essentially four different subcommittees coming out of our task force that we are looking forward to interacting with the NRC with. It's -- practically, what we did was we took the project plans' different tasks and we're trying to -- we're standing up subcommittees that are focusing on each one of those that we can then work with interacting with the NRC in order to really try to identify issues ahead of time and have essentially issue resolution and come up with things before they -- the -- the utility -- before the vendors start trying to put forward their concepts for full licensing efforts.

I know one of the comments earlier was essentially, like, have we looked at this in terms of, like, essentially outside of the reactor rules and regulations, and that is one of the things that we are looking at essentially, our sub-task force too, was something that we had identified a need. And so we are looking at that as well.

MEMBER BALLINGER: I am looking at this, and I am a metallurgist, but I've had the PRA injection and I look at -- I see future for PRA. Why?

MR. HOLTZMAN: So the reason for that was we had -- we initially had thought that we were going

to have to do a lot of the PRA work that we had identified now. And then as we started thinking about it more, we realized that we needed to have further clarity for what the actual ATF concepts were going to be before we could really make a -- a big push in that area. It was decided that any work that we did now would be subject to what the actual concepts were and what the actual benefits and changes that planned operation were going to be, that it didn't make sense to start this immediately.

MR. CSONTOS: And let me just add on that. That this has been public -- publically provided, so that's why we can talk about it is that in the NEI report on the economic benefits that came from the -- that -- from the EPRI study, you know, it identified three different classifications of benefits -- confident -- confident -- a non-confident and a confident but only specific -- for specific reactor types, okay? And some areas -- are specifics.

And in that way a lot of the PRA pieces were not really that confident. And so in terms of some of the benefits that are there we are just -- it's -- it's at this point something that we need to evaluate better to see about going to the future to see about

getting those.

MR. HOLTZMAN: And that is -- and that's not specifically mentioned on this slide partially because it's under a different NEI task force. But that is something that we are looking at and continuing down the path on this year in terms of really continuing to flush out what are those benefits that we think we can attain? And what are the conditions and assumptions associated with those? And that way, as we go forward and start trying to lay out -- our vision for the implementation of ATF is effectively that, you know, we identified -- these are potential benefits that utilities are able to utilize for any of the different concepts. And then because each plant is limited by different aspects, they would then be able to figure out what are the benefits that are actually useful for them.

MR. CSONTOS: And that's the safety benefits?

MR. HOLTZMAN: Correct. That is part of the Safety Benefits Task Force at NEI. Okay. So in summary, again, we belief ATF presents a great opportunity to implement more efficient practices at the NRC and in order to -- and an opportunity to really

help industry. We believe that the increased reliance on modeling and simulation is going to be a benefit for the overall industry and is going to help us develop more parallel processes in terms of our licensing approach and implementation for ATF. Again, we see this as an overall -- we see this as an iterative process, as a -- we see the project plan as a living document. But I know NRC also mentioned in that we are looking forward to having lots of interactions as we work forward trying to, you know, get this implemented and rolled out to industry.

MEMBER SKILLMAN: I've got to ask -- I am surprised that your first bullet isn't ATF presents an opportunity to enhance nuclear safety. It's almost as if your first bullet says this is a nifty, dandy way to find our way through the regulatory maze.

MR. HOLTZMAN: So we debated about that honestly a little bit. It was -- we decided that it was going to be self-evident that ATF was -- we don't -- we don't necessarily think that it -- we need ATF in terms -- we don't believe that the plants are currently non-safe and that we therefore don't believe that the roll-out of ATF represents a fundamental change of safety that we need to do. Industry believes that

ATF allows for the utilities to have additional economic benefits associated with it without a degradation of safety so that we are maintaining our existing safe operation of nuclear power plants while creating additional flexibilities and other considerations through the -- that we're evaluating as part of benefits to help drive economic benefit for the plants.

MR. CSONTOS: This bullet is there because of this project plan. And the purpose of the meeting was to focus on the project plan for licensing. So there are other pieces where ATF can present opportunities. It's just that this one was focused on this plant and how a more efficient process could be developed.

CHAIRMAN SUNSERI: Any other questions from the remaining subcommittee members for the --

MEMBER MARCH-LEUBA: You're still double the required quorum.

CHAIRMAN SUNSERI: Yes, we're good. All right, well thank you for your presentations. And we appreciate you coming down here. I guess now I would like to ask the members of the audience here if there is anyone that would like to make a public comment, please come to the microphone, yes, and state your --

state name and then who you're with and your comments.

MR. MARKLEY: Okay, I'm -- I'm Mike Markley. I'm the chief of reactor -- Operating Reactor Licensing for Region II plants. I also have the Hatch Plant. Been with the NRC 30 years, 37 years in the business. So let -- spent six years for the ACRS, too, working for Dr. Apostolakis. So I -- I really appreciate the environment you have here.

As an overview, although the topics long preparation to license accident-tolerant fuel, there was no discussion on the licensing in accordance with 50.36 or 50.90. So no discussion --

MEMBER MARCH-LEUBA: Can you talk closer to the microphone?

MR. MARKLEY: Okay. There was no discussion of licensing per 50.36 or 50.90 today -- and not in the plan. None about exemptions in the plan. Some discussion of topical reports, but even if they do develop the topical reports, that doesn't get you to a plant-specific licensing approval. There's lots of discussions of developing a risk-informed approach, but it appears to have flaws.

10 CFR 50.69 is a risk-informed treatment of structure systems and components, but it excludes

fuel as a primary barrier to fission product release. So I am not sure how they're seeing this huge benefit of ECCS relaxation from that. I don't see how they get a coping time that would justify it, either. They certainly need to revisit the accident analysis that go over five percent of uranium-235 enriched. And that creates a lot of problems in licensing space.

There's a lot of unresolved technical issues that affect licensing and we're glad to see the ACRS looking at this. And I hope you will look at each concept as they bring one forward. There are a lot of licensing issues. The LTAs, the five percent is a design feature of the plant for most of them -- COLR updates, spent fuel pool storage, transportation -- there's a lot of them. As far as the NEI comments, we agree with the comment that each concept should -- is unique and should be evaluated on its own merit. We disagree with the assumption that -- and I am -- these are all my comments. I do not represent any part of the NRC organization -- disagree with the assertion NRC can rely on DOE codes and methods.

With regard to the draft ATF plan, disagree with the position that the NRC does not need to perform independent confirmatory analysis. We rely on that

for licensing decisions. And the NRC has a statutory obligation for reasonable assurance of public health and safety -- and that's part of it. As far as the LTAs, I filed a DPO on the NRC staff's June 29th letter on LTAs and the NRC feedback to Hatch. It departs from prior tech spec and prior regulatory practice for amendments, exemptions and NRC-approved methods.

The public's being excluded from the process by allowing Hatch and others to pursue this 50.59 approach, or non-licensing approach. And that's it. I -- it's -- again, appreciate your time opportunity to give comments. And these are my comments, again.

CHAIRMAN SUNSERI: Yes, thank you. Other comments?

MR. ENNIS: My name is Rick Ennis. I am a senior project in NRR's Division of Operating Reactor Licensing. And they talked a little bit about the LTA program just being a critical path as far as this ATF program and NEI had shown the slide -- it shows a number of LTAs are scheduled to be inserted in the next couple of years. On May 19th, 2017 NEI sent a letter to NRC requesting confirmation of the regulatory positions presented at the NRC Regulatory Information Conference

last year in a discussion on accident-tolerant fuel lead test assemblies.

The NRC responded to that letter on June 29th, 2017 and -- concerning the regulatory path for lead test assemblies. And in part that letter said that the use of lead test assemblies may precede the availability of approved analytical codes and methods prior to the conduct of representative testing consistent with the intent of the lead test assembly standard test specs. And that letter also indicated that the staff believes that the licensee not need to obtain an exemption from 10 CFR 50.46 or the 50.468 adopted by the commission in order to load lead test assemblies into the reactor core and irradiate those lead test assemblies.

The position stated in the NRC's June 29th, 2017 letter were not coordinated with the staff in NRR who are responsible for licensing or 10 CFR 50.59. And there's a number of staff members with significant licensing experience who do not agree with the position stated in the NRC's letter. We performed an in-depth review of the regulatory framework regarding use of lead test assemblies and based on that review we conclude that lead test assemblies must be analyzed

with applicable NRC staff-approved codes and methods before they're used. And until the 10 CFR 50.46 8 rule is issued, licensees will continue to need exemptions from 50.46 and Appendix K to Part 50 for use of cladding materials other than Zircaloy or Zirlo. And in addition, exemptions would be needed for fuel pellets other than uranium oxide.

And in some cases licensed amendments would also be needed depending on the plant-specific wording and their design feature specs for fuel assemblies. Would also note that the June 29th, 2017 letter stated that the view provided were preliminary and don't constitute formal positions by the staff. We've had continued internal dialogue on these issues in order to formulate a regulatory framework on lead test assemblies that's clear and consistent with the NRC's principles of good regulation. Thank you.

CHAIRMAN SUNSERI: Thank you. Any other comments from members of the audience in the room?

(No audible response.)

CHAIRMAN SUNSERI: Okay. Now we will open up the phone line for those listening in.

MR. BROWN: The bridge is opened.

CHAIRMAN SUNSERI: The bridge line is now

open for comment. Any member of the public wishing to make a comment state your name and then your comment.

(No audible response.)

CHAIRMAN SUNSERI: All right, we have nobody making comments so we will now close the phone line. And I will now ask the members of the subcommittee, do you have any comments? We'll start with Ron.

MEMBER BALLINGER: No further.

CHAIRMAN SUNSERI: No further comments from Ron. Jose?

MEMBER MARCH-LEUBA: I do have a couple of comments. First, following up on some of the -- what we just heard -- if we have a follow-up subcommittee or a full committee on this topic, I would like to hear more about the LTA regulatory basis. Just one or two slides to -- to let us know. Because I thought it was more relaxed than what I just heard, so obviously I was mistaken.

Then on a more substantive topic, I have two comments and don't get too hung up on the first one. Okay? The first one is I think we're overdoing it. We are grossly overdoing it. If this was 1960 -- I have an idea about coating fuel with chromium --

I would go to my boss and tell him, yes, I have a great idea. He will say take two months off, get Joe from the shop, go paint a couple of cladding with chromium, put it in autoclave and see how it works. And this is becoming a 100-man year operation and 12 years of calendar. And the -- I think we're overdoing it.

However, what we are not overdoing is -- is the part where I think we are missing -- is that for this thing to become economical, we didn't talk about NEI, that they are going to want to have compensatory measures, relaxations on ECCS, on -- on -- on the stuff that they want to relax. I would spend more time on licensing those compensatory measures than the chromium-coated fuel. So -- it really needs a detail for a PRA analysis on whatever we're going to do to make sure that the net effect is not negative because the -- the -- partial effect of this fuel is going to be good. Otherwise we wouldn't put them in. So it's the net effect of what we're exchanging them for to make them economical that we need to want to license them. So I -- I would transfer some of the funding to that part.

CHAIRMAN SUNSERI: So let me ask a clarifying question on that. So -- and maybe the proper

terminology isn't defense and depth, but what I hear you saying is -- I mean, a lot of our safety is in effect defense in depth. We have multiple barriers, if you will, to protect something. And in -- what you're saying is if we are finding a benefit in one barrier, that is going to allow us to compensate by reducing another barrier so that the net effect stays the same, are we looking at that effect and ensuring that is the case? Or, you're advocating we shouldn't do that and --

MEMBER MARCH-LEUBA: I think we ought to -

CHAIRMAN SUNSERI: And improve safety by strengthening the one barrier and not reducing the others. Is it?

MEMBER MARCH-LEUBA: My intuition is telling me that we are spending too much time and money on the easy part -- on the good effect. And we are not making sure that the bad effects are not -- do not overcompensate for that one. So -- so that is -

(Simultaneous speaking.)

CHAIRMAN SUNSERI: All right, apology. So you had another one?

MEMBER MARCH-LEUBA: The other one is that

-- it is related to that -- we are doing too much. I think it's a little overkill.

CHAIRMAN SUNSERI: Okay, all right. Good. Dick?

MEMBER SKILLMAN: No, thank you. I have no further comments.

CHAIRMAN SUNSERI: No other comments? Mike Corradini, are you still with us?

(No audible response.)

CHAIRMAN SUNSERI: And Pete Riccardella, are you still with us?

MEMBER RICCARDELLA: So for a personal thing and he's not with us any longer. I don't have any comments. Mike had a few that he emailed me and I'll just repeat them. Let's see, he's saying -- he doesn't think that -- he thinks it's a little premature to have a letter this -- pretty early in the process. And it's not clear that a letter is needed. But if NRR does desire one, we need to focus on the PIRT process and follow that carefully. That's all I have.

CHAIRMAN SUNSERI: All right, thank you, Peter. Well, I would just conclude by thanking the Department of Energy, Idaho National Labs, NEI, NRC staff for coming to visit with us on relatively short

notice. I know we need to try to catch up to where you're at in process so that we have a good understanding as it moves forward. So obviously has a lot of stakeholder interest. Many avenues. And we want to do our job to support whatever needs to be supported. So with that we will adjourn today's meeting.

(Whereupon, the above-entitled matter went off the record at 12:27 p.m.)

U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY

Clean. Reliable. Nuclear.

Overview of DOE's Accident Tolerant Fuel Program

National Laboratory R&D Support to Industry and NRC

ACRS Subcommittee on Metallurgy and Reactor Fuels
February 23, 2018

Bill McCaughey
Acting Director, Advanced Fuels Technologies

Jon Carmack
Senior Technical Advisor

AFC Advanced Fuels Campaign

NTRD Nuclear Technology Research & Development

Outline

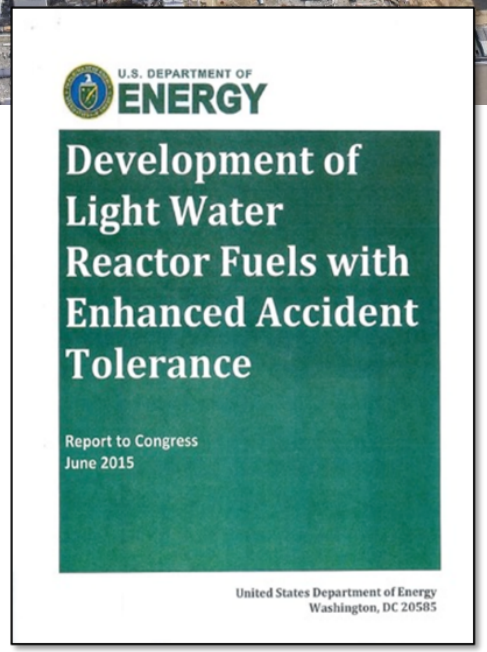
- Congressional Direction and Development Plan
- National Laboratory R&D Support
  - Irradiation testing
  - Post irradiation examination
  - Safety testing
  - Advanced modeling and simulation

Congressional Direction and Development Plan

Following the accident at Fukushima, Congress directed the Department to start developing fuel with enhanced accident tolerance that can be used in existing light water reactors.

The Development Plan:

- Defines the general attributes of accident tolerant fuel.
- Lays out an aggressive 10-year schedule starting in 2012.
- Establishes the goal of inserting a lead fuel assembly or lead fuel rod in an operating commercial light water reactor by 2022.



Development Plan

- Phase 1: Feasibility Assessment and Down-Selection
  - FY 2012-2016
  - Collaborative partnership between DOE, industry, and universities
- Phase 2: Development and Qualification
  - FY 2017-2022
  - Industry led efforts supported by DOE national infrastructure and universities
- Phase 3: Commercialization
  - FY 2022 and beyond
  - Industry commercial activity deploying ATF into existing and future reactor systems

Development Plan Being Updated

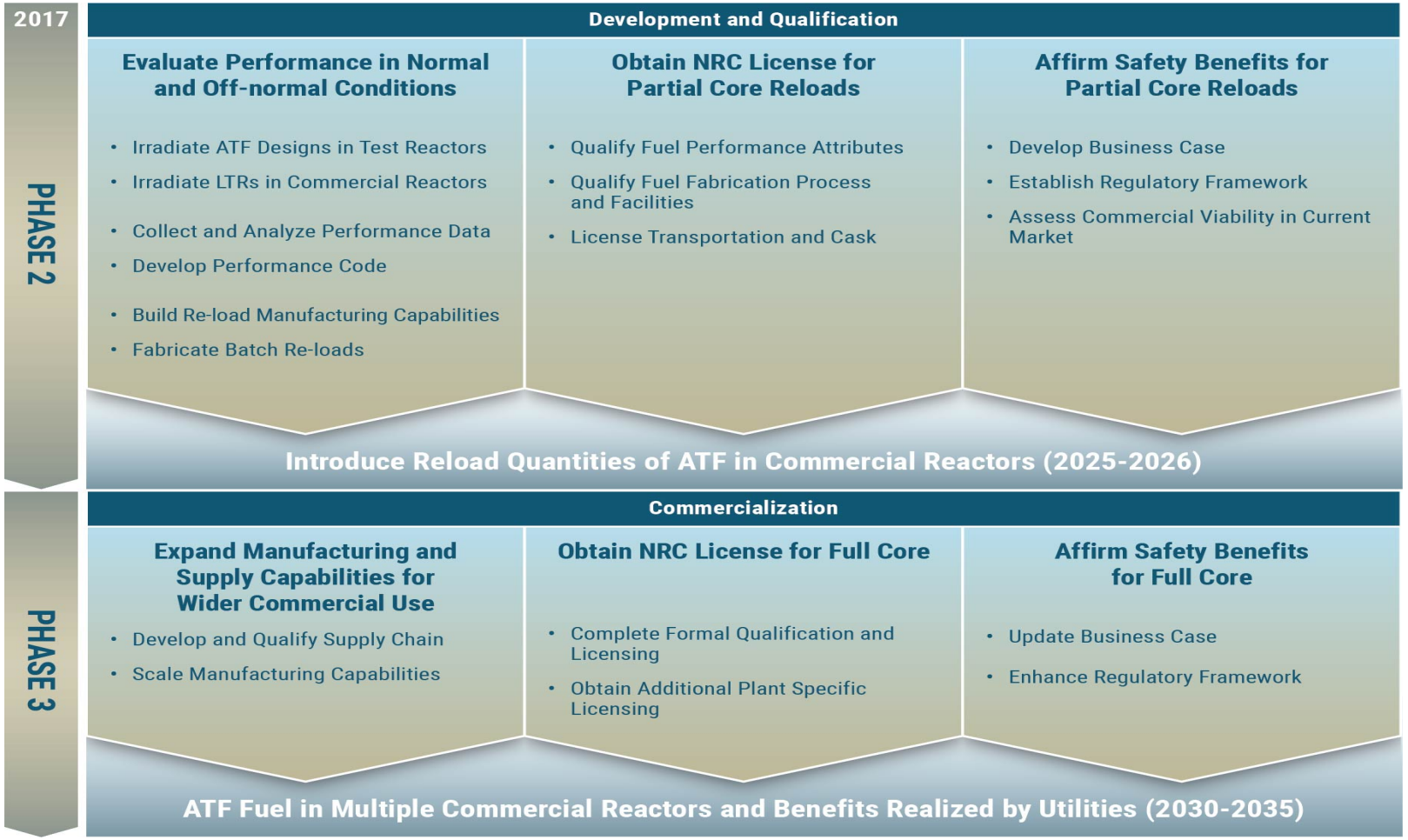
1. Revise the end state of Phase 2 (Development and Qualification) to include more than one set of lead fuel assemblies/lead fuel rods at one reactor.

2. Update and provide more details on the activities that make up Phase 2.

3. Describe Phase 3 activities (Commercialization).

4. Identify roles and responsibilities across multiple organizations, DOE, fuel vendors, utilities, EPRI, NEI, and the NRC.

Industry Input to Development Plan



U.S. DOE- Continues to support industry teams working to insert ATF into LWRs

Framatome

- **Cr coated Zr**
- **Increased fuel pellet conductivity**
- Additives
  - Chromia dopant

GE

- Develop advanced **ferritic/martensitic steel alloys (e.g., Fe-Cr-Al) for fuel cladding** to improve behavior under severe accident scenarios
- Objectives:
  - Characterize candidate steels
  - Study tube fabrication methods, neutronics, fuel economy, thermo-hydraulic calculations, regulatory approval path
  - Initiate ATR testing with UO_2 and two cladding materials.

Westinghouse

- **Cladding** concepts:
  - **SiC** and SiC ceramic matrix composites;
  - **coated Zr alloys**
- **High density/high thermal conductivity fuel pellets**
- First batch of U_3Si_2 pellets were sintered using finely ground powder
- Pellets were pressed using pressures of 6,000-10,000 psi and sintered at temperatures of 1400° C

U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY

NTRD Nuclear Technology Research & Development

DOE is providing resources for ATF Irradiation Testing and Qualification Infrastructure –

ATF-1 Initiated irradiation Feb. 10, 2015
ATF-2 fueled irradiation (Spring 2018)

Test Series	ATF-1	ATF-2	ATF-H-x	ATF-3	CM-ATF-x	ATF-y
Test Reactor	ATR	ATR	Halden	TREAT	Commercial Power Plant	TREAT
Test Type	Drop-in	Loop	Loop	Static/Loop	LTR/LTA	Static/Loop
Test Strategy	Scoping – Many Compositions	Scoping – Focused Compositions	Focused	Focused Compositions	Focused Composition	Focused Compositions
	Nominal conditions	Nominal conditions	Nominal	Accident conditions	Nominal conditions	Accident conditions
Fuel	UO_2, U_3Si_2, UN	Down-selected concepts	Selected	Fuel rodlets from ATF-1 and test rods from ATF-2 irradiations	Concepts selected in 2016	Test rods from LTR/LTA irradiations
Cladding	Zr w/coatings, stainless steels, advanced alloys					
Key Features	Fuel-cladding interactions	PWR Conditions	PWR/BWR Conditions	Integral testing	Steady State Irradiation	Integral testing
Timeframe	FY14 – FY18+	FY17 – FY22+	FY18-FY22+	FY18 – FY25	FY18 – ?	FY18 – ?

ATF-1 TEST MATRICES & STATUS

A wide range of fuel pellet designs and cladding materials are in the test matrix; ATF-1 capsules are ideal for scoping studies

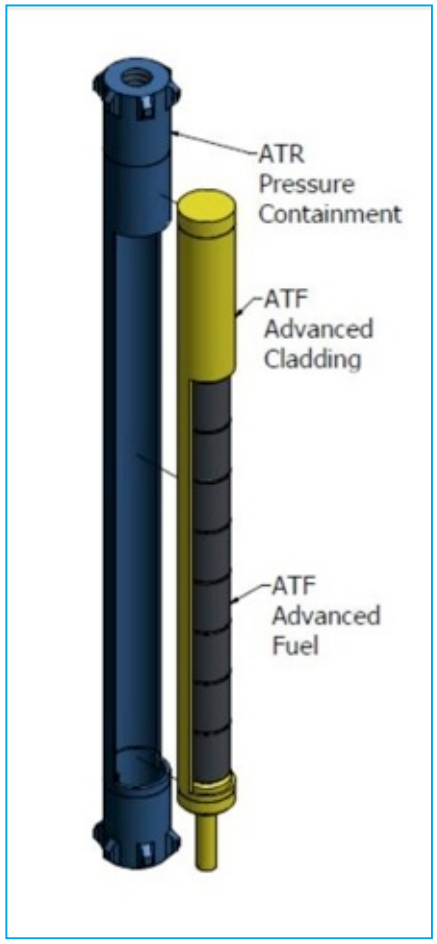


Table 1. Summary and Status of ATF-1 Capsules

Capsule ID	Concept Lead	Fuel Type	Cladding Type	ATR Insertion Cycle	Status
ATF-00	AREVA	UO_2	Zirc-4	157C-1	PIE
ATF-01	AREVA	UO_2	Zirc-4	157C-1	In Irradiation
ATF-02	AREVA	UO_2+SiC	Zirc-4	157C-1	In Irradiation
ATF-03	AREVA	UO_2+SiC	Zirc-4	157C-1	PIE
ATF-04	AREVA	UO_2+Diamond	Zirc-4	157C-1	PIE
ATF-05	AREVA	UO_2+Diamond	Zirc-4	157C-1	In Irradiation
ATF-06	GE	UO_2	Alloy-33 (UNS R200033)	157C-1	Post-Irradiation Cooldown
ATF-07	GE	UO_2	Alloy-33 (UNS R200033)	157C-1	In Irradiation
ATF-08	GE	UO_2	APMT (FeCrAl Alloy)	157C-1	Post-Irradiation Cooldown
ATF-09	GE	UO_2	APMT (FeCrAl Alloy)	157C-1	In Irradiation
ATF-10	Westinghouse	U_3Si_2	ZIRLO	157C-1	In Irradiation
ATF-11	Westinghouse	U_3Si_2	ZIRLO	157D-1	In Irradiation
ATF-12	Westinghouse	U_3Si_2	ZIRLO	157C-1	In Irradiation
ATF-13	Westinghouse	U_3Si_2	ZIRLO	157C-1	PIE
ATF-14	Westinghouse	U_3Si_2	ZIRLO	157C-1	In Irradiation
ATF-15	Westinghouse	U_3Si_2	ZIRLO	157C-1	PIE
ATF-17	ORNL	UO_2	FeCrAl Alloy	157D-1	In Irradiation
ATF-18	ORNL	UO_2	FeCrAl Alloy	157C-1	PIE
ATF-20	ORNL	UO_2	FeCrAl Alloy	157C-1	In Irradiation
ATF-29	Westinghouse	UN-U_3Si_2	ZIRLO	160A-1	In Irradiation
ATF-30	Westinghouse	UN-U_3Si_2	ZIRLO	160A-1	In Irradiation
ATF-31	Westinghouse	UN-U_3Si_2	ZIRLO	160A-1	In Irradiation
ATF-32	Westinghouse	UN-U_3Si_2	ZIRLO	160A-1	In Irradiation
ATF-33	Westinghouse	UN-U_3Si_2	ZIRLO	160A-1	In Irradiation
ATF-34	Westinghouse	UN-U_3Si_2	ZIRLO	160A-1	In Irradiation
ATF-41	LANL	UN-U_3Si_5	Kanthal-AF (FeCrAl Alloy)	160A-1	In Irradiation
ATF-44	LANL	UN-U_3Si_5	Kanthal-AF (FeCrAl Alloy)	160B-1	In Irradiation
ATF-45	LANL	U_3Si_5	Kanthal-AF (FeCrAl Alloy)	160A-1	In Irradiation
ATF-73	ORNL	UO_2	FeCrAl Alloy*	160B-1	In Irradiation
ATF-74	ORNL	UO_2	FeCrAl Alloy*	160B-1	In Irradiation
ATF-75	ORNL	UO_2	FeCrAl Alloy*	160B-1	In Irradiation

**These rodlets contain multiple fuel cladding chemical interaction experiments. The rodlet is Type 304 Stainless Steel, but small FeCrAl coins lie next to fuel slices inside of the rodlet.*

ATF-1 PIE Status

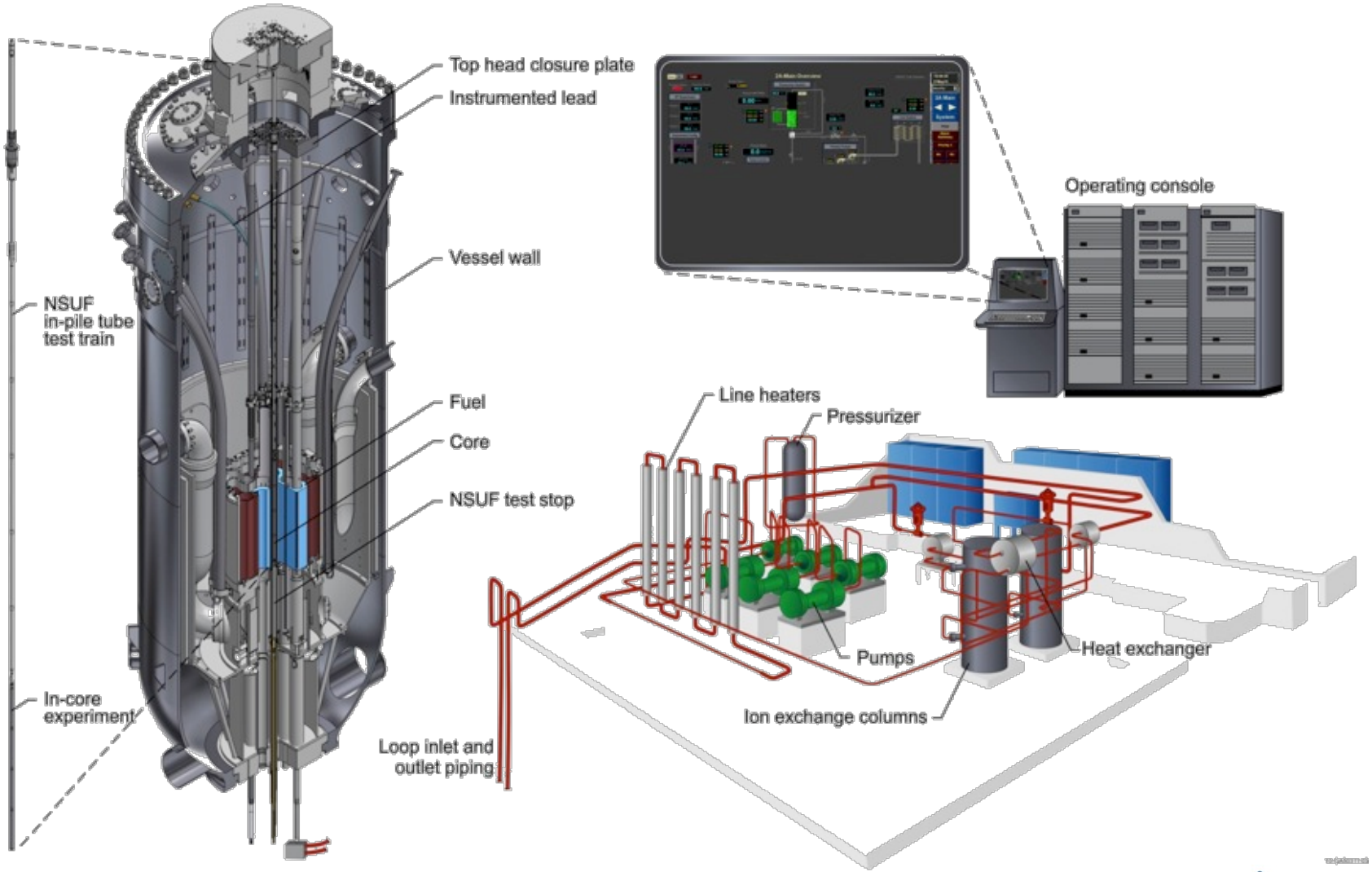
- The first set of Areva ATF-1 rodlets are through baseline PIE (UO_2+additives)
- The first set of Westinghouse (U_3Si_2 + Zirlo) should complete baseline PIE by March ‘18
- The ORNL LOCA rodlet is waiting for shipment to ORNL
- The next round of PIE will begin in February ‘18
- A second shipment is schedule for September ’18
- An in-cell pycnometer (density) should enter service Jan ‘18

Status of PIE Exams for Current Experiments

	Areva ATF-1A Set 1	Westinghouse ATF-1W Set 1	ORNL LOCA Set 1	GE ATF-1G Set 1	LANL-1 ORNL-FCCI	WEC-1A WEC-1B LANL-1
Receive at HFEF	Feb ’16	Feb ’17	Feb ’17	Feb ’18	Feb ’18	Sept ‘18
Capsule Disassembly	Mar ’16	June ’17	June ’17	June ‘18	June ‘18	TBD
Rodlet NDE	June ‘17	Oct ‘17	Sept ‘17	July ‘18	July ‘18	TBD
Baseline Destructive	Sept ‘ 17	Oct ’17 – Mar ‘18	TBD	TBD	TBD	TBD
Advanced PIE	TBD	RTE in process	TBD	TBD	TBD	TBD
Final Baseline Report	Sept ’18	Sept ’18	Sept ’18	TBD	TBD	TBD

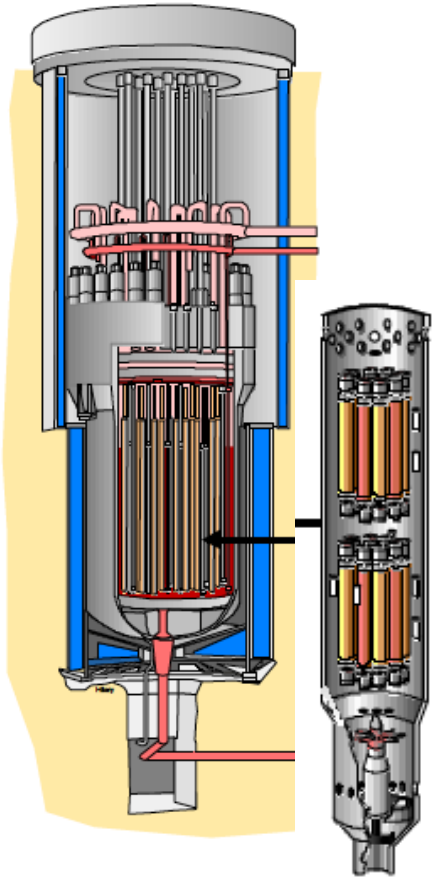
Complete In Progress Behind Late Problem Future

Steady State PWR Loop Irradiation in ATR – (ATF-2)



Halden ATF Collaborations

- FeCrAl Alloy and SiC creep test (In-Process)
- ATF cladding and fuel experiment under the EHRP
- 3D MBM V&V Experiment
- BWR/PWR Loop



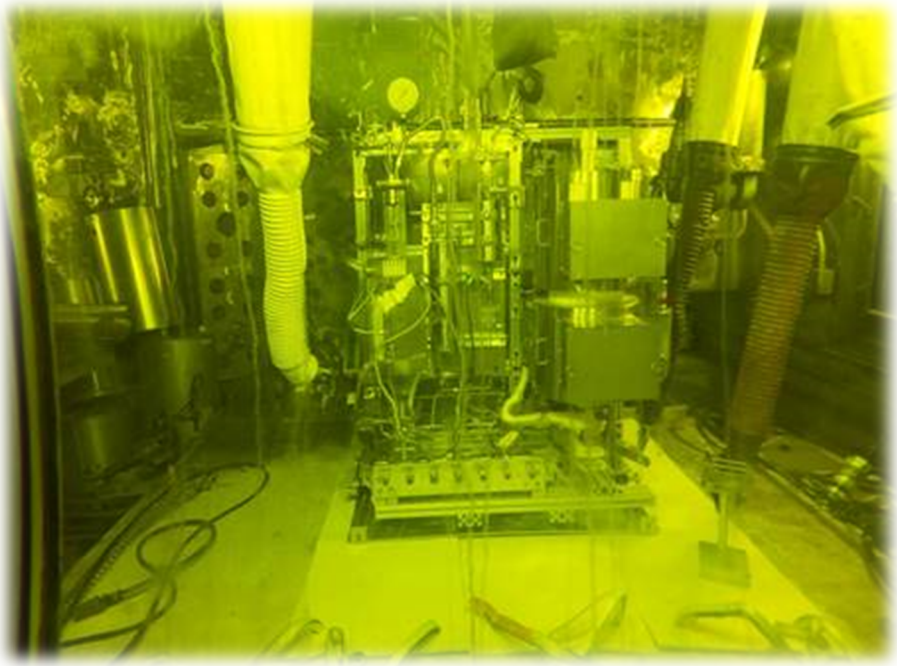
The Halden Boiling Water Reactor (HBWR) is a versatile tool for nuclear fuels and materials investigations:

- More than 300 positions individually accessible
- About 110 positions in central core
- About 30 positions for experimental purposes (any of 110/300)
- Height of active core 80 cm
- Usable length within moderator about 160 cm
- Experimental channel Ø:
  - 70 mm in HBWR moderator
  - 35-45 mm in pressure flask
- Loop systems for simulation of BWR/PWR conditions

U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY

NTRD Nuclear Technology Research & Development

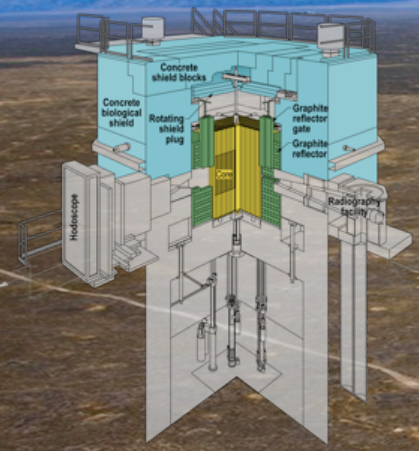
Integral LOCA Test Facility established and available at ORNL in shielded hot cell

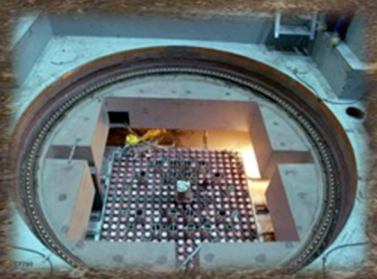


- Internally pressurized
- Steam environment
- 5° C/s heating
- To 1200° C
- 3° C/s cooling

Four post-LOCA samples tested at 1200YC with internal pressurization of 0.0, 4.14, 6.21, and 8.27 MPa.

Transient Reactor Test (TREAT) Facility





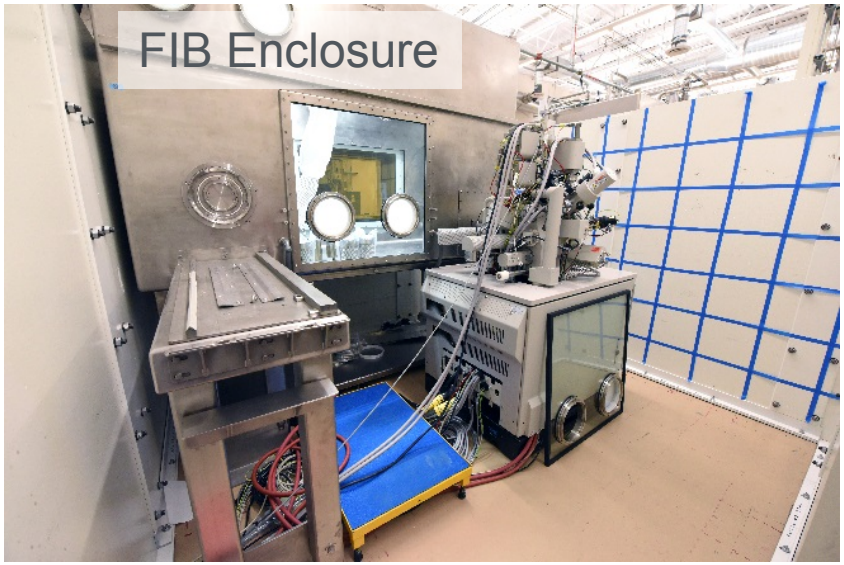
- 100 kW Steady-state power with 19 GW Peak Transient Power
- Core: ~1.2 m high x 2 m. dia.; surrounded by 0.25 m graphite reflector
- 19 x 19 array of 10 x 10-cm. fuel and reflector assemblies
- Fuel: 0.2 wt.% high enriched UO_2 dispersed in graphite
- 12 steady-state and 8 transient control rods
- Instantaneous, large negative temperature coefficient (self protecting driver core)

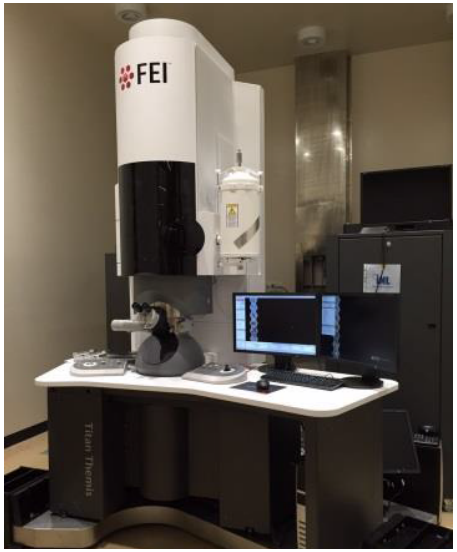
TREAT Experimental Facility Restarted in 2017.

IMCL Update

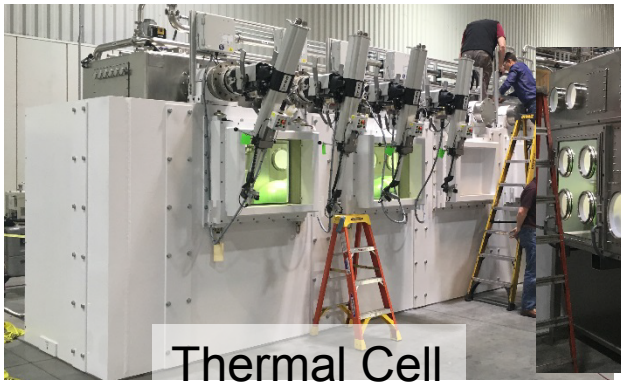
Irradiated Materials Characterization Laboratory (IMCL)

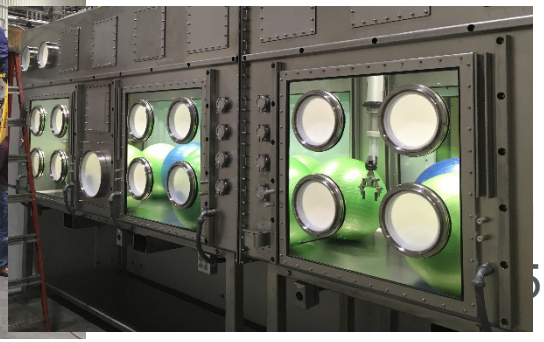
- IMCL post-irradiation analysis capability
  - EPMA, FIB, FEG-STEM, μ-XRD, thermal analysis, sample prep
  - Shielded enclosures around each instrument for handling irradiated fuel samples
- Current status
  - Facility construction complete
  - Hot cell and equipment installation on-going
    - FIBs Spring 2018
    - TCM
  - EPMA in operation
  - TEM in operation





TEM

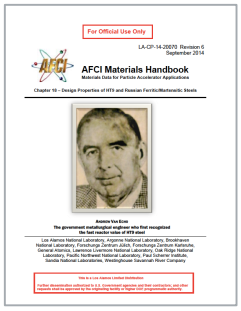




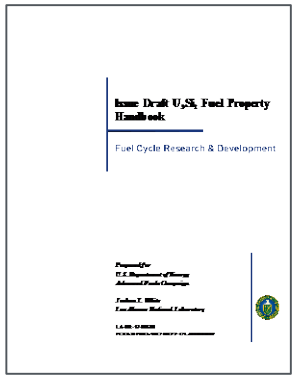
Fuel System Handbooks

Uniform Handbook Guide

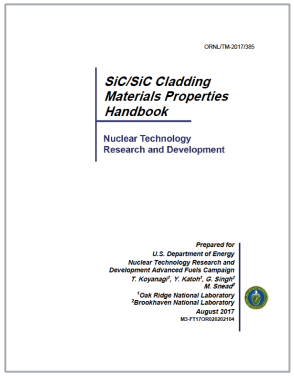
Metallic Fuels



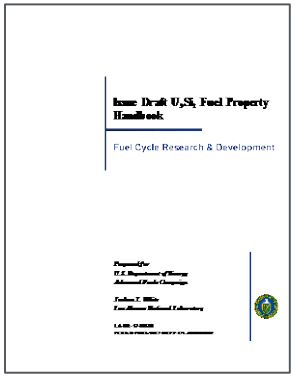
FR Cladding



FeCrAl Cladding



SiC Cladding



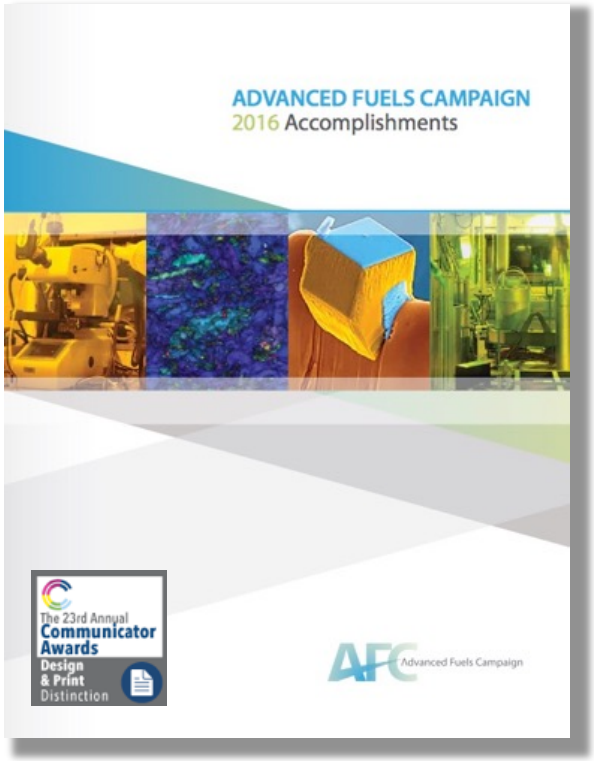
U_3Si_2 Fuel

Advanced Modeling and Simulation Support (NEAMS)

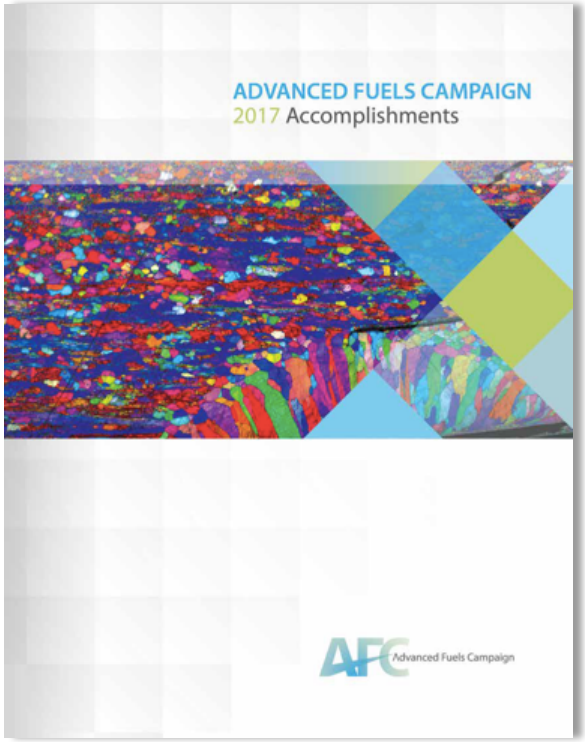
- Accident Tolerant Fuel High Impact Problem
  - Cluster dynamics for iron-chrome aluminum (FeCrAl) cladding
  - Rate theory for microstructural changes in U_3Si_2
  - Doped UO_2
  - Fission gas behavior of U_3Si_2
  - U_3Si_2 swelling
  - Engineering scale modeling
- Exploring NEAMS tools coupled to NRC codes for confirmatory analyses of accident tolerant fuel
  - Recently established capability in a working meeting with NEAMS, CASL and NRC.
- Other NEAMS Collaborations
  - Westinghouse test stand and U_3Si_2 work
  - IAEA Coordinated Research Project (ACTOF)
  - Halden
  - MIT Integrated Research Project

2016 and 2017 Accomplishments Reports

http://nuclearfuel.inl.gov



2016 Accomplishments report

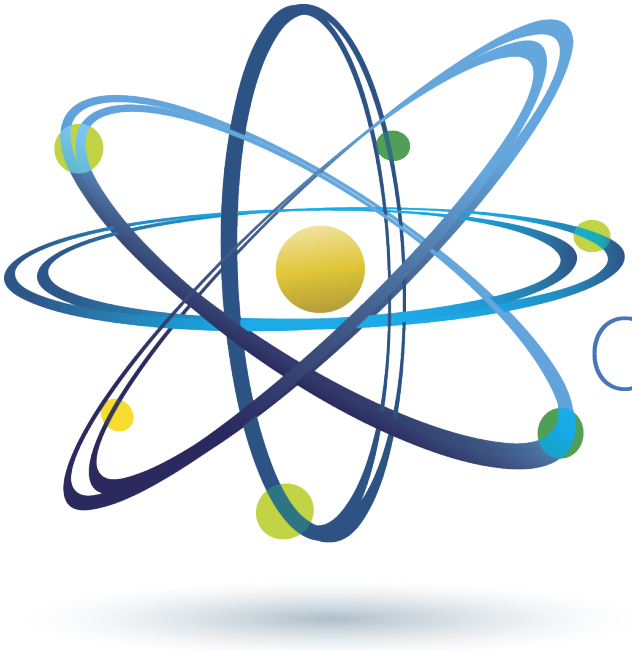


2017 Accomplishments report

Summary

- **Phase 1, Feasibility Assessment and Down-Selection, is complete.**
- **Phase 2, Development and Qualification, is expanded and accelerated to support industry.**
- **National laboratories are supporting the industry teams and the NRC:**
  - **Irradiation testing**
  - **Post irradiation examination**
  - **Safety testing**
  - **Advanced modeling and simulation**

Questions?



Clean. **Reliable. Nuclear.**

Status of Preparations to License Accident Tolerant Fuel

ATF Working Group

February 23, 2018

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Overview

I. Background of ATF
II. ATF concepts
III. New fuel licensing process
IV. Draft ATF project plan
    a) In-reactor regulatory framework
    b) Fabrication, transportation, and storage
    c) PRA
    d) Analysis capability development
    e) Public comments received

I. Background of ATF

- Industry along with DOE are developing fuel with enhanced accident tolerance
  - Longer coping times during loss of active cooling conditions
  - Three major U.S. vendors are participating
  - There are ATF concepts outside the scope of the DOE program
- NRR, RES, NMSS, and NRO are working together to prepare for licensing ATF
- NRC has signed ATF-related MOUs with DOE and EPRI

II. Near-term ATF Concepts

- Coated claddings
  - Multiple vendors
  - Standard zirconium alloy material with thin coating applied to outside
  - Intent is to reduce corrosion and metal-water reaction
- Doped fuel pellets
  - Reduce PCI by increasing pellet creep
- Steel cladding
  - FeCrAl

II. Longer-term ATF Concepts

- SiC (ceramic composite) cladding
  - Pursued by multiple vendors
- U_3Si_2 fuel pellets
  - Higher fuel density
  - Limited information on fuel performance
- Lightbridge
  - Helical cruciform fuel rods
  - Metallic fuel co-extruded with clad

III. Fuel Licensing Process

In general, the following major steps are necessary to license a new fuel design for unrestricted, batch application:

1. Conduct research to fully characterize the material, mechanical, chemical, thermal, and nuclear properties and the evolution of these properties with time-in-reactor. This step supports analytical model development in Step #5.
2. Conduct separate-effects and integral testing to fully characterize the performance of the new design features under the wide range of accident conditions reflected in UFSAR, identify degradation mechanisms, establish performance objectives, and define design requirements and analytical limits which ensure acceptable performance.
3. Conduct separate-effects and integral testing to fully characterize fission product release (e.g., chemical forms and release kinetics), core melt progression, core relocation, and mechanical and chemical interactions in order to characterize source term.

III. Fuel Licensing Process (cont'd)

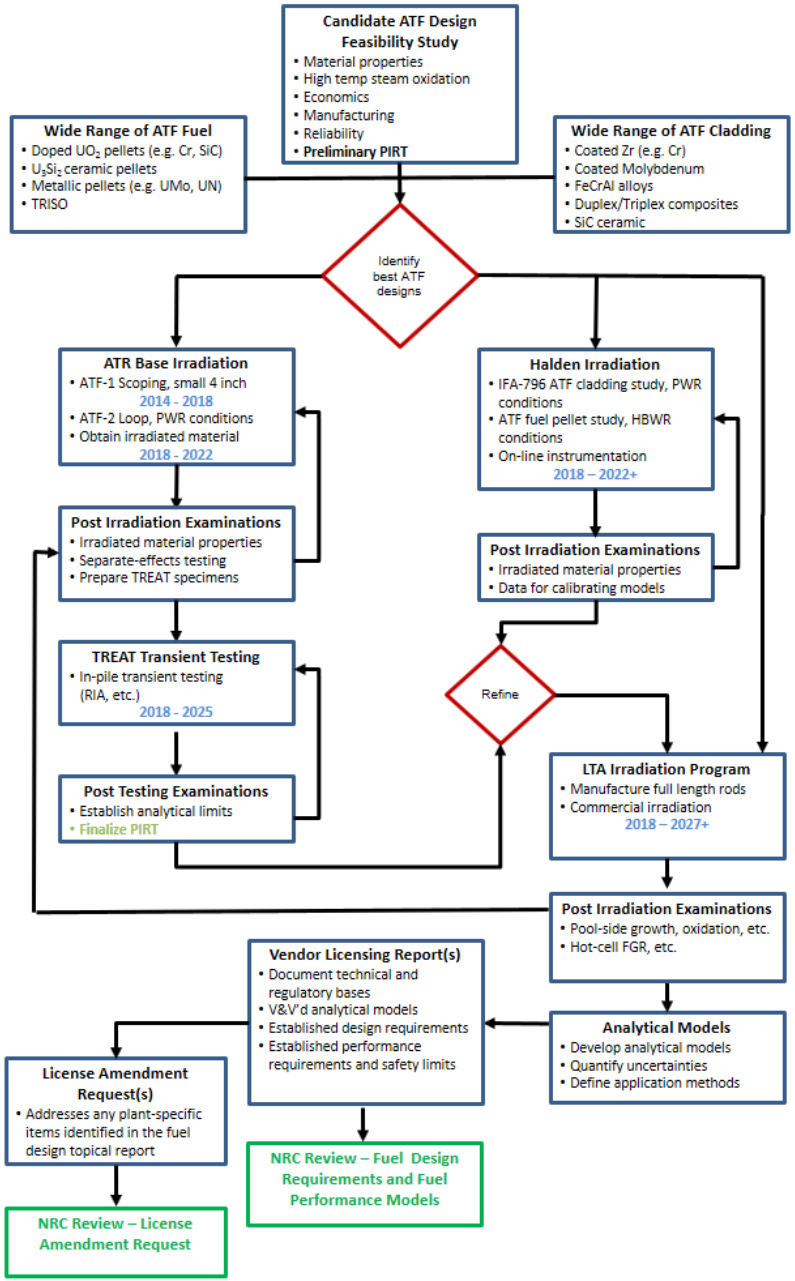
4. Based upon Steps #1 - #3, identify any existing regulatory requirements (e.g., GDCs) that are not satisfied or where new design-specific regulatory goals and requirements are necessary to support the unique design and performance features.
5. Develop, calibrate, and validate analytical models which simulate the performance of the new design features under normal and accident conditions, quantify uncertainties, and define an application methodology.
6. On a plant-specific bases, define Technical Specification Safety Limits, Limiting Safety System Setpoints (LSSS), and Limiting Conditions of Operation (LCO) which ensure acceptable performance under normal operation, AOOs, and postulated accidents.

III. Fuel Licensing Process (cont'd)

7. On a plant-specific bases, **demonstrate** that all design and regulatory requirements are satisfied*.
   - During normal operations, maintain geometric stability, integrity, and compatibility with reactor internals, co-resident fuel, and handling equipment.
   - During AOOs, maintain geometry, integrity, and ability to perform intended safety functions.
   - During postulated accidents including safe shutdown earthquake, maintain geometry and integrity to the extent required to perform intended safety functions:
     - Ability to insert control rods
     - Ability to achieve safe shutdown
     - Maintain known, coolable geometry (includes minimizing fuel fragmentation and dispersal and fuel melting)
     - Limit fuel damage to satisfy allowable limits on on-site and off-site radiological consequences

*Severe accident mitigation, SFP criticality, transportation and long-term storage addressed separately

ATF Licensing Flowchart



- Many parallel and in-series programs
- Level of effort proportional to degree of departure from existing designs
- Critical path items:
  - Long-term base irradiation programs, including commercial LTAs
  - Separate-effects and integral testing of irradiated fuel specimens
  - Development of analytical models and methods

Dates based on discussions with INL and industry

IV. Draft ATF Project Plan

- Outlines activities associated with preparing the agency to conduct efficient and effective reviews of ATF designs
- Includes preliminary estimates of lead time necessary to complete activities in each area
- Intended to be a living document

Assumptions

- NRC will not perform independent, confirmatory testing
  - data will be available from DOE, industry, and others
  - data will be of sufficient scope and quality to allow NRC staff to perform code assessments and confirmatory analyses
- Interaction with DOE, EPRI, vendors, and other organizations will take place:
  - in real time
  - in advance of experiments when possible
- Interactions with external stakeholders will keep staff and stakeholders informed about developments that can affect activities in the plan

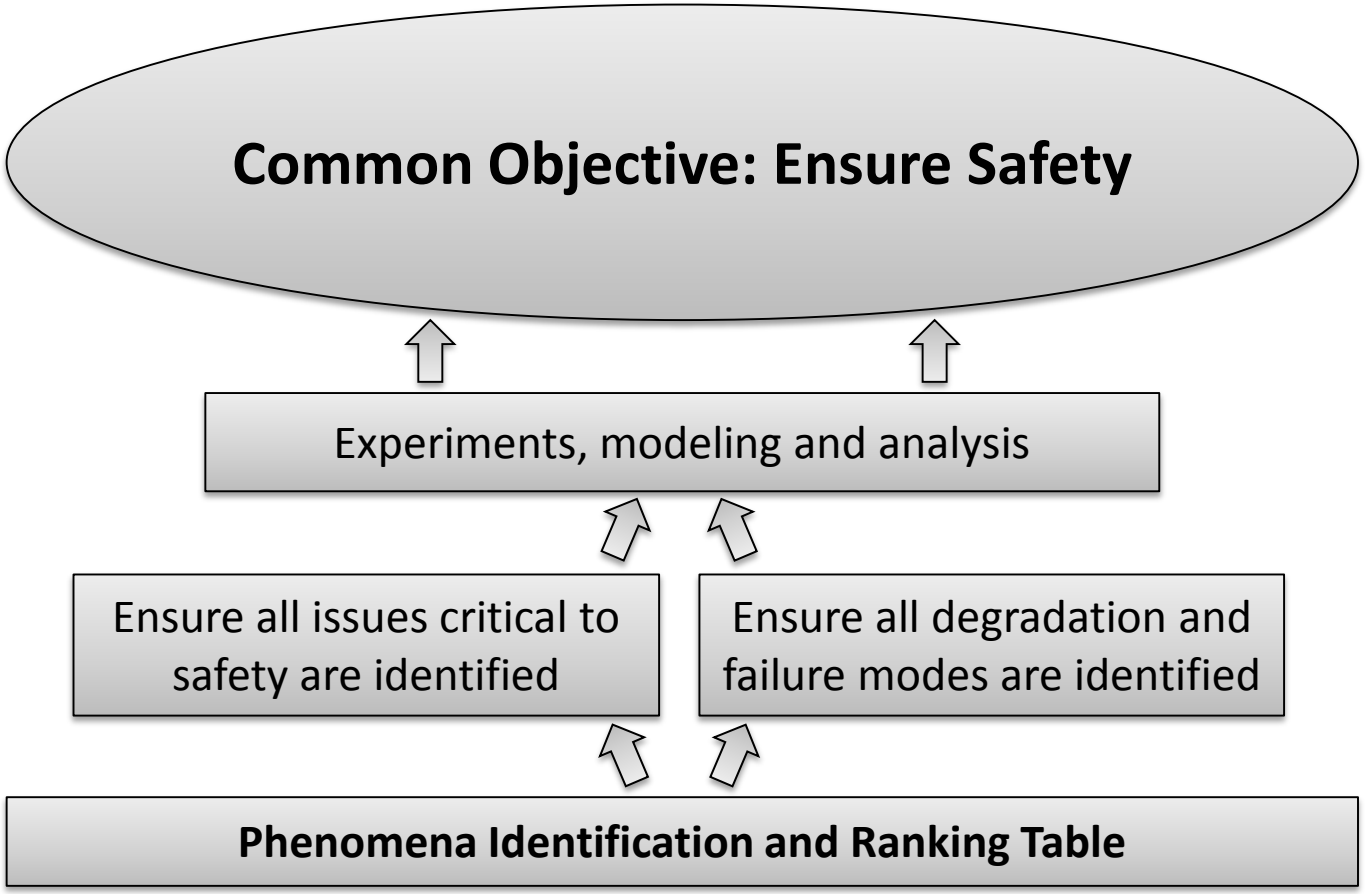
Stakeholder Interactions

- Identifies key technical domestic and international update meetings, experimental program review meetings, and conferences
- Staff are committed to participating in industry project update meetings to maintain programmatic awareness of industry and DOE efforts

a. In-Reactor Regulatory Framework

- Staff recognizes that there are potentially two types of changes needed:
  - changes to allow batch loading of ATF
  - changes crediting the benefits of ATF

PIRT process is part of ensuring safety



Using PIRTs for ATF

- Level of effort will be proportional to departure of ATF concept from current fuel designs
- Desirable for NRC, DOE and industry to coordinate PIRT exercises
  - NRC: inform regulatory requirements
  - DOE: prioritize research
  - Industry: develop safety case
- Applying best practices for expert elicitation

b. Fabrication, Transportation, and Irradiated Fuel Storage

- Existing regulations (Parts 70, 71, 72) are considered adequate
- Specific proposals with new materials (e.g., longer-term designs) may require new analysis, new regulatory guidance

c. Probabilistic Risk Assessment

- PRAs must represent the as-built, as-operated plant to the extent needed to support the application, which is in turn important for:
  1. Licensee PRA use in risk-informed programs (e.g., 10 CFR 50.69)
  2. Review of the results of licensee PRAs in risk-informed licensing applications
  3. Use of NRC PRA tools in reactor oversight (e.g., the Significance Determination Process)
  4. Developing perspectives on the change in risk due to ATF
- The role of PRA-related information in the ATF licensing review itself is dependent upon the approach industry takes
- Coordination with deterministic activities is important to support assessing changes needed for selection of core damage surrogates, system success criteria, sequence timing etc.

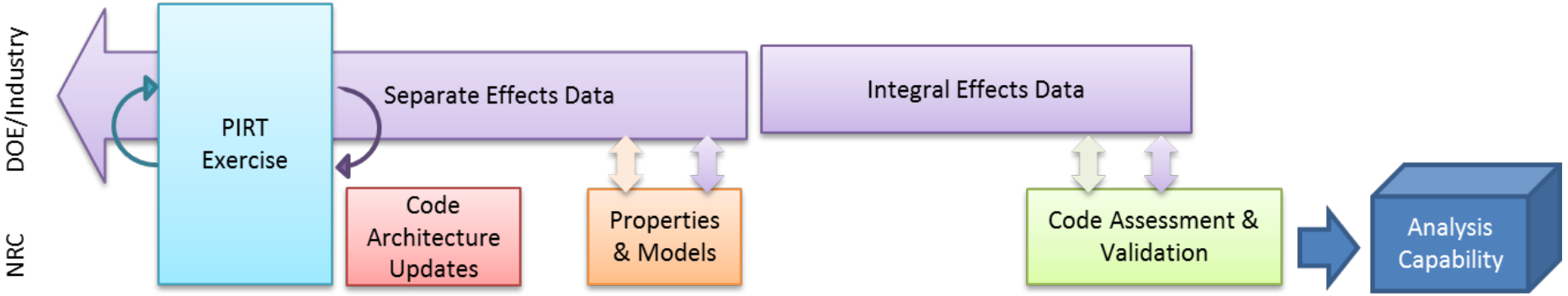
c. Probabilistic Risk Assessment (cont'd)

- Identified PRA tasks:
  - Remain engaged throughout the process
  - Licensing review support (as appropriate)
  - Agency PRA model pilots
  - Licensing and oversight guidance updates
  - Update of agency PRA models
- The project plan does not currently factor in:
  - Regulatory initiatives that might be requested in order to maximize the operational or economic benefit of ATF
  - Graded treatment for mixed cores

d. Analysis Capability Development

- Disciplines include fuel performance, thermal-hydraulics, neutronics and source term analysis
- Planned process:
  - PIRTs will be conducted to assess and identify information gaps
  - Code architecture modifications that make the codes more flexible and easier to evolve
  - Develop and add new material properties and new models
  - Complete integral assessment of each of the updated codes
- Lead times to develop full analytical capabilities can vary by discipline, code, and ATF design
  - Near-term designs: 1-3 years
  - Longer-term designs: 3-6 years

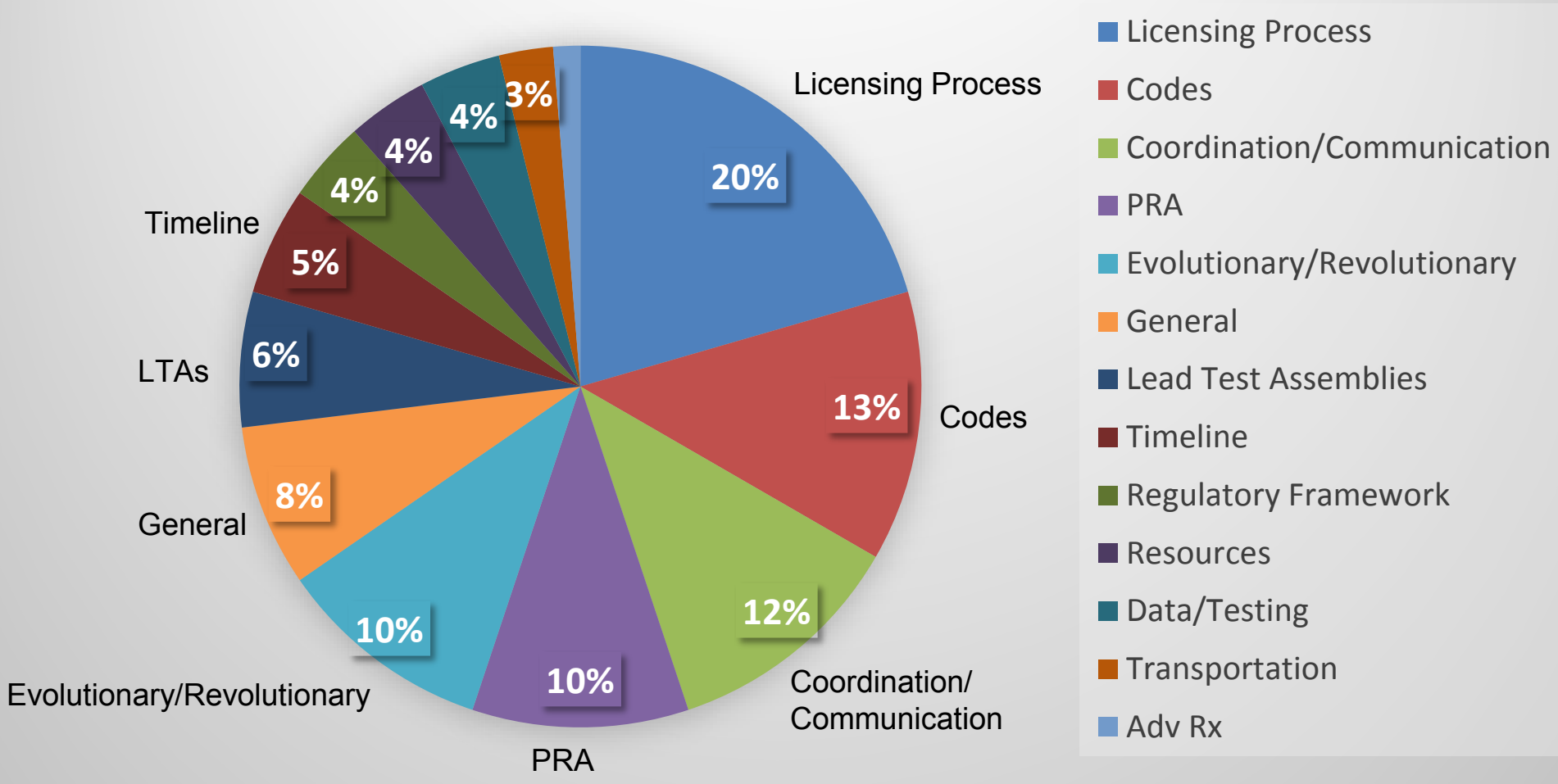
d. Analysis Capability Development (cont'd)



f. Public Comments

- Draft plan published in the Federal Register on December 21, 2017 for 45 day public comment period
- Received nearly 80 comments from
  - U.S. Department of Energy (DOE)
  - Louisiana Energy Services (UUSA)
  - Nuclear Energy Institute (NEI)
  - Pressurized Water Reactor Owners Group (PWROG)
  - General Atomics
  - Southern Nuclear Company
  - Westinghouse Electric Company
  - three individuals

Draft ATF Project Plan Public Comments

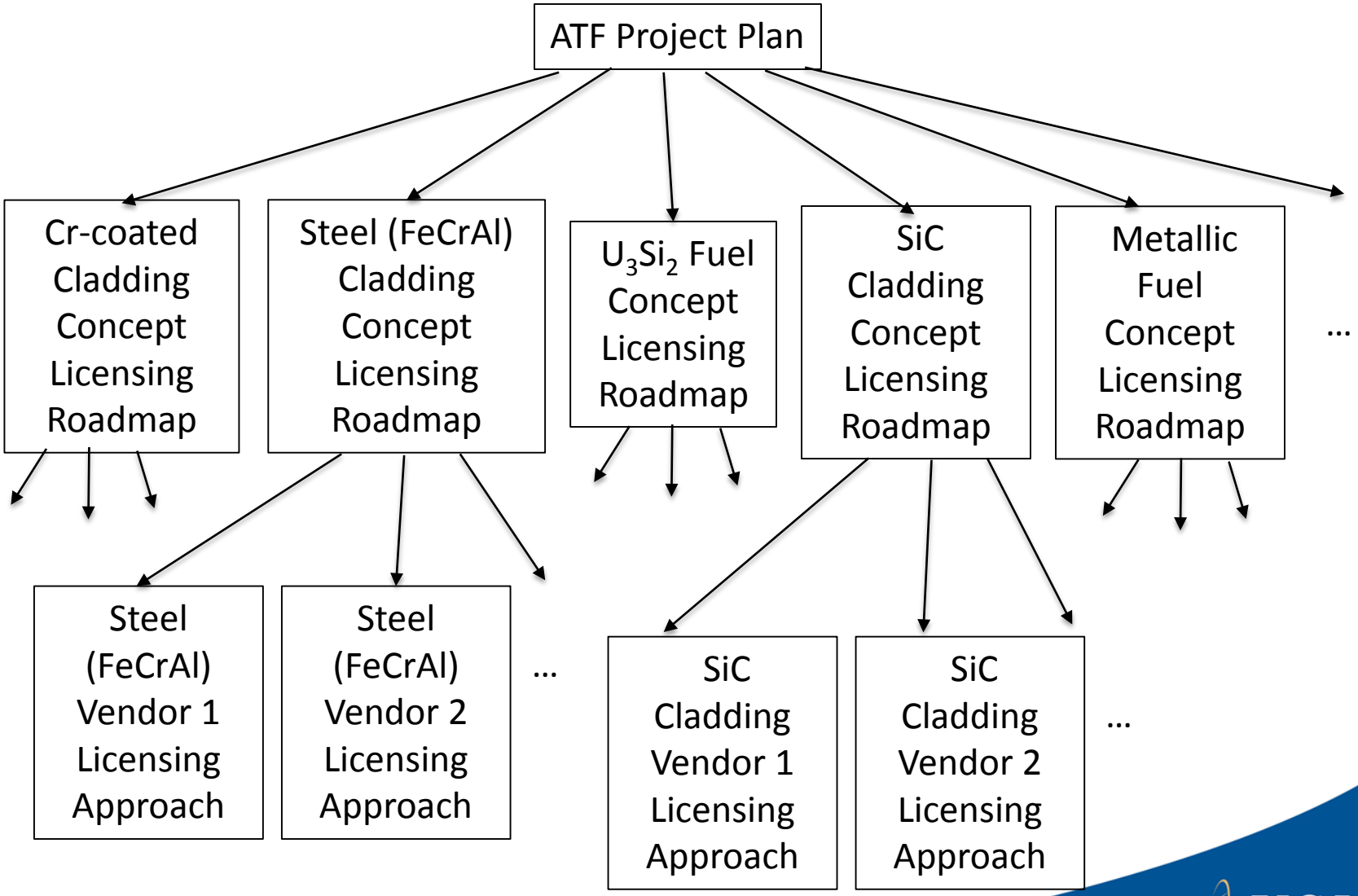


f. Public Comments (cont'd)

- Concerns with regulatory requirements associated with lead test assemblies
  - Outside scope of plan
  - NRR steering committee working to address
- Emphasize importance of communication/coordination
  - Staff committed to continue and seeks to enhance
- "Evolutionary" vs. "revolutionary"
  - Language removed replaced with "near-term" and "longer-term"
- Opportunity to transform fuel licensing process
  - Staff continually looking for efficiencies, open to specific suggestions

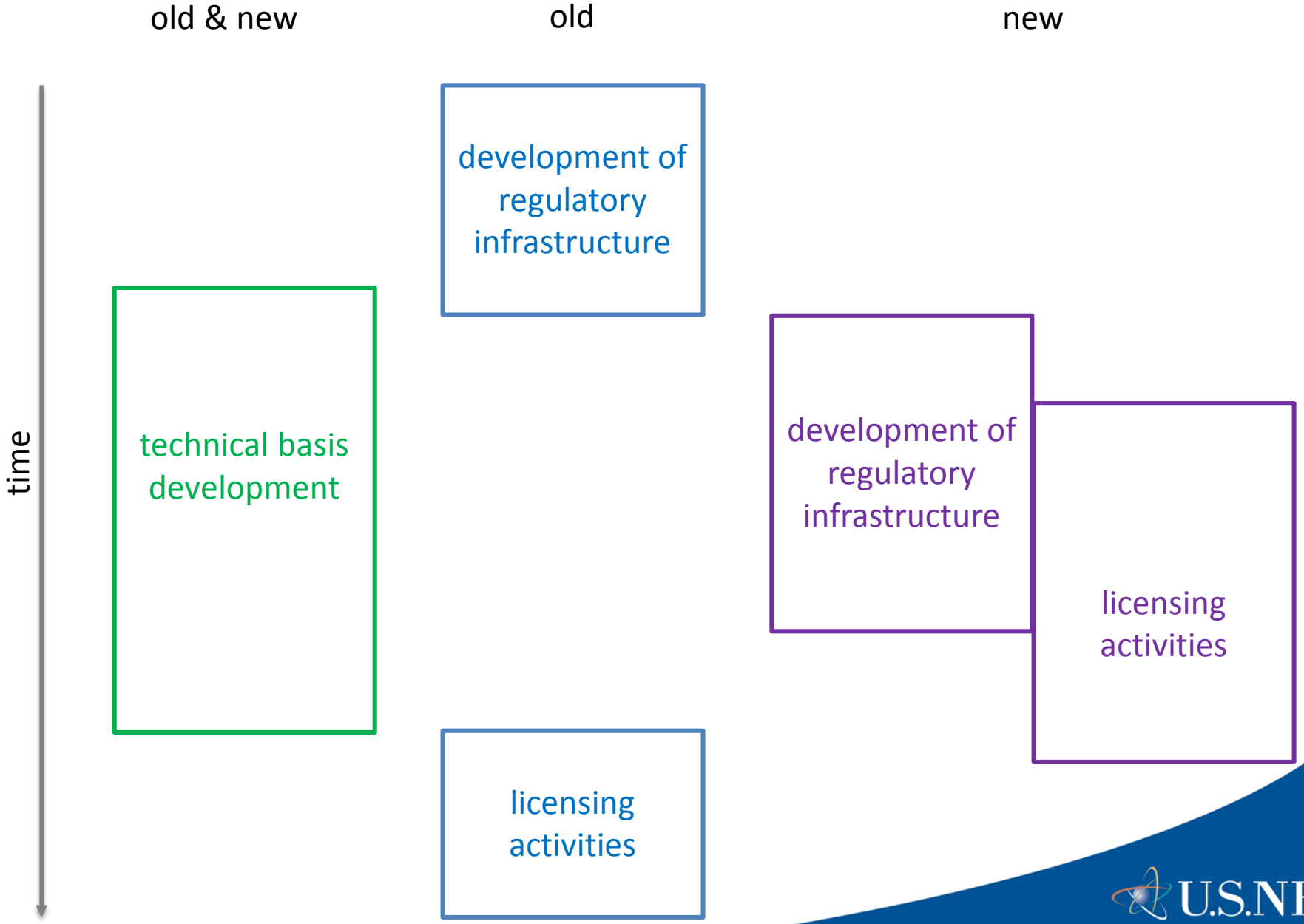
f. Public Comments (cont'd)

- Plan does not support industry's deployment schedule & staff is not employing a graded approach
  - The plan did not present a schedule but rather individual activities, many of which can proceed in parallel
  - The staff is committed to minimizing the lag between the time required to establish the technical bases for safe operation and the completion of licensing activities
  - The PIRTs will inform the licensing roadmaps for individual concepts
  - The PIRTs will facilitate employing a tailored approach for each concept, thus enable a graded approach



Licensing Efficiencies Under Consideration

- Expediting regulatory guidance
- Use vendor inspections to verify data intended to support licensing activities (e.g., topical reports)
- Change process for topical reports
- Leveraging the use of DOE codes


old & new
old
new
time
development of regulatory infrastructure
technical basis development
development of regulatory infrastructure
licensing activities
licensing activities

f. Public Comments (cont'd)

- Leverage DOE/advanced computational capabilities
  - Need for confirmatory calculations
    - Depends on the strength of the technical basis presented by the applicant
  - Use of non-NRC codes
    - Staff and licensees have used the same codes in the past (e.g., Fluent for dry storage casks)
    - Effectiveness and efficiency of using a non-NRC codes depends on many factors (e.g., readiness of existing NRC codes, V&V needs of non-NRC codes; learning curve for the non-NRC codes)
  - Simulations in lieu of experimental testing
    - At this time, the staff is not aware of any computational tool that obviates the need for experimentation to support licensing decisions
    - Staff is receptive to addressing this issue as the state of the art warrants it

NUCLEAR ENERGY INSTITUTE

Andrew Mauer
NEI

Ben Holtzman
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Al Csontos
EPRI

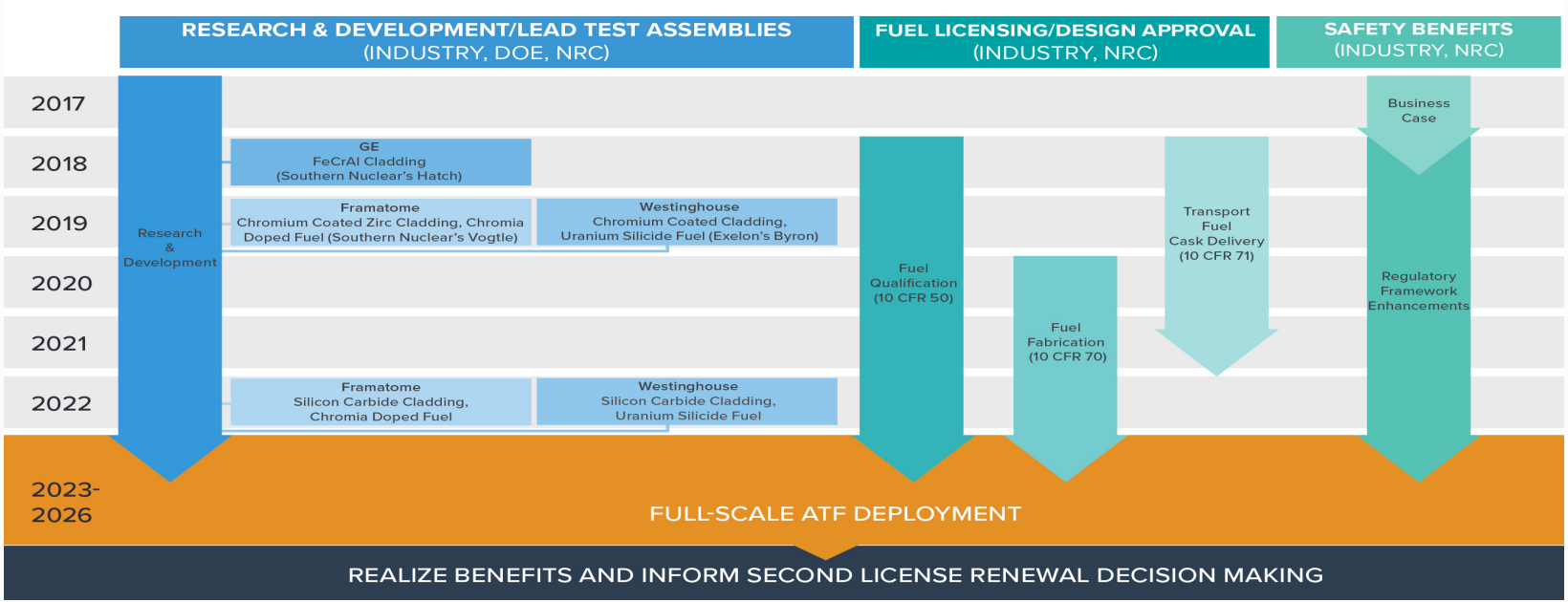
ACRS Sub-Committee on
Metallurgy & Reactor Fuels
February 23rd, 2018

Accident Tolerant Fuel (ATF)

NRC Project Plan

Accident Tolerant Fuels: Path Forward

Support initial ATF deployment in the early to mid-2020s and achieve meaningful steps toward NRC regulatory changes that recognize safety benefits



ATF Concepts Under Development

framatome

- Cr-coated zirconium alloy cladding
- Chromium doped UO_2 fuel

GNF Global Nuclear Fuel

- Fe-Cr-Al cladding
- Chromium-coated zirconium alloy cladding

Westinghouse

- Cr-coated zirconium alloy cladding
- SiC composite cladding
- U_3Si_2 high density fuel

Lightbridge

- Zirconium alloy cladding
- Metallic uranium alloy

NEI

Lead Test Assemblies in US

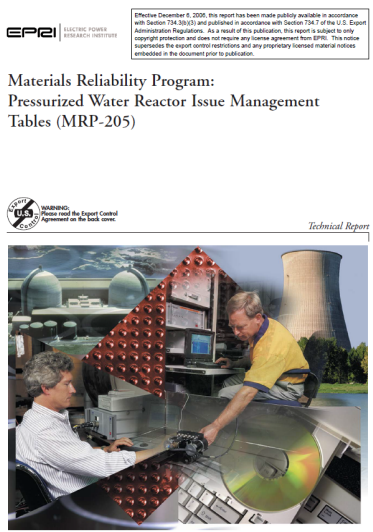
- Southern Nuclear Plant Hatch Unit 1 - Feb 2018 with GNF
  - Iron-chromium-aluminum fuel cladding material (Non-Fueled Rods)
  - Chromium-coated zirconium cladding
- Exelon Plant Byron Unit 2 – 2019 with Westinghouse
  - Chromium-coated zirconium alloy cladding
  - Uranium silicide pellets
- Southern Nuclear Plant Vogtle Unit 2 – Spring 2019 with Framatome
  - Chrome-coated fuel rod cladding
  - Chromium doped fuel pellets
- Exelon Plant Clinton – Fall 2019 with GNF
  - Iron-chromium-aluminum fuel cladding material
  - Chromium-coated zirconium cladding
- Additional LTAs under commercial development

NEI

Expert Elicitation: PIRT Process

- Potential Collaboration on SiC and Advanced Fuels PIRTs:
  - Existing regulatory guidance focus on metallic clad with UO_2
  - Advanced fuels to include U_3Si_2 and metallic fuels
  - Provide guidance on potential design criteria for specific ATF concepts to inform R&D priorities with early NRC engagement
- Discussions with NRC, DOE, EPRI, and OECD/NEA on domestic and international cooperative efforts to minimize duplication of PIRT elicitations
- NRC/EPRI Memorandum of Understanding Addenda on ATF identified cooperative efforts on expert elicitations
- Issue resolution reports to be done separately:
  - Prioritized plan to address identified gaps

PIRT Gap Analyses



Issue Resolution Report

EPRI ATF PIRT Research Collaboration Vision

Foster ATF stakeholder engagement that addresses technical and regulatory issues

Mission

- **Foster cooperation** between **ATF stakeholders** to **accelerate** development of R&D data, models, and technical bases for full core implementation of new ATF designs that can tolerate the loss of active cooling in the core for a considerably longer time period, while maintaining and improving the fuel, system, and plant performance during normal operations.

Goals

- Facilitate **information exchange & collaboration**
- **Identify** technical/regulatory gaps, **areas of synergy**, and common opportunities for research collaboration
- **Foster integrated, approaches to resolve technical and regulatory issues** for full core ATF implementation

Phased Approach

- Phase I:
  - Establish PIRT Steering Committee
  - Identify common goals, needs, and technical focus areas through PIRTs
- Phase II:
  - Review current technical bases and establish PIRT technical committees to address key focus areas
- Phase III:
  - Develop issue resolution reports separately for stakeholder needs
  - Coordinate tests, modeling, and risk/deterministic analyses to address PIRT identified priorities

Leverage global resources to identify, prioritize, and target R&D to accelerate innovation

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NRC Project Plan Implementation Timeframe

- Past licensing of new fuel and cladding designs with current licensing practices has taken up to twenty years.
- The safety and sustainability benefits of ATF need a more efficient licensing approach to fully realize the benefits.
- Further refinement of the draft project plan is needed to support ATF within industry's desired timeframe.
- Future alignment is needed between NRC and industry regarding schedule milestones

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NRC Project Plan Detail and Path Forward

- The level of effort should be commensurate with the safety significance of the design changes.
- Regulatory stability needs to be established through the project plan for all designs
- Each ATF concept is unique and should be evaluated on its own merits rather than being binned into the broad categories of evolutionary and revolutionary designs.

ATF Research and Development

- We support the NRC's position that independent testing of ATF performance characteristics is not required.
- Close collaboration between NRC, DOE, the national laboratories and the fuel vendors will eliminate the need for NRC independent development of codes and methods as it did for NRC independent research and development of fuel performance data.
- There is significant uncertainty in the time needed for NRC independent computational models development. Close alignment with DOE and national labs will enhance regulatory efficiency and stability.
- The NRC project plan should include tasks to develop confidence that advanced M&S tools can be used reliably in the regulatory process.

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Advanced Modeling and Simulation (M&S) for ATF

- Benefits of Leveraging DOE Advanced M&S Programs for ATF:
  - Benefits vary between near-term vs. longer-term concepts:
    - Near-term concepts can leverage existing approved codes
    - Longer-term concepts need code development for vendors and NRC
  - Reduce iterations of irradiation testing and post-irradiation examinations with confirmation to blind data sources and potentially advanced NDE
  - Design evaluations (transition cores, fuel performance phenomenon etc.)
- Advanced M&S (NEAMS/CASL) could be leveraged for longer-term ATF concepts as tools for both regulators and industry

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NEI ATF Licensing Task Force (LTF)

- NEI ATF LTF has been working to address many of the aspects of the NRC draft Project Plan since early 2017
- Four subcommittees have been established, aligned with the main tasks in the NRC draft project plan, and we look forward to frequent interactions as we finalize the development and implementation of the project plan:
  - In-Reactor Regulatory Framework
  - Fuel Cycle, Transportation and Storage Regulatory Framework
  - Probabilistic Risk Analysis (future)
  - DOE, Fuel Vendor and NRC Collaboration on Research and Development

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Summary

- ATF presents an opportunity to implement more efficient practices at the NRC
- Industry is committed to the pursuit and development of accident tolerant fuels on a timeline that supports initial deployment in a commercial reactor in the early to mid-2020s.
- Close collaboration and alignment between industry, DOE, the national labs and NRC will be required.
- A shift in the NRC's licensing approach is needed in order to license ATF and realize the safety and economic benefits from these advanced technologies.
- The implementation of the proposed changes to the project plan will enable parallel progress for several ATF concepts using an approach tailored to each ATF concept while leveraging the modeling and simulation work now available to the NRC.
- Industry stands ready to meet with NRC staff to work on the details of the plan.

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Questions?