FY2021 CINR Workscope Specific Q&A

Infrastructure FOA

What is the due date for the Infrastructure proposals?

When the FOA comes out, it will have the actual date, but we expect it to be November 12, 2020.

Can a current PI on a Reactor Upgrade award submit a FY 2021 proposal?

Absolutely. And I guess I probably should have added this. There was a preclusion on that. It's actually been gone for several years, but there is no, no preclusion to keep someone that's got an open application from applying.

Are only off the shelf items available for funding or can you fund custom built pieces?

Absolutely. I certainly recommend you go to the NEUP and NSUF websites and look at the previous year's awards. That will give you a good idea what was thought highly of in previous years. Last year we funded a reactor upgrades proposal, where the university intended to build the control rod drive mechanisms on their own with a local vendor. But, please, if you want to do that, explain how you're going to do it in the application. Things like quality assurance, you don't have to write out the whole program. But, please try to let the reviewers know that you've thought of everything. How are you going to do it? And also, very importantly, for reactors, how you're going to get it licensed.

For sharing our facilities as a partner, if we are funded, can we recoup expenses and charge a user rate?

Absolutely. If it's through NSUF, we will pay you for your expenses, obviously, talk to us about that. We understand if a professor has this equipment in the corner of a laboratory, it's not necessarily very easy to get outside people in, but it is something that is thought of very highly. But, of course, you can recoup your expenses and nope, no intention that you do this for free.

Is there any desire to avoid repeated equipment (i.e. PIV systems, flow imaging at different institutions), such as if a few universities already have been awarded a GSI for a PIV system but this new institution wants to propose one as well?

We would like to reduce duplication but there's certainly an understanding of why you might need your own…basically explain why you need your own. It very well could be were the only people within a thousand miles that have one of these. You know, I'm not going to get my students on a plane to fly to this other place to use. Now, if it's research only equipment, then maybe that's a little bit harder to explain why it has to be at one place and not another.

Can renovation of hot cells be considered in a reactor upgrade proposal?

Certainly, once again, that sort of thing has been funded in the past. It should have, once again, a good explanation of why you're doing it, how it ties into the reactor. One of the things that you should try to avoid in reactor upgrade proposals are things that just happened to be in the same building as the reactor. That's not a very good time. Reactor Upgrades had been very popular for these expensive proposals, because there was no cost match required. But reviewers are certainly savvy enough to say, “what does that have to do with the reactor?” In many cases, it has a lot to do with it, but you'll need to explain that.

Is there any restriction on the number of co-PIs?

No. But, certainly you will want to explain why you have a co-PI. Since this is either buying a piece of equipment or building and installing a piece of equipment. If the co-PI is there just a person who's going to use it then feel free, but there's no restriction that I know of.

Can a GSI that would involve multiple pieces of equipment be proposed? That would be under the $250,000 budget recommended.

Certainly. What I talked about before is there's no limit to what you can actually apply for. There are things that are reviewed better: if Professor A wants one thing, Professor B wants something completely different, unrelated, and the same with Professor C, those are not going to be reviewed as well as even three professors that want to all buy things that go towards one laboratory or one research goal. But you can certainly apply for multiple pieces of equipment in any case under GSI.

If a PI is considering a custom design, how far along should the design be before submission?

Well, that's up to the PI. I would recommend that you feel you have a good design, and that you explain it and be very clear in the proposal. There's no limit. This is not a development call. We wouldn't have funding through this call, too pay for, let's say, a firm to figure out how to build something and then to build it.

Does the non-LWR environment material testing capabilities include material characterization instruments, such as DC DSC calorimetry or TGA mass loss?

Sure. That's what we're trying to fill in gaps that we can see that exist. And really, there's not a lot of that going on, particularly for irradiated materials. It doesn't all have to be for radiated materials, but those are the things that we think are special.

If the PI of some current General Infrastructure Project has a good idea for another equipment this year, is he or she eligible to apply for this year's General Infrastructure FOA?

Yes.

Integrated University Program S&F Institutional FOA

The Fellowship supporting materials/recharge costs for the work of the student?

I'm not sure I understand the question. Of the $52,000 each year, it’s broken down. Basically, the student receives tuition and they do receive a monthly stipend as long as they're eligible for that monthly stipend. If they seek outside employment, we have to take that into consideration, and they wouldn't be eligible for that stipend at that point. During their internship, it's often anticipated that the internship is not paid, but if it is a paid internship, the stipend is adjusted. Another way of answering is that all of the money is going for the student, or the tuition of the student, either scholarship or fellowship. It doesn't go to a faculty member; it doesn't go anywhere else.

Do the students still submit separate applications for fellowships and scholarships?

Absolutely. This is just the overarching agreement we're talking about here, for the university. If you're accepted though this FOA, the university is just authorized to accept scholarship and fellowship students. They still have to apply individually and be awarded through the process that we've been going through for the last 10 years.

Is there any reason to think that a university that was approved at an earlier time would be declined this time?

No. I don't think we anticipate if we approved them at one point in time, unless there's a large change in their programs or their offerings to the students in regard to nuclear energy programs.

Does the IEP program provide the institution any overhead?

No, it does not. It is all support for the students. The university may not collect any indirect costs on this action under this funding opportunity.

Will faculty or students submit the application, and it will be submitted by the student? They will go in under NEUP.gov and start their own application and submit it there.

That's a separate process. This is to be submitted by universities. It's got to be initiated by a faculty member, go through and be approved by the university. This is a university institutional authority, authorization. Individual students will apply later. This funding opportunity (2265) will be for the university itself to apply to be on the approved list. The same standard procedure, which we've done previously, the RFA, request for applications, for students will be issued as a separate process still in place, similarly offered as in previous years.

Can some of the funding cover some costs for the student? For instance, say the student needs to run radiation tasks at a center, charging 600 plus dollars an hour and the radiation center is already on-site, so there is no need for NSUF funds. Can any of the funding that would go to the student cover that before their work, as part of their program?

It may be possible but may depend upon an individual's situation, there is a limit on how much money is available for the general purposes of research, or discretionary funds that students can have.

Is there a cap on the tuition being charged?

There's a cap on the amount of funding that we offer through this fellowship program. The funding opportunity announcement will detail all the categories and restrictions of each category (the stipend, the tuition allowance, what it can be used for, and so forth).

Will the student be allowed to accept other fellowships, if given an IUP Fellowship?

No. You cannot have more than one fellowship. If you have anything else…this question comes up every year, TA support, another fellowship, etc., you have to choose one or the other.

Could we get more clarification on how you apply for the Scholarship and Fellowship?

For this particular FOA, the university needs to apply to be an IUP approved university. Once that happens, the student then applies for the Scholarship or Fellowship on NEUP.gov

Are universities allowed to require non degree work, say, three hours a week of grading for their home department from IUP Fellows?

If it required of all students, and as part of their educational program, I would say that's probably allowable, as long as they don't get paid for it on top of what they're getting through the fellowship.

Where can we check the IUP approved University list?

You can go to the NEUP.gov website. Click on **Scholarship and Fellowship** across the top. There you will find a link to the IUP approved Universities. However, the current list is being retired. All Universities interested in continuing the program will have to re-apply. A new list will be created through this new funding opportunity announcement.

Is there a maximum number of months that a student should have been a graduate student beyond, which they cannot apply for the fellowship?

Yes, that's explained in the RFA, and that will come out later. But it will be similar to the previous years, last year in particular. Any restrictions will be detailed out in the RFA.

Is there a submission limit, such as, one institution can submit only one application to this overarching program?

It it's expected to only receive one (1) application from each institution that's interested in becoming an approved university to administer these scholarships and fellowships. We only need one (1) co-operative agreement per university. As multiple Scholarship and Fellowship applications come in each year, those multiple awards will be administered under one agreement.

Nuclear Reactor Technologies (RC)

RC-1: Advanced Reactor Materials

During the webinar, you emphasized that you would like us to try 1) two types of AM techniques (powder bed fusion and direct energy deposition); 2) high temperature tension, creep and fatigue tests. While reading the proposal call, I realized that it states that "together with data from in-situ process monitoring of the AM processes, and possibly modeling and simulation techniques, to arrive at a reasonable assurance that the AM component would perform structurally as designed". Do we need to add the goal of printing some reactor components in this proposal? If this is the case, what type of components would we need to demonstrate?

In applications, we would like to use the proposed acceptance criteria/protocols to provide some reasonable assurance that the build would perform for the intended lifetime mechanically, i.e., it would meet the design performance that the designers expect when designing the components to meet Code requirements (e.g., design parameters such as allowable stresses, etc.). The proposed acceptance criteria/protocols could involve printing the parts and witness specimens of some kind, or other proposed methodology. So, we are going for you to make the case that the proposed methodology would provide such discriminative "tool" for an owner/buyer to accept "good" parts with reasonable assurance and reject "bad" parts with confidence.

This is the current practice in a less challenging scenario of accepting reactor forgings and the like fabricated out of wrought metals. We are looking for something that would serve similar functions so that a 3D printed component can be put into service for reactor applications for whatever lifetime that it is designed for, which could be very long.

Whatever you propose that could address the above would be appropriate. Based on the challenges described above, it would not be appropriate for us to be too prescriptive. Simply put, we are looking for good ideas to come up with a set of acceptance criteria/protocols that could be put to practical applications. So, anything that requires very long test times or one of a kind characterization technique would not be practical.

Do we need to perform machine learning based modeling and simulation to predict properties? Do we need to add in situ monitoring technique to the proposal?

As I've replied in Q1, we (and the technical reviewer(s)) will consider any proposal that would help us to meet the challenges. There is no such thing as a "must have" in a proposal at this time. All proposals will be considered and reviewed. We are looking for proposals that would have the potential to become practical acceptance criteria for 3D printed components.

I know that ORNL has quite a bit of effort on AM of reactor component. Do you suggest that we collaborate with them?

The general sentiment for NEUP calls is that collaboration with other universities, industry, national Labs and non-profits is always encouraged if such effort would increase the "value" of the proposal. We cannot comment on the specificity of this question, though.

RC-1.1: Development of Qualification/Acceptance Protocols for Additively Manufactured Metallic Components Under Elevated Temperature Cyclic Service

Are only liquid/fusion base additive manufacturing processes of interest? How about metallic alloy fabricated by solid state additive manufacturing techniques?

I'm not familiar with that technique. However, if they fall in between these two data, we will consider that within scope. Because there are quite a number of different additive manufacturing techniques, instead of covering all different processes, we really want to concentrate on the two mentioned.

Do you have any specified characterization technique in mind?

No. This is a very interesting and difficult question. The challenge is how do we characterize the sort of material in the initial condition and we have confidence that the structural response of these AM components will follow what the designers have designed the components for. So, about 10 years, or 20 years, or 30 years. But this is what we really would like to have help from the university community to help us figure that out.

Is material for containment structures that are non-metal, for example, made of cement materials, of interest?

No, is not within the scope of this call. The focus of this call is 316H.

For RC-1.1, are you interested in certain components such as coolant tubes or heat exchangers?

No, we don't have any specific components in mind.

For RC-1.1, does one need to address both creep and fatigue life as the targeted performance index?

Yes, we do because those are the type of structural failure modes that advanced reactor components will see.

For RC-1.1, are you interested in developing a code case for additive manufacturing as a manufacturing technique?

Yes. Ultimately. We are interested in understanding the technique in terms of this type of acceptance and qualification methodologies.

RC-1.1: Does one need to model/test the fatigue performance under radiation, in addition to the given temperature, and lifetime expectation conditions?

As far as the irradiation is concerned, we're taking baby steps. This is a very challenging problem. So, first of all, we are just interested in having some ability to accept AM components for each, for softly high temperature surface on the mechanical loading, or thermal transient. So those are the things the radiation performance of the AM components and soft corrosion aspects we will have to defer to future work. So, we just concentrate on high temperature, mechanical, response.

For RC-1.1, how much focus should be on the process parameters as they are now, pretty much optimized for 316?

The scope of this is not in perfecting the AM processes. So, in terms of optimization, to get that to the AM process, to be even better than the current state of the art, is not what we are aiming at. So, obviously, that if you want to develop an acceptance protocol, you would have to be able to screen out bad components, as well as a screening in good components. So, therefore, we would sort of let that to the PIs to come up with some schemes so that the acceptance protocols will be discriminative.

For additive manufacturing and metallic materials, should the work also include testing in radiation environment?

No.

For RC-1.1, are modeling or experimental procedures preferred?

While experimental, I think that obviously, that the acceptance protocol will involve software testing characterizations. Also, additional mechanical property testing to help you to understand what needs to be looked at so that is all within the scope. In terms of modeling and simulation, that could foreseeably be one of the players.

What high temperature properties are of interest?

RC-1.1: The mechanical properties in terms of potential creep, fatigue, and creep fatigue, and also ductility of the material.

RC-2.2: as far as high temperature, mechanical properties graphite actually gets stronger and the stiffness gets higher under radiation and at high temperatures. So, really room temperature is going to be sufficient for any kind of mechanical testing.

For RC-1.1, do you expect to perform hipping operation after PBF or DED?

I don't know what the current state of the art is, so therefore, that it could be us printed, it could be under some heat treatment. I will just leave that with some of the standard, state of the art in practice in the additive of space.

Will someone at DOE provide the additive manufactured samples for RC-1.1?

Not specifically. Now, obviously, the DOE program has sponsored various programs that there could be some 3-D printed to samples that one can associate but that will probably be between a PI and individual program, so for this call, we're not prepared to try to supply AM materials.

If I had a question about specific details of the work I would like to propose, can the TPOC help me decide what to do, if I contact them by phone or email?

Due to the procurement rules for the NEUP Program, I cannot comment on specific details of your proposed work cannot be commented on. I would suggest that you review the scope statement, the webinar presentation and the Q&A carefully to address your questions.

What sample geometry and dimension will be of interest, where is the AM metal expected to be used in the nuclear reactor?

The additively manufactured components of interest are for structural applications in advanced reactors. They could include vessel, flange, piping, intermediate heat exchanger, tubesheet, etc.

What stress mode (tension, bending, shear etc.) is of interest?

Structural components for advanced reactor applications generally would experience three-dimensional stress state due to pressure and thermal transients. Thus, AM components would expect to see similar stress state.

Do we need to come up with different protocols for powder-bed-fusion vs. direct energy deposition samples?

As emphasized at the webinar presentation, the scope of this project is not to develop and to improve additive manufacturing processes. Rather, the objective is: given an AM fabricated component, develop a suite of procedures such as testing, characterization, process data, modeling and simulation, etc. that would be effective to ascertain that the AM component would meet the structural performance metric as specified by the designer for prototypical operating conditions (loading, thermal transient, etc.) of a high temperature reactor for its intended design lifetime.

To be specific, the scope calls out 316H stainless steel, a maximum operating temperature of 650C and a 100,000-hour design life. So, there is a definite design window that can be targeted.

Are there any specific documents that we can refer to when responding to the regulatory framework/requirements?

That would be the ASME Boiler and Pressure Vessel Code, Section III, Division 5 rules. It provides design rules and design parameters (e.g., allowable stresses, based on long term creep rupture data) for mechanical engineers to do structural design for advanced high temperature reactors.

Would collaborating directly with ASME/ASTM standards organizations be viewed favorably for this topic?

The objective of the call is to develop qualification/acceptance protocols to provide a reasonable assurance for AM components to perform structurally as designed for elevated temperature cyclic service and intended design lifetime in order to meet regulatory requirements.

The intended applications of these AM components are for nuclear service. Being able to use the information and R&D results developed through this work as the technical basis to support incorporating the qualification/acceptance protocols in codes and standards is an important consideration.

For RC 1.1, do you have any preference between laser powder bed fusion and laser direct energy deposition?

There is no preference. As stated during the webinar, we would also consider any proposed work that include both methods.

Effective qualification/acceptance protocols will be necessarily based on materials characteristics and properties, and not on the AM fabrication processes.

It says the proposed work can be based on either Powder-Bed Fusion or Directed Energy Deposition (DED) method. My query is regarding DED method, which covers not only powder-based processes but also wire-based processes. Can we propose the work based on wire-based Directed Energy Deposition method? Also, DED method uses laser, electron beam or plasma arc as a source of energy to melt the powders or wire. Can we propose the work based on plasma arc energy source in the wire-based Directed Energy Deposition (DED) method?

For the scope of RC 1.1, we are interested in two powder based additive manufacturing processes: powder-bed fusion process and directed energy deposition process with powder feed. We are okay with the energy source being either laser, ebeam or plasma arc, but wire feed processes are out of scope for this call.

Under powder bed fusion, are you only interested in laser powder bed fusion or is electron beam powder bed (EBM) process also of interest?

The additive manufacturing processes that are within the scope of RC 1.1 include powder-bed fusion and directed energy deposition with powder feed.

We are interested in powder-bed fusion processes with any energy sources that can be used to 3D print metallic reactor structural components with good precision.

In the program description for RC-1.1, it states "*Any mechanical properties testing would have to be practical for the protocols to be used to accept AM components. For example, test duration longer than 100 hours would be problematic.*" Since creep and fatigue are both listed as the properties of interest, can you clarify the requirement of "<100 hours" experimental design? Should we propose more aggressive but short test, or more realistic test plan to simulate the reactor operation?

The objective of this Call is to develop qualification/acceptance protocols to provide a reasonable assurance for AM components to perform structurally as designed for elevated temperature cyclic service and intended design lifetime in order to meet regulatory requirements.

When one purchases an AM component, it is expected that the seller would be able to produce "evidences" that the component is what the purchaser is paying for and it would perform mechanically as designed. The scope of this Call is about finding out what kind of "evidences" that the seller needs to show so that the buyer has a reasonable assurance that the AM component will perform as intended. Whatever are the "evidences" the seller needs to produce, they need to be practical and can be produced in a reasonable time frame.

When implementing in-situ monitoring techniques for this work scope, is there a preference to utilize existing monitoring techniques already applied within industry or is development and demonstration of new techniques within the scope of this work? Is there a preference between the two from a DOE perspective?

The emphasis of the scope is on developing qualification/acceptance methodology and criteria for AM components for nuclear service. We would prefer to adopt existing industry methods as part of the acceptance protocol though we would consider the development of new methods as a part of the overall scope if the existing methods are deemed not satisfactory.

Is there a preference for electron or laser powder bed fusion? The FOA does not specify.

We are interested in powder-bed fusion process and directed energy deposition process with powder feed. The proposal can concentrate on either one of these processes. Though as we stated at the webinar, we also consider proposals that include both processes. We are okay with the energy source being either laser, ebeam or plasma arc.

Effective qualification/acceptance protocols will be necessarily based on materials characteristics and properties, and not on the specific AM fabrication process.

Is there a preference for laser-blown powder or wire-arc DED? The FOA does not specify. (Am I correct to assume laser-blown powder is preferred?)

We are interested in powder based processes at this time. So wire-feed processes are out of scope.

RC-1.2: Effects of Radiation Induced Microstructure Change in Graphite

For RC-1.2, is there a preference of a modeling or experimental lead proposal?

That would be experimental at this point. We just don't know enough about the actual mechanisms, which is why we're trying to focus on the mechanisms before we can actually do the modeling.

Why is 316H the only material of interest?

It is the material of interest for this particular scope because it has been called out by a number of advanced reactor developers for different concepts (commonality) and 316H are materials that we know a lot about in terms of properties for the raw product form, therefore, we at least know how it behaves in terms of the raw product form, therefore we have certain things to target.

For RC-1.2, is there a specific Graphite material that should be focused on?

No. Fine grain, large grain, well, medium, large grains not really considered nuclear grade. But medium grained and fine grained, super fine grains, all of those we think, would behave similarly as far as the micro structural changes. So, no, there's nothing that's specific.

For both technical areas, is there an emphasis or a desire to include DOE NEAMS tools such as Moose or Marmot?

For both RC-1.1 and RC-1.2, there is no specific preference in terms of what modeling and simulation software, or techniques are used.

Is there still interest in research on Alloy 709, like tweaking the formulation?

Yes, we have an interest in data in terms of the DOE-NE program, but not specifically for RC-1.1 scope.

Is there a list of previously funded atomistic modeling and simulation of graphite radiation damage?

Not readily available, but I can go ahead and try to take a look at that if people want to get ahold of me personally, go ahead. I will try to generate a list that they can start with. If that list is produced, we will provide that to all applicants.

RC-1.2: Is surrogate ion or proton irradiation relevant to simulate neutron irradiation?

Great question. Sure. I think that why not, we don't know what the mechanisms are. Let's take a look at that and what we can do is we can compare them with the bulk neutron irradiation and see if there's any real differences at this particular point. That's probably good enough for a research endeavor like we're trying to do, so, yes, that's correct.

Are only metallic materials being considered for AM components? What about ceramics, such as SiC?

Only metallic and for demonstrating the qualification acceptance protocol - we will only look at 316H grade.

For RC-1.2, how much interaction with graphite creep experiments at ATR is expected?

Minimal. The irradiated graphite will be available for any anybody who is performing research on this. So, we have irradiated graphite in samples that are readily available for anybody. All you have to do is ask and we'll send it out to you. But as far as interaction with the creep program, we're, you know, you do not need to go in and put any kind of emphasis on interacting directly with the AGC program. But we do have samples and we will make them readily available for anybody who wants to do this research.

For graphite, what types of modeling efforts would be within the scope for this topic? Also, how many graphite grades are of interest?

Well, let's start with the second one. That one's easy. If they want to focus on the major grades of graphite in the AGC program, that would be probably the most beneficial since there's more information in the last 20 years on the 5, 6, 7 grades of graphite that's in the AGC program than pretty much any other nuclear grade of graphite that's been produced in last 20 years. So, focus on the six major grades of graphite and AGC. That would be very good. As far as modeling is concerned, what I would like to do is, like I said, I think the emphasis should be on understanding and determining the mechanisms so it takes an experimental approach, But, of course, any kind of modeling, once you have that information is going to be desirable, specifically, basically, to scale up. So, we're going to be looking at not nanometer, which is the crystallographic link scale, but we're going to be looking at the micron, sub-microns if you will, hundreds of nanometers on up to mm length scales. So, some kind of modeling effort once you have a good understanding of the mechanisms is probably going to be appreciated. But, of course, the emphasis is going to be on the experimental approach so that we can truly understand what is going on at the at those link scales.

Are studies of variations in base composition of 316H of interest?

Let me see if I understand, presumably referring to the chemistry of 316H. If that is the question, then the chemistry specification of 316H test range, so ASTM and ASMG have the chemistry specification. Additionally, for division five applications that the code has additional restrictions in terms of nitrogen titanium, that is the information that can be obtained from looking at the division five. We are looking at any AM fabricated components that is within this chemistry spec from ASTM, ASME, as well as division five.

Is Software development of interest in either scope?

RC-1.1: Software development by itself would not help us to do acceptance. So, if whatever computational methodologies that that is needed together with some sort of chemistry testing characterizations of the witness samples, and mechanical property testing of the witness sample, how to use all these sort of very large data sets that is collected during the AM processes, all of that, I see will be necessary in order to come up with the software credible acceptance of protocols that can be used as to screen in or screen out AM components. I don't see that the solely software by itself can accomplish that. RC-1.2: I think it would be a minimal advantage to look at anything from a software aspect. Again, we're sort of starting from scratch here, trying to understand mechanisms, and then once we do then we can start expanding out into those things. So, basically, a minimal advantage for that.

What properties are your target for the qualification?

Currently, for metals, we only do room temperature tensile to accept a heat of material for high temperature reactor applications and for stainless steel 304H and 316H. We additionally require to have an acrylic fatigue test done and it's done for stainless steel at 600 degree Celsius and the cryptic test will have a one hour hold time. We require that the material can withstand 200 cycles of this acrylic fatigue without seeing low drop before we will allow that heat of 316 raw metal to be used to fabricate high temperature reactor components. Therefore, even for the raw metal that we do have, this type of additional high temperature testing for advanced reactor applications. So, in terms of the AM that I think that we are asking the PIs to offer, we imagine what needs to be done. Obviously, we need more than what we currently are testing for, so the tensile property will not be enough to let us know whether or not the AM components can deliver the type of mechanical properties performance at high temperature for soft extended design lifetime. RC-1.2: The focus will be on mechanical properties, physical, if you will, modulus stiffness, modulus strength, tensile compressive, flexural, I would suspect that you are going to want to focus on tensile and compressive. They are probably a little easier to understand and they will all be done at room temperature. There's no need to get fancy and do any kind of elevated temperature at this point. We're looking for mechanisms, so keep it simple. It will be those kinds of mechanical and elastic type testing at room temperature.

Is the graphite irradiation study limited to structural graphite, whereas graphite matrix used in HTGR fuel elements also under consideration?

Great question. Let's focus on just the Structural Graphite for now. Matrix material, simply because it is not graphitized, is going to be potentially, well excuse me, it does have a different irradiation performance and so there may be differences in the starting mechanisms that change the microstructure. So, let's start on just the Structural Graphite for now and leave the matrix to another day.

How will the additive manufacturing work proposed here, and FC-1.1, coordinate with NE-5 NEET Crosscut Advanced Manufacturing Program?

The Advanced Manufacturing Program is much wider, has a much wider scope than what we're looking at here. Our focus here is really for developing these acceptance criteria for protocols for 316H, because of its focus for advanced reactors. The AMM program is not currently focusing on this area, and so that's why we took it upon ourselves to look at this because of its direct application for advanced reactors. There isn't a direct to any kind of overlap on what's going on in A&M AMM. We are not interested in improving the AM processes, printing different ways and optimizing the AM process. We just want to use whatever the state of the art will more concentrate on how to accept components that are fabricated by these two AM methodologies.

For RC 1.2, would you consider atomistic and/or mesoscale simulations as an acceptable tool to help identify mechanisms?

No. Well, not atomistic simply because that work has been done. There's been a lot of work out there. I'm not saying it's complete, and we still need to do that kind of work. For this specific call, we're looking at, say, the next link scale up. If you want to take a look at the atomistic, and how that influences the microstructural changes, at the next link scale up, say, at the hundreds of nanometers, and sub-micron, that's perfectly acceptable. But, to go in there and just focus on the atomistic models is defeating the purpose of this specific call, which is we want to look at the next link scale up.

For RC-1.2, can destructive measurements be performed on the irradiated graphite samples that are available?

Yes.

In RC-1.1, is the in-situ NDE intended to be used for predicting material performance or to verify the manufacturing process is controlled and verify the final component/material is equivalent to the material that went through the host of destructive testing as part of the qualification process?

Currently, effective and practical methodologies that can be used to qualify an AM component are still under development. As in-situ measurement techniques are being developed to monitor the AM process, it was stated in the SOW as a possibility to use such information as part of a multi-pronged approach, together with structure-property relation, modeling and simulation, some ex-situ properties testing and characterization, etc., towards qualifying an AM component. We encourage PIs to develop innovative approaches that would help to address this challenge problem.

Reading between the lines RC-1.1 work scope appears to be leading towards an ASME Section III code case for additively manufacturing 316H. However, since this work scope is to be university led and not industry, I'm assuming the code case is not and expected outcome, correct? Is development of the 316H and data package for a code case within scope? How do you see the results of a successful project being applied to a 316H code case?

We are using 316H as a focus so that all proposals can address the same material. As stated during the webinar, performance information for wrought 316H is well understood in the Codes and Standards space so there will be one less variable to be looked at in the development. Again, the objective is to develop qualification/acceptance methodologies that the AM component would meet, with reasonable assurance, the intended design performance. Thus, being able to screen out “bad” AM components is also important.

Any scientific information, data, etc. developed by this project to support the adequacy of the proposed qualification/acceptance methodologies would be part of the deliverable. The ultimate application of the methodologies developed by the PI(s) would be in the ASME Code space. But the development of an ASME Code Case is not part of the scope. It will be considered as future work.

RC-2: Microreactor Cost Reduction and End-User Application Integration

Is the numerical simulation of heat pipe micro reactor by MOOSE and SAM 3-D plus 2-D coupling of interest with this work scope? The work will focus on the core design to improve heat transfer coefficient and reduce fuel cost.

At a very high level, not to give advice on one area or another, but we've had a very in-depth work in that area currently, just in general, with applying some of these NEAMS toolkits and their optimization, specifically for heat pipe micro reactors. We did have significant activities within last year's call; it was very heavily weighted on the optimization integration of heat pipes. So, we are not necessarily looking for a high level or really focusing too heavily on the heat pipe reactor itself in terms of its optimization. To be responsive to the call language, we would want that activity to look at specific technologies that reduce cost and be able to get some indication of how that technology would reduce the microreactor cost. If the scope is developing overall simulation models, probably not very responsive to what we are currently looking for. If it is modeling a specific technology option or innovative technology that can reduce cost that would be of interest.

Will proposals be considered that meet the cost-reduction goals of the call? But do not use Marvell or Magnet?

We highly encourage the use of Marble or Magnet, but if a proposal can show that they are employing other experimental capabilities to show the viability of a technology or regime that may be cost effective, that will be taken to consideration, but we are definitely opening up the door to utilize some of the facilities and infrastructure developed within our program. So, I wouldn't necessarily preclude it, but it is highly encourage the extent possible, even if the proposal would potentially lead to subsequent work that would be directly applicable within Marble or Magnet, that would be encouraged as well. I would not rule everything out that is not directly within the experimental work scope if there is a strong enough case of an experimental regime.

For production cost reduction proposals, is there an accessible database of technical specifications and designs of micro reactors considered for a commercial deployment?

I would not say that there is an open database per se of going into the exact proprietary details of micro reactors in the program. We do have a variety of technical documents out there that may give a ballpark in terms of crosscutting technologies for specific types, such as heat pipes, or gas cooled reactors that maybe generally applicable. I would sense that if a proposal is looking at addressing for specific technology that's where we are heavily encouraged working with some of these stakeholders, and end users, even reaching out to potential micro reactor companies or developers to see what they would be willing to share from that regard. I think most of the data that we have would either be on former reactors, similar to some of the technology be considered with heat pipes or just other generic, high temperature gas reactor data that may be readily available. There is no general database that has micro reactor design information. Developer information cases are proprietary and require partnerships with them. We do have generic designs that could perform a basis of some of this work, and if there's interest, reach out to me (Jess Gehin), and I can make connections there.

Even though budgets have not been set, do you have any idea how many awards you might be hoping to give in this area?

When we were putting the scope together, we would usually base it off of previous years, and what our expectations and funding levels were. So, I would say, with the caveat that nothing's been determined yet, but I would assume all anywhere between two to three within the scope area, is our ideal number, which shifts one way or the other depending on final budget allotment, but I believe that was our mindset as we went into this.

Are concepts other than heat pipes allowed?

Yes, absolutely. I know it seems it is very heat pipe centric, and so far, it has been heavily weighted towards that. Primarily a heat pipes have been less technically mature for applications and microreactors. Within the objectives, the R&D program is to really bring some of these less mature technologies to fruition, realizing that some other technologies have relatively mature bases, especially if you're looking at gas reactor or other type of liquid coolants. But if there is work that can be very specifically be related to other concepts that are micro reactors and utilizing other technologies, yes, we are more than welcome. Actually, it would be good benefit with what the amount of so much work going on for heat pipes, universities can really do a good job of notifying us on what are some of the shortcomings and other technical hurdles specific to micro reactors - other technologies that are being considered by the commercial stakeholders. So yes, it is not just limited to heat pipes.

Are shielding and other deployment concerns solutions invited to apply?

It is a relatively broad scope. Those are areas that can be invited as well, but there needs to be a clear explanation of what the benefit of the particular technology would be from a cost savings for that. Now, from a shielding standpoint, that could be something in terms of reduced emergency planning zones or other applications as well. Most of the work we have really been focused on, and that I have heard from the stakeholder community, has really been focused more on reducing size to increase reflectors or advanced moderators. If they are engaged and have a close relationship with a stakeholder that the state shielding concerns, maybe an issue and cost of material and things like that is one possibility. We try to keep it as broad as possible, but the key is we highly recommend you show a direct correlation of how it can be a significant cost savings over what is currently being considered.

Is there an interest in proposals aimed at developing artificial intelligence algorithms for autonomous monitoring and control?

Employing algorithms within the context of existing technology, in terms of the governance to move or operate existing technologies or sensors or that I think that would be viable, but in terms of standing up a brand new sensor technologies, that's not really what we're looking for in the scope area. If this is connected to the objectives of this call, which is related to cost reductions or applications testing, then it would be relevant. Developing algorithms and methods for autonomous operation would not be as responsive to call. And there's likely, maybe other areas in this CINR call that may be more applicable for that group.

Will proposals that include an industry partnership with a micro reactor developer be given extra consideration?

Not extra consideration, in that sense; I think it would just be good advice. Because our program is very heavily focused on helping commercial stakeholders for their near-term demonstration and getting a lot of specifics. We have at a high level, on a cross cutting level. But if you are looking for a cost reduction and that, it would be beneficial to at least engage stakeholders and commercial entities that are interested; they always get a sense of what some of their needs are.

We do have ability to engage with industry, but really going down the technical details and their needs I think it would be beneficial. I am not going to say yes or no. It would not put one proposed over another, and that's not really my place to say, but I would say, you know, it would be sensical. It would not be wrong given the focus of the program to bring these. It seems to make sense to try to engage our stakeholders to the best of their ability.

Is advanced materials and manufacturing towards micro reactor design, an interest in this work scope?

We are not looking to step on other scopes that are in other programs that are really dedicated to standing up, in a general sense, some of these. But if there are components are that are fabricated from that type of methodology - that there can be a clear connection to how they will benefit directly micro reactors and a strong economic case - that may be something worth considering. But in terms of developing new manufacturing techniques or items like that, I do not believe that would be as responsive to this particular call. It may be more viable and other scopes within this particular CINR this year.

Are the micro reactors that are targeted to be fixed or should they be transportable after operation?

At the Department of Energy, we are really focused on fixed applications. So what that means is, on the anticipated the micro reactor, it is factory fabricated transported, nearly fully assembled to where it will operate and then the site where it is put out is where it will operate for its lifetime. We are not looking at some other applications that would be considered more defense applications where you would operate it, pick it up move it to another site and operate it. That is outside the scope of the DOE R&D program.

Will other software, rather than NEAMS tools, be proposed to explore deployable technologies at the system level?

The use of software technologies to show the case about a component or a technology or on an experimental matrix; I do not really see an issue as long as there is a strong case. I would recommend using some of the NEAMS tools for design and etcetera, but I understand that for different component technologies, the NEAMS tools may not be applicable if you are designing, a single heat pipe or a single heat exchanger, items like that. So, we are not precluding only used NEAMS tools for standard finite element analysis of items or things like that. It is not a requirement, although NEAMS is putting effort into developing capabilities to support microreactors, and we would encourage proposals that would use those capabilities and help apply those capabilities.

Two test facilities were mentioned in the RC-2 call. Should a proposal address two topics or facilities?

No; essentially the overall arching premise of the scope is making these economically competitive and these are two pathways that can be considered. We want to give that versatility and open up the whole experimental infrastructure we've had, but you are not obligated to use both. You can use one or the other in your call. You are not obligated to have one that reaches into either. We just want to put everything on the table and make them available to interested University collaborators.

Can you explain the capability of the test bed at INL and is the involvement of INL personnel helpful?

I will give a very brief answer because to describe the capability would take much longer than what we have right now. My recommendation is, yes, I believe the best pathway is to contact INL, either Dr. Jess Gehin directly from this call, or on that website I listed at the end gives variety of point of contacts within the microreactor program that can give you ample information on these facilities. Those documents up there are ready to serve as a good starting point, and it gives you direct contact from individuals in the laboratory structures that can help guide you in terms of expected capabilities and specific technical specification of the facility.

Would you be interested, at this point, on implementing a system of special base isolators or helicoidal springs at the base of the microreactors to achieve a modular design that can work on different sites?

The portion of the call that this would be target is focused on performing research and development activities that can significantly reduce microreactor costs. The call is not looking for specific technologies because we are open to a range of potential technologies that could achieve this cost reduction. Therefore, in general, if your proposed research in this area can address this goal, then it would be relevant to the call. I would suggest that you clearly indicate the potential for cost reduction in your application.

RC-3: Liquid Metal-Cooled Fast Reactor Technology Development and Demonstration to Support Deployment

Is bearing and seal development and high temperature tribology of interest in this call?

Yes, bearing, seal, and tribology would be an interest and we are looking for better seals and better bearings that can work in sodium.

For areas like this that haven't been called out in our examples, these should really point back to our technical POC. The difference with the technologies as we handle fast reactors, chloride reactors, and high temperature reactors is the R&D in those areas have moved at a different pace and are not always complimentary to each other. So, by reaching back to the technical POC, you will understand what has been proven and what areas that we need to advance, so your application will find the right space.

Are oxygen sensors to monitor liquid sodium of interest?

The base technology needs to be understood, meaning what technology has been done in the past and what we should be able to create again and how their proposed technology improves upon that. Fast reactor technology is probably one of the most amassed, detailed information we probably have. Over the course of the last 60 years, a lot of that information has deteriorated and a lot of the knowledge to construct some of these components has also been lost. So, that's why it's very important for everybody who wants to submit to be sure they understand what is being resurrected, what needs to be continued to be researched, and the only way to really do that is to reach back to the technical POC, Chris Grandy.

Are innovative, high temperature, neutron detectors included in advanced sensors?

The issue is looking for a very specific data to high neutron detectors for sensors. This may not be the call, but realize this should question should be mailed with follow-up information to the technical POC, Chris Grandy, for more information.

What TRL is expected for materials that can be tested in METL?

A TRL of 3 or 4 would be the starting point for testing in METL. The thing we need to make sure is that we don't disperse foreign material around in the loop in METL, so that is one of the concerns we have, but it could be TRL 3 or 4 types of materials. The issue that we are struggling with is putting something in METL that has any sort of degradation that could be detrimental to the loop and the health of the loop. So, those are going to be questions that anybody who brings a proposal forward is going to have to address and get confidence of the staff.

In development of thermal hydraulic test articles for gathering data for thermal hydraulic code validation in a prototypic environment, particularly, what kind of data and code are you speaking about that you would like?

There are various codes out there that are used to understand the behavior of SFRs. There are CFD codes and there are other codes associated with that. There are folks that are interested in improving the validation of those codes. People could be conceiving thermo-hydraulic test articles, which could go into a vessel in METL, which would support the validation needs of those particular codes. There are probably others that are also out there, but those are the ones that we know of.

Is liquid lead reactor included in this call, or is it just for liquid sodium? Is a collaboration with an ANL essential for this work scope?

The collaboration with Argonne is important because what we are targeting are experiments that are going to go into METL or using technologies to enhance the capabilities of the facility itself. There are technologies of which both the SFR and LFR share, like under sodium viewing, can be used in both technologies. So, a person could propose technologies which would go into LFRs that would then be tested in sodium.

What about sensors other areas might have?

That could be another area, too, like flow sensors and so on, which could be used in both technologies.

RC-4: High Temperature Gas Reactors (HTGRS)

RC-4.1: Heat transfer characterization in horizontally oriented micro high temperature gas reactors (HTGRS) under pressurized conduction cooldown (PCC) conditions and

RC-4.2: High Temperature Gas Reactor Fission Product Source Term

Do you consider NEAMS simulation tools, such as MOOSE, MOOSE-based animals for HTGRs for simulation research?

NEAMS simulations toolkit is always welcome. I think at this point, it is a DOE directive that we should encourage use of these tools. So, if at all possible, that would be our preference.

What would be the source of data for the circulating activity phenomena?

We can make certain AGR data available. I think, again, the source, the reactor source term is going to be very design dependent. So, there's going to have to be a lot, or some assumptions, on reactor design to come up with total circulating source term. But in part, I think that's part of the intent of the call, as well. It is focused on behavior and within the pressure boundary. But it's also going to look at source term from the core, as well. It is designed dependent and we can assume, you know, some generic design, maybe for our analysis and provide a source term as input, then for you know, a representative design, put it like that. So, I think that should be fine. I know I mentioned the AGR data that's not going to be something in terms of, you know, giving a specific source term or a specific design. It's more it could help guide assumptions on the fraction of release of different fission products from the core depending on temperature.

Are there any particular reports that are worth looking at to learn of specific horizontal thermal hydraulic issues and HTGRs?

As far as I know, this is a relatively fresh area on the reactor designers out there that's playing with this orientation, kind of blazing a little bit of their own trail. So, my guess would be, as far as I'm aware, there's not much to be found in the open literature. Most of these projects are tied down under IP. The idea would be to take a small experimental set up, I guess, and flip it around horizontally and see what changes. But, apart from that, there is not much data out there. So, for both scopes, we highly encourage you to communicate and reach out to the vendor that are developing these designs that you might be modeling your experiment on.

What advances beyond currently published research is really required for near wall heat transfer?

We're not going to be looking at near wall heat transfer. That was a scope we had originally planned, but we're actually going to be focused on the two I mentioned here. One for horizontally oriented micro high temperature gas reactors and one to determine source-term behavior.

What radionuclides would be of interest? Are we supposed to examine a number of them in the experiments, or perhaps, focus on a limited set?

We can leave that to your proposal. But if you look at the available data and reports, you can see what efficient products have been dispersed, for example, the AGR program. We won't be looking at the details in your proposal to see if what you plan to examine makes sense reasonably.

Are you interested in fission product migration, or diffusion and structural graphite?

I would say no. That has been the subject actually of some calls in the past years. This is really focused more on the behavior of circulating activity.

On fission product transport and the cooling system of HTGRs is modeling and simulation of interest, or only experiments, or both?

Both. We want some experimental aspect. But if there is modeling, we welcome that as well. The key, consistent with most of our past calls in this area is that we'd like the focus to be on experiments, simply because it's not as of interest to have a purely theoretical mod and sim type project. We would like to have it backed up with some experimental data because there is a lack of that.

Is decay heat removal and horizontal micro reactor prismatic designs primarily through an RCCS?

That design detail is probably tied down under IP for the various HTR designers. I would not necessarily assume such a specific system, but obviously, some kind of a heat removal system on the outside of the vessel. So, it can be pretty generic at this point. We're more interested in how the heat moves within the vessel component as opposed to outside the vessel at this point.

Are DOE facilities available for liftoff and plate-out experimentations?

No. It is not part of the plan for this call. That would have to be something that the PI would pursue separately, possibly through something like NSUF. That is not something that we plan for this call.

I am assuming the main objective for RC- 4.1 is to get experimental heat transfer data for horizontal micro HTGRs?

That is correct. We are more focused in that case on experimental work, than simulation work. But of course, it is always advisable that you do check results with either CFD or the new NEAMS tools if possible at all.

For RC-4.2, is the main focus on producing generic experimental data and modeling to produce source term behavior?

Yes, that is a good way to summarize it.

Do you know which U.S. based HTGR designers are considering a horizontal HTGR?

We did include two references in our written call. There are publicly available websites, for example. You're welcome to take a look at that.

RC-5: Pump Scaling Technology for Molten Salt Reactors

Is bearing and seal development and high temperature tribology of interest in this call?

A general statement, again, is that details of the proposal prior to submitting them should be vetted with David Holcomb (Technical POC) or Lou Qualls (NTD) and their contact information is provided in the presentation.

Specifically, the call is self-explanatory and has pretty focused things, in which you need to be able to relate what you are doing to how this is supporting or advancing the TRL of pumps for molten salt reactors. Yes, these are component technologies so explain how it fits into the call.

Are you interested in developing new materials, or only using alloys available in the market, such as Hastelloy N?

We are not against new materials. The question that comes into play is time, such as the life cycle and time that it takes develop what people call a new material. Now, I would ask that if they're going to develop a 'new' material, which I'm unsure if by 'new' they mean something that is not in the ASME quals or something that may be closer to a maturity path versus something that was brand new. Again, it would really fall back to what they're talking about and the details and the time horizon of which they're promoting something.

You need to look at what the purpose is, too. For example, if this is a new material for a gasket, it's not exactly a boiler and pressure vessel code use, but you certainly need to have enough knowledge of it so you could standardize it, so someone could buy it. So, that probably an ASTM type standard on this. Yes, we are interested in materials that support being able to connect and disconnect pumps, as well as just extending their lifetime.

For 5.1, is high temperature fretting, wear and contact fatigue of interest?

We have not seen enough examples of pumps running to go ahead and say that we saw a lot of fretting and wear. If you can make an example and show that you're thinking that contact fatigue is actually a stressor in some pump design, then, of course, we are interested in that.

We are certainly hoping the pump tips don't actually touch, so that would not be a source of contact. So, that would mean that in the bearings you would, of course, be interested in contact wear in bearing for pumps.

How are these important features, listed in slide number 6, related to MSR pumps?

High temperature operation is certainly one complex chemistry, an impact on corrosion rates. I would also throw erosion issues in there when dealing with potential mass and movement. Inspection for maintenance, when we're installing and removing pumps and being able to have a pump that is viable. You can look at it and understand what is going on with the pump, since it doesn't have life cycles, it's probably first of a kind. Also, I would also go back to important features and include repeated sealing with thermal cycling conditions. As for the last item, removal, inspection and maintenance, what is the inspection process, how are these maintained, is there a maintenance process or just dispose and replace? I think those are pretty specific to the call for pumps.

You might start with a small capacity range, because there are several uses for smaller pumps, particularly in early phase research to support demonstration loops. You can't currently purchase commercially small-scale pumps to support loop testing. On the other hand, you would like to have the technology capable of scaling, so that it would support relevant things for at least microscale reactors, if not for larger-scale reactors.

Are you looking for more like one technical aspect of pumps, or are you looking more for a project that results in a whole new pump design?

It is acceptable to look at both approving potential current designs, as well as designing something innovative and revolutionary. The infrastructure to support mass manufacturing is lacking. So, to build on a current design has challenges, as much as coming up with an innovative design because current designs may be built for different types of systems, like liquid flowing systems, which doesn't necessarily mean that they are going to work or be the best choice for an MSR because of the radioactive materials that are going to be in the fluid and also the corrosion issues from the salts. We are interested in revolutionary improvements, but if you can improve the engineering part so I can do better maintenance, better inspections, and make a stepwise improvement in current pumping, we are also interested in that. It is difficult to evaluate two different proposals and I wish that we had more money, but we are interested in both your overall improvements and specific technology improvements.

Are canned rotor magnetic bearing pumps of interest?

There is a current project that is working on this. So, yes, canned rotor magnetic bearings have some very desirable capabilities for molten salts because they're sealed up and they have no contacts. So, they might go for a substantial period of time. Your biggest challenge on this is that this is a revolutionary type of improvement and this is a limited amount of time and budget. If you can do a canned rotor magnetic bearing in three years, or $800,000, then yes, we are very interested. I suspect that you may end up needing to work on some specific aspect of this.

While this is specific to pumps, we are really trying to support, not just expanding research over the side of the plants, but its commercial applications. So, some of these types of designs would need to be very specific on their use. To ensure this isn't a one-off, it would need to be something that can be replicated and used in technology and potentially upscaled for different types and sizes.

Do experimental activities have to be done in molten salts?

Conceptually, that is okay, but appears to be technically difficult to validate performance for a pump without using the material that it is pumping. If you can explain in your proposal how you are going to accomplish that without using the material, then you might not have to. I can't imagine how a seal would be validated for leaking molten salt without using molten salt. Unless you can provide an argument that would be very similar for FLiNaK or FLiBe would be able to provide for those materials, I struggle to understand why this wouldn't happen and it would probably have other issues.

Will tests utilizing actinide bearing salts be prioritized?

We don't think that the pumps have an awful lot to do with the actinides, unless you think that something is going to play out in there. So, there's not a particularly strong reason, except for density matching and for natural uranium salt. We are not, especially at this level of a proposal for a university, expecting you to put highly radioactive materials in your demonstration. Pumping a material with less than 1% uranium doesn't look an awful lot like material without that 1% uranium in it. So, there's no real need that you have to utilize actinides (or certainly things like the transuranics), which are beyond the scope of this call. We would love to see them, but it is unrealistic.

RC-6: PLANT MODERNIZATION R&D PATHWAY: IMPROVING AUTOMATION USE IN NUCLEAR POWER PLANTS

Have the research pathways in LWRS, been recently redefined?

We have added two pathways, the Flexible Plant Operation in Generation and Physical Security, otherwise, they have not been redefined in recent years. About three years ago, we did a pivot to focus on the economic competitiveness of the fleet rather than materials aging, but not this year.

For RC-6, is there an interest in proposals that focus on next gen LWR, designs, SMRs, et cetera, or is there a preference toward the current existing LWR fleet?

For the Light Water Reactor Sustainability Program, we are only focused on the existing fleet. There is an SMR program, R C 11, which focuses on those aspects that was presented yesterday evening.

In the plant modernization area, is development of alternatives for gas-filled power monitoring detectors an area of interest?

That is outside the scope of this call. The application of that seems interesting, not necessarily tied to this call.

For RC-6, are there specific reactor operations that are of interest? For example, should proposals focus on design basis accidents, startup/shutdowns, normal operations?

I think any type of process system would be applicable for demonstration. This would go across control system monitoring; it goes beyond that to decision making. So, startups/shutdowns, response to abnormal conditions would be applicable.

In RC-6, would testing platforms linking automation controllers to the plant simulations be of interests?

The focus is on the automation, trustworthiness, and transparency. The tools that our platforms use, the support, that would be important, but not the main focus.

Is it of interest to look at the resilience and economic value of existing LWRs?

I am not quite sure what that is tied to so, perhaps whoever put that in would clarify that, but specific to RC-6, the economic usefulness of an approach would be important. But, again, not the main focus. It is really looking at developing or transitioning classic trustworthiness. It looks at resilience of data, the robustness of the data sets from adversarial manipulation and things like that, and then transparency; those are the two key elements to be looking for in developing a methodology that the stakeholders can use to confirm the trustworthiness and then leverage transparency.

For RC-6, will digital twins be considered?

Digital twins are a key platform. It would be the data sets that would be used for decision making. The ability to bring in automation in a meaningful way and have high levels of process and program automation in both the ECS systems and the IT Systems Business side is a challenge. So, a digital twin that represents the physical plant would be a very important piece of that. That is an important element that should be considered by those that are going to work on this: how they represent the information and then prove the trustworthiness.

In the LWRS materials research area, I heard something about weld repair techniques. Will this topic be included in the FY 2021 FOA?

The scopes for the FY 2021 FOA are as written, so no, not solving techniques.

For materials, are existing materials a priority, or is new materials development of interest?

We are looking at existing materials in the current fleet. As far as advanced materials, we are looking for replacements for various systems.

Are strength and ductility changes the only mechanical properties of interest? Are toughness or cyclic properties of interest?

The key property for reactor pressure vessel steels is fracture toughness, and that is the main interest for this task.

Are irradiation effects on stainless steel RPV claddings of interest?

Not for this call.

Is there any specific RPV steel of interest? Will nickel alloy be considered?

We are looking at RPV steels in the current fleet of reactors; they do contain some nickel materials. We are not looking at replacements for reactor pressure vessels. So, we have to use what we have in the current fleet of LWRs.

What kind of facilities that INL are available to use?

We would encourage use of NSUF materials library for this, which does not include necessarily INL also as partners within NSUF or other national laboratories in some other locations. This this solicitation is specifically for R&D support, not access to any of the facilities. If facility access is required, that would be a different scope.

For RC-6, would large-scale laboratory experimental validation be acceptable, or would the proof-of-concept be based on implant testing or application?

Without knowing the details of what the suggested scope is, it is a little hard for me to say one or the other. Initially, you're going to have to lay out the methodology and framework, depending on what type of data to validate that it may require some data sets that comes from the plant to support the learning and the testing in the qualifications. So, I would say that that's a necessary component if it's available, but I wouldn't say that that would stop the other from occurring and being impactful, because the initial methodology and framework discussions are the starting point in a very big piece of what's important in this call.

Is methodology development important for AI, machine learning approaches to be used?

It is. I also think developing a nuclear approach to trustworthiness is a piece of that, so that methodology would feed into that. I think most people are aware, that work in this area, that there are some definitions around trustworthiness already. Now, what we need to do is develop something that would be applicable to the nuclear industry. So, that methodology needs to be evaluated and perhaps changed a bit, so specific to the nuclear industry.

RC-7: Risk-Informed Systems Analysis R&D Pathway: Extension of Legacy PRA Tools to Accelerate Risk-Informed Applications for LWRS

For RC-7, is the focus of using traditional event/fault tree analysis or would approaches like Bayesian networks be acceptable as well?

The general idea is to help augment or improve legacy tools. So, if those newer methods can be integrated with the tools and the existing models, then it would be considered.

RC -8: Materials Research Pathway: Characterization and Modeling of the High Fluence Effect on Reactor Pressure Vessel Steels

For RC-8, are Ebony and ASTM E 900 the only models this work scope is targeting for improvement?

Yes.

For RC-8, which type of proposal is more preferable, an in-depth analysis of one aspect of radiation effects, or a comprehensive analysis of all radiation effects using big data/machine learning techniques?

One versus another, it depends on the details. You could have a crosscutting proposal that is not well written, or a detailed one that is, and vice versa. So, it's really hard to answer those kinds of questions.

For RC-8, are there specific length scale modeling methodologies that are either encouraged or discouraged?

At this point, we are just looking at ways to improve current prediction models.

RC -9: Flexible Plant Operation and Generation Pathway: Development of Thermal and Electric Power Dispatch Simulation Tools

In RC-9, are you looking for software or hardware development?

The software primary goals are installation tools that can be used to predict the behavior of these nuclear power plants coupled to hydrogen generation. So primarily software.

RC-10: Physical Security Pathway: Evaluation of Physical Phenomena Data Impact and Improvements

No questions.

RC-11: Advanced Small Modular Reactor R&D

Is grid scale resilience modeling of interests in this work scope?

General reaction I'd probably be not. There would be certainly some interest, but this applies not only to the grid resilience, but other technology development. While we look at all of the technologies, and take them seriously, those that really get the best favor are those that specifically leverage the characteristics or capabilities of small modular reactors as opposed to just any other plant. The grid scale resilience is such a broad use type that one would have to be a lot more specific on what is related to grid scale resilience that SMRs can either enable or are uniquely well suited for that, and there probably are some examples, but again, it's really important for RC-11 to tie it to the specific characteristics or utilization of SMRs.

Are innovative detectors for reactor power monitoring an area of interest?

Everything in that area would be worth consideration. The same remarks would apply here as above. What I mean is, what is it about the design, the compactness, either restrictions or flexibilities of SMRs that would drive the interest in the specific sensor?

What kind of sensors would be of interest?

We're really interested in applications that show direct applicability to a current reactor technology developer. So, I guess I would kind of put it back on the person, asking the question, go make a case about why a certain sensor is directly applicable and who have they consulted, or which industry entity have they teamed with. Just show that relevance to the program.

Should there be a collaboration with specific SMR companies to develop reactor's specific technology?

That is definitely not negative in an application if we see that direct relevance. If we see a active reactor technology developer onboard with pursuing something that gives it a whole lot more merit in my book than something that's a lot more generic.

Are design advancements associated with a take back program for recycled fuel from domestic and international market needs a viable activity?

There's a number of different ways that you can interpret those words. Does that mean like receiving the used fuel back in the US, I would see that as the spent fuel program. However, it's trying to say design advancement on a small modular reactor could use or expend the used fuel within the reactor, that could be an option, although that seems to be like an entirely new reactor technology to be pursued rather than just an enhancement. It sounds like it belongs more in the fuel cycle category, unless it's tied specifically to an enabling characteristic of a particular or class of SMRs. And again, we prefer, for this category, funding those technologies that span more than a specific design. It certainly may focus on a design for the purposes of demonstration or case study but it needs to be technologies that are broadly applicable.

Are compact steam generators of a different type than MIT had still of interest?

Yes, I believe so. There are lots of different SMR technologies in the advanced SMR category and the compact steam generators apply to not only primary system, but as you get into diverse applications can be more intermediate heat exchangers. So, I think there's room for additional work in that area. Yes.

Will secondary side energy conversion systems, something other than steam cycle, be of an interest in this work scope?

That is something that is fitting more under the Integrated Energy System scope. The scope area is CT-2.

How much interest is there in autonomous operation capabilities?

My response to that would be similar to a question, a few questions ago, where I think that the applicant needs to make the case why it's valuable. Who did they consult with? Is there a reactor technology developer that is showing interest there? That can provide additional merit.

What specific design techniques are you looking for? Are you interested in the reactor design based on the shape optimization technique?

I think our goal is looking at it from a bit higher perspective. We're looking to make SMRs more efficient, easier to manufacture, that kind of thing. And so, it's kind of, in that realm. A proposer needs to justify their proposed project, as far as how accomplishing those goals.

Is an industrial partner, needed and helpful for a university proposal? If so, how do we get faculty connected with one?

I would say that it's not actually needed. However, I do think it's helpful. As far as how faculty can get connected, either direct outreach to those entities or maybe through the GAIN program or through some other avenue. I know that at least some universities many have a special office that helps facilitate faculty alignment with industry. So, they should seek that out at their own university.

Will technology development, other than reverse osmosis for desalination be of interest?

I would see those kinds of technologies being developed for use with nuclear power. They would fit under that other work scope, CT-2, the integrated energy systems scope which covers anything that is not energy.

Are there specific SMR designs of interest, LWR or non-LWR? Will additional consideration be given to proposals that include industry partnerships?

I wouldn't say that there's a specific reactor type that is particularly of interest. I think that they are all of interest. The more applicable the components that are under development are across the reactor fleet, the more merit it has. However, in my view, if there's a particular technology developer that also sees enough value to put their own time and resources into it, then that also shows industry interests in seeing that component development proceed.

For diverse applications, should the application focus on technology development or system modeling simulation?

I would say component development. Last year, we had more assessment studies in the scope. This year, the intent is to be more focused on the actual things that go thump. As you get into the systems modeling, that begins to move over more to the integrated systems category.

Are design advancements to SMR fuels included in this topic?

Yes, but tying it into how the small modular packaging of the nuclear energy facilitates that particular fuel type or vice versa.

Are innovative, intermediate heat exchanger technology ideas within the interest of the call?

Sure. In fact, we very recently awarded a very similar topic to a small business entity.

I am working with a team on developing antineutrino detectors for the next generation of safeguards (more efficient and portable). Would this work be fit for this workscope (RC-11 under the sub-topic of advanced safeguards to multi-module plants)?

At a high-level, it appears that your topic could fit within the RC-11 scope; however, it would need to specify how the proposed project would improve the deployment potential, operations, or overall utility of SMRs to meet domestic and international market needs. To ensure fairness across all applicants, DOE cannot pre-review any concepts or white papers.

We would like to propose cable aging management research (design and characterization of sensors and life expectancy model based on the sensors' output and correlated

mechanical/dielectric properties). If we show that this is an issue relevant to the cables of a particular SMR design, would you be interested in this type of topic for RC-11? Also, is there cost-sharing required for the proposal?

There is potential for cable aging management research to be applicable to SMRs. The project's applicability to this topic area would depend on how the proposed project is structured or what the project's focus is on.

Cost sharing is not required for projects having a university or national laboratory lead. Universities are permitted to propose cost-share, but it is not required. If a project is led by an industry entity, a 20% cost share is required.

Fuel Cycle Technologies (FC)

FC-1 Material Recovery and Waste Form Development

FC-1.1: Innovative Separations Chemistry for High Value Used Fuels

Is the recycling of HALEU only focused on recovery of U and maybe Pu or could it be expanded to look at other valuable elements/isotopes?

The main focus is really on U and Pu. It's a lot more valuable than some of the minor actinides, especially for the HALEU fuels especially because of the higher enriched uranium, but I can understand the need to recover other actinides for waste management purposes, if you will. But I will say this focus is really on the higher valuable U and Pu.

Is the recycling of HALEU in LWR fuel not part of the scope?

Yes, any kind of fuel that contains HALEU. It's metallic fuels, TRISO fuels, molten salt fuels that are a part of this workscope, as long as it's HALEU fuel.

What form is expected for the spent fuel to be separated? Dissolved in nitric acid? Or?

We're not restricting what the form of the spent fuel can be. This is where you can be very innovative. We know that spent fuel is normally dissolved in nitric acid on the front end for recycling or reprocessing. If you can propose a process that doesn't involve dissolution in nitric acid, that's great. If you can propose one that involves dissolution in hydrochloric acid to achieve the separation that you're hoping for, that's fine. We are leaving it up to you to be as innovative as possible to recover the U and Pu.

What level of purity of the recovered U from HALEU is required (i.e., high purity for use in a LWR or lower purity for use in an advanced reactor)?

We are not restricting you on that. The purity requirements are going to be different and the advanced reactor designs that are out there right now include both thermal and fast reactors. Some of them will have a different purity requirement like the sodium fast reactors will have a different requirement than the molten salt thermal reactor. We are not restricting you on the level of purity. There's a range of purities that will be required. We recommend tailoring your proposal to achieve a level of purity that is relevant for these technologies.

Is the spent fuel in the original form, as metal, TRISO, etc.?

The fuels can be in any form. We are not limiting you in this area. Recognize that the HALEU can be in a variety of different spent fuel forms.

Is the goal for FC-1.1 and FC-1.2 for recovering U and Pu only, or does the goal also include separating highly radioactive actinides from the waste for further remediation?

It is of interest recovering isotopes for waste management and remediation purposes. But because we want to come up with ways to recover HALEU and Pu which are much more valuable to help improve the economics of reprocessing. This is more focused on getting those high value metals from the used fuel.

Are ion-exchange materials responsive to the FC-1.1 call?

Ion-exchange materials can be responsive to the FC-1.1 call if they can potentially recover HALEU from spent HALEU fuel, which would be intensely radioactive and contain a variety of other fission products and actinides. The assumption of some head-end operations (e.g., fuel dissolution) to facilitate uranium recovery by the proposed method is reasonable.

As an industry leader in used fuel reprocessing, can you suggest university contacts that we may contact about possible interest in our support of this workscope?

All teaming has to be done by the participants with no federal involvement. The *Nuclear Science and Engineering Sourcebook* is a publicly available tool that may be helpful and is can be found at https://neup.inl.gov/SitePages/Related_Documents.aspx.

FC-1.2: Nuclear Fuel Cycle Separations Chemistry

What is the level of theory desired for modeling of solvent extraction?

Please contact Christina offline to discuss the nature of this question, then the answer will be posted here in the Q&A.

Do all of the aspects in bullet point number 4 have to be addressed, or is it ok to just address some of the items, e.g. the radiolysis of an extractant?

It is not necessary to address all of those areas. That's a non-exhaustive list of areas that are of interest in the workscope.

Is a mix of experiments and simulation desired or is simulation alone acceptable?

Both are acceptable.

For recovery of valuable elements (and presumably isotopes), what level of purity is expected (e.g., available to commercial market or limited to nuclear market)?

We are not restricting that since there are a lot of different markets that will require a different level of purity.

Is an ion exchange approach responsive?

Yes it is. Also if you can develop a method for HALEU for FC-1.1 it also applies there.

Would liquid extractions with polymers also be of interest for FC-1.2?

Yes.

FC-1.3: Understanding, Predicting, and Optimizing the Physical Properties, Structure, and Dynamics of Molten Salts

Would only ab initio MD based simulations be considered? What about classical MD and development of potentials for molten salts that can be used to study large scale and longer time scale behaviors?

We are not restricting this to ab initio MD-based simulation methods. We would also like classical MD simulations and longer time scale behaviors are of interest.

Could the computational work include limited experiments for validation?

Yes, but since FC-1.3 is more focused on computational work, you should be sure to lean more towards that. The idea of using experimental methods or data to support computational models would be fine.

Is modeling desired for an FC-1.4 on experiment? Can both modeling and experiment be included in both FC-1.3 and FC-1.4?

Yes, that's allowed. FC-1.3 is more computationally focused, while FC-1.4 is more experimentally focused.

What types of molten salts chemistries and thermo-physical properties are of main interest? Salts for FHRs and MSRs and separations?

Yes, any molten salts that are applicable for the uses in FHRs and MSRs would be fine.

Can a national lab post-doc be part of a full proposal with a university partner (FC-1.3)?

Yes.

One of our proposals based on only modeling with experimental support was rejected with a comment that experimental side is not strong; Any suggestions on how to improve it?

Please look at the feedback that came back with your proposal review and it should tell you what was weak and might need to be improved.

FC-1.3 and FC-1.4: Should the molten-salt chemistry be targeted toward more reprocessing than molten-salt reactors?

These workscopes are inclusive and can focus on either area.

For FC-1.3, is a letter of intent required?

No, it is not required for FC-1.3. A letter of intent is only required for NSUF.

Does FC-1.3 require an LOI or a user agreement in the pre-application?

No, it does not require either one in pre-application or full application.

For FC-1.3 pre-applications, does a user agreement need to be approved by the submitting institutions (in my case UIUC/Argonne) prior to submission or is this reserved for the full-proposal?

Not for the pre-proposal stage, instead that is for the full proposal stage of the process.

For FC-1.3, what is meant by "multicomponent models for prediction of phase diagrams" and "advanced models to guide experimental efforts to manipulate salt thermophysical properties"?

We are looking for computational models that will enable us to predict phase diagrams of multi-component (i.e., at least ternary) mixtures of molten salts. The objective is to reduce the need to perform exhaustive sets of experiments to generate phase diagrams. The "advanced models" we refer to in item 3 of this topic are predictive computational models that can help us identify, prepare, and analyze salts that are expected to have improved thermophysical properties. This should reduce the need to evaluate multiple random salt compositions to find those compositions that have better properties of interest (e.g., thermal conductivity).

FC-1.4: Understanding the Structure and Speciation of Molten Salt at the Atomic and Molecular Scale

FC-1.4: Are characterization methods such as x-ray and neutron scattering carried out at DOE national labs of interest for this work scope?

Yes.

FC-1.4, is it desired to add some modeling to the experiments?

It's not required, but you can do it. There's nothing wrong with doing that.

FC-1.4, would there be interest in conducting in-situ synchrotron studies?

Yes.

You mentioned that the NEUP program wants to cultivate and grow the next generation of young scientists in this important area. However, the grants are only two years. How does a 2-year University grant reconcile with PhD graduate students in 3 or 4 year study?

Even though these projects are for two or three years, it doesn't mean that after two years you are done. There are ways to continue those projects if they are successful. Something that starts out in a new area, could even end up being a graduate student's dissertation, if the project is successful. These workscopes are focused om innovative ideas, not just in the lab, but also for the nuclear industry, in general.

Why are some workscopes for two years and some three years?

Three workscopes are for $400K and 2 years duration while one workscope is for $600K and 3 years duration. The first two are new workscopes so they focus on developing innovative new processes. We decided that having a two year time frame is enough time to decide if these innovative ideas are successful or not. The one for FC-1.3 is a computation-based project, and we've found in general cost is less expensive than an experimental based project. That also explains why FC-1.3 is a pretty well established workscope is actually a longer 3-year project at $600K.

FC-1.3 and FC-1.4: Should the molten-salt chemistry be targeted toward more reprocessing than molten-salt reactors?

These workscopes are inclusive and can focus on either area.

We have several ideas that we think are responsive to your work scope. However, since your work scope has a limited budget, we are unsure whether we will be able to pursue all our ideas. Can you let us know which ideas are most responsive to your work scope?

We rely on you to propose a project that can be accomplished using the budget provided in the FOA. We cannot explicitly tell you what to focus on, but the work scope description describes what we are looking for in general terms so that you can develop innovative approaches to addressing the needs outlined in the work scope.

We would like to do a combination of experimental and computational work that complement each other. To increase the amount of funding available for the experimental and computational studies, can we submit applications under FC-1.3 and FC-1.4 and reference the complementary applications submitted in the other work scope?

You will have to determine whether it makes sense to submit separate proposals under FC-1.3 and FC-1.4, but you are not allowed to reference the other proposal in either application. (For example, you cannot reference the proposal you submitted under FC-1.4 in the proposal you submitted under FC-1.3, and vice versa.)

FC-1.5: ADVANCED SALT WASTE FORMS

Update on items of interest for FC-1.5:

The recovery of Cl or F from and the immobilization of waste streams composed of various combinations of NaCl-MgCl2-CaCl2-UCl3-PuCl3 and LiF-NaF-BeF2-CaF2-ZrF4-ThF4-UF4 is of interest. The accommodation of halide will likely determine the efficiency of direct immobilization in waste forms whereas the accommodation of cations will determine the efficiency of immobilizing dehalogenated salt mixtures in waste forms. Both are of interest. Appropriate chemical surrogates can be used to identify suitable host matrices for particular species and combinations, including phase durability and composition limits.

Are zeolite-based waste forms of interest?

Yes.

Is there a preference for chloride or fluoride?

The proposals specifically say either or. We are looking at chloride right now, but we are also looking at fluoride.

Are waste forms for electrochemical processing waste primarily of interest, or are projected molten salt waste streams more of interest?

Waste forms for any high-level radioactive salt waste stream is of interest.

Which actinides are you interested in recycling and which should be encapsulated in waste?

This request does not address recovering actinides for recycle.

Are waste form samples required for proposals that focus primarily on chloride recovery?

Yes, chloride or fluoride. As the proposal stated, we are looking for samples to be to be sent to the national laboratory for testing.

Does the testing at the DOE sites need to be included in the budget and the 20% funding limit?

No. Testing at national labs will be completed under separate funding. Tests with materials generated under NEUP will likely be tested at Argonne or Pacific Northwest National Laboratory.

Which national laboratories will do sample testing?

Pacific Northwest National Laboratory and Argonne National Laboratory.

Are ceramic waste forms of interest?

Yes.

FC-2: Advanced Fuels

FC-2.1: Fuel-To-Coolant Thermomechanical Transport Behaviors Under Transient

For FC-2.1, would proposals that include a focus on thermal hydraulics in addition to thermal mechanics be of interest?

My feeling is you can't avoid thermal mechanics if you are aware of thermal hydraulics, so that is completely in the scope. There's strong connectivity between these different physics and you can't really focus on one without accounting for the other, so that's fully expected.

Will the U3Si2 fuel type be considered as relevant for this call?

The base fuel types being considered right now are UO2 or doped UO2, which have the highest priority. If other fuel types were to be considered, there would need to be a strong case as to value the proposition. From the program standpoint, UO2 and doped UO2 are the primary fuels, along with its coated cladding. Other fuel types, like U3Si2, are not recommended at this time.

Are NEAMS codes to be used in modeling and simulation proposals? If so, which NEAMS codes?

We are encouraging NEAMS involvement, but it doesn't have to be NEAMS codes. Some of the phenomena that we're talking about may have opportunities that don't necessarily fit into a particular NEAMS code. If it does, then that is what we would encourage, but there are some things that might not really fit well into the capability of the current NEAMS toolset, even. Those are things to be evaluated by the proposer.

You mentioned doped fuels are of interest and how they may behave differently. Should only dopants as Cr and Al, as in the adopt fuel, be considered or are other dopants also of interest for this call?

You should only consider dopants that are the primary candidates, such as Cr2 and also the Cr Aluminum variants. You should only use what the current vendors are using in their primary, as we want to give you the most opportunity here to get people involved in what is highly relevant. Right now, our priority is the existing doped fuels that the vendors are now considering in their prime priorities.

Are experiments required for FC-2.1? How about empirical data?

They can't be required, but we'd like to have recommended what is necessary to accompany what is proposed. We would like to see the connectivity between experiments and modeling, but actual experiments may not be necessary when there's data available. If data that is available from historical experiments could be used in a new way to support some of this development, that would make sense. It's about making the connectivity to develop the phenomenological understanding and, hopefully, extending that into some kind of a model that can be incorporated into a tool. We are interested in understanding phenomenon and how it can be or needs to be tied to modeling.

Are the proposers expected to use TREAT facilities? Do experiments have to be done on irradiated fuels?

There is no requirement, specifically, for facilities or irradiated fuels. This is only three years and this is hard to answer. You don't have to tie it to experiments, but we want to know how it can be tied. If we're going to do modeling, suggestions for modeling should be tied. We'd like to at least see what you recommend be done and then others will see if it can be done. The budget and scope of this is not intended to support this project designing an experiment for TREAT. However, maybe it could lead to something like that in the long run. The fact is that we're doing tests in TREAT underneath the program funding and related work and there's a lot of things that are already easy tie-ins for experiments that will be on-going for the next few years on high burnup fuels. There's historical data out there. There's potential to run some smaller separate effects experiments that could connect in well with some of the objectives of these integral type behaviors. A good response would automatically start giving ideas of what we would need, as this is a new area that hasn't been explored much in the U.S. There are a couple experiments overseas, but they don't seem well calibrated and that is one reason we will be doing this work, so this can fit into what we plan.

If we propose experiment that utilize TREAT, will we need to apply for NSUF access as well?

I don't think that is required. If it makes sense, it's okay, but it's what this recommends we do and not necessarily where. It's not required that there has to be an NSUF access. It may lead us to testing, but it isn't a necessary condition.

If we propose to use TREAT for transient testing, will it be problematic as these might be limiting funds for TREAT? If TREAT cost cannot be justified in this program, we can design a unique fuel containing electrodes through the fuel pellet center, enabling a temperature gradient with rapid power ramp that can mimic the temperature profile of the fuels under normal and during transient. This will be unique to conventional furnace or laser rapid heating with more realistic temperature profiles close to the reactor application. Is this acceptable for transient testing?

TREAT tests are not desired as the timeframe and cost of the proposals are insufficient. It would be highly beneficial for the proposal to consider working with TREAT experimental designers to support the development of TREAT experiments for subsequent HBu and ATF efforts. Alternatives out of reactor experiments would be welcomed and encouraged, especially if the data could be used to support subsequent TREAT tests. I would encourage the proposal to present a strong argument to support the connectivity of the out-of-cell test to TREAT test.

For the high burnup fuels, do we expect to use the irradiated fuels above the desired burnup to test what conditions/parameters limit their application? If so, would you guide us to where to obtain the irradiated fuels from national labs?

The proposal call is focused on HBu fuel (i.e. >62 GWd/MTU). The applicant would need to focus on fuel conditions (fuel rod and microstructural conditions) in the applicable HBu range (i.e. 68 to ~84 GWd/MTU). Strong arguments would need to be made otherwise.

In addition to thinking about new experiment designs, proposals could also consider complementary connectivity to previous/ongoing/planned experiments (primarily at ORNL/INL in this area). This does not mean that scope can be added to existing projects, but details/data could likely be provided dependent on the specific interest. (For example, one could develop a new method to analyze a behavior that would be applied to a planned experiment in TREAT.)

FC-2.2: High Burnup LWR Fuel Rod Behavior Under Normal and Transient

Can a surrogate rod be used and get irradiation from a proton accelerator, versus a reactor, to get an equivalent anti-burnup condition?

Answer: This shouldn't be ruled out, but the time limitation should be considered. This qualifies as a novel proposal and is not unreasonable.

Does the effort need NQA-1 one quality assurance for this call?

We are not in the ballpark yet where this might provide data that would support a licensing application at this time. It seems a little early to require NQA-1 at this time. This would not be a requirement for data generated in these proposals. We really want to understand the phenomena, or how energy is transported. This isn't at this stage yet, but this is a reasonable question

Can the PI use a university reactor for irradiations?

If it fits the need, then it should be well described in the proposal and how it fits into helping to understand what is going on or what is limiting.

It is unlikely that the university reactors can achieve such a high burnup within a reasonable time frame, or even using ATR or HFIR. In the past, we have demonstrated and published the work in using high energy fission fragments, e.g., 100 MeV Xe to irradiate UO2 fuels to obtain high burnup structure. In this way, the irradiation damage level and the fission gas content can be well controlled within the HBS. Do you envision that this is a viable approach?

Performing test reactor irradiations are not advised. Accelerate irradiation techniques would be considered. However, the applicant needs to make a strong argument as to why the accelerated irradiation technique generates the same microstructural response observed in PWR reactor conditions.

Can you repeat the key difference between FC-2.1 and FC-2.2?

In FC-2.1, we're trying to extend our understanding of what happens in the transport of both energy and/or material (if it occurs) when we're in a transient. A key test is the type of thing that we think we may have to do in TREAT, where we really want to understand not only what is happening up to a point in which the fuel might get to the coolant, but even if that occurs. So, FC-2.1, really looks at the phenomena associated with the transient themselves.

Whereas in FC-2.2, we're trying to understand what is going on. It gets into this high burnup mode of in the high 70s and understanding what is going on under normal and transient conditions. It's almost more fundamental and it is certainly related to the other one, but this is much closer to coordinating with work of the NEAMS program. Obviously, understanding has to ultimately be related to what a NEAMS program capability can deal with. This is almost more input to what we've already proved and is aimed at improving the ability to predict the fuel rod response under these transients. They are looking for what is most limiting, such as fission gas, pressure on the clad, large particles digging into the clad. FC-2.2 has a little more of a connection to high burnup cores and associated behaviors that are of greatest importance to considering high burnup core design and its implications. This is somewhat different, but if more clarity is needed, questions should be sent to Nathan and Colby.

We are hoping to get a couple synergistic proposals in each of these two workscopes.

We have the unique capability to fabricate UO2 with controlled microstructure, grain size, pore porosity that can mimic the high burnup structure. There might be some questions whether or not we can really simulate the HBS structure in real fuels, particularly fission gas. We are working to demonstrate the possibility of incorporating fission gas into the high burnup structure. On the other hand, the HBS with well controlled microstructure enables the possibility for separate effect experiments to pinpoint the key variables/microstructure, e.g., porosity and grain structure. By combining the Xe-irradiated high burnup structure (or possible real irradiated fuels if available) and using the simulated HBS a model system, we will open up a wide range of opportunities to study what the key materials/microstructure characteristics and parameters (fission gas, temperature, pressure) on fuel behavior (e.g., fragmentation, dispersal and interaction with coated cladding). Would you mind sharing whether or not the simulated HBS could be a good component in complementary to irradiated fuels?

This is a very good question and one that needs to be addressed. I would hesitate to advise a proposal to include this work, as it has been identified as a data gap. That being said, it could generate highly valuable results. I recognize this is a non-answer, and I would simply suggest that the applicant investigate this area further to see if a strong case for the work can be made.

Do you prefer experiments to modeling or do you like to consider both modeling and experiments?

Yes. Ultimately, experiments and modeling go hand in hand and sometimes one leads the other. In FC-2.1, it will lead into things that modeling will have to consider, whereas FC-2.2 is already hand in hand with existing models. Relations with NEAMS are encouraged to see what can be done in coordination. Beyond 62 (and we know we are clean with NRC up to 68), so this is the next big jump where the fuel is changing due to the gradients and stresses in it and may be quite different from what occurs with normal fuel and design bases, accidents, and transients. We are getting into a new area and it's a wonderful opportunity for the universities to start getting close to the state of the art we are pushing with this program.

What is the fuel type of main interest to the program? Is it UO2 or doped UO2, the same as FC-2.1, or other fuel types, such as metallic fuel, or are they equally of interest to the program?

The fuel type for this call should only be one that is used by our 3 ATF vendors, either UO2 or doped UO2. This is the same for FC-2.2 as for FC-2.1. Other fuels, such as metallic, may be interesting, but are not to be included.

For the high burnup fuels, do we expect to use the irradiated fuels above the desired burnup to test what conditions/parameters limit their application? If so, would you mind to guide where to obtain the irradiated fuels from national labs?

The proposal call is focused on HBu fuel (i.e. >62 GWd/MTU). The applicant would need to focus on fuel conditions (fuel rod and microstructural conditions) in the applicable HBu range (i.e. 68 to ~84 GWd/MTU). Strong arguments would need to be made otherwise.

In addition to thinking about new experiment designs, proposals could also consider complementary connectivity to previous/ongoing/planned experiments (primarily at ORNL/INL in this area). This does not mean that scope can be added to existing projects, but details/data could likely be provided dependent on the specific interest. (For example, one could develop a new method to analyze a behavior that would be applied to a planned experiment in TREAT.)

FC-3: MATERIALS PROTECTION, ACCOUNTING AND CONTROL TECHNOLOGY

Does nuclear criticality and criticality safety play a part?

I have not traditionally included that in our scope in the sense that it is a specialized area, and oftentimes I think there is a specific call for proposals that is in that in that area. Obviously, criticality is extremely related to safeguard. If the perspective PI thinks that there is enough overlap between their criticality research and the ability to measure actinides, either directly or indirectly, in a fuel fabrication facility, or a pyro processing, or aqueous or novel recycling facility, then it definitely could overlap and it could be applicable.

Could you give a few examples of which materials are especially interesting to you?

Primarily the main item of interest is S&M; either NRC or IAEA guidelines for S&M is what really drives the program. Of course, there are potentially indirect ways to measure that, but considering this as a domestic program, we often have plenty of access and information at hand at these sorts of facilities. It's not in a black box like sometimes the international community, or IE, has to deal with, but really we're talking about uranium and plutonium primarily.

Is this scope mainly focused on computational or experimental work?

For the most part, I would say, experimental. We have funded some modeling. Because we have a limited of projects, I personally trend toward trying to fund experimental work. But certainly, I believe many of our proposals have had 2 or 3 phases, and one of the phases is often modeling in order to set up the problem, and then some experimental work to validate or to strengthen what was done in the model.

Do novel detector applications form a part of this scope?

That is a pretty open-ended question, but I would say, in general, yes, and I am very interested in seeing novel detector design when it comes to having a very specific application for safeguards.

Will materials like high entropy alloys be of any interest in this category?

I am actually not familiar with that subject. If that topic can help in some way when it comes to making nuclear material accountancy measurements, then I would say, yes.

Will materials control and accountancy for repositories be captured by this scope?

That is actually a gray area. I would say no. I did mention long-term storage on a slide, so that is a fair question. I am more interested in characterizing and measuring unique waste forms that may be associated with recycling fuel from advanced reactors, and ultimately, that may result in something that goes in a repository. But the further along you get to the right there is more uncertainty. So, there are plenty of challenges, and plenty of uncertainty when it comes to characterizing and measuring advanced reactor waste forms without going so far as to start getting into repository related research.

FC-4: Spent Fuel and Waste Disposition

Is recycling considered in the work scope?

No, we're looking at storage and disposal of the spent fuel directly out of the reactors. Recycling is a key, different area of investigative focus. The radioactive products of the recycling would eventually have to be disposed, but we aren't addressing it in this program. That is a separate program.

Is the thermo-mechanical behavior of engineered barriers of interest in FC-4.1?

Generally, the answer is yes. It would come under the area of interest of improved understanding of new concepts, re-engineered, natural barrier systems.

To what extent does this scope include transuranic waste, if at all?

Transuranic wastes would not be considered in this topic. We are looking at the higher-level waste from the defense area in the manufacturing of the defense nuclear fuel and the byproducts of that production, which are basically the decay products from the uranium and the manufacturing of plutonium. I don't see transuranic waste as being a part of this, no.

How do the site characteristics mentioned relate to the Yucca Mountain site? Is there a site which is more preferable than Yucca Mountain?

We are looking at alternatives to Yucca Mountain. The selection of the site and where we are looking is really a political decision and our job is to come up with the technical basis for a suite of alternative disposal sites. We are looking at generic disposal sites like the ones mentioned, as we've spent years studying the Yucca Mountain site and we don't think there's too much more we can study there, so we are looking at all the alternative geologies. So, no, we think we have exhausted the investigation of the Yucca Mountain site characteristics and are not considering doing anymore there.

What in-situ testing of the welds and housing of metallic parts are of interest? (This will be to monitor the property change of the enclosure vessel.)

Without more detail, generally speaking, we're not looking for ways to monitor changes in the properties to the enclosure vessel, partly in the disposal location, because we feel that the changes in properties are going to take place over very long periods of time, like sanctuaries. This would occur long after the disposal site is closed and so we don't think we'd be in a position to monitor that level of detail in the changes to the container at that time. Outside of this program, we're looking at ways to monitor changes in the containers during the near-term storage and transportation era, but not during the disposal.

For sensors external or internal to the DSC, which one is preferred?

Off hand, we would prefer the external one because there is less interference with the operation and loading of the fuel into the canister. If there's a way to monitor for the properties we are looking for listed on slide 10, we would be interested in the external sensors, yes.

Are new models for the coupling of heat and mass transfer within a repository environment be of interest?

Yes, the specific areas on slide 9 would need to be considered. The best details of an answer to that would come from Prasad Nair or Dave Sassani.

Is solid state additive disposition for strengthening the cannister locally in the scope?

No, we've added scope like that in previous years. This year, we're looking for monitoring the internal conditions of the canister, not looking for monitoring or improving the cannister itself.

Could you elaborate on the data improvement for models? Are there existing codes to be used to perform sensitivity analysis? Or are models supposed to be developed as new ones?

We definitely have existing data and we definitely have existing models. I think we're primarily looking at enhancing the data and enhancing the models. I don't think anything precludes developing new models, which are often better and with enhanced features over existing models, so I think we'd be open to those and they would fit within the scope of what we are looking for, yes.

Is deep bore hole concept considered in FC-4.1?

No, that was a concept we looked at a couple years ago and I think we've moved on beyond that at this time.

Are cementitious materials considered under FC-4.1 for the overpack instead of metal alloys or metals or are they more favorable?

The idea of this exercise is to come up with new ideas and our past research is focused on metals for the overpack, but the body of knowledge changes and if somebody has an idea that cementitious overpacks have an advantage over the metallic ones we've been looking at, I think we'd be very open to that.

Is only spent nuclear fuel considered as a ceramic waste form, or are tailor made waste forms for specific waste streams or elements also of interest to this call?

The short answer is no. The long answer involves the way the forms preexist, where the nuclear fuel is fabricated as ceramic pellets or a bunch of ceramic pellets. This specific program is looking at how to store, transport, and dispose of this fuel. The fuel pellets are all stacked up inside tubes and bundled together and we aren't going to change that. The high-level waste is fabricated into glass and this program doesn't look at changing the feed stream or changing the waste form, that is a given from the upstream process. There are other DOE programs that are looking at different fuel forms and high level waste forms, but not this program.

For FC-4.2, does this proposal need to address all sensing functions or can it only be a few of the listed items?

We would be happy with a few of the listed items. The list is the full suite of things we would like to monitor, but any one or more of those would be of interest to us. People have done quite a bit of work already, so you've got to be familiar with what is available out there.

Where is the repository site and how do we know the underground environment of the long-term waste repository?

We do not have a site and that is by law right now. It is still Yucca Mountain, but since it's been discontinued for a while, we've been doing generic studies of all kinds of formations, clay, crystalline, and to some extent, we're looking at some unsaturated sites, too. So, we don't have a particular formation at this time, but we're starting around different formations and considering other critical processes in generic terms.

Regarding FC-4.2, what are the constraints on the duration over which external measurements on the DSC can be performed?

FC 4.2 is looking at the long, extended storage and transportation of the fuel. We don't have a specific timeframe for that, but we are planning in a couple centuries timeframe. So, that would be likely a minimum of 100 years for a timeframe.

Is there a preference for a certain type of repository, such as salt?

Yes, we are looking at all kinds of formations, including salt. For the past 10 years, we have studied different formations and salt is one of those. In fact, there is actually work going on in research on understanding the brine flow. You can look for publication online that are already out in this area.

Will the monitoring parameters be the same or different for sensors external and internal to the DSC?

Yes, we want to monitor it for the same aspects/conditions, so the parameters would be the same in that regard. Some of the technical specifications for the equipment would be different as to whether they were physically located inside or outside the canister. On our equipment specs, we've listed what those parameters would be.

Can a coupled experimental computational proposal be considered under FC-4.1?

The short answer is yes, but it depends on what processes you are modeling. There's a lot of work being done already. We have multiple processes and integrators to do the computations and performance assessments. There is a significant amount of work going on out there, so you can develop new methodologies for representing processes and modeling them. So, this will have to be seen on a case by case basis.

Is retrievability considered a topic under FC-4.1?

Answer: The regulations ask you to have a retrievability option for a period of time before the repository closes. The problem is that if you have a specific repository site and you have designed some of this, then it becomes more important to design something for retrievability issues. In general, before you close a repository and if there is a need to retrieve, then, yes, we should plan for that.

You mentioned a need to monitor corrosion. Is this corrosion of the internals? If so, is this spent fuel or are you anticipating long-term storage of wet DAP spent fuel?

Answer: It is considering the corrosion internal to the cannister, not external. It is primarily focused on corrosion of the fuel assembly. The intention is to store the fuel dry with a helium blanket on it, but dry is relative and, typically, there is a small amount of moisture left in the cannister, even after drying. So, that moisture is a concern to us in the area of corrosion. Generally, the fuel is stored dry with a helium blanket and corrosion would occur under conditions where there was some water left inside.

What are the dose limits to be rad hard for sensors in FC-4.2?

Question will be answered at a later date.

Would a non-dry neutron poison barrier technology, such as a water-based colloid, be under this scope?

That scope would be looking at the FC-4.1, new concepts or approaches for alleviating post-closure criticality concerns, and all various fill materials for the cannister that would have long radiation moderators in it and neutron poisons. Water is typically not a friend to radiation and criticality. That isn't to say that there is some colloidal dissolved in the water that it wouldn't be an interest to us. You have to be sure you don't introduce any situation that might cause criticality in the container. Liquids should generally be avoided. You have to worry about the moderator and long-time exposure for that. So, colloidals may be a temporary fix, but if you can propose something that really makes it happen without being a moderator, that would be fine.

Are models for fission gas movement within the repository of interest?

Yes. Gaseous releases are also considered in the performance of releases. Not all fission gas and any other gaseous elements coming out of the container are analyzed within the context of natural barriers. Yes, we do analyze many different releases and that has to be accounted for in the performance assessment.

When you mentioned data quality, is big data or machine learning something you are interested in?

Many of the national labs are looking into the data machine learning stuff. It depends on what is being proposed. I would encourage people to look at what's done and where there's the most bang for the buck, as opposed to just taking all data and trying to machine learning.

What is the concentration of water in the stacked fuel?

Generally, in the container, the spent fuel is very dry compared to the outside of the container where it's exposed to ground water and it's not the spent fuel that will see a lot of corrosion. The residual water that might be there in the container can be quickly consumed within the claddings and other things fairly soon. So, you have to make a case for how much water there is and how much corrosion can be generated as a result.

We have those numbers and have done research on that, but don't have the numbers right now. Typically, it's very, very small amounts. There are instances where water can be trapped inside the fuel tubes. Unhydrated water of the uranium oxide that is residual after the drying process is the situation that we are concerned about, such as when the concentration of the water is greater than what we designed for.

What buffer materials are of interest and what range of water content in the buffer are of interest?

This is assuming the buffer outside the container. Usually, most of the buffers we have studied is bentonite and fully saturated environments. A significant amount of work is being done on how that bentonite dries up or gets exposed to high temperatures and what happens to its performance. It generally does swell with heat and then it performs to retard the radionuclides from moving out. There are studies that are looking at modifying the content of bentonite. Worldwide, bentonite generally is being used as a buffer material and people have looked at additives to the buffer material. Getting a totally new buffer would be interesting, but whether it adds to the knowledge base is a question that you have to ask.

Are modeling and testing of microstructures achieved during the fabrication and repair of the casks of interest?

No, they are not part of this topic. We are interested and have looked at it in the research topics of other years, but this year it is not considered as part of the topic. We are looking at existing containers, so we are not fabricating any new cylinders to be like existing containers. We are less interested about it this year.

For FC-4.2, are simulation results sufficient for developing the sensor and monitoring techniques?

At some point in time, we'd want to prove them with prototypes. Initially, simulations would be acceptable and are something we would want to start with. If they look extremely promising, we would take it a step further and do prototypes, so yes.

Are neutron and gamma tomography techniques considered for spent nuclear fuel monitoring?

Yes, that is one way of doing it.

Would it be of interest in this program to have a virtual reality simulator of repository process facilities?

It is not clear from the question whether it is surface facilities looking at how to bring waste into the facility and then deal with it or if it is the underground facilities. So, we haven't spent much in generic studies to look at any of the surface facilities. If you're looking at subsurface facilities, at this time the interest is fairly low on that. In the subsurface facilities, if the model relates to the topics of interest here, such as how it relates to the fate and transport of the radionuclides, it might be of interest. Usually, all that happens when the repository is finally closed. The facility you're talking about would be the drift and any closure shafts. We do look at what kind of permeability and operational and closure issues they bring about. So, yes, those are the 2 or 3 things that could be applicable to investigate.

What did you mean by data quality and model enhancement? Do you have numerical models and model results that are available for PIs?

This is FC-1 and we have a lot of models that are looking at different aspects. Typically, in the performance assessment, we consider how good the dataset is in its uncertainties. These uncertainties are propagated through the whole system of calculations. There is an element of quality of data in how it is being used in representing safety analysis. So, yes, we do want to look more at how the quality of data affects things. It is always combined with the performance assessment software and that's what we're doing with it.

Besides light water reactor used fuel, are advanced reactor spent fuel forms considered?

No, not at this time. The scope is limited to spent fuel and existing defense waste.

For FC-4.2, for corrosion, are we looking at the fuel behavior in addition to the cannister corrosion?

Yes.

For FC-4.2, are spintronics based nuclear sensors of interest?

If it monitors one or more of the attributes we are looking at, then the answer is yes.

Crosscutting Technologies (CT)

CT-1: Crosscutting Research – Cyber Security Research and

CT-2: Integrated Energy Systems Design and Modeling

Is the focus more on an entire control architecture, or more on the secure communication methods?

Specifically, on the security aspects, we would not be looking at an entire control architecture, I think for that. There are probably some other elements of the call that might be of more interest for whatever specific reactor technology is being controlled, and so forth. But if you are looking at the security architecture of that control system, that is of interest.

Is supply chain security considered out of scope for this year? You highlighted wireless communications more.

It is not out of scope, but what's most of interest is the wireless and remote operations, The only things completely out of scope are the things we mentioned as not being of interest, So if it fits within the general description of what we provided in the call then it's in scope.

What is the difference of focus between the NEET crosscut 2 area (wireless technology for nuclear instrumentation and control systems) and CT-1 crosscutting research (cybersecurity research)?

I'll try not speak out of turn on the nature of the other call, but the other one is focused on the actual sensor technologies, and this call is focused on securing the communication, so specific elements of cybersecurity protection.

Is hydrogen production preferred end application for IES?

Not necessarily, it is one of many that could be considered. We have done work on hydrogen, but we are open to other concepts as well.

Is integrating heat storage to high temperature advanced systems of interest?

Yes.

Is experimental validation work of interest?

That is a fairly broad question. If it is experimental validation of the kinds of concepts that we discussed in the presentation, then yes. As an example, if there is a model developed for integration of an advanced system, with heat storage, and you have a facility that could be utilized to validate some of that model, that is great. An outcome from a proposal that has an experimentally validated model of some aspect of an integrated system that falls within the interest areas - that would be very much of interest.

Is the IES software available for inspection by faculty and students?

Yes, there is quite a bit that has been put together with regard to the modeling and simulation tool set. Much of that actually has been recently moved to open source. If there are specific questions with regard to how to access that, how to assess what has already been developed with regard to component models, we can certainly provide a broad summary of that and provide that information fully to the community that's applying to the CINRs. It is fairly comprehensive, and some of those tools just were authorized to open source as recently as last week. So absolutely, some of those are out there, and we can certainly answer some of the more detailed questions and provide information broadly.

Will developing small scale IES at universities be of interest?

Many universities have self-contained power systems, something that that is operating on campus, to provide power and heating on campus. Modifications of that evaluation of that relative to, the scope within the IES program here, and how it relates to nuclear systems. I think that can be very applicable. I'll use an example, if you had a really small-scale nuclear system that could power a campus, that would be a really interesting topic to consider, and that could be crosscutting between the micro reactor program and the IES program. However, we would have to understand a little bit more detail.

Is control system design and optimization for IES integration of interest?

Yes. I will talk to our modeling and simulation lead about putting out some very general information. For example, here is where you will find details on what we have already done in control systems that can be built upon. So, we have done some of that work, but it is absolutely not complete. I want to make sure that proposals build upon are the tools and capabilities existing and do not go off developing something new, because we want those to integrate with the other tool sets.

Is the efficient management approach, besides integration, of interest?

If the management approach is administrative or technical. Efficient management approach would be things like machine learning and variable demand forecasting to predict batching and so forth, then yes. If we are talking more about administrative management, then probably not.

Is there any specific small modular reactor or micro reactor preferred for integration?

No, definitely not. We are open to all concepts that are out there. Focus on reactors that are realistically out there under development and not a novel, new idea, but otherwise it is fair game. We hope that all of the different reactors potentially coming to market have options to work in the integrated energy systems context.

CT-3: Transformational Challenge Reactor R&D

CT-3.1: Integrated Thermofluidic Experimentation and Modeling for TCR Core Components and

CT-3.2: Materials Characterization of Additively Manufactured TCR Core Structural Materials

For CT-3.1, is it desired for projects to be both experimental and computational or purely experimental?

In both of these areas, we're really focused on getting data. The most important thing is the experimental component. The modeling component of it is definitely secondary, definitely a lower priority.

In CT-3.1, are the components intended specifically as fuel elements or generic parts that will be tested in the TCR?

Clearly, no fuel components will be shipped. Some of the components will be surrogates for fuel or fuel associated components that silicon carbide then other structural materials: additively manufactured, steel, or Inconel for example.

In CT-3.2, should we concentrate on all three materials? Should we do all mentioned mechanical testing?

Certainly, no, is the is the answer to that. Ideally, you can address multiple materials and mechanical testing. We have listed the litany of material characteristics for that. The idea is that these activities will supplement existing testing. So TCR.ORNL.gov does have a list of publications that we have released through TCR, and those will cover some of the testing that we are doing.

For CT-3.2, how closely will the applicants need to coordinate during the proposal stage with Oak Ridge on the materials that will be supplied?

During the proposal stage, I do not think it is incredibly critical. Again, TCR.ORNL.gov has a lot of information, or what is in the public literature has a lot of information, on the components, the materials, the approaches that we are using for printing. And, of course, you can certainly contact Kurt or others here at the laboratory for more information on those.

In CT-3.2, since the samples are provided, can you confirm that there is no need for AM monitoring to be done by PIs?

In both of these tracks, there's no additive manufacturing expected, it's actually discouraged, on the advocate. We will provide the elements. And then, for the second one on the data, during manufacturing, we will collect that spatial manufacturing data for the different components. That is why it's very imperative that the data in 3.2 does have spatial fidelity.

The CT-3.2 area seems less focused on research and more focused on strict characterization and testing. What would a successful proposal in this area focus on? Should we just focus on our capabilities and experience to do that characterization?

Yes. The short answer is yes. The long answer is, again, very much focused on the characteristics of these of these materials as a function of location within the material and then tracing that back to the larger digital platform.

In CT-3.2, do we have to characterize all mechanical properties mentioned, creep fatigue, fracture, tensile testing?

No, but, multiple of those characteristics would be ideal.

In CT-3.1, you mentioned that the measurements need to be consistent with prototypical conditions of a helium gas reactor. However, you mentioned in the draft scope of the call that high-temperature measurements are not needed. Can you clarify?

They are not needed if there is a way to replicate or get meaningful data at a lower temperature with a lower temperature setup. As far as what is relevant, we are looking at temperatures of up to 500 degrees C, or somewhere around 300 to 500. For testing, we also here have testing activities that we have undertaken. And we have some of that information, again, through public literature, that we have right now.

For CT-3.1, can you confirm that the duration for the project is two years?

Yes, it is two years.

In CT-3.1, is high resolution measurement desired for velocity and temperature in addition to the temperature or pressure/temperature?

It would be nice to have that, but it is certainly not something that is required. The idea is that when you have flexibility of additive manufacturing, you can manufacture very, very complex, say, cooling channel geometry or flow structures that require more advanced modeling and simulation. So, getting appropriate data to support that is the objective.

How do we go about getting samples from TCR in CT-3.2?

That will be coordinated with the manufacturing and materials testing lead here at Oak Ridge National Laboratory, upon the recipient receiving funding for progressing through that. The first step obviously is to really understand what the current situation is regarding testing for TCR.

In CT-3.2, should the characterization and testing focus on bulk testing, or is small scale testing also valuable?

They are both valuable.

On the environmental effects, are you interested in stress corrosion cracking?

Currently, that is not a priority.

Does CT-3.2 include any instrument development to obtain spatial distributed properties?

No, not directly. We do have good amount of instrumentation activities under TCR, and no, those would not be high priority, it would be pretty low.

Do you have any preference or a priority in CT-3.2 for one of the three types of materials you mentioned?

No, not necessarily. The silicon carbide material is reflective material and material associated with fuel elements in the current TCR core design. The metals are structural materials, and encapsulation for our advanced hydrite moderator.

Is ion irradiation analysis a must in CT-3.2?

No.

Can you be specific about what you mean by 3-D location data in CT-3.2?

The idea with additive manufacturing as an additional platform and characterization during manufacturing is that you can generate a digital history of the part that is built it as a function of location in the part. In additive technologies, you build a part voxel by voxel, roughly speaking, so you do have an entire history of every voxel in that part. The temperatures in time, as well, as any manufacturing defects or manufacturing irregularities that occur during those processes. The idea is that the testing that we have is tied back specifically to that data with that spatial resolution. So, locations of failures or components, for example, are of interest.

A follow up on the 3-D location data question: Can you confirm the locations provided will be on the surface, or will there be a need to cut the samples to get the points inside it as well?

Thankfully, for nuclear, a lot of these structures are pretty thin, or they would be hollow, essentially. From a reactor physics perspective, a lot of the metals need to be thinner to benefit the reactor deployment and optimize fuel utilization. So, for the metals you are looking at thinner components, silicon carbide, is going to be a much thicker material.

Following up on the 3-D location question: Will the marked locations be physically on the samples?

Every sample will have a digital history for that sample in spatial resolution. One of the challenges is making sure we can tie any type of characterization back to the location during manufacture. So, it is really important to use a process that you can trace that back. We do have approaches to handling different samples because, again, it is not just sampling a bunch of different printed components. It is sampling this specific component and tying that back to the data that was used, such as print direction, power deposition, those types of things. So, it will have identified features.

In CT-3.2, regarding the environmental effect and temperature range, is there a preferred reactor type for this task?

TCR, design helium-cooled, gas reactor, pressurized forced flow, at 300 – 500 C, is the is the targeted demonstration at this point. Material temperature is for the fuel, could potentially get a little hotter than that.

Are thermal properties of interest?

Yes, they are. But again, please visit the publications page, TCR.ORNL.gov, and look for the mechanical and thermophysical properties that we are looking at for additively manufactured steels and silicon carbide.

For CT-3.2, is in situ mechanical testing of interest?

Not necessarily.

What type of description are you looking for under quality assurance programs in CT-3.2? Can you please provide some details there?

For both of these, we wrote some similar language regarding QA, because we were doing a demonstration of a nuclear reactor, and this data should have some rigor level in a QA space. So essentially, tracking components, test data, test conditions, are very important. How that would actually look like is that the QA representatives for TCR would review the QA plan and assess it and suggest any potential changes to that plan, in order to fit the plan usage of this data for TCR.

For CT-3.2, are the materials export controlled or restricted in access in any way, i.e. U.S. citizen only or export controlled?

No, we will not be sending geometries or elements that are subject to export control restrictions, which is what we are watching out for here.

Will specific temperatures, stresses/strains, and other relevant mechanical testing conditions be specified for the PIs?

What would be relevant to TCR demonstration are temperatures up to 500 to 700 C for silicon carbide materials and operating in any environment.

Just to do a meaningful scaled experiment at lower temperatures we need information about the reactor and operating conditions. Is this information available from TCR, or should we just pick any gas reactor?

It would be best if you looked at what we have in the open literature for TCR, at this point it should be sufficient, if it is not, please certainly reach out.

For CT-3.2, is there a preference on destructive versus nondestructive characterization tests?

There is not.

For CT-3.2, is neutron irradiation attractive?

We have an existing campaign that is going to cover the scope of these materials in relevant reactor conditions, so it would be a pretty low priority.

In CT-3.1, can you clarify what precisely the supplied specimens are? Are these fuel assemblies with cooling channels already built in?

No fuel is going to be shipped and any types of geometries would not be subject to export control restrictions, or at least that is the hope. Effectively, what you will be getting are geometries that would help in ascertaining coolant behavior through cooling channels, in between structural and fuel elements inside the TCR core.

For CT-3.2, is it implied that ion irradiation is of lower priority compared to the mechanical testing component?

It is a lower priority; it is not as low as neutron irradiation though.

If a proposal has an expert in additive manufacturing as a participant, would that be an advantage or not?

It would be neither an advantage nor a disadvantage.

For CT-3.2, is 3-D computed tomography with voxels smaller than 1mm 3 attractive?

Yes, it is. Again, please consider reviewing some of the literature that is out there for the TCR program. A lot of different characterization we have done to date on subcomponents.

In 3.2, what quantity of bulk materials will be provided?

It will be whatever is necessary to fit the bill and get the testing done. The articles are going to be smaller for both metals. Silicon carbide, at most you are looking at samples that are in that few-centimeter range, probably. Again, those are based on current approaches and what we have existing for manufacturing printers and furnaces for the silicon carbide CDI; they are not very large components.

Since there are a few spatial thermal property characterization devices, will CT-3.2 support some of this development?

Yes, if there is a clear path to getting data.

In CT-3.2, will material volume be sufficient to allow us to machine our specimens, as per ASTM standard E8/8M?

Yes.

In CT-3.2, can you ship large samples with tungsten as a surrogate for uranium?

We would not be interested in that.

For CT-3.1, thermo fluidic will depend on geometries of test samples. Could you give more specific information about the geometries?

Yes. There should be sufficient information in the tub of literature to wrap your head around what the geometries look like. We are looking at channel, plate, kind of semi-plate, thin cylindrical channels, and thin straight channels distributed through fuel elements and around fuel elements. So, you have angular flow in some places and some more exotic shapes. Again, at TCR.ornl.gov publications, there should be a few images of what those geometries look like. So, you are looking at silicon carbide with some roughness.

Can we propose specimen design rather than TCR provided ones?

No; we are interested in looking at the printed components for TCR.

You mentioned the target temperature for SiC is 500 to 750 C. Is it the same for the 3-D printed metallic parts?

It is less. Fuel gets hot, and the heat is removed from the fuel. The peak fuel temperature is going to be somewhere in between 600 and 670 C. Let us say that's fuel that is additively manufactured and densified. For metal components. it will be more akin to the temperatures of the coolant. so, we are looking at 300 to 500 C.

CT-4: Advanced and Small Modular Reactor Materials Accountancy and Physical Protection

Is this work scope for computation or experiments or either?

This work scope would be for either.

Will generic design basis threats be provided for, or could they be suggested for, a general assessment of the physical protections?

One of the difficulties with universities on the physical protection side is not having access to some of the sensitive information. That is certainly something that can be provided. You might want to consider a good lab partner that can help provide that guidance. That is something that has been done in the past. There are different ways that you can look at more of a generic threat to try to stay out of the sensitive space.

Does this work scope include development of small footprint neutron spectrometers that can actively or passively detect the emission of fast neutrons from radioactive materials as part of MC&A?

One clarification here is that we are focused on domestic regulatory requirements. Keep in mind, for this particular area, if you're going to be proposing a project, we are interested in how the vendors are going to meet NRC requirements for US bills. Sometimes technologies may be a little bit more suited for the international safeguards area or more for detection and remote detection, which are not of interest. We are specifically interested in materials accountancy needs that are going to be needed for various reporting requirements for NRC.

That being said, that particular technology could be something that might be needed for small reactors or for sealed cores, which could be considered.

The regulatory needs are not completely defined, and we have some work to do in the larger program to help define what those needs would be. We are still trying to understand a little bit more about what on that side would be needed in terms of measurement technologies.

Will new reactor concept designs be supported?

No, new reactor designs would not be supported under this particular work scope. This is just focused on materials accountancy and physical protection for generic classes of reactors.

Can traditional LWR MC&A be used as a template for MC&A? Could you investigate this as part of the workscope?

A lot of the basis for traditional light water reactor MC&A centers around the fact that you have large discreet fuel assemblies, which are difficult to seal, and it is difficult to remove material. So, the NRC requirements take that into account; in the Code of Federal Regulations, Part 50 and Part 52, has a reduced MC&A set of licensing requirements for those types of reactors.

For advanced reactors, if you're if you're looking at something that's more of a traditional fuel assembly, and that could be a light water reactor type design or it could even be a sodium reactor type of design, where you have the discrete fuel assemblies, you're probably more likely to fall into that existing MC&A approach.

As you move towards the advanced or the more novel fuel types, like the pebble beds or the liquid fueled reactors, increasingly different approaches are needed and sometimes those are not necessarily spelled out well in the regulations. As you move more towards those novel fuel types, you are more likely to be in the Part 74 regulations, especially with the liquid fuel type of designs.

So, it really depends on what sort of general class of advanced reactor that you are interested in exploring.

Could attractiveness assessments be included as part of the physical protection assessment?

That could play a role. That is certainly something that has been done.; I am not sure that it has been done for all the different types of fuel and reactors, especially some of the new novel ones. There has been work on attractiveness in the past, both in the open side and on the more on the sensitive side. However, what we are interested in is more along the lines of attractiveness along with ease of access. Physical protection requirements may take into account how difficult it is to access the material. For example, if you have a sealed core that just has a 15 or 20 year design life versus fuel assemblies, or other types of fuel, that have to be removed periodically, that could have an effect on both the MC&A requirements and the physical protection. So, taking into account the difficulty of access is an area in which we could use help.

If there was an industry company developing a pebble reactor, and they were also looking at MC&A regulations to design their reactor, would an industry partnership be a factor in assessing potential proposals?

Although there are no additional bonus points for partnerships in the review process, partnerships are encouraged, especially with somebody in the program. It helps guide the work and lets us know where the gaps are and to make sure that we are not reinventing the wheel. In this case, because our ARS program is so tied to the vendors, it helps us to know that there is a specific need and a good application space for it.

Is there a minimum of unaccounted for nuclear material established since most methods are statistical?

The requirements, with those sorts of details, are listed in 10 CFR 74. It is usually listed as a percentage of the physical inventory and so that can change quite a bit depending on the size of the reactor. A small modular reactor may still have a more significant amount of material, whereas microreactor will be quite a bit less. So, if Part 74 is required for that type of a system, is going to change. When you get into the sort of issue, I highly encourage you to just make sure that you understand the regulatory space.

Are you looking at physical protection only from the viewpoint of diversion of material? Or would you also consider a threat to the release of radioactive material?

It is both diversion material and depth of sabotage; basically, everything for which NRC is interested in for protecting the health of the public.

Would design modifications that results from an MC&A assessment, such as addition of accounting tanks, be captured by this activity?

Yes, certainly anything that is proposed is a design change, particularly if you are looking at safeguards by design and security by design. Those are all things that we would be interested in. It is really just a matter of if that's something that's applicable to the particular reactor. So, an accountancy team may be more applicable to a molten salt reactor; I am not sure that that is quite as useful for any of the other reactor design types out there. We do highly encourage safeguards and security by design in this area.

Is there a safeguard by design document available for advanced reactors?

There has been a lot of work on safeguards by design in the international community. NRC refers to international safeguards when it discusses Safeguards by Design, and that’s where more of the work has been done in the past. The following link shows the IAEA reports in its Safeguards by Design series, based on facility type:

https://www.iaea.org/topics/assistance-for-states/other-documents

There are some publications on Security by Design, as well:

https://prod-ng.sandia.gov/techlib-noauth/access-control.cgi/2013/130038.pdf

Is there any preferred reactor type?

No. At this point, the program, especially the along with the demo program, is designed to be supportive of several different types of reactors. Anything is on the table. It is mainly just addressing the physical protection needs.

CT-5: Nuclear Materials Discovery and Qualification Initiative R&D

Does this work scope include adding extra data from experiments?

Yes, if you need that dataset in order to answer this call and to do the work that we asked, you could add materials and information from experiments. You are not required to use an existing dataset, but it is difficult to obtain more data. There is no exclusion for generating your own data.

Are machine learning methods within the scope of interests for establishing structure, property relationships?

Yes. We would encourage using machine learning. We would also encourage you to consider how to apply physics-based modeling with machine learning. Machine learning as a technique – great. There is a lot of work to do there. However, because there is lots of materials physics, we want this tool to be broadly applicable to classes of materials. We would most highly regard usage of machine learning that is also considering physics.

Is this work scope focused on machine learning tools for MOOSE or developing models using existing MOOSE capabilities?

You can do both. I would recommend that you use the existing capabilities that are available to you, if they allow you to do what you need to do. However, if you need to build some kind of capability, then please do so. It would go into MOOSE. We are doing work already to incorporate different aspects of machine learning and reduced order modeling into the stochastic tools module. So, there are already some basis there, but we would greatly encourage added capability there.

Are you seeking out primarily computational proposal, with maybe some experimental support, or is a proposal that is evenly distributed between experiment and computational data acceptable?

We envisioned this as primarily modeling and simulation oriented. However, we would not exclude if you would demonstrate the entire process of experiments and modeling and simulation to meet the goals that we have requested.

Can you provide examples of materials that the program currently considers for cladding, fuel, and core materials?

We are a new program, and so, we are not highly focused on any one material system yet. We are in support of advanced reactors. Therefore, I would urge you to focus on materials that are for advanced reactors, that then is very broad. This is more an answer of exclusion rather than inclusion: we are not particularly interested in LWR type materials. As we are looking at advanced reactors, we are looking at extended environments and temperature, radiation of mechanical properties. So, if you are looking at materials that are more advanced, that same structural materials, that would certainly be encouraged, and that also could link back into the experimental question. If you feel there is a measurement you need that is not currently available because of the new extended environments, that would probably be a good application as we look at the computational tools. You could look at existing materials for LWR's, but in different aspects or for advanced reactor conditions, that would then be considered a new use case.

Can you please elaborate a little more in detail on existing data analytic tools in the MOOSE framework?

There is the MOOSE Stochastic Tools module that is being developed. Please go to the mooseframework.org website and look at the Stochastic Tools Module page. There' a lot of documentation there that describes what is in the stochastic tools module so far, including examples to use it.

Can you give some examples of databases that can be drawn on?

No, that's part of the call – for you to identify a database and decide how to, and if, you want to use it. That has been one of our efforts. We have had a struggle finding, suitable datasets. E-mail Allen Roach for further information on this. Now, we found some datasets that are close, but nothing really perfect, and this is where we're hoping that maybe some of the university researchers have already started on their, for example, structural materials, and had been developing a database. That is what we are looking for here. If we could find a partnership, that would be great. This also, again, back to the experimental question. If you have a database that you think is ideal, but you have got a couple pieces of information you need, that would be a good application for experiments too.

Mission Supporting Nuclear Energy (MS-NE)

MS-NE-1: Integral Benchmark Evaluations

What kind of support documentation is needed?

We may have to wait until Dave returns to ask him to clarify when he's back from vacation. One of the things that there was from previous NEUP review processes where proposals may state that certain entities from industry are supportive of a project. Yet, there is no indication to demonstrate that support such as a memo of support or a memo indicating a need. There may be other ways to demonstrate it, that's kind of the simplest where, if you were working with an industrial partner, then them acknowledging the importance of this benchmark to support, not just their work, but other reactor designs of the similar type maybe, what would be, in my opinion, something valid to demonstrate that. We can ask Dave to provide a more formal answer to that question.

Does the scope encourage new experiments or evaluation of existing experiments?

This scope is more for evaluation of existing experiments. The challenge with new experiments is new experiments are quite expensive, and often the expense required to perform an experiment is well outside the available funds under the NEUP award. If I was proposing an experiment in something like the ATR, I would not be able to cover that with the NEUP award. I know I've seen some very simple experiments at universities that could be done fairly cheap. But, again, the onus of the proposer would be or that the PI would be to explain why such an experiment could be performed and fit the goals of the benchmark evaluation process and also be evaluated as a benchmark within that three year period and the budget of the NEUP award. But typically, we haven't funded the performance of experiments just because that cost is well outside the funding envelope of the NEUP award.

MS-NE-2: Nuclear Data Needs for Nuclear Energy Applications

No questions.

Nuclear Energy Enabling Technologies (NEET)

NEET-1: Advanced Methods for Manufacturing

Are there specific materials or systems that are of interest (structural, fuel, cladding, coatings, etc.) for the high throughput/combinatorial approach?

The call is focused on the approach followed and we are not restrictive on the demonstration material or component. However, saying that, good motivation/justification should be given for the demonstration choices with beneficial impact(s).

Would a proposal on the use of modular, precast reinforced concrete fall within the scope of NEET-1? Such as an approach to reactor building construction would be agnostic to reactor type (i.e., advanced, micro, small modular). The project would enable rapid building construction at remote sites.

Yes, your proposed topic falls within the NEET-1.1 category.

We currently have a proposal written, but it is geared more towards nuclear. Should we make it broader in scope, i.e. include other areas that may benefit from the technology?

The funding call is from the DOE-NE; proposals applicable to benefit the nuclear industry are sought.

Powder metallurgy is explicitly mentioned in the call. Does it mean that you are primarily interested in this process? We are thinking of proposing something related to binder jetting 3D printing + powder metallurgy. Is this consistent with the interests of this call?

Powder metallurgy was given as an example. PI's can propose and justify any process.

What materials are of interest? Is it the structural materials (e.g., stainless steel)? Or high-temperature structure materials (e.g., Tungsten or ceramics)? Or fuel materials (e.g., U3Si2)?

We are not prescribing the material type nor the application. It is up to the PI to justify the choice.

What attributes of the manufacturing process are valued the most important? The easiness to produce parts with a new/different geometry? The capability to produce complex geometry? Or the microstructural stability and/or mechanical properties of the manufactured products during the service?

It is for the PI to justify the rational and choices made for the proposed research. During the CINR presentation, it was indicated that the choices should be justified with the view of industry application and demonstration in mind. Saying that, the CINR does not stipulate the technical readiness level for the proposed work, although it is recommended to include in the justification the potential future attributes to application.

Is concrete 3-D printing of interest?

Yes, it is. We have seen some applications for 3-D printing. I cannot speak on some of our prior awards, but I believe we did have some funding for advanced forming for concretes. So yes, we are interested in that as well.

Is meso scale computational modeling of the microstructures of 3-D printed parts of interest?

If you put it into context of one of the NEET applications, it comes down to the justification of why you want to do it and how it's just going to accelerate qualifications or the irradiation knowledge of changes in the microstructure – then it will be relevant because it is one of the advancements for manufacturing.

For NEET-1.2, is this only for additive manufacturing processes?

Definitely no. Advancement for manufacturing is very crosscutting amongst a large variety of fabrication processes so we are specifically interested in other methods as well: how can we improve current processes that are out there to accelerate the work and to make the work more reliable. It is not just limited to additive manufacturing. Even significant changes that improved forging technology would be acceptable in this area as well.

For NEET -1.2, do you have any specific materials in mind? Is a new material, OK?

I think new materials are acceptable as long as we can see the traceability to an end use. I think that's one of the factors that we need to be considering when we're looking at our applications -tying it to the concept where it's going to be used so we can see that it flows into the supply chain.

Are there any specific modeling capabilities that are of interest for this NEET workshop?

No; we are not descriptive on the modeling methods to be used.

Is a collaboration with a National Lab, Oakridge or INL, encouraged?

Your team members and collaborators need to make sense in regard to the work scope and the justification. It is important to have a goal in mind. Therefore, make sure that your full package of collaborators are each contributing to the end objectives.

For NEET-1.2, as a foraging application, do you have a specific material or materials in mind?

Materials that would be those that are relevant to our current fleet of advanced reactor materials. Those are the ones we have the most interest in, but we are not specifying specific materials because there's quite a few that are being used or are in consideration for use.

NEET-2: Wireless Technology for Nuclear Instrumentation and Control Systems

No questions.

Nuclear Energy Advanced Modeling and Simulation (NEAMS)

NEAMS-1: Advancing Material Modeling in System Analysis Module (SAM)

In NEAMS-1, what specific fission products are desired since tritium is already heavily supported by NEUP and DOE programmatic funding?

The obvious ones, such as cesium and strontium, would be of interest. We also mentioned corrosion products there and we did leave that a bit open to interpretation. We aren't looking for anything necessarily exotic, but more of what you'd expect. Specifically, tritium is not something we will take in this NEUP call. The primary reason is there's a near term need in industry collaboration project. The timeline for NEUP may not match the near-term needs. This call is more general, including fission products. We are not seeking tritium transport in this call.

What reactor designs fall under the purview of NEAMS-1, any and all non-LWRs?

Yes. Salt is of particular interest. It's open to all reactor types, but in terms of near-term needs, the salt cooled reactor is certainly something we want to address in the near-term.

On SAM code, is it only for 1 phase flow or is 2 phase flow desirable, too?

Right now, we are focused on a single-phase flow model. If a proposal seeking different approaches were open for ideas on how to develop models, they should still be within the structure of a single-phase framework.

For NEAMS-1, what type of molten salt reactors are more interesting, solid fuel or liquid fuel reactors?

We don't specify and are open to both.

NEAMS-2: Corrosion Modeling for Molten-Salt-Facing Structural Components

In NEAMS-2, would a combined experimental computational focus be of interest? What proposals involving model development and new experiments be of interest? In NEAMS-2, would proposals involving model development and new experiments be of interest? In NEAMS-2, are there enough corrosion experimental data for calibration and validation of mesoscale models, or are we allowed to propose performing experiments, too?

Potentially. This is a hard question to answer without knowing what specific experiments. They weren't explicitly prohibited in the call, so this would be on a case by case basis. It's not out of the realm of possibility, but, in general, the main emphasis should be on computational work. An exclusively experimental proposal would not be responsive to the call. We are really interested in the development of corrosion models that would ultimately reside in the GRIZZLY code. Experiments for validation or to help resolve some important physics or chemistry, in this case, would be worthwhile, but should not dominate the effort.

In NEAMS-2, should projects use the NEAMS tools, such as Yellowjacket and GRIZZLY?

Yes, it's acknowledged that there might be some other things that would be part of a proposal, but those should be the final product and it should find its way into the NEAMS tools.

For NEAMS-2, do you have any particular type of alloys in mind, say nickel-based alloys? Do you think integration of machine learning tools with existing microstructure-based codes will be within the scope? Do you want to model specific molten salt reactor structural alloys?

Any of the alloys that are allowed by the boiler and pressure vessel code for high temperature applications would be of interest there. This is something that's a pretty new area for us and the options are pretty wide open there as long as there are viable candidate materials. We intentionally didn't specify alloys, but we're particularly interested in alloys that are being pursued by our industrial stakeholders. In terms of nickel alloys, I would make sure to connect the alloys of choice to potential industry usage. The machine learning tools mentioned would definitely be of interest.

Does studying salt chemistry data and property prediction fall under any of these calls?

Not explicitly. The closest one would be NEAMS-2 for corrosion, but here we're more interested in the corrosion mechanistics and developing models for corrosion. That requires some understanding of salt, but isn't an explicit generation of salt thermochemistry or thermophysical data.

In NEAMS-2, would fundamental understanding of the corrosion electrochemistry be included?

Absolutely, yes.

If NEAMS-2 is focused on modeling capability, would a model alloy be of interest?

It depends what is meant by model alloy. If the question is if the proposal would be based around a particular model alloy, such as certain stainless steel, then that would be of interest.

Are any flow conditions of interest in NEAMS-2?

This is more of a chemistry problem than a thermohydraulics problem and so we haven't specified flow. Anything that is relevant to the MSR and FHR designs that are being pursued are of interest.

For NEAMS-2, would conducting corrosion experiments fulfill this scope?

We are open to experiments, but the proposal should not be exclusively experimental.

Are you interested in stress effects on corrosion in NEAMS-2?

Yes. There are enough difficult problems just around the corrosion with salt, but the inclusion of stress effects would be viewed positively. This is specifically called out for interest.

NEAMS-3: Next Generation, High-Fidelity Pebble-Bed Simulation

For NEAMS-3, is the neutronics method desired to be deterministic only, or is the Monte Carlos method okay, too?

We didn't specify. Ultimately, we would want to introduce the method into the deterministic tool. If there are Monte Carlos solutions there, that would be of interest as well. We are interested in the transient phase, so if the proposal is able to do that, it would essentially be doing NEAMS-3 and NEAMS-5 at the same time.

NEAMS-4: Fundamentals of Multiphase Boiling Flow for High-Pressure, High-Void Conditions

In NEAMS-4 scope, could you elaborate on how high the system pressure is expected to be in experiments?

We don't need to go all the way to the boiling water reactor operating conditions. As long as you demonstrate the importance of pressure effect, it is acceptable.

Is there any interest in two-fluid model fundamentals related to NEAMS-4?

We're not seeking two-fluid model development in this call. We are thinking high resolution experimental data, closure model development suitable for the tools we are developing within the program, so this is aimed to be for CFD and CTF or sub-channel closure models.

For NEAMS-4, is the focus on experiments or modeling? Any suggestions on measurement techniques?

It has both experiments and modeling focus and both of those are acceptable. In terms of experimental techniques, we've intentionally left that vague to see what types of solutions might exist.

In NEAMS-4, would you confirm which flow regime is the priority?

The high void fraction region is the priority.

Nuclear Science User Facilities (NSUF)

NSUF-1: Nuclear Energy-Related R&D Supported by Nuclear Science User Facilities Capabilities

NSUF-1.1: Testing of Advanced Materials for Sensors and Advanced Sensors for Nuclear Applications

In NSUF-1.1, is this scope ITAR restricted from an export control standpoint?

I guess certainly it could be but all NSUF work is intended for open publication. So, it would be unlikely we would accept something like that.

Are you interested in dose information or a particular type of radiation?

It would be helpful to have some specifics, but you may not want to get into that right now. If you can relate it to the goals in the work scope, then we would be interested to see the proposal.

Are you interested in correlation with mechanical properties, creep, or fracture toughness?

Absolutely.

I believe this is probably for NEET-2, is the use of radiation harvesting for sensor power sources of benefit?

The business case side of it is definitely part of the overall consideration.

For NSUF-1.1, can the sensors be located outside of the containment?

For 1.1, I do not think we have restrictions for where the sensors are located; it has to support a nuclear industry.

Is environmental exposure of interest, either simultaneous with the radiation or separate?

We are looking for a nuclear environment, so it has to be for harsh environments.

For testing of advanced materials for sensors, is using of electron beam acceptable to approximate gamma dose?

Certainly, I guess that is something that you could use for a pre-characterization. NSUF does not offer any electron beams, but we do offer a variety of high-level gamma irradiation facilities. So obviously we would like this testing to be as close to the prototypic environment as possible, so that industry would be more likely to want to adopt these technologies.

For the NSUF scope, should we look at a particular structural, material, steel or concrete, or can we have a broad approach?

So, obviously, you would need to find materials that are important to DOE office of Nuclear Energy; steels and concrete certainly cover that. So, write the proposal for what you would like to see.

What level of dose irradiation are you interested in for NSUF?

These are generally for in-core applications, so obviously, it is very high dose. But it would have to be at least whatever it is appropriate for the lifetime of the detector; and that can be variable. We can work on that, and you can actually contact me (Brenden Heidrich) for the technical side of trying to plan the experiments where I can assign other tech leads for that. We can figure that out, but it would need to be around the actual dose it should experience in or near the reactor.

Are you looking for a particular type of radiation in the NSUF scope?

Once again, it should be like the prototypical environment, so neutron and/or gamma.

For the NSUF scope, can we use wireless RF transmission equipment?

Certainly, wireless has been an area of investigation for a while. Reactor vessels tend to be big Faraday cages. So, you just have to explain how that would work. But wireless is certainly of interest.

NSUF-1.2: Irradiation Testing of Materials Produced by Innovative Manufacturing Techniques

For NSUF-1.2, is ion irradiation an attractive option, or is neutron irradiation a must?

I personally prefer neutron irradiation. Unless the proposal can specifically provide the leap or the direct comparison between the results found in ion irradiation and what the effect will be as part as part of the neutron irradiation. But preferably if ion irradiation is used, it should be used as an interim state for down selection for neutron irradiation.

For NSUF-1.2, this is a follow up from the first question, can you give some specific examples of existing materials you have in mind?

No; we do not want to limit it to specific materials. It is for the PIs to describe and justify why they would like to look at that material. It is really not only to do an evaluation for the science sake, the approach much conclude with an end purpose and application in mind – that will make it more effective.

Is a modeling component allowed as NSUF-1.2?

I do not think so.

For NSUF-1.2, will advanced fuels be considered?

YES. NSUF 1.2 is associate with manufacturing process and integrated digital frameworks to support qualification and certification for licensing. The applicant should ensure the proposed work does not fall under FC-4.

NSUF-2: Nuclear Science User Facilities Access Only

Will the INL HPC call be more general than just nuclear materials workscopes, such as if a user wants to do CFD analysis of a nuclear fuel element within this scope?

The NSUF focuses on irradiated materials and nuclear fuels. So, that particular example that was mentioned there would come within the scope of the CINR FOA, within NSUF's mission. Now, whether the appropriate software is currently available on the INL computers, I don't know. So, obviously, there will be a licensing issue. The way that licensing is treated is described in detail in the FOA.

Would you please expand upon the meaning of readiness? Does it mean preparedness to be/to use the facilities or maturity of the technology?

This basically means that the material that you're going to irradiate, for instance, is available, all the technology for preparing that material is commonplace and straightforward of application. So, for instance, if you're wanting to irradiate an additive in manufacturing material, we require that you actually have the material in place and available, so that it can be sent within three months to the NSUF for machining of samples, etc. In some particular cases, where it's a straightforward technologies commercial material that would be accepted. I would also like to mention something that is very important here. Full materials that are going to be obtained from a DOE program, we require, at least at the full application stage, a letter saying that those materials are going to be made available by the program. So, in essence, if you're supplying the material, we need to know that you have that material, that you have that material fabricated, so there is going to be no challenge in terms of being ready for insertion. If it's a library material, obviously, we have to be, we supply, that said there are no concerns. If you have a material that is coming from one of the DOE programs, we need a statement that you have access to it in the preliminary application and in the full application. We need a sporting letter from that particular program saying that you have been given permission to have access to that material.

Can I request NSUF access in any workscope or just the NSUF workscopes?

This year it is restricted to the NSUF-1 and NSUF-2 workscopes only.

Do you only support experiments at NSUF or partner facilities?

We only support access to the NSUF partner capabilities, and those are not necessarily all the capabilities available, let's say, for instance, Oak Ridge, or PNNL, etc. The specific capabilities available are listed on the NSUF website. We also reserve the right to suggest alternative places for doing pieces of work. In particular, it's very important to get the right reactor to do any radiation. There's no point doing certain things in the ATR, when it would be much more straightforward if performed in say in the MIT reactor.

Can you please clarify: Is Preliminary development effort also required for NSUF-1, as well?

We have a readiness criteria, so for NSUF-1 and NSUF-2, we require that the material is essentially ready to go. In other words, that material, or a sensor because it senses are also included, has been fabricated and has been tested/characterized. So, in other words, the particular material or sensor is available to insert within the reactor, or to provide to NSUF to get ready to insert within the reactor within three months of award.

Last year, no NSUF-1.2 proposals were funded. Are PIs encouraged to resubmit their proposals?

There's no restriction on preventing people from resubmitting a proposal. However, essentially, the review process begins from scratch again.

Is it possible to include ion irradiation in addition to neutron irradiation within an NSUF-2.1 workscope? The purpose would be to qualify ion irradiation for accelerated screening of material to guide new materials for industry applications.

There's no reason whatsoever why it would not be considered. That is a very worthwhile project and the use of ion beams as surrogates for neutrons radiolysis is one of the things that were particularly important, that we regard as being particularly important, so, yes it will be accepted.

What is the reason that Industries are the only allowed applicants for NSUF-2.1?

I'm afraid that I'm not at liberty to comment on that particular issue. That is, it is not the first time that we've made that particular decision. As mentioned, the 2019 call was also industry only.

Is the main focus of the NSUF-1.2 workscope the materials produced by advanced/innovative method for the existing fleet or advanced reactors?

AMM program supports both existing fleet and advanced reactors. The call is not only for materials produced, but can be parts of components/products as well.