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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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RELIABILITY AND PRA SUBCOMMITTEE

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WEDNESDAY

APRIL 24, 2013

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ROCKVILLE, MARYLAND

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The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B1, 11545 Rockville Pike, at 1:00 p.m., John W. Stetkar, Chairman, presiding.

SUBCOMMITTEE MEMBERS:

JOHN W. STETKAR, Chairman

J. SAM ARMIJO, Member

DENNIS C. BLEY, Member

HAROLD B. RAY, Member

MICHAEL T. RYAN, Member

STEPHEN P. SCHULTZ, Member

WILLIAM J. SHACK, Member

NRC STAFF PRESENT:

JOHN LAI, Designated Federal Official

YUNG HSIEN JAMES CHANG, RES/DRA/HFRB

DON HELTON, RES/DRA/PRAB

SEAN PETERS, RES/DRA/HFRB

JING XING, RES/DRA/HFRB

ANTONIOS ZOULIS, NRR/DRA/APOB

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

P R O C E E D I N G S

1:00 p.m.

CHAIR STETKAR: Okay. The meeting will now come to order. This is a meeting of the Reliability and PRA Subcommittee. I'm John Stetkar, chairman of the Subcommittee meeting.

ACRS members in attendance are Steve Schultz, Dennis Bley, Harold Ray, Sam Armijo, Mike Ryan will be joining us, Bill Shack and Joy Rempe.

John Lai of the ACRS staff, is the designated federal official for this meeting. The Subcommittee will hear the latest developments on the HRA methods and their application in response to Commission's SRM-MC062-010.

We will hear presentations from the NRC staff. There will be a phone bridge line. To preclude interruption of the meeting, the phone will be placed in a listen-in mode during the presentations and Committee discussions.

We have received no written comments or requests for time to make oral statements from members of the public regarding today's meeting. The entire meeting will be open to public attendance.

The Subcommittee will gather information,

analyze relevant issues and facts and formulate proposed positions and actions as appropriate for deliberation by the full Committee.

Rules for participation in today's meeting have been announced as part of the notice of this meeting previously published in the Federal Register.

A transcript of the meeting is being kept and will be made available as stated in the Federal Register Notice.

Therefore, we request that participants in this meeting use the microphones located throughout the meeting room when addressing the subcommittee.

The participants should first identify themselves and speak with sufficient clarity and volume so that they may be readily heard.

We will now proceed with the meeting. And, Sean, do you want to say something?

MR. PETERS: Yes, I'd like to thank the Subcommittee for taking the time to work with us on this topic.

What you're going to hear today is what was requested back in December, which was the understanding a little bit more about the psychological foundations for the IDHEAS method and more about the applications to all events and we definitely look forward to hearing

your comments.

To let you know, Jing has taken this project and done a tremendous amount of work to get this to this first stage. Trying to get the various stakeholders to come to some type of cohesiveness and agreement has been an incredible challenge on this project and Jing has really mastered that up to this point.

But just to let you know, it's definitely a work in progress and we are having continuing meetings to try to enhance this product. So, we are definitely looking for input from the ACRS Subcommittee here and would be happy to incorporate fresh ideas or new ideas for incorporation into our IDHEAS project.

And with that, I'll pass it to Jing.

MEMBER BLEY: Before we start -

CHAIR STETKAR: Dr. Bley.

MEMBER BLEY: - may I make a statement?

CHAIR STETKAR: You may.

MEMBER BLEY: My conflict in this area has actually grown and my company is involved with the staff in developing various aspects of this work.

So, I should not participate in deliberations with the Committee on this topic.

CHAIR STETKAR: Thank you.

Anyone else?

(No response.)

CHAIR STETKAR: Okay. And, Jing, I don't know who all is out there on the bridge line. I understand there are several people out there.

They can hear us. If you need help from them, just let us know. We'll open it up and get them to participate.

MS. XING: Okay. I think earlier I told our team the bridge line is made one way. So, they probably on bridge line now, but they expect - thank you. I appreciate that.

Okay. So, thanks, ladies and gentlemen, and I really appreciate your being here to review this work. And especially I notice you are just up from the previous meeting without any lunch break.

And as Sean said, the first topic for this afternoon - can everyone hear me? The first topic for this afternoon is to go over our literature reviews that we have pretty much done in 2011 and which we never gave the Committee a briefing of the whole story. So, today you will first hear the story.

And the second part for this afternoon, I will have the matters that we are still in developing expanding our early work into the Level 2 domain.

So, here just you saw this slide back in

December, the IDHEAS - the products from IDHEAS.

So, what we have now is the cognitive basis for human error analysis. It was developed for to provide a technical basis for human reliability analysis and actually also for human factors engineering. And the report is right now in peer review and we intend to have it published in FY14.

So, taking ACRS' suggestion from last meeting, we started the peer review in February. So, the drop-dead time is the end of May of this -

MEMBER SHACK: Now, how broad is the peer review?

MS. XING: In terms of the broadness, it's globally. So, we have about seven members committed, seven people committed to provide some review. And this include university professors and the people who work in the government agency - other government agency, and the industry expert like people who have - who are well-known in the government or in cognitive engineering like Christopher Wickens - well, he didn't commit. I don't know if he's there. And also staff from other countries. From German and British and Halden in Norway.

So, because this review is purely voluntary and this report is over 300 page, so we told them they

could rate the review at different levels. To the very high level of coverage and the soundness of the approach, and to the deeper level. If they like to provide us in-line comments, that will be highly appreciated.

MEMBER SCHULTZ: Jing, have you determined how you're going to incorporate the comments of the peer review into the document, or are you going to modify the document based on peer review comments, or are you going to incorporate peer review as an appendix?

MS. XING: It's hard to say that now. What I had in mind is we're probably going to do both. Since we are out of our staffing support, there's a contract there, so we probably cannot address every comment.

And also because this report is quite comprehensive in terms it covers every major area of human performance, some of our expert reviewer only work in one particular area. So, they probably have lots of detailed comments in that area and may not necessarily address it.

So, I'm thinking by the end we collect all the comments. If they're really major comments, we need to address them.

And for the detailed comments are really - or for some comment like you would need to, for the work or add lots of details when they just classify the

comments and put them in appendix and develop then for the future document.

MEMBER SCHULTZ: Thank you.

MR. PETERS: This is one of our concerns with the peer review is that out in the real world there are a lot of people that have very detailed knowledge on one particular area.

And Ms. Xing said this is supposed to be a comprehensive across all the human performance domains. So, we are a little bit worried about getting too focused in particular areas of the peer reviewers and not focusing off of the other areas.

So, I think Jing is going to try to take those comments and try to maintain at least a relative balance across the report. And we could feasibly keep some more of the detailed comments like you had indicated in an appendix or something like that in the back of the report. It's feasible for that.

MEMBER REMPE: Jing, I need to interrupt something too that I missed earlier because I was doing some file transfers, but I do have an organizational conflict of interest although I'm not personally involved with this work.

And so, I know I've declared it in prior meetings, but probably ought to have it on the record.

Sorry.

CHAIR STETKAR: Thank you.

Jing, you mentioned several peer review participants and you've discussed, you know, detailed comments in very specific areas.

Have you assembled the whole peer review team? Are you trying to develop any sort of consensus high-level peer review comments?

I mean, in many cases a peer review benefits from people with different perspectives and experience kind of trading off things among themselves in a team rather than sitting isolated in a little closet writing their own comments and sending them to someone.

So, have you organized peer review team meetings, or is this simply individual experts providing you comments on a report?

MS. XING: It's the individual expert.

CHAIR STETKAR: Okay. So, that's not really a peer review process as we understand it for many other functions.

MR. PETERS: Yes, we are somewhat fiscally constrained at the moment. Research took a very major hit to their funding. So, the actual ability to formulate a team and fund people to come out to the meetings, we have to really rely on a strictly volunteer

basis for this.

CHAIR STETKAR: Volunteer and individual.

MR. PETERS: Exactly.

MS. XING: In fact, if we can have that funding, I would review our - the report of the IDHEAS level internal procedure event report that's coming out pretty soon to review.

MEMBER BLEY: Jing, maybe I could offer a point of clarification doing this as an independent peer review, but also this project has had a number of meetings along the way with experts from a broad variety of organizations, not just the authors of the report involved in discussions and feedback.

So, there's been in that way, a bit of an in-process peer review.

CHAIR STETKAR: But as a developmental type.

MEMBER BLEY: Yes, I mean, they've had meetings, had people in, talked about what they're doing.

CHAIR STETKAR: Yes, thank you.

MS. XING: The early version of the report has been in a peer review that, peer review means you are outside our development team by a number of NRC staff and INL senior staff. So, those we have a more goes through the workshops. We have had standing progress

of that.

Okay. So, this work was conducted by a big team and Erasmia Lois was the project manager. April Whaley, which was - compared all the different pieces works into this to produce this single report.

And I was the architect for this project. And the rest of our team members pretty much work in - we have weekly meeting, and they work in a parallel fashion.

So, each member work in one individual cognitive function, but we use the weekly meeting to make sure we're coordinating each other.

So, for this I will briefly talk the goals and the process of the development of this cognitive basis and some limitations we have in this report.

And then we can either quickly go through the five cognitive functions or look at - select what functions to look at details.

And also, I would like to have some time at the end to talk about some additional study of the literature review and the operational experience review in our effort of expanding the method for Level 2 domain. And those materials are not in the report that you may have produced so far.

So, what's in the middle in this gray box

is a very high-level cognitive basis for human performance. And this is essentially the cognitive basis they use, you know, pretty much all the HRA method either explicitly or implicitly.

And why each are there is we don't - there hasn't been enough effort to look into these. Therefore, we know that some performance influencing factors like fatigue, we know if you are high fatigue, that you have a high chance to make a failure.

But a lot of methods did not explicitly have the explanation how a performance shaping factor, a factor a party to the task makes a failure.

So, because of this implicit, it introduce a lot of subjectivity, variability in the HRA practice.

So, our effort here is try to make this cognitive basis more explicit by look inside this gray box and see what are the mechanisms to make this function work. And how do it fail? And how is it different performance influencing factors that would affect the chance of fail. So, that's our goal with this project.

So, we must - explicitly we try to identify cognitive mechanisms underlying the operational failures in internal procedure events.

The literature review is limited for those operation, the task is in the more procedure event

situation.

Also, identify the factors that influence human performance where possible and identify how those factors actually affect the chance of failures.

And develop a structured cognitive framework to compile this information and use it as a psychological foundation for the IDHEAS method that we are developing.

So, faced with the goal we set in -

CHAIR STETKAR: Before you go to the next timeline here, can we go back to the previous slide?

What elements of the review and kind of the framework that's laid out in the report are limited because of that first bullet? In particular, the qualification that says internal, procedural events. Because as I read the report, it doesn't seem to be limited that way.

The IDHEAS methodology gets very procedure-centric and says we're only going to do this for internal events, but I wasn't quite sure how this basis document is limited that way.

Could you explain a little bit where you think it is?

MS. XING: Yes, that clear in the later slides, but I give you quick -

CHAIR STETKAR: Okay. Okay, fine.

MS. XING: I can give you a quick -

CHAIR STETKAR: No, no, no. That's fine. We'll wait until we get there. Thanks.

MS. XING: Okay. Okay. This very messy slide. I don't like messy slides. It kind of give you the project timeline and the milestone what happened here.

So, we start this activity in October 2010. And we are - we are in - we're close to P4 in the process for external peer review.

I'd like to briefly talk what happens difference between the first period and the second period.

In the first period, we - our team decided to do this literature review. We didn't have a very clear idea how this should be done.

So, it's easy to come up those five basic cognitive functions, because it's almost universal in all the major cognitive literature.

And let's say for the - we started with the function, the detection. What does exactly "detection" mean?

It means you say something, you perceive something and is that about your readiness sense of how

to work or about how your brain to interpret what you see.

We didn't have a very clean structure how to do that. So, we basically went to search everything we think related to detection function and it took our team a tremendous amount of time to collect a huge amount of information.

And just to give you an example, once I search the keyword the forward retina in the public medical database, that was back about seven years ago, it came up like 30,000 articles.

So, and our team, they try to organize and put those selections in most relevant information. And when we talk relevant, we use the procedure event as a framework.

So, and at the end of that period, we presented the work to ACRS and also some of our own staff and people feel you have a lot of use for information here, but it's not - they don't know how to use it because it wasn't well structured if you still have the memory for the April 2011 meeting.

So, after that meeting, ACRS meeting, we - the team decided we need to come up -

CHAIR STETKAR: Let me interrupt you here.

Just for the record, you have not presented

this to the ACRS. You presented it to our subcommittee.

MS. XING: Subcommittee.

CHAIR STETKAR: So, be very, very careful when you put things on the record or in writing. The ACRS has not yet reviewed any of this material. We have not written a letter report on this.

So, any feedback you received as today, will be individual members in the Subcommittee setting.

MS. XING: Okay, okay.

CHAIR STETKAR: Thank you.

MS. XING: Thank you.

So, at that point we decided to come up with a framework how to do this related to their method and participating our product. And also, that's when we decide the scope of there.

At that time, our team's goal was to develop the IDHEAS method for internal procedure events only. So, we set up the goal of the scope of literature review for that.

And, therefore, for every function we didn't do like a thorough task analysis, but we kind of - our team got a sense, okay, what are the detection function in the control room for the procedure event?

And we determine some like you going to respond to alarm. And you check the indicators and you

monitor the status. So, we're trying to get a sense of those.

Then we focused - then we developed a set of keyword where you're going to search in the literature.

Those keyword in the paper in the report and those keyword are particular for this procedure event scope.

For example, when we try to decide the decision-making, the scope for the decision-making function, there was a large amount of literature distributed in decision-making, which means the decision was made by people at different locations with different responsibilities and receiving information from different situations, different set of information, that kind of situation. Then we decided to lay that out of our real scope.

So, what we have here in this report is not say only apply to internal matter, apply to external, no. It's applied to general human performance, but some aspect of human performance were not covered in this review.

CHAIR STETKAR: You know, I guess I missed that reading the report. It's been a while since I read it, a couple of months, but I didn't get the sense of

that qualification in the report.

MS. XING: Yes, and another -

CHAIR STETKAR: I do from the IDHEAS methodology report. But my concern here is, is the fundamental psychological basis report being influenced too heavily by narrow focus in the application?

MS. XING: It's not -

CHAIR STETKAR: I mean, I'm starting to get that sense -

MS. XING: Yes.

CHAIR STETKAR: - and it bothers me a bit.

MS. XING: It's not to influence, but it just is the scope. You have a big pie. You do not cover the entire pie. You need a piece or two of that piece of pie.

MR. PETERS: John, which report are you referring to? Are you referring to the -

CHAIR STETKAR: I'm referring to 2114. NUREG-2114.

As I read through that report - and as I said, I think I would have flagged it if I found too many references to only procedures and only internal events.

MS. XING: And -

CHAIR STETKAR: I didn't get that sense

reading that report. I got the sense that it was more comprehensive and that the report on the methodology application of these principles, basically, suddenly gets focused into everything works in terms of procedures and internal events and in the main control room.

MR. PETERS: You're referring to the methodology report, referring to the Phase 2 report, the joint report with EPRI for control room -

CHAIR STETKAR: Right - well, that's the - yes, I'm referring to the thing that I think will be discussed in this.

MR. PETERS: Okay. I was just trying to refer, because what we are talking about today will be the Phase 3 report which will be the generic applicability method.

So, perhaps we will -

CHAIR STETKAR: Okay. Maybe I have a disconnect here, but -

MS. XING: Yes, another part I'm with you is the sense we recovered, is very comprehensive. Let me talk a little bit about the source of the information we're having.

So, first we talk when we talk the scope, let's talk about the coverage of the area. And then

we talk about the depths of the information coverage.

The source of information we look for, you can separate into several layers. On the very bottom there we look at cognitive neuroscience literature which really talk about the inside of the brain, how you actually make a decision, which part of - that part is universal.

CHAIR STETKAR: Yes.

MS. XING: So, regardless where you are, you are inside or outside the control room, you know, inside part of your brain, those hardware, wire. Those are universal.

And then on top of that we look at the psychologic experiment, the cognitive and psychologic experiment.

From that experiment, we have some limitations. There are, for example, let's just use decision-making as an example.

There are some psychological experiments if they involve people at - two different person receive different set of information and how they make decision with this kind of uncertainty.

And that kind of literature is not included just because our team with the limited time we have we focus on those more like the control room

decision-making you already have a procedure that will pretty much give you a basic starting for your decision.

CHAIR STETKAR: That's the point that bothers me. You have a procedure which is a book and it's a reference. It's only one piece of reference material that you have.

Reference material that you also have is your own knowledge and training, your environment, what people are screaming at you or saying to you in a very controlled manner. So, it is not a procedure-driven context.

As much as other people might want to make you think that it is, it is not. And that, I didn't get that procedure-driven context as I read through NUREG-2114.

It seemed to make a lot of sense that says procedures are part of the whole stew that affects a group or an individual's decision process, but I now hear you telling me that I have procedures.

So, therefore, the way I think is guided by those procedures.

MS. XING: That's -

CHAIR STETKAR: And that's not the message that I'm getting from 2114. I am getting the message from the EPRI-driven methodology, and I have real

problems with that. And we've discussed that in the past.

MR. PETERS: Yes.

CHAIR STETKAR: But my fear is that too much of that procedure-centric view of the world is creeping into this part of the process.

MEMBER SCHULTZ: I agree, John. I thought here we were working to develop a general model, general picture incorporating the other elements of the environment as they affect all of the pieces of the model.

MS. XING: Yes, I should say there's no way that procedure event kind of plan is not influence this work, because this was part of the entire IDHEAS project.

At the time we conduct the literature review, the project team had a clear goal. We were going to develop a method for procedure event only.

So, that's why in 2012 last year when we tried to extend the method to the broad scope, we have to do a lot of additional literature review focused on those - the areas that was left out, yes.

MR. PETERS: So, I guess what I'm hearing is Jing says we took that original scope and expanded it. And, John, what you're telling us is that you didn't catch that original scope.

It's not only that original scope in what you read. You read in the - in that NUREG, you read that it is more applicable than just procedural-driven.

CHAIR STETKAR: That's what I read. And, in fact, there are many examples that show how procedures can sometimes aid and can sometimes detract from effective decision-making.

MEMBER SHACK: Now, there was a certain emphasis on dealing - you're dealing with trained people.

CHAIR STETKAR: You're dealing with trained people.

MEMBER SHACK: Knowledgeable people.

CHAIR STETKAR: That's right. That's right.

MEMBER SHACK: And in teams.

CHAIR STETKAR: Yes, in teams.

MEMBER SHACK: So, that's not a general -

CHAIR STETKAR: You're not putting me out in the middle of the desert and saying, make a decision today.

So, it is focused on team dynamics, knowledgeable, trained people that do have procedures to a greater or lesser extent available as one of their aids. But, as I said, the discussion in the NUREG,

anyway, seems to strike a balance among all of the influencing elements.

I don't want to call it influencing factors, because that means something different.

MR. PETERS: So, Jing, you mentioned earlier that there were pieces that were - pieces of the psychological literature that were left out of this report.

Could you elaborate on what types of things are not included?

CHAIR STETKAR: Well, she mentioned one thing about distributed decision-making. That if you're down the hall and somebody calls you and says it's raining outside, and I'm sitting in here and somebody calls me and says it's precipitating outside, we might make a different decision about what we're going to do about that, because we might be receiving slightly different information as opposed to us all sitting in the same room together.

And there are probably a few other things, but -

MS. XING: Yes, so it's like you go to - for the high level, it's more influenced by procedure. But if you look at the bottom levels, the neuroscience part, that part isn't really universal part.

And, also, limitation in the second bullet, the factors, how the factors affect different - affect human performance. We didn't get much of that down in the report.

And so, it was towards the later stage of the literature review the team members feel like it's just too much. They don't know how to go to that part of literature and don't know how to put it together.

So, we didn't do a systematic work, but we collected lots of example how the individual factor would work, that you will see in the appendix.

So, we wouldn't say that's a very - we can't judge how complete that part is, but we put as much as we could find in some parts there.

And also, the third bullet is the structure of the cognitive framework and we already had some issues when our team used that.

So, in the report we talk a lot about mechanism, mechanism. The mechanism if you look at the Appendix A and B, you will see appendix - the word "cognitive mechanism" sometimes means some good thing. You need to have to make people perform more reliably.

And sometimes mechanism means a bad thing, make you fail. So, that's whenever we try to fix it.

And I also receive some very initial

feedback from the peer reviews in the information meeting I went in March. And interestingly, all the three international - three or four international reviewers there, they all told me the same thing. They feel very confused about the last function, the teamwork and communication.

CHAIR STETKAR: That, of everything in the report, is probably least well-developed.

MS. XING: Yes, they feel like -

CHAIR STETKAR: And I think the report acknowledges that.

MS. XING: Yes, they feel very confused how that one was handled. So, there's still some - there's some limitation. Some, we can't address them.

So, just a look at this is the strategy we decided to work in. So, first off, this was already - we start this in the very first place when we decide to have the literature review.

There are human response in the PRA event. And within the response there are human-centered tasks, what are the tasks the human does.

And the intent of each of this task is supported by a set of high-level cognitive functions. So, our literature will focus on each of these five functions.

And for every function, we try to list it in the following. First, as we just talked, the scope of the cognitive function in the nuclear power plant control room tasks. When we say control room tasks, our mental models or procedure-driven tasks.

So, we try to identify what objectives the functions try to achieve there and that gave us the scope for the rest.

Then we look at the cognitive mechanisms which ask how the human - how humans perform the function and what make the humans reliably achieve the function objectives.

With that information, we first located the error causes or sometimes we refer as the failure mechanisms. And we group this failure mechanisms into what we call the proximate causes, which we saw in Item 3 is almost like connected part of Item 2. So, you know this how you make it work, and these are the things to make it not work.

And the last part we look has affects of PIF, like what are PIF, performance shaping factor, or the aspects of performance shaping factor lead to those error causes.

So, the report for every chapter is for one function. And each chapter is a structure based on these

four layers. What you say the first layer, the tasks is more based on our experience, these people have control room operation experience.

The second level is largely based on the - it's largely based on neuroscience and cognitive psychology literature. That part is more - it's less influenced by internal/external procedure.

And when you come to the third part, the error causes, we are more focused on what happened inside.

Probably you can find 100 different error causes and we manage to report results relevant to the procedure-driven performance. And the effect of PIF then would pretty much focus on the control room performance.

So, then at the end we structure the important - we put all the information into a structure like this. You're probably already familiar.

On the top is the cognitive function and we group - on the third column are all these different failure mechanisms.

We group these failure mechanisms into proximate causes. And also for the failure mechanisms, we look into the information, what performance shaping factor would influence this mechanism.

One thing I like to point out is when we actually used this to develop the IDHEAS method, we find that the proximate causes really doesn't help us, which initially we thought it would help us by grouping these causes together. Then we find, okay, when you group together, you lose the detailed connections.

So, we actually really used the failure mechanisms. Never really - never really use the proximate cause. It's just the easy way for you to think about it. Instead of think about a hundred failure mechanisms, these mechanisms fell into three categories. That's all we used for this.

MEMBER ARMIJO: Could you give just some examples of a performance influencing factor, then a mechanism and then a proximate cause just -

MS. XING: Okay.

MEMBER ARMIJO: - to put it into something -

MS. XING: Let me quickly see if I have one here.

CHAIR STETKAR: You're going to walk through that in a few slides.

MEMBER ARMIJO: You know, just a quick little example.

MS. XING: Okay.

MEMBER ARMIJO: I don't want -

MS. XING: Let's talk real quick example for detection. One proximate cause here is cues or information not perceived. That's a proximate cause. You didn't perceive the cue or information.

And the failure mechanisms, these are some examples of the failure mechanism. It can be because the cue salience is low. Like you've got - one alarm is critical, important. You got several alarms - several hundred alarms all there with the equal salience.

Or you are - you've been working for a long hour or nothing happened and vigilance is getting low. So, even something happen where they didn't say anything like one quart for the airport as the security people. If you don't say very often, you often don't say that that's a vigilance. That's another way to make you not state the important information.

Or your working memory capacity is overloaded. You have a good -

MEMBER ARMIJO: I see that the PIF is a proximate cause, but what are the mechanisms?

MS. XING: Okay, the mechanisms is not here. The mechanisms - this is a mechanism. The mechanisms, let's say, talk about the salience mechanism.

We are - I'm looking at this entire room.

My focus is on the members I'm talking to.

What my vision says to do is first to do is find the important information relevant and filter out those relevant information. That is a mechanism.

If in the vision -- like if you all wear the clothes like those chairs, there will be less chance I can identify you. So, that's a mechanism.

MEMBER ARMIJO: So, mechanisms are related to your physical capabilities, eyesight, hearing, other things that input data into your brain?

MS. XING: Yes, mechanism is more related once you pass your - the sensation part, how your brain process this information.

MEMBER ARMIJO: Okay.

MEMBER BLEY: This is for detection, Sam.

MEMBER ARMIJO: Yes, this would just have to be a detection thing, but -

MEMBER BLEY: This is -

CHAIR STETKAR: But in detection, you got more to think about.

MEMBER ARMIJO: This is the one where data is coming in, in some way and you're processing it.

MS. XING: Yes, you are processing it.

MEMBER ARMIJO: Okay.

CHAIR STETKAR: The understanding

decision-making one is a little bit more obscure.

MEMBER ARMIJO: Yes.

CHAIR STETKAR: But it gets the idea through a little bit better.

MEMBER ARMIJO: Okay, thank you. That helps. Get that into the mic.

MS. XING: Okay. So, in the infrastructure -- that's another weak - limitation in the current report. We didn't explicitly call up these mechanisms. So, we primarily focus on the failure mechanisms.

Okay. So, that's just to give you an overview of the process and the considerations there. Now, I have a choice for you. So, here are the five cognitive functions.

We can spend the next 20 or 30 minutes either talk one function in a greater detail, or quickly go through all the functions.

What is your choice?

CHAIR STETKAR: I think, Jing, we, at least the Subcommittee members, obviously a bunch of changing faces, some of who now need to be silent, have been exposed to sort of the big picture.

So, it might make more sense and it might be a little bit easier for some of the members present who haven't had that background to select one and walk

through it.

MS. XING: Yes.

CHAIR STETKAR: I think that might be a little it easier. So -

MS. XING: Okay. So -

CHAIR STETKAR: - if you can do it that way.

MS. XING: - the decision-making process, which one you pick?

MEMBER ARMIJO: Decision-making. This is not meant to imply there's a sequential, because communication, coordination are starting right after you've detected something, normally, I would think.

(Laughter.)

CHAIR STETKAR: That's one of the discussions.

MEMBER ARMIJO: That's part of it?

MS. XING: Yes, that's one of the -

CHAIR STETKAR: That's why her figure on - if you go back to Six, Slide 6, why it's in sort of the middle there.

MEMBER ARMIJO: Okay.

MS. XING: Yes.

CHAIR STETKAR: The others are more or less sequential.

MEMBER ARMIJO: Yes, right. Got it.

MEMBER SHACK: More or less.

CHAIR STETKAR: And iterative.

MEMBER SCHULTZ: Well, as we described or you describe/discuss decision-making, can you discuss the connections between and among the elements here?

MS. XING: Okay. So, how about let's do this? We can start with detection and -

CHAIR STETKAR: No, let's not start with detection, because that's the easy one that we've walked through too many times.

MEMBER ARMIJO: Decision-making.

CHAIR STETKAR: Let's start with decision-making and -

MS. XING: Okay, let's just go through decision-making.

CHAIR STETKAR: - depart from it as necessary.

MEMBER ARMIJO: What's wrong with understanding?

CHAIR STETKAR: Decision-making is good.

MEMBER RAY: Decision-making. I answered first.

(Laughter.)

(Discussion off the record.)

CHAIR STETKAR: We'll get back to

understanding. Some of the threads will -

MEMBER RAY: I've made lots of decisions where I didn't understand what I was doing.

MEMBER SHACK: Well, that's never stopped us before, right?

(Laughter.)

MEMBER RAY: Well, but that's part of the thing. You need to understand before you make a decision. That's what I think.

MS. XING: I will quickly walk you the first slides of every element. Then jump to decision part of the paper. So, just so we get a sense of how they're related.

So, for detection, it's the process of perceiving information in the work environment allowing humans to perceive a large amount of information, but focus - selectively focus on the important pieces of information.

And the scope in the control room procedure event basis detect - like detect the salient signals, alarms and identifying the perceived pertinent information, monitor parameters. They are the major functions.

So, once you get this information, you will go to understanding stage. Which understanding is

evaluation of the current condition to assess the plant status or to diagnose the problems and abnormalities.

So, you receive those information in the detection stage and you come to assess and verify the information. The information might be misleading.

And you receive many pieces of information. You want develop a coherent representation.

And you need to maintain situational awareness, what happened in the immediate past, what is going on now and what might go on next.

And another part for understanding is you want the diagnosis of abnormalities. So, that's what the understanding part.

Together detection and understanding many cognitive model to call this a state as diagnosis - diagnosis including detection and understanding.

Okay. Now, we have a good understanding and we can go to detection.

CHAIR STETKAR: Just for - that's a good - 23 is a good one for folks who haven't thought about this much, because there's some subtleties in here - you've characterized it as understanding. In the report, it's called understanding and sense-making.

And the sense-making part of it is important to some of this and it's important to the way people

respond to things.

So, if you could just go through these five little attributes here, I think it might also help.

MS. XING: Okay. So, let's say, you probably still can make an understanding of some simple things, some simple things. But for complex task, these are the things to make you work in a more reliable way.

The first element is data content. The data you receive has to come as a meaningful - have to be meaningful, make sense to you.

And if they are misleading or conflicting, it's likely you not have a greater understanding of what's really happening.

So, that - and the next element is mental model. So, where you have understanding is you have this information - external information come to your brain.

And one famous quote about visual understanding, this is by a professor from MIT many years ago, you see a cat, because you know a cat. If you don't know a cat, you don't see a cat. You see a bunch of lines and something.

So, you have this mental model of what's happening. You put this information you receive into that mental model and generate your understanding of

the situation.

So, a good mental model is critical for understanding. It's developed through training and experience.

So, the next stage is you have good data, you have good mental model and you need to integrate them together.

And you can - you may have many different versions of a cat. So, you see a white cat, a black cat, a kitten, all this you have. Now, you generalize them all.

When you see a new cat, you kind of compare to the cat in your mind or you might compare the cat to an image of a tiger for someone who grew up in the jungle.

So, you have to select the right - you have to choose which mental model you should use here and confirm your understanding. Maybe you reject your mental model looking for other mental model that fits the data better. So, this is the integration stage.

And to support the integration, you need attention and working memory. So, attention control will ensure that all parts of the cognitive process and understanding are achieved.

You tried to understand this, you were

distracted by something else, your attention was paid to other things. When you come back, you might have lose your mental picture/image.

And working memory is critical. Because understanding here is you kind of try to bind all these different pieces of information, external and the internal, binding them together, hold them together, and that is done. The mechanism for that is working memory.

So, but unfortunately, working memory is very capacity limited. So, you can only hold at maximum - if you want to relate some information together, you can only - the magic number for that is about four. You can relate four different things together.

If I read you a sentence that have ten different concepts -

CHAIR STETKAR: As you get older, it gets down to about 0.7.

(Laughter.)

(Discussion off the record.)

MS. XING: Just before that magic number four, there's another magic number. If you don't try to relate them, I need to hold them like my to-do list. Use this information like later on. The magic number for that is about nine or ten, something.

So, just for those two number, I myself have a good collection of a full box of papers. And you can easily find 5,000 article experiment trying to think of what's the number. There have been a long history fighting people trying to fight on these two numbers.

Finally they realize, oh, you are talking different thing. So, that's about working memory. It's a critical element.

CHAIR STETKAR: The key is the four isn't 400.

MS. XING: And also the belief process. The belief process is different from your mental model. Mental model is your understanding, your early - you get it from early years.

And the belief is more like your individual, which I believe this is what happened. And that can greatly influence your final understanding.

So, like we saw that in TMI, you data relate this is wrong. So, you wouldn't go looking for information in that direction.

So, these are the things that make you do a good job with your understanding less likely making error.

CHAIR STETKAR: Or can cause you to make errors, because you have a mental model with the way

the world works and you discount validate it because it doesn't fit your mental model. And people do that all the time.

So, this understanding is a lot more than just -

MEMBER ARMIJO: Oh, yes.

CHAIR STETKAR: - saying, you know, this is a cup.

MS. XING: To me, I see just a white and black thing there.

CHAIR STETKAR: And now that Harold has left, you can describe decision-making.

(Laughter.)

(Discussion off the record.)

MEMBER ARMIJO: Given you have understanding.

MS. XING: So, decision-making by definition is the judgment of what should be done and the decision to do it.

So, decision-making within the control room is characterized as involving experts and it being largely driven by procedure in the internal, procedural event. So, this is an element that is highly infamous by procedure event.

So, therefore, when we decided the scope

- so, this is at the time we think - or our team believed the - initially we got - we talked to some people on our team who think, oh, there's really no decision-making in control room, because you do everything by procedure.

Still, the procedure tell you to do - by procedure you up your diagnosis, you - procedure lead you to do the feed and bleed. You still need to - the operator or the shift supervisor still need to program the sequence of this, your plant.

You do a feed and bleed. When you do that? And how you do this and you want this where something need to be done precisely at some time, or after, okay, you do something that needs to be done precisely at some time these are all the same. So, you still need to make the decision.

And in the first high-level station decision-making, a lot of time the procedures, or you finish the trip procedure.

Now, you come to step and you need to decide there may be one to help you do the diagnosis. Maybe not one single procedure there for you. You need to make a decision -- choose the alternatives between these procedures.

Or even you are in a procedure, sometimes the procedure presents you different alternatives. You

need to make a decision of that.

And that there are also situations that the scenario does not quite match the procedure. You need to probably not come up with an entire new procedure, but you need to make some deviation, modify the plan, the response plan.

So, those are the decision-making we look into. So, those blank boxes, I will fill them in for now and talk about the method expansion.

Okay. Here I guess because most people are not interested in the neuroscience part, so I skip the neuroscience model for decision-making, only present a high-level decision-making model.

The most influential decision-making model in the area is done by Gary Klein who has done lots - did lots of decision study for military and aviation.

So, his model is a naturalistic decision-making model. By naturalistic decision-making it means you - the early decision-making study had normative decision-making model like you have several choices.

You find some way to compute which choice give you the best gain. And then you choose the one that like give you - supposedly you want to achieve some point at the shortest time and that's your function.

And your decision would be based on that function, which choice gave you the shortest time.

And he finds that doesn't really work in the naturalistic setting. And look at those military commanders, the fighters. If they're going to do such a calculation, they just make a decision.

So, he thinks the decision-making in a naturalistic setting is based on your - some kind of like pattern match. Through your experience, you already develop a lot of basic pattern like Situation A will be Decision A. Situation B would be Decision B.

If you come to a situation kind of between A and B, you probably quickly come up in a decision combination like that. So, and you do this - you do this pattern match-up first.

So, you start with the situation on the top, and then you use the situation generate as a cues important element and use those cues. That will lead you to create a story, a pattern. Okay, this is a pattern.

Suppose you have time. And if you have time - if you don't have time, okay, this is a pattern. So, my decision should be go, fight, fly the missile.

Suppose you have more time than a second

and you want to, okay, wait a second, this is a pattern I want to upload in the mental model I start before, bunch of mental model for situations similar to this and make - use your mental model to make a mental simulation simulating if I take this action, what's going to come out of it.

And you do this in a cycle for a while. And finally you take your decision. Then you use your - you choose your decision. Then you use your decision to - that decision will activate the actions, scripts which are the new settings more like procedures steps.

And you put that into your action scripts and still you don't immediately put into action. You still go to a cycle of mental simulation. Probably you make a decision. Your problem already change. The status already updated. So, you take more information making more mental simulation and then you put into action.

Or if you still - you don't feel comfortable with your mental simulation, you have a fear, I'm not sure what this - if this action is really going to lead to my goal, you will try to locate your situation, try to get more data.

So, you go through this detection, understanding, mental simulation again and here is the

point that you have to put your action towards.

So, this is the process of how you make a decision in the naturalistic setting. And in this process you will use your - like your mental model comes from your long-term memory.

And your mental simulation and the pattern match, those rely on your working memory. So, this is - what we will call this is a basic mechanism of how you make decision.

So, here is a list of the elements that make the function reliable. Because in the naturalistic setting, your decision always come from a goal. You just don't make a decision randomly. You make a decision to achieve certain goal.

So, goal management is important. It's a base decision. You need to have a clear goal. And these goals need to be prioritized.

Sometimes, I guess a lot of times, those goals are conflicting. So, you need to have strategies how to make which goals the most important. You need to enforce them.

And then you have this pattern recognition stage or pattern match. The situation to make a decision is matched to some decision you have made before.

So, and basically you gain this through your

training and experience, which I would say in the internal procedure situation this is also largely driven procedure helps you do a lot of things.

And mental simulation is assess the pattern and outcome of the decision. Presumably the procedures already feed a lot of mental simulation for you. And still it's the situation slightly deviated from your mental model. You need to do more mental simulation to say, okay, if that's the - that's going to work.

And in the decision-making process, there are many different kind of biases and good wishes. Like an example, I typically make a decision based on my wish instead of the real situation.

And as in the profession, you cannot let that happen. So, you have to assess your bias of your decision.

For example, one type of bias is -- my pattern recognition is only based on what happened very recently, but not think of the broad history.

So, they can interfere your decision-making and you have to assess or be aware of your bias and suppress your bias to make a clear decision-making.

And of course as we saw there, attention and working memory are important in holding the information and binding the relevant information

together.

So, at this mechanism level I can't, I mean, all these mechanisms applicable for your procedural or non-procedural event, but something like in the procedure make - in the decision-making, for example the team decision-making. And there, there will be some mechanism about how you achieve a team decision-making, a team decision. How you achieve a consensus. Those information are not included - and the mechanism are not included in this list.

So, any question on this?

MEMBER RAY: Well, I know that John said we're too focused on procedures or somehow we didn't want to be bound up by procedures, but somewhere in all of this the simple task of following a procedure must - the decision is I will take the next step in the procedure, I guess.

CHAIR STETKAR: Sure.

MEMBER RAY: So, that would fit in with all of this as one way to make a decision, which is I'll continue with the procedure that I am following.

MEMBER ARMIJO: Or you decide to stop because you get another piece of information.

MEMBER RAY: Yes, that's right. I just wanted to translate it into how at least I normally think

of things that go on in the control room as being governed by procedures.

They're not inconsistent with this decision-making model you are describing, right? You're not having to -

MS. XING: No.

CHAIR STETKAR: They're not inconsistent, Harold, but let me read something. I don't want to read too much here, but it says, in a very familiar setting in which the cues match almost perfectly the procedural guidance, the operator may follow the procedures for full diagnosis needed. In a familiar setting that deviates just slightly from either procedural guidance or from previously encountered situations, the operator will have to adapt some and plan a response based on an analogous experience. In a novel setting, the operator will have to construct a new response plan using his or her knowledge of the plant and system and previous experience. Each of these options, but particularly the last two, may be seen through the lens of the integrated - whatever you call it - normal decision-making model.

MS. XING: Yes.

CHAIR STETKAR: The operator or crew will use cues presented in the situation to construct a story

of what is happening and how the scenario is unfolding. This mental image will be used in developing a response plan and alternative actions. The response plan may be largely prompted by procedures or entirely conceived by the operators. The operator may evaluate the response plan or action scripts from mental simulation to evaluated suitability and put it into action. One of the defining features of decision-making in a nuclear power plant is the dynamic nature of the event. Maintain the appropriate situational awareness updating the mental model of the situation and planning response accordingly are important steps.

And it goes on. So, you're right. Procedures do play - and this is - this is a description, and I think it's a really good description. It's from the NUREG. It says, procedures play a role, but they're not the only thing.

If you believe that the world is acting specifically exactly the way the procedure says it ought to work, then you'll probably follow the procedure and you might be right or you might be wrong.

If you're ignoring the procedures, you're going to make your own decisions and you might be right or you might be wrong.

MEMBER RAY: Yes.

CHAIR STETKAR: So, this framework although Jing has mentioned procedures, procedures, procedures, is general. And some, you know, she takes the next step in here and all of everything else you're going to hear is general. It isn't just procedures.

MS. XING: Yes, the same procedures in this sense does not work for no procedure. This works for the situation. It's just the length in the known procedure situation there are probably couple more mechanisms than what we listed here.

So, it's not about applicability. It's about the completeness.

CHAIR STETKAR: Okay.

MS. XING: So, I didn't make this - sorry I didn't make this clear up front.

CHAIR STETKAR: That should be something I think, you know, as you go through the process - I don't know what feedback you have received from your peer review crew.

Some of that notion in the report should be made a little bit more explicit that why in the sense of completeness do some of these attributes - are some of them limited because you have focused on that type of an environment.

MS. XING: Yes, thanks.

MEMBER RAY: Well, yes. I did notice that this talked just about the control room, for example, in one of the earlier slides. That's all we're talking about, isn't it? Control room.

CHAIR STETKAR: The slides do, but the report doesn't. See, that's the difference between sitting in this meeting room with this presentation.

I hate to do that, but this is a tailored presentation that, in fact, is, I believe, more narrow than the document that's being presented.

I just do. I mean, that's my own opinion because - that's right. So, I think you have, you know, to be a little bit careful in that sense.

MEMBER RAY: Well, I am trying to be and that's why I asked the question I did. But like I say, I took it that we were starting with something that was bounded by the walls of the control room, because that's what it said.

MS. XING: Sorry. I think that's my fault did make it confusing in the first place. As we said, we have the applicability and the completeness.

So, as far as applicability, what we talk in this report is applicable to internal or external event procedure.

In terms of the completeness, there is some

part above the external event not included in the report.

CHAIR STETKAR: Remember, though, and I have to keep bringing you back, the term "internal event" and "external event" is an artificial construct of people who draw little boxes that have "and" and "or" gates.

People who work in the real world don't make those distinctions. They don't know, oh, my God, I have a PRA internal event going on because that pump tripped - oh, no, wait a minute. It's an external event because the pump tripped because the wind blew down my power - no, wait a minute. Maybe that's a loss of - they don't think that way. They don't know.

And most of what's in this document applies to the way people think. It doesn't apply to internal events or external events or control room or procedures or some scope of some artificial PRA construct, and that ought to be the power of this report.

How someone wants to interpret this report and use it for some narrow focus is their business, but this ought to be the starting point.

MEMBER SCHULTZ: In fact, it should not. It should not distinguish between internal and external.

MS. XING: And, in fact, 99 percent of the literature reviewed are not in the nuclear domain.

CHAIR STETKAR: Sure. And that's - because

I don't think that a, you know, just because I have a degree in nuclear engineering and used to be in a nuclear power plant, I don't think I'd fundamentally think different than an airline pilot or somebody who runs a chemical plant or any other trained professional.

MEMBER SCHULTZ: I'm afraid if you had taken those thousands of references and said, I just want those that apply to nuclear plants, you would have gotten a very small number.

CHAIR STETKAR: Well, I'm not sure. There are a lot of people who have gotten degrees and go to a lot of conferences.

(Discussion off the record.)

MS. XING: A lot of literature, you know, for neuroscience literature is not anything about nuclear power plant.

This cognitive literature, people like to take the abstract out of an airplane setting because that's easy to understand. They don't like take an abstract out of a nuclear power plant setting, because it's too complicated. It's hard to control an experiment in that study.

So, I appreciate this comment and will make sure in the final report -

CHAIR STETKAR: I think in terms of, you

know, if you say, for example, there are five line items on this slide, if there was a more holistic treatment of the decision-making function, it might have seven or eight.

MS. XING: Yes.

CHAIR STETKAR: I think that you don't necessarily need to identify those, obviously, but at least kind of highlight the fact of where this framework might be somewhat incomplete because of the way you've needed to bound the problem.

MEMBER RAY: Well, let me ask - try one more time here.

Is goal management in this context then if we're looking at this slide and the five items on there, it says, decisions to be made have clear goals and can be prioritized.

Okay. Can they also be reflected in a procedure?

MS. XING: I, you know, my understanding, the procedures already prioritize the goals for you.

MEMBER RAY: Exactly.

MS. XING: I'm not sure about that, but that's just my general understanding.

MEMBER RAY: That's right. And so, I'm just saying it's permissible, I would guess, that goal

management could involve a procedure, for example, use of a procedure.

MS. XING: Yes, but still like this is what I've learned. When you - in the training class they instruct when you try to do a feed and bleed, even all the information pointing you to the direction of feed and bleed, you will still think about the use - you still try to preserve the plant as much as you can.

So, even - so, that's the point even you - the procedure probably already prioritize the goal for you to do the feed and bleed, but you may have additional goals and other consideration.

MEMBER RAY: Well, it's an interesting proposition. Not all people operating a nuclear power plant have gone to MIT and have a nuclear degree.

CHAIR STETKAR: Thank God.

MEMBER RAY: And many of them simply are trained to follow procedures.

CHAIR STETKAR: Well, but even there, Harold, if you look at the procedures - and feed and bleed is an excellent example. The procedures basically first cue you to find out whether you have adequate secondary heat removal.

And they then instruct you to try like heck to get adequate secondary heat removal back while you're

monitoring critical safety functions.

And finally when it gets to a point of no return in the procedure which is written very crisply in black and white, it says initiate feed and bleed.

In the real world if you know that any minute now, just any second now you're going to get that feedwater pump running or get that valve open or whatever it is, you might hesitate. You just might hesitate, because you have a conflicting goal now restoring something that you're familiar with, or dumping a bunch of water in the containment.

So, even though the procedure if you read it according to training and everything else points you toward feed and bleed because that's the safe thing to do, there is indeed a conflict there. And somebody needs to make a decision that says, Ralph, open the valve now.

So, it's an excellent example of that conflict between perhaps - the ultimate clear goal in this sense is maintain core heat removal, but how you accomplish that may not necessarily be so clear.

MS. XING: Okay. Thank you.

So, we can look at the proximate causes and error causes. It's kind of funny because we identify the error causes first and group them into proximate causes, but they ought to be presented in the way like

we identify proximate cause first.

So, these are the three proximate causes we group here. One is that you have incorrect goals or priority setting. Think of the feed/bleed example we just talked where you have a goal conflict there.

And another proximate cause is the incorrect internal pattern match. Match the situation to what you have.

So, in that example, error cause for this would be you did not update the mental model to reflect the changing state of the system. So, you could use the wrong model.

And also the proximate cause is incorrect mental simulation or evaluation of options. For example, if the system response is inaccurate or not updated quick enough and you may not get to make the correct simulation of what's going to happen for your proposed action.

So, and this very mechanism really manifests in the operators incorrectly predicting how the system would response to the proposed action.

I think for this section we have totally about between 15 to 20 error causes. So, I only put some example here for each.

And PIF, performance shaping factors, as I said earlier, this is the relatively weak part of our

- in our report. It has a lot of limitation.

The majority of our literature review, the information we put here are from the lab studies. In those lab study, most the lab study don't study performance shaping factors.

They will never study - they don't study workload, but they will say, okay, what's the difference between you monitor three airplane versus monitor 20 airplane.

So, that's - so, we have to - our team have to make a lot of our own inferences, which we got some - we got a situation like this and some of our team member may say, okay, this is a workload factor from three airplane to 20 airplane. We got more workload. You make more detection error, but because you have a high workload.

And another person would interpret, oh, you got a task complexity issue there. Because 20 airplanes, there got to be more relation between these airplanes.

So, therefore, the performance shaping factors that we put there is really stay at a very high level. We think this is relevant, but it may not be the only factor work for this.

And in the extreme case you can say probably

all the performance shaping factor would work for every situation. Training always matters. Complexity always matters. Workload always matters.

That's why later we have some expansion. But for now for what we report in the literature we give since we couldn't really process this and give a clear distinction. So, we just put some examples in the appendix instead of saying this performance shaping factor is exclusively work for this failure mechanism.

CHAIR STETKAR: I know you said at the start that you're in the process of receiving feedback from your peer reviewers.

Where are you in that process? Have you received reports from all of your reviewers, or are they coming in, or are they being prepared?

MS. XING: No, we actually haven't received any formal review back.

CHAIR STETKAR: Okay, okay, okay.

MS. XING: Those -

CHAIR STETKAR: Then I won't ask the question I was going to ask. I just wanted to know where you are.

MS. XING: Those feedbacks only I met those reviewers in a meeting. So, we had some verbal exchange of information.

CHAIR STETKAR: Thanks.

MS. XING: So, when you look at those PIFs, the very first example is very tricky when you say, well, a conflict in the goal. Is it task complexity or work process? It's really hard to say. So, it's very much a subjective judgment what you put there.

And the next one like not updating your mental model, it could be because of high workload or it could because the situation is so complex.

So, that's we see the performance shaping factors information we put there is only give you a high-level direction, not explicitly tell you how to work them. And we will see more of this in the extension work.

Okay. So, that's about the decision-making. And if you like, we can jump to see the expansion which I will talk more about the performance shaping factors.

CHAIR STETKAR: Just -

MS. XING: Another function?

CHAIR STETKAR: No, I'm not going to let you off that easily, but you don't have any slides for it.

Do you have any slides for the - what I tend to call crew dynamics or you call it team coordination?

MS. XING: No, I didn't prepare slide for

that.

CHAIR STETKAR: You didn't, yes, okay. Never mind. Go on.

MS. XING: For the reason I mentioned earlier.

CHAIR STETKAR: That's a difficult area. It's the area I think that you mentioned earlier from preliminary feedback that the report is - I don't necessarily say weakest. It's just least definitive in that area.

MS. XING: Yes.

CHAIR STETKAR: But it does make some progress at least to try to organize information. But if you don't have any slides prepared, then I guess we'll just skip it.

MS. XING: Yes, I couldn't -

CHAIR STETKAR: I was going to try to challenge you in that area.

MS. XING: Okay, but I could just briefly talk -

CHAIR STETKAR: All right.

MS. XING: - about some progress we have there.

Now, basically when we have as we pointed out in the report, when we worked on that function,

it is a separate function or it should be part of other functions.

That's interesting. We had a similar debate here in our expert elicitation workshop regarding communication. So, should it be a separate failure mode or it's just a moderate factor moderate the other failure mode. We haven't solved that problem yet. We'll solve it next week.

CHAIR STETKAR: One of the reasons that I bring it up is that in the NUREG report it is, as I said, kind of the least definitively developed. However, when you go to the application, the methodology, IDHEAS, it suddenly becomes divided into very, very distinct, little pieces.

MS. XING: Actually three.

CHAIR STETKAR: Right. And I was curious about how that very distinct, very crisp three-piece approach to the world evolved from what's in the broader document.

So, I don't know if you want to talk about that now or whether you want to talk about it in the next -

MS. XING: I can talk about it now to give you the transition to that. So, when we decide - in the early stage when we decided this function and we

said, okay, that's really the person who is responsible for this part. There's really not so much about communication teamwork because it's a three-way fix.

There's really not no real teamwork there, because you really a supervisor with instruction to the other operators and the other operator performance excuse the action and report back.

CHAIR STETKAR: Jing, is that the way the real world works?

MS. XING: That's what - I don't want to put this on record. I don't think that's the real way.

CHAIR STETKAR: I don't think it's the way the real world works either, and I think we had many -

MS. XING: That's what we -

CHAIR STETKAR: - examples from the real world that says the real world does not work that way not only in the nuclear power industry, but in many other industries.

MS. XING: I think the real world work differently. And, like, we cross this - like in the Halden study we see, let's say we have the European countries and us, United States, and the Japan plant with this observation.

In European, they work really like a team.

It's not a supervisor issues instruction to others. They all - whenever they put a malfunction there, they see something abnormal, they immediately group together to the center of the room and have a talk. Then go do something.

CHAIR STETKAR: Okay.

MS. XING: And in the America team, it's more - it's not that much a group, but it's - they have some conversation. Talk about more than just procedures.

And the Japan even has participator study with some other source of information I heard. Some plan basic at the Japan plant. They never talk. So, each person stays in his own set, do what he's supposed to do. They don't get together and talk.

"Never" is a word that they use. I guess it's a little bit exaggerated. I'm sure they talk.

CHAIR STETKAR: Yes, but, I mean, you've highlighted sort of three different ways that people may work together or not work together.

MS. XING: Yes. So, when we did that, okay, let's just stay to the American way or the America, what does the procedure said? And you have this three-way communication. It's always supervisor read out the procedure and you read back.

CHAIR STETKAR: How did we lose all component

cooling water at HB Robinson during the fire event?

MS. XING: Sorry?

CHAIR STETKAR: How did we lose all component cooling water at HB Robinson during the fire if people followed the procedures and read back in a very structured manner?

It's an American plant under a real event -

MS. XING: I guess -

CHAIR STETKAR: - that missed very important functions going on in the plant. So, how did we do that if that's the American model?

So, I'll challenge you that -

MS. XING: There's a failure of communication.

CHAIR STETKAR: Okay.

MS. XING: That's in the failure mode we captured.

CHAIR STETKAR: Okay.

MS. XING: So, you have this basic communication, but there always chance like you fail communication. You didn't start the communication. You need to communicate that message. You did not start it and then you come to the factors that can come to play.

That's not a high priority or I just forgot or a lot of times this factor is a major player in a situation like that. And I think distraction is in the situation in Robinson case. You got distracted.

Some recent experiment in Human Automation Lab that MIT found when you try to follow this restricted procedure if you have an unexpected add-on task somewhere, you do it very shortly.

Then you are very likely make a mistake for the rest of the procedure even the procedure is still there.

So, all this can cause a failure often a three-way communication wall. That's why I say we look at the potential failure mode, failure mechanism for communication. And really we didn't do much about the teamwork and coordination. So, that was early stage.

And later on we complete this work in 2012 when we try to expand the work into the Level 3 PRA, other situations, and we reviewed like the Fukushima report and other things reported and then look at the SAMGs.

Really you find there's more communication function rather than there's a three-way. The communication is there. It's more like it's a task like you need to communicate this risk happening.

Or when there is high-level decision-maker, the plant people, do some good work to inject water, you probably should communicate more than just do it.

You should communicate why you need to do it, and what if you don't do it. So, there's more communication issues we should model than just this three-way communication.

So, that's why in the initial setting we try to put this as three separate functions. Communication, teamwork, and in the report what we initially called as supervision, later we - just last week we decided it's really not supervision. James challenge me, what do you mean by supervision?

Okay. You really talking about network coordination. In a severe accident, you have this many different function whether this coordination can go through. If the coordination fail, you would fail sometimes.

So, those really act as individual task which are critical for the success of your goal. That's why we put them as three separate functions.

But since that is still in development, we're going to have a series of workshops look at those each individual function. We may either merge them. They may stay as a separate function or we merge them.

That's still in development.

CHAIR STETKAR: I guess my only feedback and it's obviously a work in progress in this particular area, would be that in the same sense of the other macrocognitive functions that you - in the context of NUREG 2114, don't get too trapped into a particular construct in this teamwork communication, whatever you want to call it, element, you know, similar to the passage that I read earlier that although procedures may be important, there are other things happening in terms of things that influence decision-making. And the report at least makes you aware of those other features.

So, in the same sense of this communication teamwork process, I hope you'll keep that high level perspective.

MS. XING: Thanks.

MEMBER REMPE: This is a questioning attitude to encourage and that would -

CHAIR STETKAR: That's part of this communications, yes. I mean, that's, you know, you can call it - I hate the word "safety culture," but -

MEMBER REMPE: I do too. That's why I said questioning attitude to -

CHAIR STETKAR: But that's part - and that's been identified. I mean, you know, the airline industry

has worked on that for a long time where the person in the right seat, you know, didn't question the person in the left seat. And people have died because of that.

MEMBER REMPE: Some symptoms is not what you'd expect when you're looking at other -

CHAIR STETKAR: So, that's part of it.

MEMBER RAY: Well, I think - and, again, I keep reflecting on as much as we might want things to be different, if this - if the kind of teamwork that you're describing or - I think it comes with the problem of beyond design basis events and that sort of thing.

But if we're going to actually have people do what you're talking about people doing on the flight deck, it's going to have an impact on the people who can be qualified to participate in that kind of a process.

You don't let just the senior aircraft mechanic become he guy who flies the airplane. And I'm afraid that in many organizations, at least ones I'm familiar with, that is what happens.

CHAIR STETKAR: Well, that's the -

MEMBER RAY: And so, if you say to people, well, here are the procedures and if it looks like a good thing to do, follow them. But if things don't look like they're lining up with the procedures, then get together and decide what to do.

I'm just not sure about all of that.

CHAIR STETKAR: Well, I think Jing mentioned that I think as you go further out into the evolution of a real event, the notion of that team and the communications becomes a lot more, let's say, difficult to define.

MEMBER RAY: I don't dispute it. I'm just saying -

CHAIR STETKAR: That's -

MEMBER RAY: - there are implications of -

CHAIR STETKAR: Oh, yes.

MEMBER RAY: - what we're talking about here that I think -

CHAIR STETKAR: But, I mean, even within the confines of just draw the block walls and close all the doors and hit the plant with some sort of challenge, then I'll keep using the HB Robinson fire until I find a, you know, until the next thing happens.

Even within the construct of that where people were operating within their own little world, there were obvious problems in terms of either a lack of communication or perhaps too much focus on specific issues.

The team didn't melt the core, but the team

didn't accomplish all of the functions that one would expect them to function, to accomplish. At least not in the time that you normally expect them to do that.

MR. CHANG: This is James Chang. I am researcher at the SACADA project.

Within this project that we have developed in connection with the training staff, we talk about how we characterize the supervision complication.

And there's two things for the purpose of this project that the eventual goal is having the method for predictive analysis.

So, what this I think that's come here when we define a PIF at this level, that's only trying to study which always having the predictive purpose in mind.

CHAIR STETKAR: Okay, great. Thank you.

MS. XING: Okay. So, we'll use the last ten minutes to talk about some additional work that's not included in the report and which one part we already talk is expansion of the scope like in the decision-making or the expansion of basic communication, teamwork, cooperation.

So, with this additional extension and the - also they did additional work for that extension.

And an important part is the third bullet. As we said earlier, those PIF, performance shaping

factor, at the high level does not really help us in developing the estimates of HEP. So, we developed one which I called an inventory of PIF characteristics.

And finally we can reconstruct cognitive basis in this level, and make a mechanism to make it work reliably. Error cause is the other one. Failure was to make a clear distinction.

So, this is early model. So, here you see the expansion for the decision-making part. Now, I fill out those columns in the right side.

So, beyond the procedure situation you could come to a situation where you need to develop response plans from SAMG event.

And you will need to make distributed and dynamic decision-making. And you need to come to a point to determine criteria is based on single person or based on team consensus. So, these are just a couple example by reading those.

(Discussion off the record.)

MS. XING: So, these are some expansion of the scope.

CHAIR STETKAR: Now, let me ask you a difficult question. We've heard that, I mean, we have the Level 3 PRA project charging ahead with lightning speed. And we've heard that this methodology, if you

will, will be used in that project.

Is that correct, or not?

MR. PETERS: Jing won't want to step into that one.

CHAIR STETKAR: That's why -

(Laughter.)

MR. PETERS: I'll just say it's yet to be determined.

CHAIR STETKAR: Okay.

MR. PETERS: My intent is to try to use as much information as we can from this project to inform that.

One of the people that are on both of these projects now is James Chang. So, he's on the Level 3 development, and he's also on the development for the IDHEAS.

So, what I don't want to do is have two separate projects that go two different directions. So, we're trying to keep it as integrated as possible.

CHAIR STETKAR: Right.

MR. PETERS: There are some differences and there may be some technical difference of opinion amongst individual team members that may come to light in this process, but we'll try to keep it as in mind as we can.

CHAIR STETKAR: Thanks. One of the reasons

I ask, Sean, is what Jing has highlighted on the right-hand slide of this slide and some of the issues that Harold brought up about response plans, distributed decision-making, less, perhaps, procedurally-based decisions tend to become much, much more important when you get out into the severe accident and Level 3 parts of the risk assessment process.

So that, you know, depending on the decisions and how wholly integrated you're going to become in that Level 3 PRA project, some of the things on the right-hand side of this slide might be more important.

MR. PETERS: I tend to agree. And any feedback we can get from ACRS or the ACRS subcommittees that kind of push to that direction to make these considerations is always helpful when trying to convince other parties.

There's a different dynamic - I know you might not want to step into that, but there's a different dynamic in that there are a lot of time and pressure - schedule pressures on the Level 3 team. And as I understand, some of the considerations they have to include are trying to expand existing methodologies into those domains versus what they would consider a new methodology here in IDHEAS.

My own impression of IDHEAS and how I think the model works for IDHEAS is I don't see it as a new model. Taking a lot of the pieces that ACRS or at least in the Subcommittee had incorporated or told us to incorporate in some of the letters that said take some of the existing work that we've done in fire and put that into a qualitative analysis portion, I don't see that as us developing something new, but capturing a lot of development that the staff has already done.

So, any feedback or anything that the ACRS could provide to help provide some high-level guidance in the project may be helpful.

CHAIR STETKAR: We should talk - and to keep us on track here a little bit on the agenda, at the end of the meeting here we should talk a little bit about that.

Because if you do want formal feedback from the ACRS, we need to - the plan for that, you know, full committee meeting and a letter and whether you want that letter.

You may want to think about it a little bit this afternoon, but focus strictly on this NUREG or focus on the NUREG with, you know, whatever is developed in the application of the methodology and the timing of that.

So, keep that in the back of your mind and -

MR. PETERS: I would love to. And thankfully Don Helton just stepped into the room for the second part of the briefing. And so, I may be stepping on his toes or his team's toes with whatever I say. So, it would be good to have in that discussion.

CHAIR STETKAR: Yes. Good, good, thanks.

MS. XING: Okay. So, and the other part to expansion is we develop an inventory of PIF characteristics, which is the basic concept. You can't just say complexity, workload, HSI, which - what aspect of this factor would affect failure of mechanism.

This is in term of the amount of work, it have the equal amount as we develop the original report. For develop this list, we rely on not just the literature, but also a lot of the event report and the whole stack of NTSB report there and also the other existing HRA method. So, try to make as comprehensive as we could get.

So, basically these are the performance shaping factors we modeled and put them in the three categories, cognitive, workload and task complexity. So, these are direct challenge your cognitive mechanisms.

And then the HSI environment and procedures is basically to aggravate your cognitive demanding. And then you have training, work process, organizational factors. This - presumably they should make your work demanding easier as of like some very complicated tasks. With the training, you can do it almost automatically.

They presumably provide barriers to error cause. There is always a cause, no matter where your training goes and that's where we focus on this.

So, for each of the cognitive function and we go through each of these PIF and identify the PIF characteristics that challenge the cognitive mechanism and trigger those error causes.

So, I put some example here - or, sorry, I put "understanding" here. So, let's look at the first column of those PIF called the context factors. And for workload here, I show two example. One is multitasking. One is interruption - another is interruption. We have to have five workload factors there.

And Phase 2 were challenges of cognitive mechanism which the integration process when you try to integrate the external information with your mental model.

If you have multitasking, you have

interruption, you likely make a mistake. So, another example, the next one is easier.

Task demand is an unfamiliar scenario. If you got an unfamiliar scenario, you are very much - you are very likely don't have a perfect mental model there.

So, this will make the connection more explicit. The extent of just talking HSI workload will give this explicit link of the characteristic link to the cognitive mechanisms.

And so, this is in the - this list is in the appendix of the volume the Generic Methodology. And we actually used this in - this list in developing the decision trees for the internal event.

CHAIR STETKAR: Now, for my benefit because I keep getting confused about which hat you're wearing when you say it's in the appendix of the generic methodology, it's in the appendix of the EPRI research report on IDHEAS. It's not in the appendix of NUREG 2114, right?

I'm staring at the appendix of NUREG-2114.

MS. XING: I am actually sorry I cannot make -

CHAIR STETKAR: I understand that, but I'm going to try to keep you separate, because there are two distinct -

MS. XING: You know, now I think I remember. I'm not quite sure it's 100 percent correct. I think we have it in both.

CHAIR STETKAR: Well, in 2114 there are some nice - as you expand your - I really like the colors, the kind of green, blue, pink. I don't know what the actual shades are, but there are actual drawings that eventually get you to individual PIFs at least in the context of the NUREG that affect, for example, understanding and it's a much larger list than what you have here.

MS. XING: I will challenge that. You know, it's a must larger list. But if you like - if you list many stats for individual examples, those individual examples will group into some characteristic topic here.

CHAIR STETKAR: Okay, I'll give you that.

MS. XING: Because I checked that list.

CHAIR STETKAR: I'll give you that one.

MS. XING: Okay, yes, but there could be I missed one or two points, but a list - I went through that appendix see if we miss any, no.

And some of them I did not use. As we said, those - a lot of PIF we put there is based on our own inference.

When I feel I'm not competent about this

inference and I did not see an example from the experience, a personal experience reveal or literature, I did not include them.

And I also exclude a lot of them which are not so relevant to the control room. For example, particularly in the HSI part we had a lot examples in the literature review report. And the majority of those example from lab setting, which do not applicable to a nuclear power plant setting. So, I take those out.

And so, the list presented isn't selective. Like, initially I got the HSI factor from all kinds of sources. Several pages. And finally narrow it down to like 10 to 20 items.

So, what we are going to do next after next week, we will have this larger development group together and go through those list and say, put those in the more operational setting.

CHAIR STETKAR: Okay. I'm not - I'll belabor it one last time. If there's anything that you can do to not change NUREG-2114 and make it focused only on quality of the display and quality of the procedures, please don't do that. Because everything I hear you saying is quality of the procedures and quality of the displays.

And that's fine for a particular

application within a narrow construct, but that's not the purpose of NUREG-2114.

MS. XING: So, that -

CHAIR STETKAR: So, if you can keep that split and -

MS. XING: Yes, we -

CHAIR STETKAR: - don't let that, you know, I'm not sure when you talk about you're getting the group together and making decisions.

MS. XING: We do lots of changes. That's why I decide to have this as a separate not changing that, because that's the foundation part.

CHAIR STETKAR: Right.

MS. XING: And this is real world implementation.

CHAIR STETKAR: That's the whole point. Okay, good. Good.

MR. PETERS: It should be in a separate report.

CHAIR STETKAR: Yes, yes.

MS. XING: And also like another example in this list, I did not include as many HSI factors that are specifically for digital interface. And, however, we would probably really need to include that, because in new reactors you do have computerized procedure come

up.

There's a whole big list of HSI factors specific for computerized procedure, but that's another issue.

So, and then finally we organize information in Phase 4 levels. On the top level is the cognitive functions and the objectives.

And the next level are the cognitive mechanisms. And below that is the error causes and the PIF characteristics.

The number on the right is just to give you a reference of how many item we put there. And this number right now is a dynamic - keep changing every week or add something new, eliminate something. So, but just to give you kind of a sense what we have there.

CHAIR STETKAR: Are there any other questions on this part of the presentation? If not -

MEMBER ARMIJO: I like the cartoon.

CHAIR STETKAR: - thank you. And it just looks too much like me. I used to have a crewcut.

(Laughter.)

CHAIR STETKAR: Let's take a 15-minute break and come back at 3:15.

(Whereupon, the proceedings went off the record at 2:59 p.m. for a brief recess and went back

on the record at 3:14 p.m.)

CHAIR STETKAR: Okay. We're back in session. Let's hear about the methodology.

MS. XING: Okay. So, thanks. Before start talking the general methodology and just, I think, reminds the history for this part. And from the beginning of the IDHEAS project back a couple years ago, the team had been focused on the small circle you see there - well, actually it should be a cube. I don't know how to draw the cube for internal at-power Level 1 procedure.

And we have this large circle of the HRA applications. Particularly we have Level 2, Level 3 HRA Projects going on.

And so, this is we try - this work represents an effort of expansion from the small circle to the big circle. The expansion is not just extension from what we develop for the IDHEAS method for procedure event. We took input from many others, particularly for HRA.

And also for the process of developing this expansion, just call it Level 2 HRA, initially is James and I, we work together. Laid out this theoretical framework of how we think it should be done, what it should have included in each part.

And once we laid out this framework to make

it a real method that implementable, we are extend the team by including HRA and PRA expert in our agency. Some people say is an expert from our research like Susan Cooper and Song-Hua Shen.

MR. CHANG: Yes, we have Don Helton, Song-Hua Shen and Chris Hunter. Chris Hunter was doing the analysis. Don Helton was knowledgeable in the Level 2 activity.

And we also had people from NRR, Jeff Mitman, knowledgeable in the low-power shutdown and is currently also doing another project involving the Fukushima activity.

Region 1 we have Rudy Bernhard, the SI. Several meeting, in the SI meeting, he express a strong interest in helping and has a very senior experience there at SI.

We also have NRO, Jim Kellum. He has 20, 30 years trainer - plant operation training experience. And then also help the plant down in Maryland develop the SAMG procedure guidance. So, all these are NRC internal staff.

MS. XING: So, what I -

MR. CHANG: I'm sorry. One more person.

John Kauffman, he is our senior people knowing the admins in the operating experience so that

we can always go to him for operating experience.

MS. XING: So, what I'm going to talk today is primarily this framework we laid out and this team will start working next week. Next Tuesday will meet.

And so, for this meeting I would more view this part of the meeting as a discussion instead of briefing something that already there as a product. So, appreciate comments from you and suggestions.

So, we're talking this middle part as a product, generic methodology for NPP applications which include all hazards and scopes, the big circle.

So, I will talk for briefly the goal and approach and talk to part of this framework, task analysis and proposed method for HEP quantification and briefly the path forward.

So, the goal, we talked this a lot in the last several previous meetings, is to develop an integrated methodology applicable to all HRA domains in this big circle.

And this method should be generic enough for all the applications and with a good technical basis. And also to make a smooth transition once it - try our best to conform with current HRA standard and a good practice. Retain and integrate the strengths of the existing method. And enhance the capability to address

some key weakness in the current method.

So, this is how the framework laid out. It's no different from - it's pretty much a copy from a PRA standard or HRA good practice.

You start by understanding the scenario, identify HFE, human failure events, and analyze the feasibility. Then you going to analyze the tasks which we typically call the qualitative analysis, analyzing the performance shaping factor, estimate the human error probability, HEP, and do dependency analysis and uncertainty analysis, which I didn't put up there.

So, this is a basic framework. We're going to keep all the same. And this is a very messy slide. So, you can now just look at on the left side, which tells the input, the strength in the existing method that we take.

So, specifically the first of three parts, understanding scenario, identify HFE and analyze feasibility, we pretty much - it's not copy-paste, but it's a very high level adaptation from fire HRA and the fire feasibility and reliability analysis report. And also in each of these element we take something from the existing report.

So, on the right side are the areas we make enhancement. So, some - and for today I will primarily

talk what's in this yellow box, the task analysis and the inventory of performance shaping factors which we already talked a moment ago. And I would like to focus our discussion on this quantification method that we are proposing.

So, the technical approach is we start from this cognitive basis that we talked earlier. And to use this for HRA, what we need is on the top part, you know. We got this and we would like to develop procedure or guidance to translate operator response in the PRA scenario into this first level for cognitive basis.

So, in other words, we try to represent EPRI's response in the PRA scenario in term of the HFEs. Then it goes down to operator task. And then for the operator tasks, what are the cognitive functions involved. So, this part we typically - this like traditionally we call qualitative analysis.

And on the bottom part we have that inventory of PIF or context characteristics who try to use that in a structured way to come up in an HEP quantification.

So, the things we need to do, which I already said, we need to come up in the procedural guidance to represent PRA scenario human-centered tasks and associated cognitive characteristics.

And we develop that PIF characteristic list, but we want to make it really in the nuclear power plant setting and come up with a method to put all this information together to estimate the probability. So, these are the tasks that we needed to do.

So, for the first part I talk about the task analysis structure. This is largely to what we already did in the Level 1 - not Level 1, the internal procedure IDHEAS that we presented to you last December. So, I'll just quickly go through.

I'm sure you know what a CRT is by now. So, develop CRT and identify critical tasks. Then characterize the cognitive aspects of this task. And perform cognitive workload analysis. And addition to that is to try to refine the PRA operational story from the cognitive perspective.

I want to talk about CRT again. Basically, CRT is the way to graphically represent the tasks and use that to identify the safety-critical tasks based on the task criticality, recovery potential and the human involvement.

Once the critical tasks are identified, we look at this cognitive features. The task goal, the functions and objectives involved. And the plant cues and the other supporting information, procedures, time

available and personnel.

With this information - this is not a complete list. We also have other items there, but that information can allow we perform a timing and a workload analysis.

See, we could lay out those tasks with their relevant time. With that, we can in the workload - in the workload the characteristics so the timeline would allow us to say which tasks.

In this example, you are doing tasks. There is overlap in Task 1, Task 2 in terms of timing. So, you are doing multitasking there when you come to Task 2.

And also maybe there could be interruption and distractions if there is spurious action there. So, and also this will allow us to analyze the time demanding and available time. So, these are just the general concept how we do collecting this information.

And because we are gradually break down the scenario into HFE then to critical task, then these cognitive functions. So, at the end before we going to quantify the HEP, we wanted to make or have a coherent understanding and make sure we do not lose the context if we keep doing this breakdown.

So, when we do the PRA scenario

understanding, we put together an operational story in the system. Now, with all the supporting information, we can refine that story to have a coherent understanding of the HFE cutset from human-centered perspective.

By doing so, it can help us to square off of those very low probability HFEs. This is based on the conversation with the PRA folks. A lot of time you come to in that you - in a scenario, you come to a hundred HFEs. You have to have a way to select the most important one. So, these provide some guidance in what situation you can think, okay.

And the context of the PIFs are in good condition. No dependency between this HFE and this previous one. So, we probably just assign a minimal HFE number. Then go to the next - otherwise you do a more detailed quantification analysis.

Of course there's some activity going on right now to - I think we have some argue, what does that mean, HFE?

MR. ZOULIS: My name is Antonios Zoulis and I'm from NRR/DRA. This kind of goes as counter to what we usually do. And when we do a PRA, it's we basically assign a conservatively value. And then if it doesn't contribute much to your access sequence, then you leave it. You don't do any further analysis. This is kind

of a little bit different.

Can you explain the - because maybe I - I don't know. Maybe I'm misunderstanding. Are you trying to say like of the lowers possible HEP you can go to, or are you saying you're screening HEP or can you explain that a little bit?

MS. XING: Okay. This is just an explanatory idea. And I - we talked about the PRA approach. You do a sensitivity analysis.

This is after the sensitivity analysis. You still have many HFE there. More HFE than you could handle.

Maybe you could use this as a screening tool to screen off those ones that you can simply assign a minimal HEP instead of going to a detailed analysis.

However, this right now, this part is just a concept. We don't know if it's really going to work or not. That's what we are trying to look with next step.

MR. ZOULIS: Okay.

CHAIR STETKAR: I tend to agree. You know, I read through this and, I'm sorry, it's just too easy to dream up ways of throwing things away.

For example, there's - I'll give you a quote. For instance, the timing of the serial onset

of salient objects is critical for the objects to be detected because of subsequent object onset can impair the working memory for intermediate preceding object - you don't have to understand what that means. It's in context.

The important thing is yet this characteristic is irrelevant to nuclear power plant tasks, because the salient objects, in other words, alarm, remain on until the operators 9intentiaionlly suppress them.

That means that because I'm at a nuclear power plant, I always understand completely what all of the alarms are telling me. So, as long as I have alarms, I can throw out this action.

That is contrary to everything that we understand. If I set that action at 1.0, maybe it doesn't make any difference, but I would have at least given me a chance to explore whether it might be important.

So, this whole notion of throwing things away because they're unimportant because for some reason I have alarms or procedures or I have - everybody is trained better than the average or any of those notions that you hear floating around, is, in fact, contrary to sort of the general way of letting things rise to

the surface and then determining whether they're important or not.

MS. XING: Okay, yes. This was the consideration -

CHAIR STETKAR: That's been a long - that's been a long tradition in human reliability analysis is that you do simplified, conservative, perhaps, large uncertainty analysis first. And if it's not important with that type of an analysis, it's not important.

I don't need to refine my analysis techniques. I don't need to get more sophisticated about evaluating particular factors that might influence the behavior.

MS. XING: So, first of all this wasn't intended against that practice. This was started after that practice, if we feel there is still too many HFE that an analyst can handle, maybe this will work.

And, again, this is just a concept. Maybe we not use these at all. So, that's - I think I already have the feedback with -

CHAIR STETKAR: It's just I was looking at a risk assessment the other day and people threw out a lot of things because they said, well, we have so many human actions in our model that everything is being driven by human actions.

Well, of course it was, because everything was manually actuated, you know. That's not an excuse for throwing out the manual actions.

MS. XING: Yes.

CHAIR STETKAR: Sometimes life is difficult.

MS. XING: Okay. Put a comment on this.

So, really I think I would like to focus on next like talk about quantification part of how we want to do that.

And the overall approach is not new. On this top row you have the HFE. You start using the - some method started working on HFE level. And some method work on task level or some work on even detail - further detail level. Then you look at this and how the PIF's a factor, the failure probability of this HFE.

What here we have in the middle is some more detailed information compared to what we have in the previous method. We have this - come to this method of identify critical tasks, how to break the critical task into the functions and objecting.

CHAIR STETKAR: Jing, and I've kind of asked you this before, and I think you gave me an answer, but in the NUREG-2114 framework there are five basic macrocognitive functions. The first four and this sort of teamwork communication issue that we're talking

about.

Here, for some reason, the decision was made to split that single thing out into three distinct macrocognitive functions.

Even though we don't understand what it is, it now has become very discrete and compartmentalized. Why?

MS. XING: Okay. Again, this is just the concept. And the reason what actually happened is not a split.

It was on purposely in the literature review report. We purposely merged those into one function.

CHAIR STETKAR: Okay.

MS. XING: And because the consideration, we talk about four procedure events, because really we don't need to separate this. Really not much teamwork and cooperation going on.

So, that's why that was the decision we made at that time. We decided let's just keep this one a single function representing this high level.

CHAIR STETKAR: What I'm worried about, thought, is that the first four are actually really complex issues.

I mean, you could subdivide each one of those four into further little bits and pieces and cells

on a spreadsheet or whatever you want to do with them.

And I'm curious why communication, teamwork and cooperation need to be assessed individually within the construct of this methodology given essentially the same visibility as understanding and sense making, which is a very complex process.

So, it just doesn't seem - I don't understand why.

MS. XING: Okay. First, we initially considered this are the separate function. You have your specific objectives in doing communication. And in the current control room, it seems when we analyze for the procedure event, all we need for teamwork or coordination is doing this really communication. That's all we needed to do.

And in the extreme case even you don't have that three-way communication, you probably still can get most the task done like the Japanese plant.

And here, I went to consider this in the big scope like in the SAMG domain and severe accident scenario.

You have this explicit goals for each of these. For communication, it's not just to help you do a better job. So, you have the agenda, the purpose of communicating the risk either to general - to your

up-level or to the lower down. If you don't do this part, you will fail. You will fail your task.

Same there is teamwork. Something specific about teamwork. Like at some point you probably need - I don't know if that will happen or not, but people talk that there will be team consensus need to be achieved for some decision and some other decision don't need team consensus. It's my single decision-maker.

So, and for cooperation you have this different center network the centers -- have certain cooperation whether you deliver the right labor force. You need the cooperation between the different side of different centers.

If this part fail, you will still fail the task. So, this is a consideration we think as initially let's treat them separately. I mean, really doesn't matter. Just like did in the earlier method. We treated communication as a separate failure mode. Then in our expert elicitation workshop we had an intensive discussion. A lot of people feel communication should not be treated separately.

Now, we're talking about maybe we should have treated it as part of the other functions. So, it's highly possible at the end Phase 3 function may

be merged to those functions. But at this point since this is your exploration, we put them as a separate.

MEMBER BLEY: Jing, can I ask a question, because I'm a little confused at this point.

You know, when I think of communication, I think of this verbal communication. But I also think of the team communicating having briefings to discuss where are we, what should we be doing next, do we understand where we are, that sort of thing.

Is that - they way you've broken them out here, is the communication only the verbal three-way communication?

MS. XING: No. Actually the communication would involve either verbal communication or maybe there's a situation communication between human and the system.

For example, like at Fukushima event people talk about the use of rubbers going to the radiation areas. What's the communication and the coordination between human and the machine? So, that's another part - that's also part of communication, we're thinking.

CHAIR STETKAR: But, see, that's - I got really confused there also because as I read the report, the communications focuses mostly on - well, again, I'll quote.

Communication is information exchanged between crew members or between crew and the machine systems.

And it focuses when you get into the details, it focuses more on the human system interface. If the displays are good, communication is good. That's the context that eventually devolves into - in the document.

MS. XING: That's not - it's not about the interface. It's about - more about the content of what you need to be communicating and the effectiveness of communication.

So, anyway, I think at this part - at this point I'm not trying to clear up the confusion, but it's good to know you have a confusion because other people will have same confusion.

That's something we're going to discuss at our meeting.

CHAIR STETKAR: It's confusing to me because if I take the same approach to, for example, the understanding sense making, single box there, if I have an incorrect mental model for whatever reason, I may fail that task, that macrocognitive function.

You know, that's a subcontributing cause. It's not part of that basic macrocognitive function.

You follow me?

A lot of the examples you were giving seemed to focus more on the analogy of an incorrect mental model, inadequate training or something like that rather than the higher level teamwork recognizing that I don't quite understand what that means anyway.

MS. XING: Yes. So, what we're going to do next in this large team workshop, we would like for each of these functions and to come up with example, operational examples. What do we talk about detection? What are the typical detection tasks in the severe accident case? What are the communications needed to do that?

And by doing that, we may come up with something different. Maybe the boxes either merged or merge into one or merge into the top four boxes.

So, but this is just initially we threw out this framework and have a team beside it. So, some examples I put there in the current report was very limited by looking at SAMG and looking -

CHAIR STETKAR: What's the distinction between teamwork and cooperation?

MS. XING: Yes.

CHAIR STETKAR: I see those as the same thing. Am I missing -

MS. XING: Like, in some example in a lot of literature behind this was driven from a lot of work data by NASA. When they talk about their research or the work they done by teamwork, which primarily means the crew, how this shuttle who worked as a team.

And cooperation is between the shuttle and the centers on the ground. So, what I -

CHAIR STETKAR: Between different teams then.

MS. XING: Yes, different teams.

CHAIR STETKAR: Okay, I got it.

MS. XING: And then what I saw in the Fukushima report, there's also analogy between the tech center and the plant people. And what do you call the Thai prime minister said Japan's president of the cabinet gave the plant direct -

CHAIR STETKAR: Yes. Seems to me like it's things progressing from individuals from detection all the way to action and execution that could be just one person.

MS. XING: Right.

CHAIR STETKAR: Then the communication and teamwork is the crew within the control room.

MS. XING: Yes.

CHAIR STETKAR: And then cooperation and

above is other teams and up to a prime minister, maybe.

MS. XING: Yes.

CHAIR STETKAR: Okay. I got it.

MS. XING: So, we don't know if - probably eventually we think we don't need a model or there's no way we can model that. But just as an initial start, we like to put that - putting it here. So, have our people with more operational experience to decide. So, it's good you have confusion. That means that's an area we need to pay attention, work on.

MEMBER SCHULTZ: What's a concern to me is that in the first presentation on 2114, it seemed - this is very complicated. And so, it seemed that what you brought to the table in that presentation was a model associated with the cognitive functions, which I thought was very understandable that you had detection, understanding, decision-making and action execution moving appropriately together and even with feedback loops on certain elements.

And you had communication, teamwork, cooperation as a base to that or a field in which that sat.

And then you had connections between the PIF characteristics and some of those. In other words, you weren't drawing lines as you show in this diagram

where all the PIF characteristics were influencing the cognitive functions and objectives.

And I think if we're moving to this type of pictorial, this picture, I think you're losing the power of what you've presented in the other model.

And also, in fact, presenting something that could be interpreted by those that are developing a model now in a very different way than what you described earlier and I think the power is being lost.

So, it may just be the picture that you've drawn here in order to tie things together and it's not that way, but I thought the approach was building and that this would be in the implementation, a way in which to use that power from start to finish.

And now, I seem to see it breaking up and arrows drawn differently and I'm not confused. I just think, again, that the power of the models may be lost here.

And I think as you said, we're going to get together and talk about this. It is extremely important that that be done now and decisions be made so that you determine whether you're going to retain that or you're going to go a different direction, because I see a different direction evolving here.

MS. XING: So far the conversation I had with

people including those reviewers for the other report -

MEMBER SCHULTZ: The other report.

MS. XING: Yes. And there's two different opinions. Some people think, okay, you have - really you have separate, different functions in the teamwork. Teamwork is not just to support individual worker, but they have additional function for teamwork.

And the other opinions what you just described in our early version. So, at this point I just would like to leave this for the team, which we would think a better model.

CHAIR STETKAR: By the way, that bottom box has changed from supervision to cooperation which already changes a mental model from the way it's been presented here in terms of what that means.

Supervision is different from talking to people in the technical support center and the emergency operating facility and the prime minister, for example.

MEMBER SCHULTZ: Yes.

CHAIR STETKAR: It could be I am the dictator in the control room and you will do things my way. That's a supervisor - it is not quite cooperation or teamwork or communication, but, I mean, that's - some of that - those notions of supervision, that supervision model

are developed in the 2114 study.

MEMBER SCHULTZ: That's the one we did first.

CHAIR STETKAR: That'S the psychological framework.

MEMBER SCHULTZ: Yes, okay.

CHAIR STETKAR: So, it sort of morphs into different notions. And I agree with Steve that it's important to understand what that is and not necessarily make it devolve into some sort of serial process that means internal events, Level 2, Level 3, emergency planning, because it's different.

MS. XING: Thanks. I do appreciate the comment. That's what I'm looking for from this meeting and -

CHAIR STETKAR: And you're obviously struggling with that one anyway. So, go on.

MS. XING: So, people have no problem with the top four functions. When it goes to this level -

(Laughter.)

CHAIR STETKAR: That's good. If that's true, then you've made tremendous progress.

MS. XING: I don't know if we can make any - how much progress we can make. At least for the time I worked at NASA, I know they keep debating if you just think teamwork is to support the individual worker, you

miss some big part of it. Then the question never really solved.

The part you missed is because you didn't model them well in the individual activity or is this truly a separate function.

So, I think it come to this setting, the nuclear power plant setting, and let our domain expert contribute what will be the best model.

So, you saw this before. So, here based on this information, we are proposing two different ways for the HEP quantification.

The first one is a scoping analysis which is to determine the HEP - just to estimate an HEP range. And this way is very much when you think about this method, you can think of like far edge would be an example for this kind of approach.

You identify this and the critical tasks, although it did not explicitly give you qualitative guidance for how to identify critical task.

When you start from the task and you break the task into two functions, combination which is detection, understanding and decision-making and execution.

So, there you have this set of performance shaping factors and HEP of the cognitive function failure

will determine by the multipliers of HEP factors.

So, this is largely - this proposal largely in this direction. So, except we're going to quantify either four function, these in the major function, or five or seven, which we don't know at this moment per our discussion. Either we want models or the three bottom as three separate function or we want to treat them as a moderator to the top four function. We don't know at this point.

And this other one is more you can - the detailed failure mode analysis you can use our IDHEAS, early IDHEAS, or CBDT as a mental model.

You are not to look at the failure of the cognitive function, but you break them - in the very detailed failure, break the tasks into the different type of failure model. And it quantifies use of decision tree to quantify those failure modes, HEP, those failure modes.

So, we are exploring these two possibilities and try to see how they work.

CHAIR STETKAR: Before you leave this - yes, you can go to the next one, because it's relevant. Have you talked very much with people from the industry about their experience with doing human reliability analysis for the NFP 805 fire transition PRAs?

Because I've heard feedback as part of - help me, Dr. Shack. NUREG-1921 is the right one in this?

As part of the methodology there, they developed a scoping -

MS. XING: Okay.

CHAIR STETKAR: - process. And I've heard feedback from people saying, yes, they try to do that and indeed all it was, was extra work that got them two high numbers. And everybody is doing the detailed analysis, because it - they just spent time deriving numbers that were too high for their purposes anyway.

So, and it's sort of this slide.

MS. XING: Yes, lots of triangles there.

CHAIR STETKAR: And from what I've heard, now, I, you know, I have not polled everyone in the business, but there seems to be a move afoot to go away from this notion of scoping, because it's an added task that doesn't seem to be buying anybody anything.

Have you had any feedback from that perspective, or is there actually still reasonable support for that, that part of the task?

MS. XING: I heard feedback in both -

CHAIR STETKAR: Oh, okay. Okay, fine.

MS. XING: People say what you just said, and that was also my impression in the scoping method

for fire HRA like is shown in this diagram. The HEP estimation pretty much started from Point 1 to really high number.

CHAIR STETKAR: Yes.

MS. XING: And more than a third of those situations modeled end up HEP 0.1.

CHAIR STETKAR: Yes.

MS. XING: So, I use the triangle to indicate those. And so, then the other voice I heard was, okay, this is as much as you can do. So, we only model the most severe situation.

So, that's - I put the slide there just to -

CHAIR STETKAR: Okay, okay.

MS. XING: I could feel what people think.

CHAIR STETKAR: Okay. As long as you're still hearing support for that sort of process, that's fine.

MS. XING: Not for support or against it, but fire HRA is the one at some point was proposed to be used at Level 2. That's why we do - we take a lot of look at what's really there, how we could use it.

CHAIR STETKAR: Okay.

MS. XING: Basically the scoping analysis and the fire HRA, it did not go to the test level. It's

more like as HEP level classified - I'm sorry. I frequently confuse HEP and HFE as a failure event. You classic model is four type of failure event in control room, ex control room, alternative shutdown and the spurious actions.

For each type of action the HEP is - the failure probability is determined by these five performance shaping factors which are the effect of fire, basically. So, visibility, the smoke. Time in fire and execution complexity, time available and time margin.

So, among these factors the time margin is primarily give you these different levels of HEP. Most of other factors will give you either low or high.

So, personally I feel we might be missing something important in this game. It's a good high-level approximation. You probably capture the most important thing. But since, now we have more information about - we know how to get down to task and function level, we have more detailed information than these five high-level PIFs, maybe we can do a better - do a more detailed, better job, but that's where we think it's going to.

MR. CHANG: It may be the scoping this work is kind of misleading. If you look at the previous slide

that the two approach, two HEP quantification approach, we look at that comparing to even the CBDT, it's a rich tool than the detailed analysis level.

The difference is that the upper one is if I say, okay, what's the detection failure probability? What's the diagnosis failure probability that come to that level?

And then the bottom ones come to, okay, what type of failure modes?

MS. XING: So, in terms of the right column when you look at the performance shaping factors, it comes to a very detailed level and probably detailed - I would say a lot more detail than CBDT.

And it's only like at what level you quantify HEP at a very detailed failure mode versus as a function, a cognitive function level.

And we feel like cognitive function level is probably the best compromise we can use. So, because it can allow us direct link to these failure mechanisms. We know why it failed.

And on the up side, it also can link to the tasks. We can bring our tasks into these functions. So, that's - we like this model at - we decide to model this at the function level.

So, this is the concept of we just talked

for every cognitive function. You look at the individual characteristics in the PIFs in that list we talked and to see how that affects the different failure mechanisms for this function.

So, this is a concept like in the horizontal there you have hopefully after you locate all those PIF characteristics, you come up in some kind of index which we talk later. In fact, we're still exploring what is this index.

The most simple one for now, you can think of the mental model, you just add up how many those PIF characteristic are checked. Five versus 20.

CHAIR STETKAR: People used to try to estimate the failure likelihood of electronic devices by counting up the number of piece parts. It didn't work so well.

MS. XING: And then you can relate to that to in some kind of relation like, for example, a relation like this to the HEP. And still we needed to - next stage we need to use our group to work out of this, how we do this index. Simply add up, or more sophisticated way. And also, how to relate the index to HEP. That part we expect to use expert elicitation, but first we need to work out this index thing.

So, we talk - we look at what's being used.

We talk fire HRA. The index there is like each performance shaping - each of these five performance shaping factors. Cognitive as one factor.

And the - their combination will lead you to different HEP level. The way to combine them is use the multiplication like the time margin. If it's less than - greater than - if it's less than 200 percent, means that you need to perform this task in - you have 30 minutes to perform this task. If you can get it down to 15 minutes, that's a 200 percent margin.

If it's greater than 200 percent margin, you're fine. If it's less than 200 percent, the failure probably will be ten times more than what it would be.

So, same way - that's the way SPAR-H we use too. You just multiply these factors. I talk to the SPAR-H people. There's a problem we have there. It can easily get you to very high HEP because of this multiplication.

CHAIR STETKAR: But that's one of the reasons for SPAR-H. It's not supposed - it's not designed or intended to actually give you a realistic quantification of human reliability.

It's some way that someone out in the region can quickly evaluate some general relative importance of something, I believe, anyway.

MS. XING: Yes.

CHAIR STETKAR: And, you know, it's okay. You know, we're closer to Los Angeles than we are to, you know, Delhi here. Within that regime, it's okay to be pretty doggone course.

But one of the reasons I wanted to ask you about the scoping is, how much of your effort right now on developing this methodology, and I realize that at ACRS we're not involved in, you know, budgeting and schedule and things like that, but if you're developing this scoping methodology and struggling with am I going to multiply things, am I going to add them, how am I going to get, you know, some sort of combination of some handful of performance influencing factors that can allow me to scale along five orders of magnitude in human error probability, you're spending a lot of time doing that for something that nobody is going to use because it's really conservative anyway.

It's not at all clear that that's a useful expenditure of time and resources. Maybe you ought to be focusing more on refining some of the detailed analysis.

And, again, we can't, you know, it's not - it's not our role for budget and schedule, but -

MR. PETERS: One of the factors we have to

consider is our SRM told us that we have to create a method for the Agency to use, I mean, or we have interpreted it that way that we have to create a method for the Agency to use, but the "for the Agency to use" was specifically in there.

And for the applications that we really have on HRA, almost all the applications are those regional or ASP analyses or STPs that are done.

So, a couple factors that we had to look into were we wanted to enhance the realism of the results, you know.

Obviously what you're saying is absolutely true. It should give you this kind of go, no-go, what are the important factors.

CHAIR STETKAR: This might be a slightly finer tuned, you know, version of that.

MR. PETERS: Yes. And the only other use that we found for our agency is this whole Level 2 portion of the Level 3 PRA project. It's one of the uses that we would be particularly using as the Agency, but in the long run, I mean, this is - it appears to be a project that's done one time and then you move on.

So, the rest of what we need to develop in this methodology is something that we can use. So, my concepts at least in the back of my mind at this moment

are that we probably need to improve some of those aspects with SPAR-H with what we learn in this project.

And the quantification scheme being one of the more important parts of the SPAR-H analysis, I think we need to put some energy onto making improvements there.

CHAIR STETKAR: Well, part of the SRM also was to try to bring together a large number of disparate human reliability analysis methods into - I don't want to say the be all end all method, but at least a more cohesive framework.

And that's - I think that part of it extends beyond this internal agency applications for significance determination or whatever, because -

MR. PETERS: The SRM did tell us to work with ACRS, industry and others to try to get - and what I'm - my interpretation of how we've implemented this is some kind of single method that almost everybody uses or at least is applicable.

CHAIR STETKAR: Because there are a lot more, you know, the NFP 805 applications is one that's ongoing right now that in many cases does have heavy involvement of evaluation of human performance.

New plants are required to have a PRA. new plants, you know, to a greater or lesser extent have

made commitments or indicated, anyway, that they want to have risk informed applications which may be influenced to a greater or lesser extent by HRA.

So, looking forward, you know, down the road here, this is an opportunity to kind of develop something that's really useful going forward, you know, beyond just sort of the SPAR-H pass/fail, is it bigger than a breadbox sort of notion.

MR. PETERS: I think you're hitting right on that. So, I guess we'll hear your feedback that that part, that future use for the industry and the world may be even more important than -

CHAIR STETKAR: I think it is much more important. I think it is much more important, but that's my personal opinion.

And it's just, I mean, if I heard something that you knew exactly how to do this part of it, the scoping, that it was just something that was so obvious that required essentially very little effort on your part, I wouldn't have even raised the question.

But if indeed you're struggling with this and spending a lot of effort on this particular part of the issue, you know, because I suspect that once you - you say a concept is being explored and you have four things there. And I'm sure that no matter which of those

concepts you explore, you're going to hear 15 different opinions about should you have a linear sum of, you know, PIFs one through seven with a multiplier by Number 8, or it could get really messy, which it probably will.

MEMBER SCHULTZ: A times B plus C minus D.

CHAIR STETKAR: To the n minus 12.

MS. XING: So, one thing we know from this two method is use this multiplication for HRA and SPAR-H. And even not everybody agrees.

And also for using this - the multiplication is a big - one of the big sources for the variability, because just two people choose two PIF and multiply differently, you end up with two other different HEP.

So, here we have information that allow us do better. Just to think of this as is it complex or not. That's just too much.

We can look at this ten individual complexity factors and the question is how we going to combine them together?

So, that's we threw up that we like the approach for that in the next couple months. We first work on this conception model. Let's just explore this. Take a couple example.

Here's an event. These are the PIF characteristic involved. And what do you think when

they come together, the likely chance? Are they going to - we try to explore this a little bit in our workshop. We got some very preliminary information. A lot of people say I can't really tell.

We try to do some - explore all this possibilities starting from simple estimation which is probably putting it too low. And some weighted estimation. You give some factors more weight than some other ones.

Or winner takes all, you know. We would like have expert to select for each PIF characteristic set for an individual function. Select the ones that are the most severe, most influential.

For example, market testing. That's one thing I heard from the expert, you know, when you are doing several things together there's very likely you make an error.

And we have lots of neuropsychology data showing actually how much more error you make when you switching between two tasks. So, we can get this kind of information to try to work.

And also, we - these PIF characteristics are not independent. Some work - they have interaction with others. Multitasking and the time available if you have sufficient time for each individual task, you

probably don't really need do a switch. I'm focused on this, finish this part, then do another task versus you have very short time. You try to frequently make a switch between those two to the level you think you are doing them identically simultaneously.

So, this part we try to use our team to work harder and the goal is to come up something more explicit than what we have for HRA and SPAR-H. So, that's our plan.

Next. And also for this summer, we would like focus on this part work, but in the relatively long term we also like to look at another possibility, which is an extension of the failure model analysis with data in the procedure event HRA IDHEAS method.

In that method, we identify the 14 failure modes which we already realized because of the scope. These 14 failure mode do not represent all the failure mode outside that scope.

So, we probably can keep on - since we already have the method of doing that, we can keep on that approach, identify additional failure mode based on the objectives.

And then for each failure mode if this failure mode is already one of the failure modes that we develop a decision tree, you can revisit the decision

tree.

The decision tree was developed for the - to supposedly have this long list of PIF characteristic. Our teams are people who have the knowledge on the operation kind of select four or five the most likely factor for the decision tree, or some decision tree factor is a group of individual characteristics.

So, then when you - this is where you see the difference between the different setting. You are in a procedure event. You select this factor. Some factor left out, because not important.

Then when you come to SAMG, SAM stage, severe accident management, some factors that you left out may become the most dominant factor.

So, you need to revisit those again almost like you need to make a lesser modification of the existing decision tree. And for the ones the failure mode wasn't included, you need to develop a new decision tree, but we have some good sense to start on that with that type of a basis we providing.

So, those are the two - I mean these two are not exclusive to each other. They are actually complementary to each other in certain - any method that you will need to look at what's the PIF factors or characteristic are important for this kind of failure

and how they work together. So, it's just at which level you quantify them at the failure mode or at a function level.

And the two types of HEPs. So, for the short term we will use expert judgment like what we just did in the early this year.

And in the long term, we're looking for to data-driven HEP estimation, at least on the SACADA project we can expand that to collect more information beyond just those EOP training. We can have the HEP more data informed. That's the long-term plan here.

CHAIR STETKAR: Can you tell us what you're doing for the expert elicitation process? Are you - I know you've done some of that or it's in progress or I'm not sure where it is, but are you looking at different combinations of, what? Performance influencing factors and having the experts say for, you know, one of A and zero of B and one of C and one of D Expert Number 1 gives you a range of the HEP, or how is that structured?

MS. XING: You talk the one we had.

CHAIR STETKAR: I don't know what you've done. So, I'm asking.

MS. XING: Okay. The one we did - where is - try to find the decision tree. Okay. If you look at the bottom, the right bottom box, that's an example

of how a decision tree look like.

So, you have a failure mode, let's say.

CHAIR STETKAR: That's fine.

MS. XING: Okay.

CHAIR STETKAR: You've helped a lot just by orienting me toward a particular path -

MS. XING: Okay.

CHAIR STETKAR: - in a decision tree. So, you present the experts with that path -

MS. XING: Yes, we -

CHAIR STETKAR: - and ask them for their estimate of HEP 3, for example.

MS. XING: Yes.

CHAIR STETKAR: Okay.

MS. XING: And we also ask for more like when they put HEP there, they put their justification and what source of information they use, what does it present.

And we also in the expert elicitation, we ask them to consider this different -- these different factors. How you think which factor are more significant than others. Rank the factors.

And also, what you think is the interaction between them if B is dependant on A or whatever the others.

So, we also collect information which can give us some starting point for the next stage, think of how these factors combine.

CHAIR STETKAR: One of the things that you left off your earlier slide was uncertainty as part of the expert elicitation process.

Are each of the experts giving you, for example, their best estimate, an upper bound and a lower bound, or an uncertainty distribution or something like that?

MS. XING: Yes, each expert give a distribution for ten percent and median and 90 percent.

CHAIR STETKAR: Okay.

MS. XING: And they will integrate all this distribution together.

CHAIR STETKAR: Thank you. I'm glad to hear that. Good.

MS. XING: So, that's what we have in the other one. But in the other one because we started from this decision tree, still we have after the first workshop of expert elicitation, the first workshop is primarily for the domain expert, the trainers and SRO, just on the expert to give their understanding, their rough estimation of this.

We even before the meeting we said, okay,

you are going to give us information based on this decision tree, but still what the information we collect really valuable which lead to the revision of many decision trees.

One example which we haven't revised is communication we talked earlier. We feel a lot of expert who feel this is really not a separate failure mode. This should be more likely affect every individual other failure mode. With our counting it, it was saying treat this as a separate failure mode. We still haven't solved that yet.

So, that's in the - and for the next activity in this method expansion, we would rely on this NRC team not to develop the decision trees, but come up with this relation between PIF characteristic and the failure probability. That's almost equivalent like developing the decision tree.

CHAIR STETKAR: I didn't quite catch that. Could you -

MS. XING: This page. So, that's what we're working on. So, we're not in the decision tree stage yet. We're not going to ask them to provide a probability. We first need to work out the model.

CHAIR STETKAR: I guess now I'm confused. I thought - I understand the concept of laying out a

decision tree and I understand that there might be different opinions about the structure of that decision tree. And it sounded to me as if you were in the process of doing that, trying to work - you thought you had a set of decision trees that would work and got feedback that required you to go back and rethink some things. And now I'm hearing, well, the next step is you're going to do what?

Abandon those and come to this thing? Because this is not the decision tree. This is that other thing.

MS. XING: Depend on what you call a decision tree. Like the scoping analysis in fire HRA, initially when I read those scoping diagram it was like very confusing. So, I replot them in the format of a decision tree.

Decision tree is you pick up these couple factors. These couple factors work together giving you a number.

So, in that sense, you are doing a decision tree.

CHAIR STETKAR: Well, in the sense of whether you're adding or multiplying things together, I guess, but - go ahead, Steve.

MEMBER SCHULTZ: I thought where you were

going was you had the decision tree and now you're using this question.

You're using this to quantify this approach to develop quantification of the tree?

MS. XING: Yes, we are try to use - we're looking at those both possibilities and come up with - one possibility is we are going to identify the failure mode - additional failure modes that needed and revisit the decision trees.

And another possibility is we look at all these PIF characteristic list same process as you do decision tree. Identify which ones are more - are the most significant ones and combine them somehow.

CHAIR STETKAR: That somehow is where I'm hanging up.

MEMBER BLEY: Could I just in for just a minute, because I was at the elicitation session. And just to try to add a little clarity, and at the end maybe a little confusion, I apologize for that, there were a set of decision trees for the various crew failure modes that identified.

So, they had - for plant status assessment there were crew failure modes such as key alarm not attended to, data misleading or not available. A series of those for response planning, delay implementation,

misinterpret. For execution, fail to execute, fail to initiate execution, fail to execute a simple case or a more complex case.

For each of those they had developed decision trees. The decision trees had a limited number of performance influencing factors or the next level up things that were thought to be the most important.

And as - and they had two workshops. The first workshop were plant expert folks and procedure expert folks talking through how this would work and psychologists and which things might be most important, did they have it right.

Then when they brought in the folks to do the quantification - well, actually in both workshops people ran into places where they thought maybe a PIF that's important wasn't there. So, they had to rearrange things.

And then also questions come up that bigger model, the one you're hanging up on, how do these fit? Really when I quantify these, it depends on the whole context in which I'm quantifying them.

Well, this pass-through assumed that the pieces in the decision tree were the only things that were important. And there's a caveat from all the people participating in that as you really have to go back when

you're going to use these and look at the context in which it's used and say is it good enough, did it cover all the things you needed under this context? So, that was one of the pieces.

And, you know, it was done a little bit in isolation of that where it's actually going to be used. And that process still isn't tested.

Might not be well laid out, but it's also not tested. So, they haven't gotten to that yet. Not to try to confuse things further, but -

CHAIR STETKAR: I was going to say so far I'm following you.

MEMBER BLEY: - they put together some rules for how you use the decision trees. And, you know, you have a two-state tree. Well, things aren't two state. Things are either completely one way, completely the other way or somewhere in between. And usually it's somewhere in between.

The rules were applied conservatively such that if you don't need all the conditions to be good, you're bad.

CHAIR STETKAR: You're bad.

MEMBER BLEY: And in some cases, that led to real concern that you'd really be biasing results if you use these in that form.

So, sometimes that led to splitting a top event into some detail so that you could kind of get a little more clarity in those issues.

Now, whether the set that was developed there is adequate is a separate story, but at least it gives them something to work with in the next phase.

But where I was trying to get to was is we went through trying to use the trees. The structure of the concept that got us to the trees came into question.

So, as they start trying to then take these first-round results on quantification and apply them to real PRA scenarios where you might have multiple crew failure modes affecting a particular HFE, there's going to be more places where that structure probably needs refinement and they haven't gotten this, you know.

My impression is that's not really been tested. It's been dreamed up and laid out, but not tested.

And when it gets tested, it's going to have problems. And whether they're easy to solve or not, I don't have a clue.

CHAIR STETKAR: And I'm still not yet as confused as I thought I was going to be, but I'm still confused about - from what I'm hearing and tell me where

I'm straying, is that if I stand way back from this and just think of a systematic way to lay out scenarios, those decision trees kind of do that, you're saying that -

MEMBER BLEY: Well, they're not scenarios.

CHAIR STETKAR: Well, okay.

MEMBER BLEY: They are playing the performance shaping factors against each other.

CHAIR STETKAR: Okay, yes. And "scenario" is the wrong -

MEMBER BLEY: Okay.

CHAIR STETKAR: Logical combinations of things.

MEMBER BLEY: Okay, yes. We changed the names.

CHAIR STETKAR: Okay.

MEMBER BLEY: In the report it talks about paths through the trees, which is you don't want to -

CHAIR STETKAR: And you're right. It's not a scenario. It's a logical combination of -

MEMBER BLEY: If this logical combination occurs -

CHAIR STETKAR: In the context of -

MEMBER BLEY: - how likely are you to win?

CHAIR STETKAR: Yes.

MEMBER BLEY: And that was real hard for the people giving estimates, because they always wanted to think, well, this isn't very likely, this scenario.

CHAIR STETKAR: Right.

MEMBER BLEY: You have to say it's not a scenario. If the real world generates this combination of performance factors, then how likely is it they fail?

And that was a tough concept for the evaluators to deal with. And I think our results are a little still corrupted by misinterpretation of that and wanting to dismiss things - wanting to dismiss combinations that they thought wouldn't happen in the real world or very, very unlikely.

And the idea that, you know, you're looking at it as if that's what there. Now, how likely is it to succeed or fail? That was hard for them.

CHAIR STETKAR: But where I was hanging up from where Jing came back to is, how does all of that relate to whatever is in the forefront of the slides that are on the screen right now, which is this notion of - not that one - the notion of somehow a body count of adding and multiplying things together and seeing where I'm on a curve from ten to the minus fifth to one. The scoping notion. Something like that.

MS. XING: Yes, it's not how these two fit

together. It's two different way of -

CHAIR STETKAR: Okay, that's what - but my question is -

MS. XING: Yes.

CHAIR STETKAR: You said, well, we did a bunch of this stuff and I just heard it needs sort of more work and refinement.

And then I heard, well, okay, we sort of did that and we're not finished with that, and now we're going to go look at this other thing.

MS. XING: Here's where they came from together. They all came from the basis, you know. You have this - a long list of -

CHAIR STETKAR: Go down to the bottom and make that the - way down to the bottom. Way down along the -

(Discussion off the record.)

MS. XING: So, let me talk to this one first. The very bottom part of the PIF characteristics. For the moment, I've got the data for this. I calculate times the number how many PIF characteristic is 100 something.

Therefore, for each individual function let's say supposedly on the average each individual function probably have plenty. In fact, there are many of them overlapping. So, each individual function

probably have 30 or 40 such PIF characteristics.

When you develop a decision tree, you are actually doing the selection. You select from this 30 or 40 factor, select those three or four most likely, most influential factor and a different path in the decision tree represent a different combination of these factors.

So, we were able to do that for the procedure event, because in that time the task is more fixed. So, those failure mode, we think it made a good representation for the control - for operator's task in the control rooms in the procedure event. So, you can identify those failure mode.

And the performance shaping factor, we know what are the performance shaping factors in the control room. Approximately we know. So, we are able to make that selection. So, you are able to narrow it down from 30 or 40 factor into only three or four. That's how we develop the decision tree.

CHAIR STETKAR: Or from what I was hearing earlier, or five or six and the relationships might be different, but go on. I understand that.

MS. XING: Yes. So, and because one consideration we put that. I think there's one or two, that you don't want to make the tree too big.

CHAIR STETKAR: Why?

MS. XING: User don't want to use big tree.

CHAIR STETKAR: Users are lazy.

MS. XING: And that's -

CHAIR STETKAR: The whole point is people in HRA for 30 years have been trying to make things simple because people are lazy, and here we are.

MS. XING: We have to respect that.

CHAIR STETKAR: No, we don't, necessarily. It's -

MEMBER BLEY: And fire PRA are doing all this detailed circuit analysis. And PRA of a system, you model all the parts of that system. And you got to know how the system works to model it. And -

CHAIR STETKAR: I've seen fault trees that go down for every pipe segment and says, does this weld leak? Does this valve leak? Does this leak?

People spend hours and hours of doing that stuff. And yet, well, because somebody doesn't want to have a hundred branches in a little logic model we have to oversimplify the treatment of human response?

I don't understand that notion.

MS. XING: Yes, that's the - but that is just a fact. People don't want to - if you make a big decision tree, they don't want to use it. And I believe it was

our partner EPRI's intention to keep the tree limited size.

MR. PETERS: We'll get that feedback of people not really wanting to use a method if it may be more complicated.

MS. XING: Yes.

MR. PETERS: Which just kind of defeats -

CHAIR STETKAR: On the other hand on the fire stuff, I'll come back to something I said an hour ago, we heard a lot of that initially on the fire stuff, which is why they developed the scoping method in that EPRI report - EPRI research report for fire HRA. And at least some of the feedback that I've been hearing is people have been saying, well, yes, it was easy, but, you know, it was just an extra step we did and was kind of worthless.

So, we decided that it was a lot more cost effective for us to just do the detailed analysis.

MS. XING: so, in the fire HRA, the only model is this five factor. And it's another fault tree, because too many express pass the record go to 1.0. HEP 1.0.

So, this really to build decision tree, you have this very high selection process which you are very likely missing some very important factor that got selected out, because whoever, you know, we have a great

team to build this decision tree. There are still important factors or scenarios that were not in our mental model we're missing.

And to come to generic methodology for all these different hazard, and no procedure and low-power shutdown lasting for a long period of time, it will be even more difficulty to make this - select three or four. Or at most, the five most influential factor.

That's why I would like to - I propose let's look at other alternative. I say decision tree. It means you are limiting to this very small set of factor.

Let's not try to create limiting. How about just select things to go through this big list. Make sure they don't miss important ones. And, again, somehow we combine this together.

In the worst scenario, you make a linear combination because you already break them down into detailed level. You're not talking eight PIF. You're talking all this detailed factor.

It should still give you pretty good - give you a reasonable first-order approximation. It will probably work better than you select those three or four most influential factor.

CHAIR STETKAR: It's just I hear that and I come back to the original SRM that says we have - pick

a number - any number of different HRA methods out there that depending on - two different analysts using the same methodology will get two different numbers. A single analyst using two different methods will get two different numbers.

So, one of the goals of this whole process was to, I thought, develop a little bit more consistency and kind of coherence, which perhaps I'm not - and certainly I'm not understanding this scoping analysis.

The decision trees regardless of what problems they may have at the current snapshot in time, seem to at least provide a way of structuring that thought process.

And maybe this does that also, but I'm not hearing - I'm not understanding how this does it, because I'm hearing you say, well, you know, maybe we - we could consider everything and decide which ones we add and multiply together or something like that.

And I'm just not understanding that scoping element well enough to see how it actually reduces variability in this estimation process.

MS. XING: We have a reference to compare with SPAR-H or fire HRA. Okay. There you have, you know, fire HRA you have these five performance shaping factors. Each performance shaping factor is going

either up or down the selection.

And so, therefore, like in the effect of fire, you will either select smoke a factor, visibility, or you will select smoke does not affect visibility. And in the complexity, you will either say this is complex or this is not complex.

So, then when you really come to judge a complex - let's say, yes, you perform this control action, is this complex or not? It's a lot of subjectivity to judge that.

And now that this PIF characteristic list we put ten factors for what all these ten factors contribute to complexity if the task isn't performed needs a coordination between multiple people that's complex. And if it involved many steps, if it rely on the central feedback, that's more like a control action.

So, you're not just look at your procedure. So, you put these factors there. And now suppose I have this ten factors. I check by box, yes, it needs three people collaborating. Yes, it has 20 steps. Yes, it lasts C can be 20 steps. It is really long.

So, I check these factors. That give me a good set of information to decide whether complexity - whether it's complex or not rather than just - I'm sure for people using SPAR-H, I'm sure, for using fire

HRA, they can think of these factors in their mind, come to a solution.

We just put this more explicitly. I think that this will help reduce the variability. Now, the question is if I check this risk factor, will this consider complex or simple?

That is the part as I - we don't know yet. That I hope with our larger team will get a better understanding.

For example, I try that in our workshop expert. We have five factors for workload which are multitasking, unfamiliar scenario, interruption, disruption and time demanding - what's the other one? I forgot.

Anyway, I try to get them give me some sense do you think one factor - how many factors would really make this really bad?

And the information I got, different people give me different opinion, but is a pretty consistent opinion. Any of this can make if it's high, can make it bad enough, you're out.

So, that's the kind of information we wish to look for.

CHAIR STETKAR: Okay, thanks. We're going to try to get through the status in the plant and path

forward.

MS. XING: Okay. We can talk about the status along the way. So, I don't know if I can tell you more than what already -

CHAIR STETKAR: No, I think that there -

MS. XING: So, we put this basic framework there, the basic knowledge for that. And the next step starting next week we have this team work together on the number of issues on what are the basic functions? What are the examples for those basic functions and these PIF factors?

And we would like to try out - probably "scooping" is not the right word because of a mental model of the fire HRA or SPAR-H but we like just the two. Work off either two.

If the team think, oh, we can't develop a decision tree, but we better do a checklist, say, or we think, oh, yes, we can't select the most influential factor, develop a decision tree.

CHAIR STETKAR: So, just so I - because I'm really being dense here, over the next three months that line item that says scoping analysis method, that could be further refinements of the decision trees, or is that abandoning the decision tree work that has been conducted to date and trying Plan B?

MS. XING: I'll probably have better answer to this question after next week.

Like for myself, my own concern is it will be really difficulty for you to develop a limited size decision tree for all these different situations.

CHAIR STETKAR: Okay.

MS. XING: So, you probably end up or actually we try to in the report we put out, let's see how many more failure mode. We end up to number 40 something, which is too many probably. People already complain 14 failure mode is too many. If we come for 47, it's too many.

And also are we able to select the most influential factor? We feel confident that we didn't miss any big fish. If not, then we better.

Under the scoping methods that we talked, you can visualize it's a very huge decision tree. Has all the 30 factors taken into consideration instead of limited tree.

So, that's the way we want - basically, you want to develop a huge decision tree. Consider all the factors or you won't develop a very precise, specific decision tree.

CHAIR STETKAR: Okay. And in the second half of this year when you say test the methodology and

selected elements of Level 2 PRA, that is the Level 2 part of the Level 3 PRA for the Vogtle plant that's in progress, or is this a - something conceptual?

MS. XING: No, at this point our management team haven't made a decision yet. So, this is just if we develop this, have something worked out. We best give a try.

CHAIR STETKAR: Oh, absolutely. I was going to -

MS. XING: Maybe you shouldn't have used the word "test." Let's say try out.

CHAIR STETKAR: I would say pilot the methodology. It's just a question of, you know, whose real world, real PRA model are you going to do it with.

MR. PETERS: Obviously we'll be doing it with the one we have. If it's part of the project or something outside of the project as a separate parallel piloting, that's yet to be decided.

CHAIR STETKAR: But, I mean, the plan is to actually use that model either in series or in parallel, if you will.

MR. PETERS: Yes.

CHAIR STETKAR: Yes, okay.

MR. CHANG: I want to say that the next three months when we're developing this scoping method we'll

take it as far as Level 2. And then also we'll print Level 2 model, look at it, there is a sequence and see that how these things - what things we consider not incorporated into here.

CHAIR STETKAR: Okay. Okay, good.

MS. XING: And also what I don't put it here, Halden next year is starting a new experiment going to the severe accident - I think it's going to severe accident analysis part. And we like to try out this, before they start collecting data and after compare with their expert data.

So, all this I think is the proper word is probably pilot instead of test.

CHAIR STETKAR: I think it's really important that - I'm still confused, but that's okay. I've been confused for the last 45 minutes, and will remain so. And I'm okay with that.

I think it's really important that you get to a point where you have some confidence in a way of translating the concepts of performance influencing factors and whatever you want to call those things, errors, into a quantification method. And then use it in a real, you know, study.

Because until you get the challenges of trying to use it in a real study, you're not going to

really understand where the pitfalls are anyway.

So, I think it, to me, it seems appropriate to spend some time, but not too much more time, working out the bugs on trying to get some way of getting from a concept to some numbers and then see how it works.

MS. XING: So, I - for this meeting I do not - I cannot clarify your confusion in that part.

CHAIR STETKAR: No, that's fine.

MS. XING: I like to hear your confusion. That's the error we like. By looking what's exist in the two major approach if you use the SPAR-H or fire HRA kind of approach, multiply, you have some issues there. Or if you use CBDT kind of approach, decision tree, you are limited with a set of factors.

Maybe there's some kind of combination or something in between we can work off. So, right now -

CHAIR STETKAR: I was actually hoping at this meeting we were going to hear a little bit more specificity on where that's going, but not quite yet, I guess.

MEMBER REMPE: If you're going to go to severe accidents, are you even also going to try and understand the interactions between the technical support center and the operators, too?

Because that would be very difficult, I think, to model at this time.

MS. XING: Yes, we actually have a discussion at HPT meeting when they were planning new experiments in 2017 frame, looking in the direction of the issues between tech center and the control room.

And the members provide enough input, I mean, not solution, just the kind of issues they visualized.

So, for example, one issue is this kind of awkward, I use is different is age of information. Like tech center information versus the control room at a different time. And you don't have the most recent. And you have - you receive - you probably have a different set of information.

You think tech center makes it - to their mental model makes the best decision. Maybe that analysis started in the control room when there's a severe accident. You can't do it.

So, right now I don't see a solution, but it was good at the HPT to try to collect all this issues.

CHAIR STETKAR: There's two thing I'd like to do. John, could you open up the bridge line? Because - for a couple of reasons.

While we're doing that, do any of the

members have any more questions for Jing and James?

MEMBER SHACK: Yes. I mean, how do I even know when I pick one of these, you know, suppose I pick whatever combination I pick. I'll get a number.

How do I make some judgement as to which number makes more sense than the other number?

MS. XING: You mean the other number from other method?

MEMBER SHACK: Yes. You know, you said you wanted to do a linear combination. You wanted to multiply them. I don't know. Take, you know, exponentials. I'll get a whole bunch of numbers.

How do I make a judgement as to which of these I would prefer to use? I mean, presumably numerically I can use any of them. I'll get some number between zero and one.

(Discussion off the record.)

MEMBER SHACK: I've got those two ends pinned down.

MS. XING: Yes. One practice I use before in a different project before I work for NRC, you were - you pick up a stack, I mean, that's when I worked for the FAA. Fortunately have a lot of event to choose.

So, you have - basically you have this -- you have this expert come, okay. Base controller tell

you these are the events most likely trouble wise. These are less trouble wise.

So, you have this ranking and then we try this different combination rule. Use a different combination rule apply to this event and say which rank.

Like, I use a linear combination. Find like one chart this event controller rank like this. If I use linear combination, I come up pretty blasting. This doesn't work.

And if I use multiplication, they rank like this.

CHAIR STETKAR: I mean, suppose you had your decision tree model which you seem to believe is that, I mean, would that give you something that you could at least compare against?

MR. CHANG: In the agency, there is method is expert judgment. It's a structure that is based on the performance shaping factor and then the expert give it weight.

And then it takes two weeks variable and then has an equation based on the weights together, the number. That could be one way that we'll try when we tried using that method to come up with some thoughts.

This is still a somewhat possible approach come to the specific way, yes.

CHAIR STETKAR: Anything else for the folks up front?

(No response.)

CHAIR STETKAR: Okay. What I'd like to do is there probably have been any number of people sitting out there on the bridge line screaming at their phones wanting to be heard.

So, first of all, somebody out there just make some oral statement like "hello" to make sure that we have the bridge line open, because we don't know whether it's actually open or not.

PARTICIPANT: Hello.

CHAIR STETKAR: Thank you. Now, is there anyone out there who would like to weigh in on anything that they've heard, make a statement, ask questions?

(No response.)

CHAIR STETKAR: We've worn them down. Okay. Yes, that's surprising. Thank you anyway.

Do we have any members of the public?

(Discussion off the record.)

CHAIR STETKAR: So, I've satisfied that requirement. Thanks out there on the bridge line anyway for your stamina, whoever is left out there. Thank you. It's been an interesting, interesting discussion.

What I'd like to do, we always do this in

the subcommittee meetings, is go around the table and see if any of the members have any final comments or statements they'd like to make.

Joy.

MEMBER REMPE: No comment. Thanks for the presentation.

CHAIR STETKAR: Bill.

MEMBER SHACK: No.

CHAIR STETKAR: Sam.

MEMBER ARMIJO: I' fine.

CHAIR STETKAR: Harold.

MEMBER RAY: Well, I was here to try and learn as you would expect. And I think it's been official I think this is an important area.

I had a hard time, though, sort of like I guess implied by Bill's question, envisioning how this actually materializes into the kind of things that we're used to dealing with.

But anyway, that was my aim and I appreciate the opportunity to be educated.

MEMBER SHACK: I wish I had been here in January to hear the simpler version of this.

CHAIR STETKAR: It wasn't simpler.

(Laughter.)

MEMBER RAY: Anyway, that's all I'd say,

John.

CHAIR STETKAR: I would ask Dr. Bley, but he'll probably just nod his head.

MEMBER BLEY: Yes.

CHAIR STETKAR: Steve.

MEMBER SCHULTZ: I guess my comment at this point would be for Sean and those two overriding elements. And that is - the first one is as you're having these meetings and discussions, I would hope that the SRM, the goals and objectives that have been set out in the staff requirement memo would be somehow captured and put on a wall or handed out at each of these meetings so that the overall arching - the overarching purpose of all this work is.

Because every time we see things, there's always this difficulty in trying to keep it contained. And the other element is as we talked earlier for as we go forward, we're talking about, well, Level 3 PRA, severe accidents and these types of applications, the question of how this is going to be done again needs to be constrained in some fashion or it will bloom again.

So, I would hope that the - I would hope that the process would be developed such that purpose of focusing and developing a particular approach be a major purpose of the project.

And that if it's not - if this element is not going to be used, for example, for the Level 3, then there has to be e placeholder there with the intention being that at some point it's going to come together.

Ideally it would be used for it. But if it can't happen now because one element is moving forward faster than the other, at least create the intention that it's going to come together somewhere down the road.

So, we didn't see the overarching program plan that would make the SRM happen, but it has to be there somewhere.

And thank you for the discussion. It was wearing, but I think in the midst of all of it I learned a lot. Thank you.

MS. XING: Thank you.

MEMBER SHACK: Of course, I mean, it's easy to issue the SRM.

MEMBER SCHULTZ: Yes, it is.

CHAIR STETKAR: That's right.

MEMBER SHACK: Down here where the rubber meets the road -

MEMBER SCHULTZ: Exactly where we saw the difficulties. Many of them.

CHAIR STETKAR: I actually think there has been a lot more progress. It's been painful. I quite

honestly, I really like the psychological framework. I think that brought together an awful lot of really good stuff.

The challenge is reducing that into something that an analyst can use in practice. So, I think that the whole project, you know, has developed a lot of useful things except now, like you said, we're getting to where the rubber meets the road and how do you translate that information into something that is six significant figures to the minus three.

That's all I can do with no uncertainty.

(Laughter.)

MEMBER RAY: John, let me just say one - I don't think that just being able to make that kind of a judgement, like you said, ten to the minus six, ten to the minus - I'm more interested in does it ever tell us anything about what we should do differently.

Training and qualifications and level of detail and the procedures that are being used, that kind of stuff, that's, to me, more rewarding than knowing what part of some remote probability this piece of the puzzle represents.

It's do we do anything differently than we did before, or are we just going to feel enlightened by the end result and that's it?

I think it's got to be directed toward something that you do differently. Either you automate instead of relying on the operators, or you train them a lot better, or you do procedures differently or you have more staffing, something.

Workload was a big piece of one of those slide puzzles. It was bigger than procedures or training. Either one.

Well, okay. That would be a payoff if we decided we needed to reduce the workload, but, you know, it's that sort of thing that I'm more interested in.

MEMBER SCHULTZ: That's where I think the benefit may well come and I think it is coming from your comment, Dennis, and your discussion that the benefit may come from the kind of discussing the guts of the process with the team versus the overall methodology and having it work well in the computer and all of that.

That the discussion of performance influencing factors and how they fit together, what's important, what's not important, those discussions could prove to be the benefit of what can be captured in terms of identifying the improvement opportunities.

MS. XING: And in that sense I have more confidence than, you know, even at this point we haven't figured out that confusion part, how these factors work

together, but we are confident each individual characteristic can make sense.

And for Harold's question just to think previously after you've done a PRA, HRA, you can say, okay, this happened because HSI is bad. So, you need to improve HSI.

That doesn't give you much information. Just like you walk to a doctor. Doctor tell you, hey, you are sick.

(Laughter.)

MS. XING: And this characteristic list and the basis will give you more information on that. You say, okay, this thing is not salient enough and the fire situation. Therefore, you need to consider improvement.

For that part, I think we already achieve the improvement up to the existing method. So, the objective for the SRM is to reduce this variability because the method hasn't tested yet.

Even theoretically I think it should improve, but we have test better to see it really is.

CHAIR STETKAR: And I echo Harold's concern is that the real strength of this process is to identify the contributors to the errors. And that's one of the reasons why I am a bit skeptical about the quick and

dirty way to get to a number, because you need to get to a number, because we've tried that in the past and it gets numbers.

MEMBER BLEY: To Harold's question earlier I point you all to a transcript of this August committee 10, 12 years ago when we brought results from the ATHENA method here.

And ATHENA is one of the methods. It was developed to look for cases that would put operators in a spot so error was very likely. You know, we're not talking ten to the minus six. We're talking 0.1, 0.5 or worse. And that ended up being unusual conditions that put you here.

One of the complaints was that, gee, this method isn't very useful for calculating the probabilities of these events, because every one of these you find, they fix.

(Laughter.)

MEMBER BLEY: I'll leave it at that.

MEMBER ARMIJO: Success.

CHAIR STETKAR: Anything else from the members? If not, one last thing and we don't' have to make any decisions here.

A couple of hours ago we mentioned if the staff would like a letter from the Committee, because

I'll reiterate for the record that anything that you've heard today are simply the ramblings of individuals on the Subcommittee.

If the staff would like a letter from the Committee, we need to understand, you know, what the topic is, when you might want it.

And of course, you know, there is quite a level of interest among at least the Subcommittee members on this general topic. So, we also need to think about scheduling, I think, another subcommittee meeting if you're going to hit that July target.

I certainly would like some of the cobwebs in my head straightened out sometime in the summer to early autumn time frame when you've struggled with all of that so I can understand a little bit better. So, keep in touch with John for that.

With that, thanks again. I appreciate it. Sean, anything?

MR. PETERS: No, I just - I'd like to thank everybody for taking the time and providing very useful insight to us.

As you can tell, we're really working hard to try to come up with that perfect mix of what's usable and not usable. There's a huge interplay between those two pieces.

And I really appreciate your input and we'll try to take it back and come up with our best shot at it.

(Laughter.)

MR. PETERS: We'll bring it back to the Committee. And in the long run, you know, in the long run we definitely will want, you know, once we've started testing it and then finalize the documentation, we would love to give ACRS a letter at that point.

If you want it on Level 3 usage, I'll try and get back to you guys.

CHAIR STETKAR: Because, I mean, we're going to eventually have to write a letter, because the SRM really was written to us. So, we can't remain silent forever.

With that, we are adjourned. Thank you all.

MS. XING: Thanks.

(Whereupon, at 5:14 o'clock p.m. the meeting was adjourned.)

Building a Psychological Foundation for Human Reliability Analysis

Presented by Jing Xing
RES/DRA/HFRB

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

IDHEAS products

Product	Intended applications	Status
Cognitive basis for human error analysis	• Technical basis for HRA and Human factors engineering	• In Peer review • Publish in FY14
IDHEAS Generic methodology for NPP applications	• Risk-informed HRA applications of all hazards and scopes	• In development • Testing in FY14
An IDHEAS method for internal, at-power, procedural events	• Risk-informed HRA of Internal, at-power, procedural event	• Peer review on 5/15/2013 • Testing in FY13-14

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NUREG-2114
INL/EXT-11-23898

Building a Psychological Foundation for Human Reliability Analysis

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Outline

I. Goals, limitations, and process of developing the cognitive basis

II. The cognitive basis – five cognitive functions

III. Additional study of literature and operational experience

Outline

I. Goals, limitations, and process of developing the cognitive basis

II. The cognitive basis – five cognitive functions

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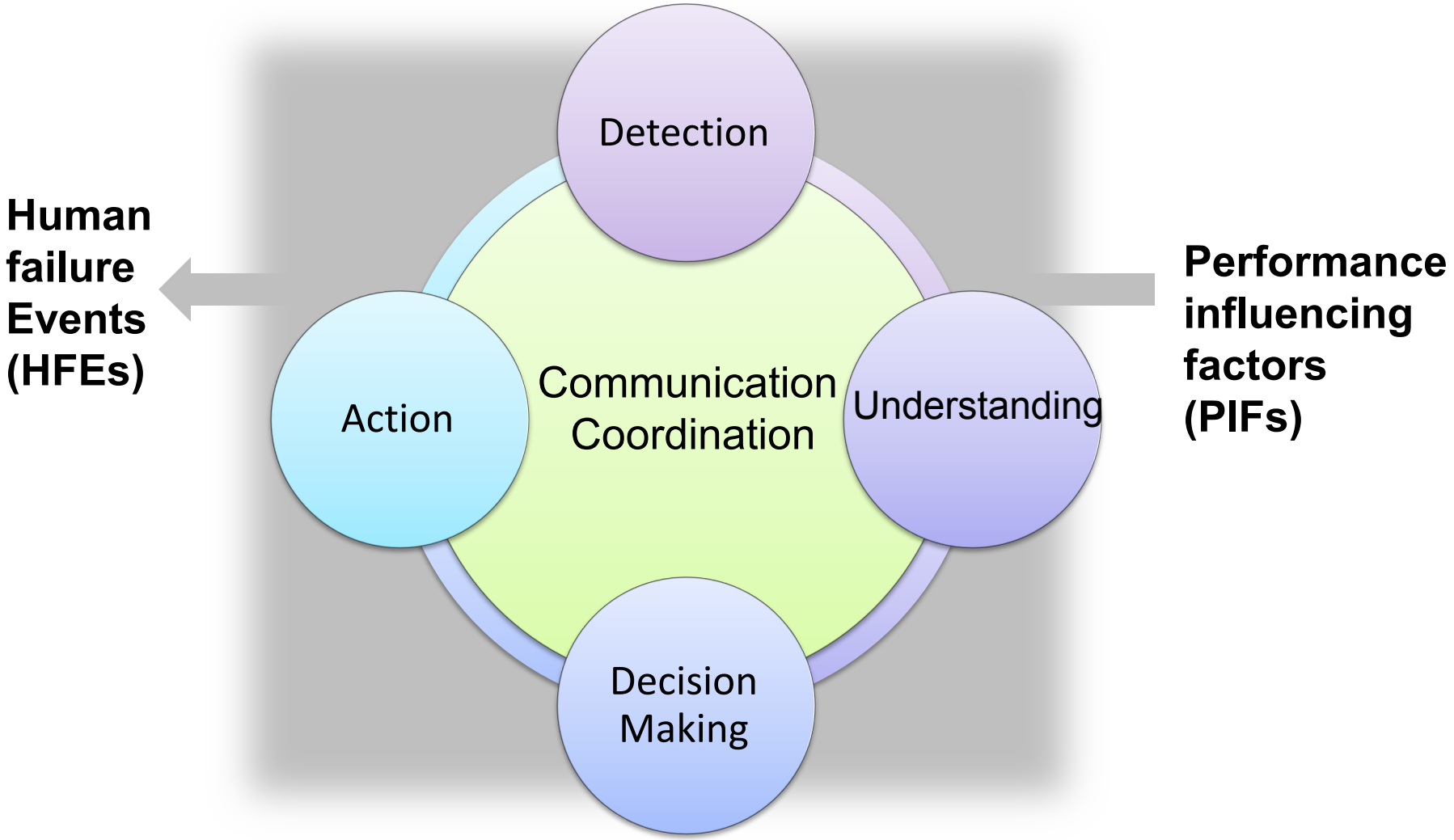
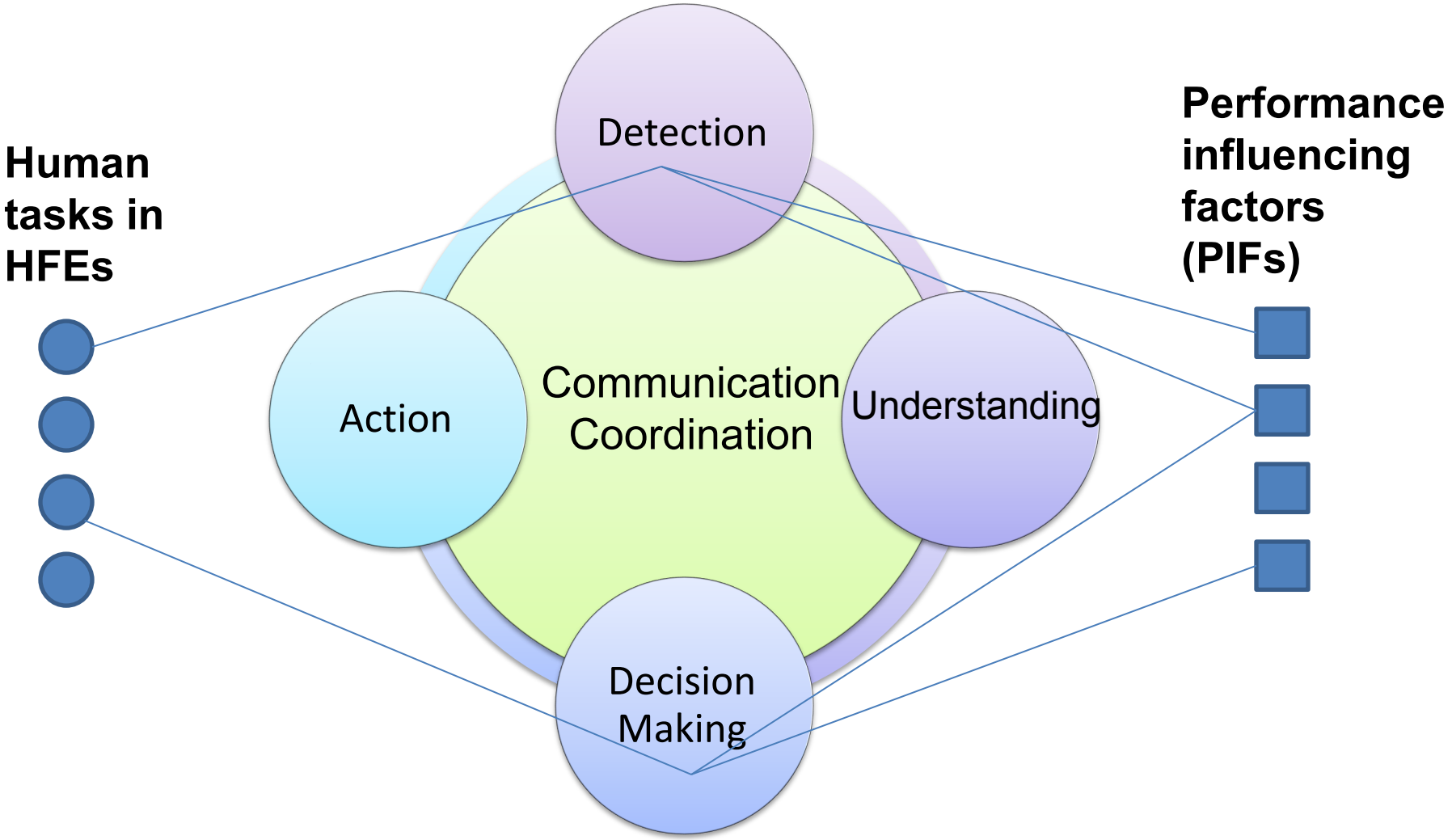
Cognitive basis used in HRA methods



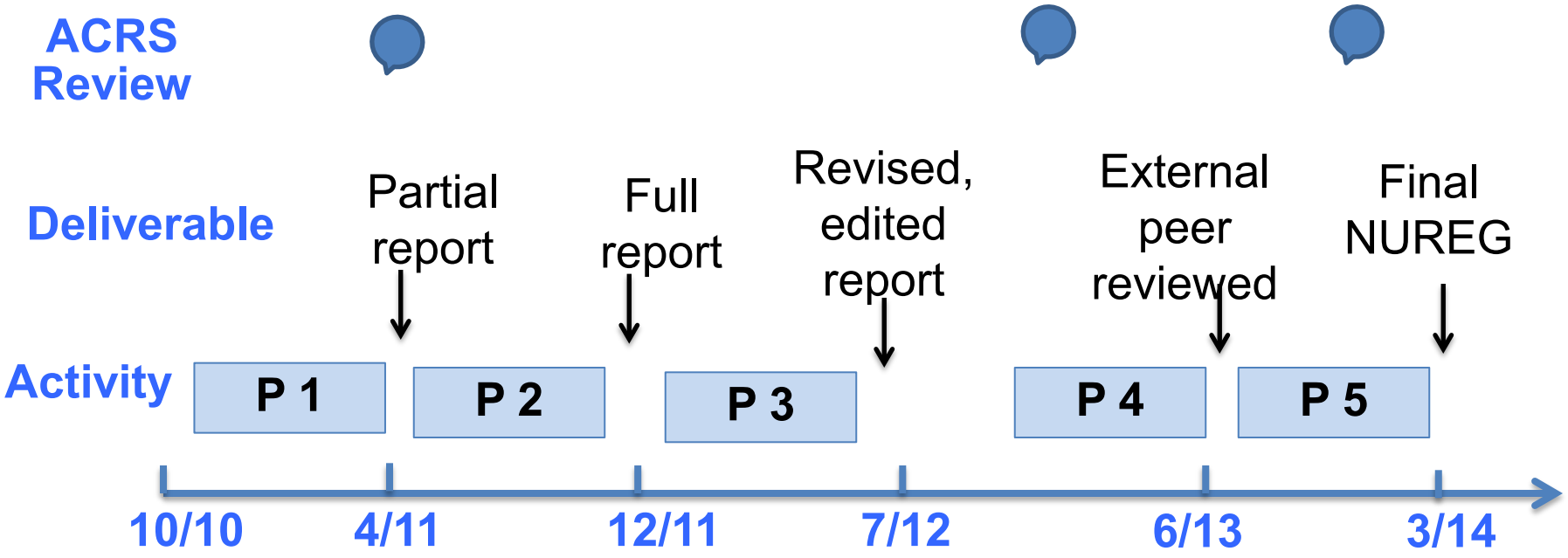
Enhance the cognitive basis for HRA



Goals of the literature review

- Identify cognitive mechanisms underlying NPP operator failures in internal, procedural events
- Identify factors that influence human performance and, where possible, identify how those factors affect the chance of failures
- Develop a structured cognitive framework that can serve as a psychological foundation for IDHEAS

Project timeline, Milestones, and coordination



P1: Initial literature review for the *Detection* function – Lack of structure

P2: Developed a framework for all the functions, determined the scope for every function, and completed the structured review for all the functions

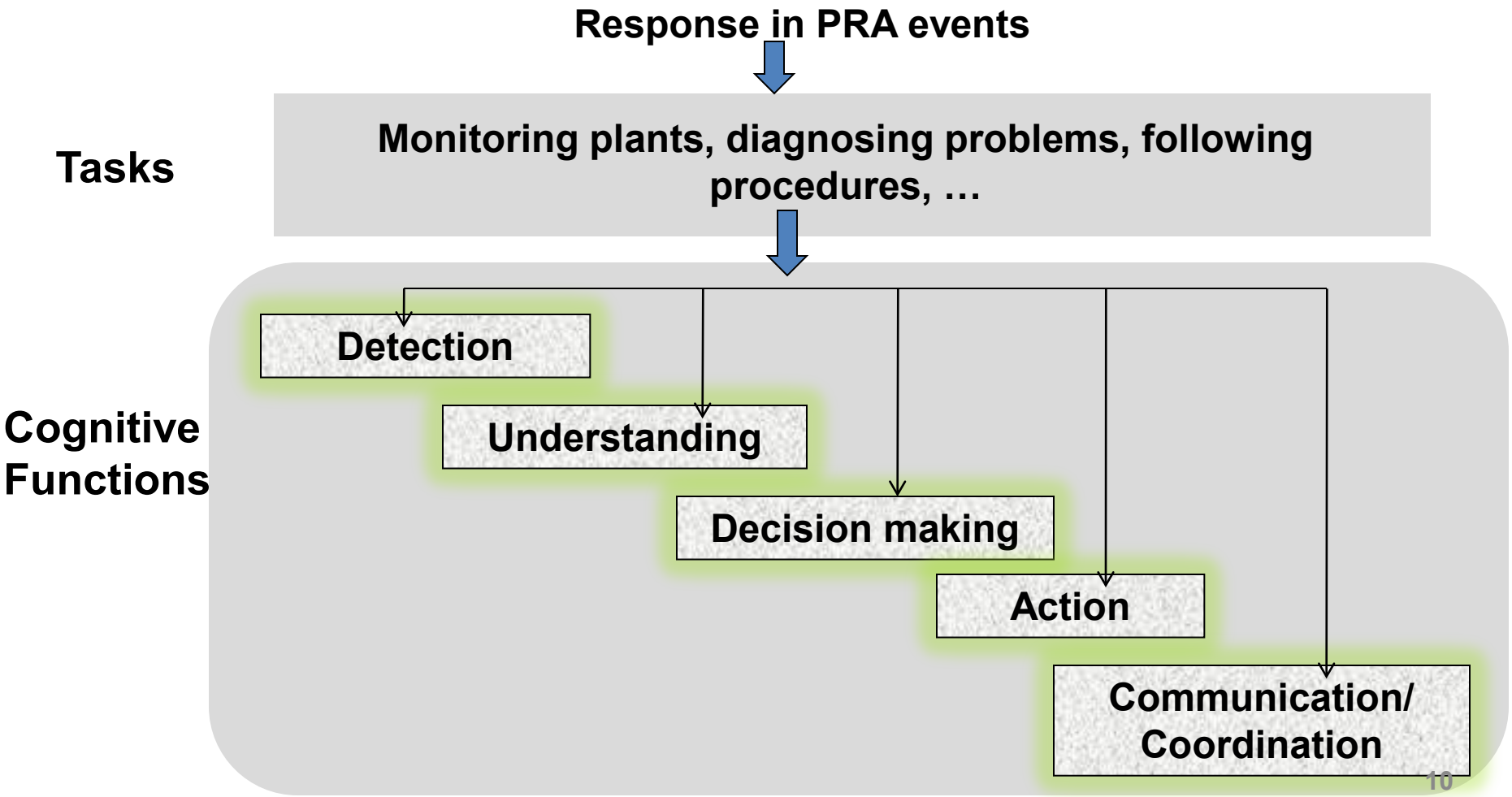
P3: Revised the report incorporating NRC and INL peer review comments

P4: External peer review

P5: Incorporate ACRS and peer review comments

Cognitive functions underlying human performance

Cognitive tasks are achieved through the following functions: *Detection, Understanding, Decision-making, Action execution, and Communication/coordination*.



Approach to developing the cognitive basis

The cognitive basis is to elucidate the following:

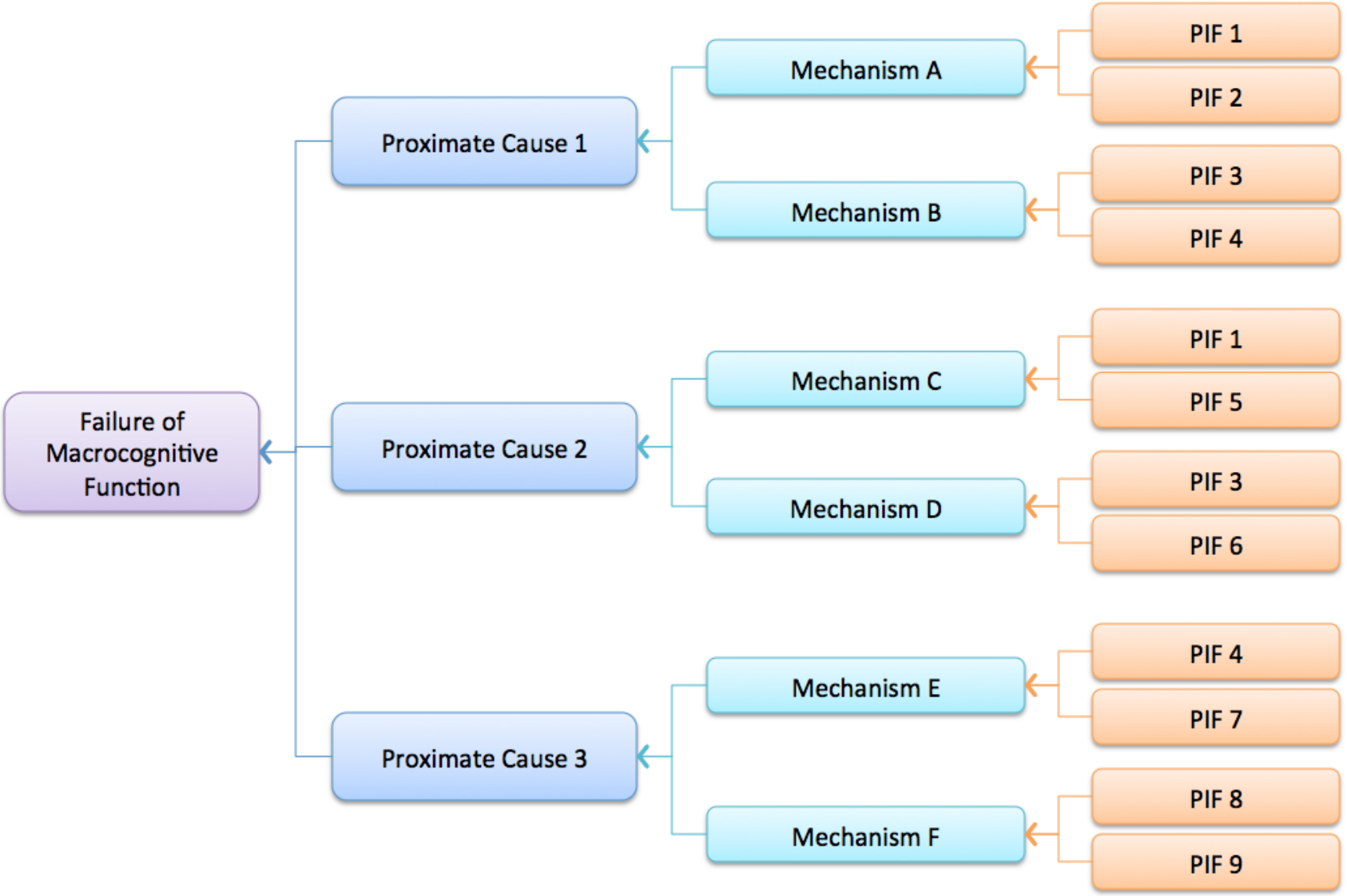
I. Scope of a cognitive function in NPP control room tasks
   - What objectives the function is to achieve?

II. Cognitive Mechanisms
   - How humans perform the function and what makes humans reliably achieve the function objectives?

III. Error Causes (i.e., failure mechanisms) and Proximate Causes (PCs)
   - How a cognitive mechanism fails?

IV. Effect of PIFs
   - What PIFs leads to error causes?

Outcome - Structure of the cognitive basis



Outline

I. Goals, limitations, and process of developing the cognitive basis

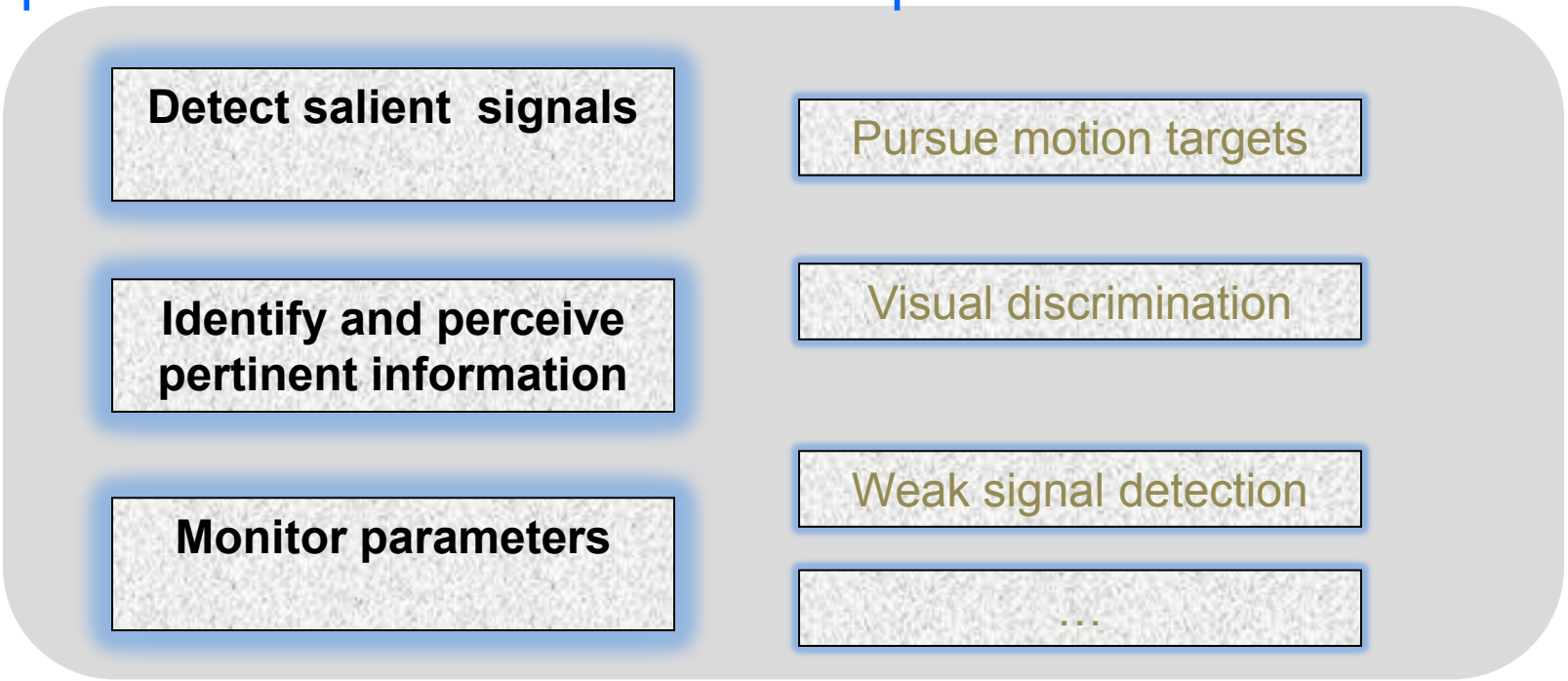
II. The cognitive basis –
- Detection
- Understanding
- Decision-making
- Action execution
- Communication/coordination

III. Additional study of literature and operational experience

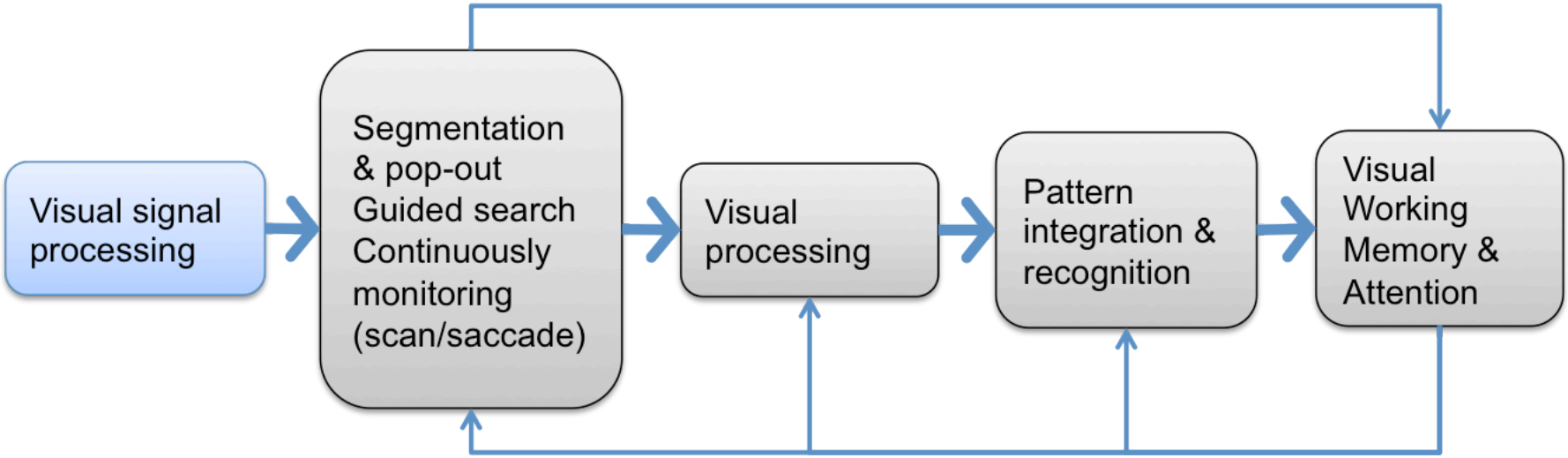
Detection - Scope in NPP internal procedural events

Detection is the process of perceiving information in the work environment, allowing humans to perceive large amounts of information and focus selectively on those pieces of information that are pertinent to present activities.

Scope of *Detection* in NPP internal procedural events



Detection – How the objectives are achieved



Visual signal processing—sense and pre-process visual signals for perception.

Segmentation/pop-out—extract salient information.

Visual feature perception—perform preliminary visual analysis of features such as contrast, color, shape, and motion.

Pattern/object integration—integrate multi-dimensional visual features into a coherent pattern or object.

Detection – Cognitive mechanisms that makes the function reliable

Cue Content - Content of the cue has to be salient enough to be detected by these functions.

Vigilance in Monitoring - Human ability to attend to or monitor cues will naturally degrade over time as a byproduct of fatigue.

Attention - Attention is the cognitive process of selectively concentrating on one aspect of the environment while ignoring other things.

Expectation - Perceiving the environment is subject to expectation (experience and bias) prime.

Working Memory - Working memory held the perceived information or items of information to identify or monitor; it is capacity limited.

Detection – Error causes and proximate causes

Proximate Cause - Cues/information not perceived

- Cue salience is low and not detected
- Unable to maintain vigilance
- Mismatch between expected and actual cues
- Working memory capacity overload

Proximate Cause - Cues/information not attended to

- Too many salient cues
- Overreliance on primary indicator

Proximate Cause - Cues/information misperceived

- Cues are too complex or similar
- Prior experience biases expectation
- Memory processing error

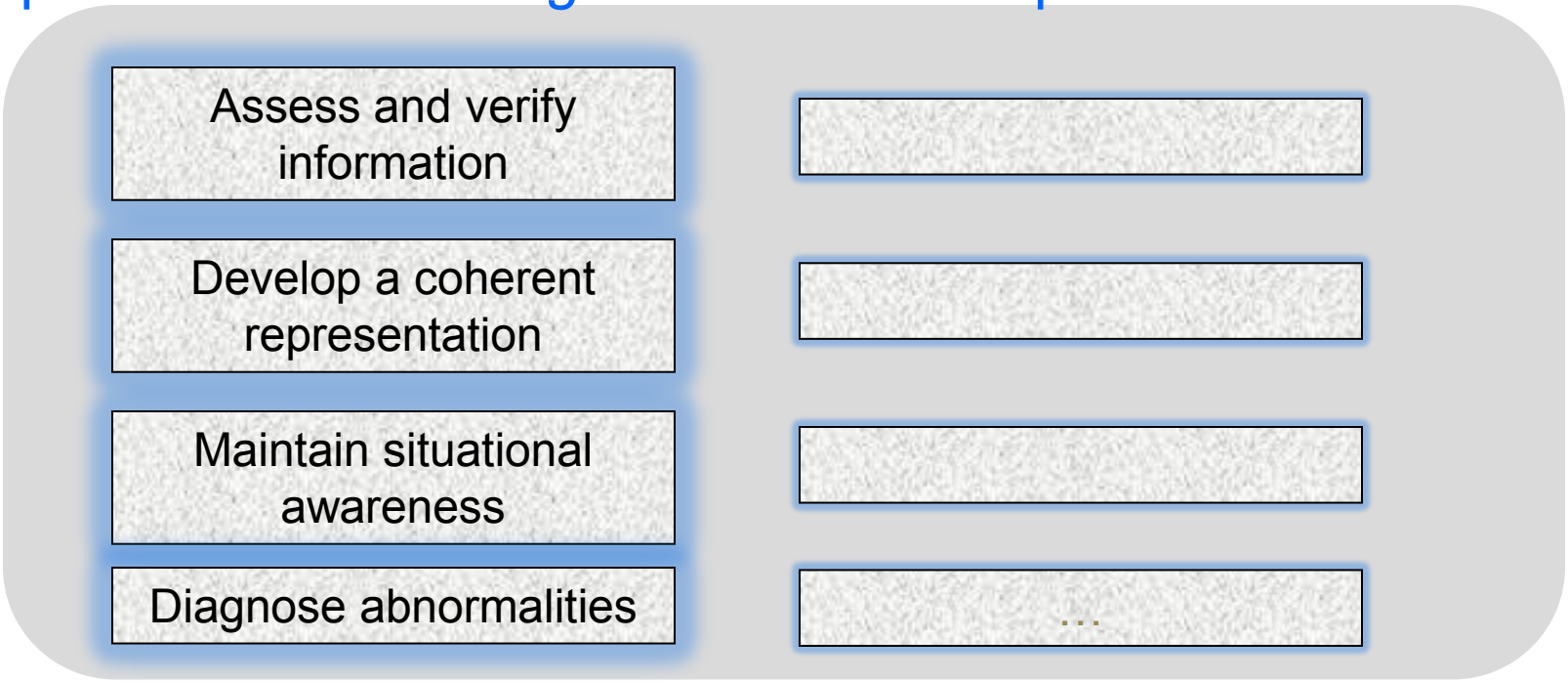
Detection – Effect of PIFs

Proximate Cause - Cues/information not perceived	**PIFs**
• Cue salience is low and not detected	Human-system interface (HSI)
• Unable to maintain vigilance	Fatigue, fitness-for-duty
• Mismatch between expected and actual cues	Training, procedures
• Working memory capacity overload	Workload, task complexity
Proximate Cause - Cues/information not attended to	
• Too many salient cues	Task complexity, HSI
• Overreliance on primary indicator	Training and experience
Proximate Cause - Cues/information misperceived	
• Cues are too complex or similar	HSI, task complexity
• Prior experience biases expectation	Training and experience
• Memory processing error	Fatigue, workload, time

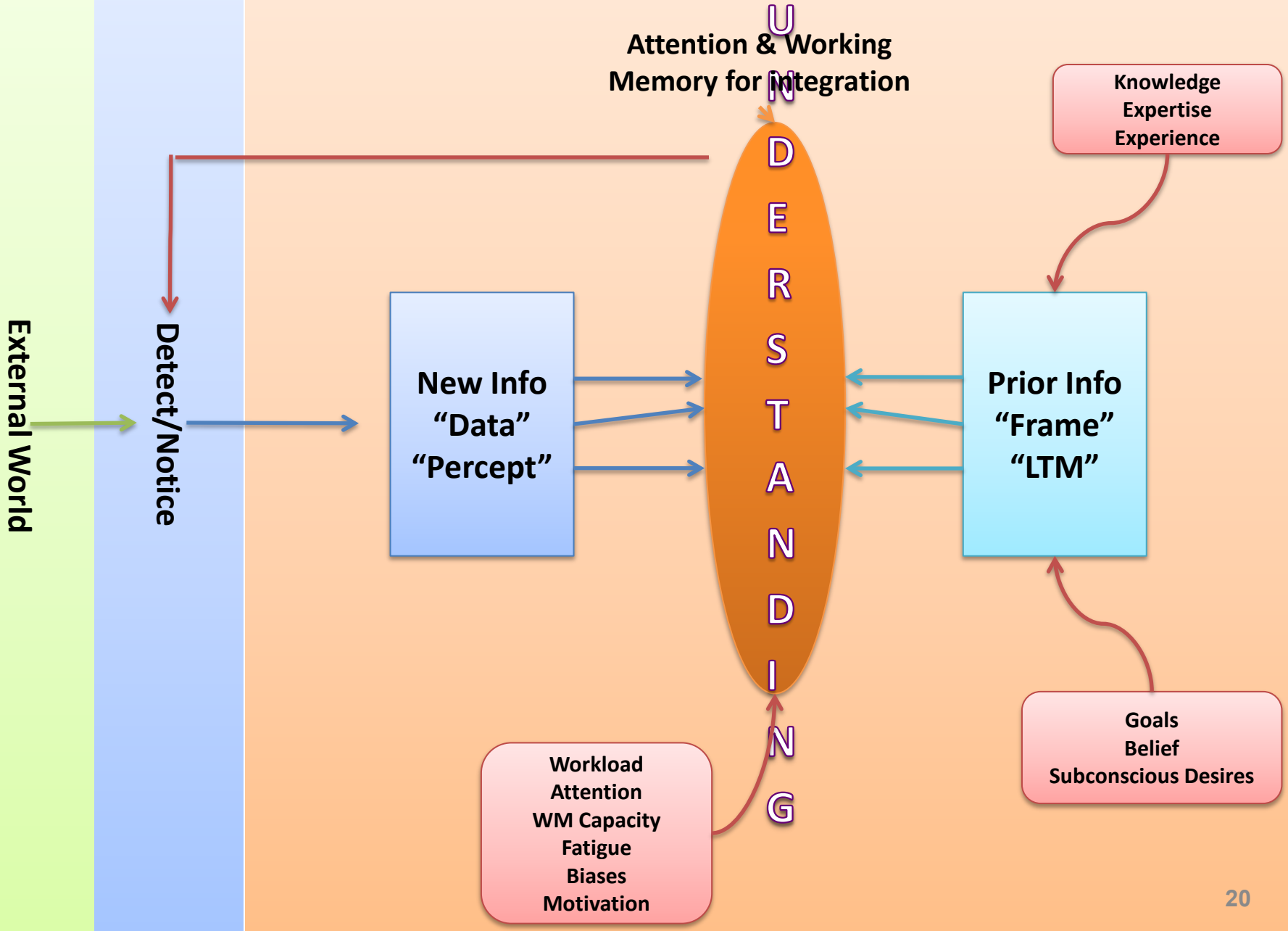
Understanding - Scope in NPP internal procedural events

Understanding is the evaluation of current conditions to assess the plant status or to diagnose the underlying causes of any abnormalities.

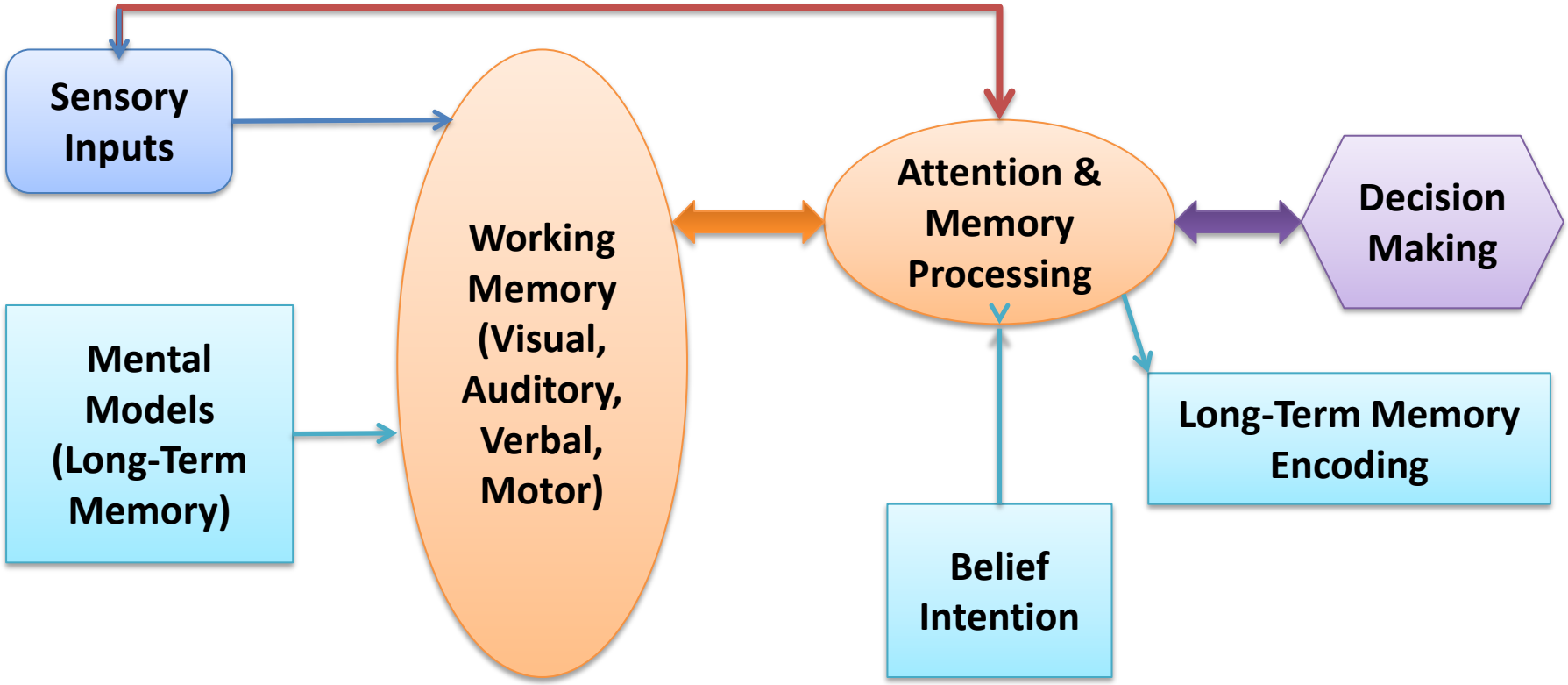
Scope of *Understanding* in NPP internal procedural events



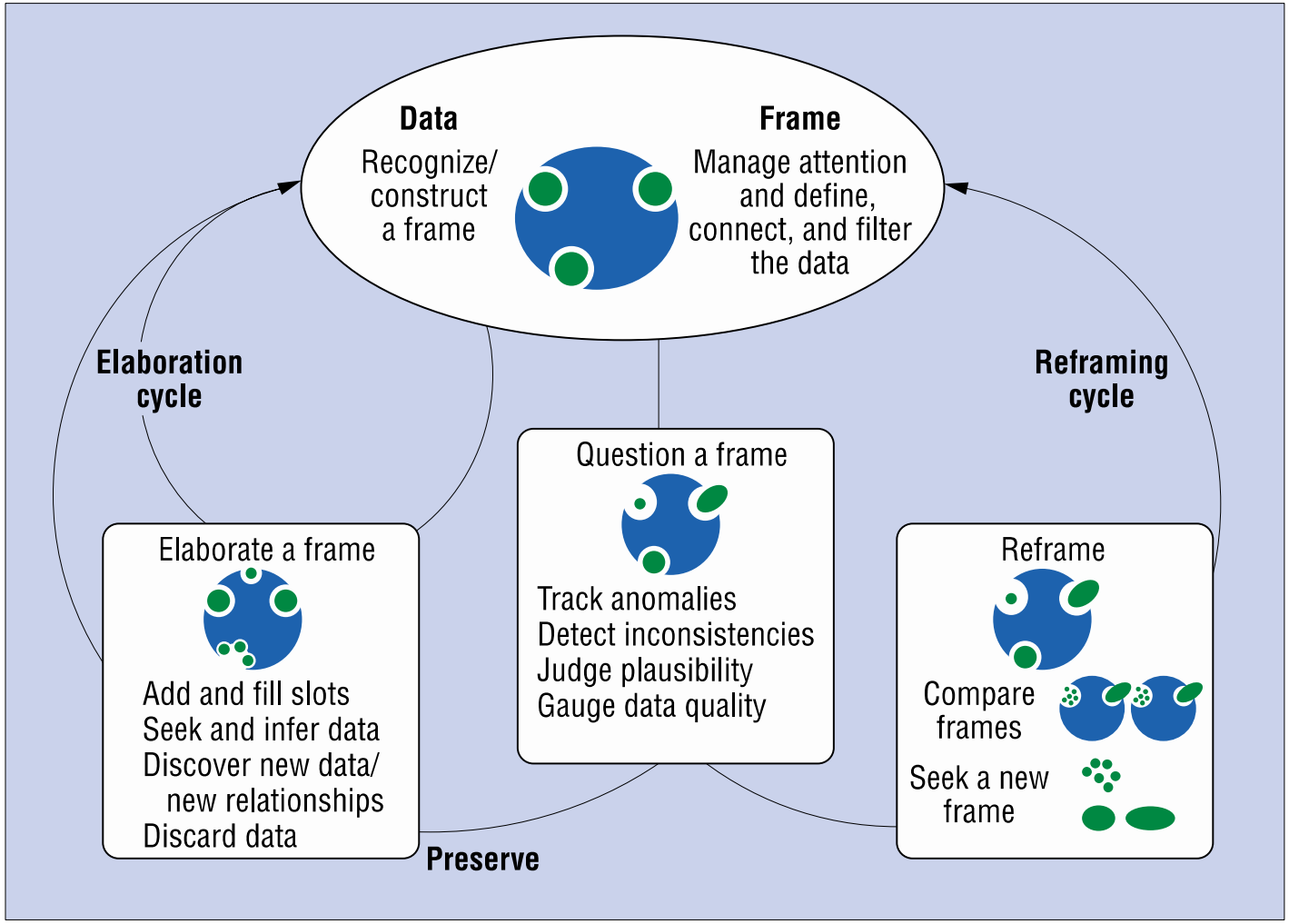
How human achieves Understanding



Dynamic process of understanding in complex tasks



Cognitive process for understanding



(Klein et al, 2006)

Understanding– Cognitive mechanisms that makes the function reliable

Data content- meaningful information, not misleading or conflicting

Mental model (frame) - Mental model is developed through training and experience

Integration of mental model and data - Mental model is integrated with data to generate understanding

Attention and Working Memory – Attention control ensures all parts of the cognitive process for understanding are achieved; Working memory is to be managed for its resource limitations.

Belief process - Beliefs modulate the integration process

Understanding– Error causes and proximate causes

Proximate Cause - Incorrect data

- Information available in the environment (including procedures) is not complete, correct, or otherwise sufficient to create understanding of the situation

Proximate Cause - Incorrect integration of data, frames, or data with a frame

- Improper aspects of the frame selected for comparison with the data

Proximate Cause – Incorrect frame

- Frame or mental model inappropriately preserved or confirmed when it should be rejected or reframed

Understanding– Effect of PIFs

Proximate Cause - Incorrect data

- Information available in the environment (including procedures) is not complete, correct, or otherwise sufficient to create understanding of the situation

Proximate Cause - Incorrect integration of data, frames, or data with a frame

- Improper aspects of the frame selected for comparison with the data

Proximate Cause – Incorrect frame

- Frame or mental model inappropriately selected or confirmed when it should be rejected or reframed

PIFs

- Complexity
- HSI

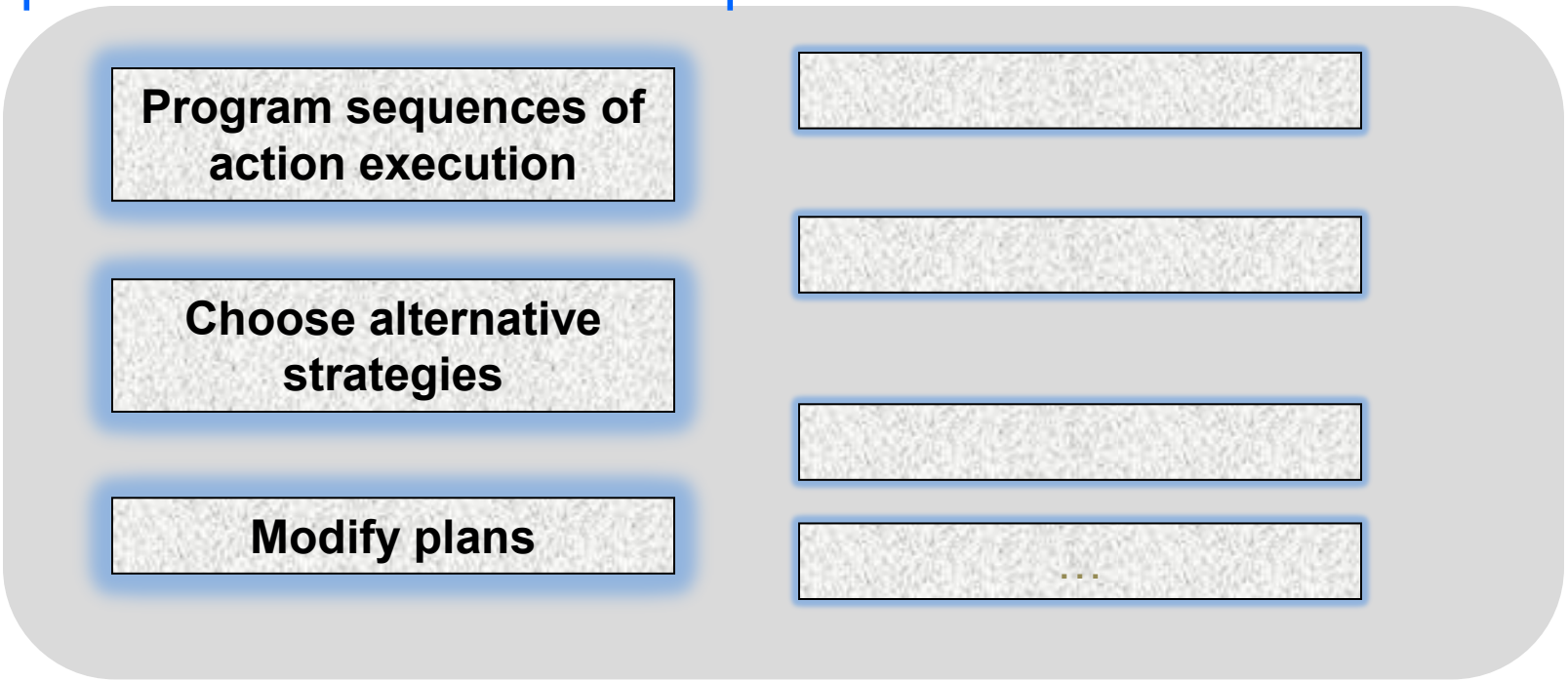
- Workload
- Training

- Workload
- Complexity
- Fatigue

Decision-making (DM) - Scope in NPP internal procedural events

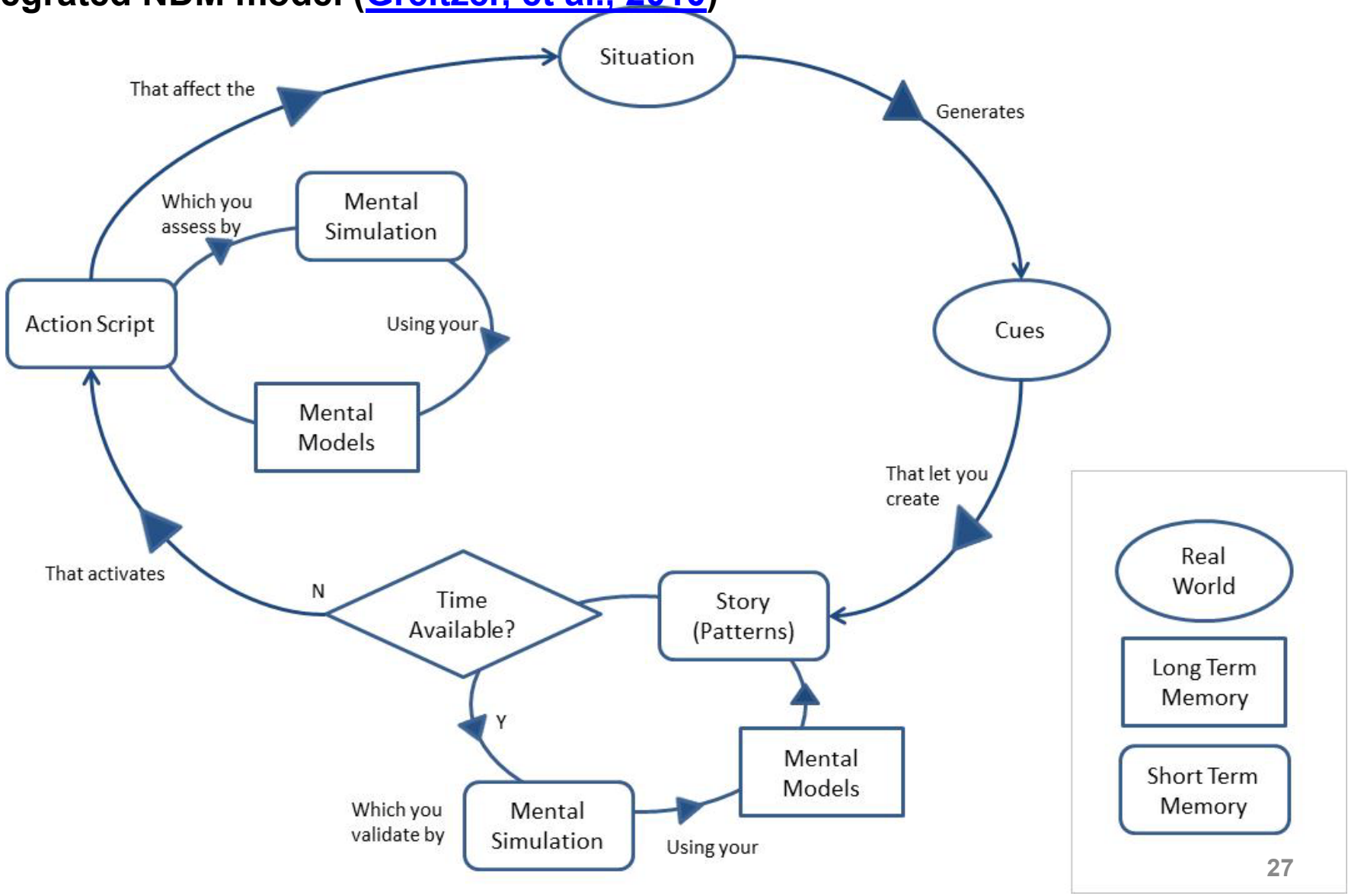
DM is the judgment of what should be done and the decision to do it. *DM* within an NPP is characterized as involving experts and being largely driven by procedures in internal, procedural events.

Scope of *DM* in NPP internal procedural events



DM – How the objectives are achieved

Integrated NDM model (Greitzer, et al., 2010)



DM – What makes the function reliable

Goal management – Decisions to be made have clear goals and can be prioritized.

Pattern recognition – Recognize the pattern of the situation/goals through training and experience.

Mental simulation – Assess the pattern and the outcome of the decision.

Inhibition of bias and wishes – Biases and wishes interfere *DM*.

Attention and working memory - Focus on information pertinent to DM and bind relevant information.

DM – Error causes and proximate causes

Proximate Cause - *Incorrect Goals or Priorities Set*

- Goal conflict. A conflict may arise in the operator's mind between the goals of safety and the continued viability of the plant.

Proximate Cause - *Incorrect Internal Pattern Matching*

- Not updating the mental model to reflect the changing state of the system.

Proximate Cause - *Incorrect Mental Simulation or Evaluation of Options*

- Inaccurate portrayal of the system response to the proposed action. This failure mechanism manifests in the operator incorrectly predicting how the system will respond to the proposed action.

DM – Effects of PIFs

Proximate Cause - *Incorrect Goals or Priorities Set*

- Goal conflict. A conflict may arise in the operator's mind between the goals of safety and the continued viability of the plant.

Proximate Cause - *Incorrect Internal Pattern Matching*

- Not updating the mental model to reflect the changing state of the system.

Proximate Cause - *Incorrect Mental Simulation or Evaluation of Options*

- Inaccurate portrayal of the system response to the proposed action. This failure mechanism manifests in the operator incorrectly predicting how the system will respond to the proposed action.

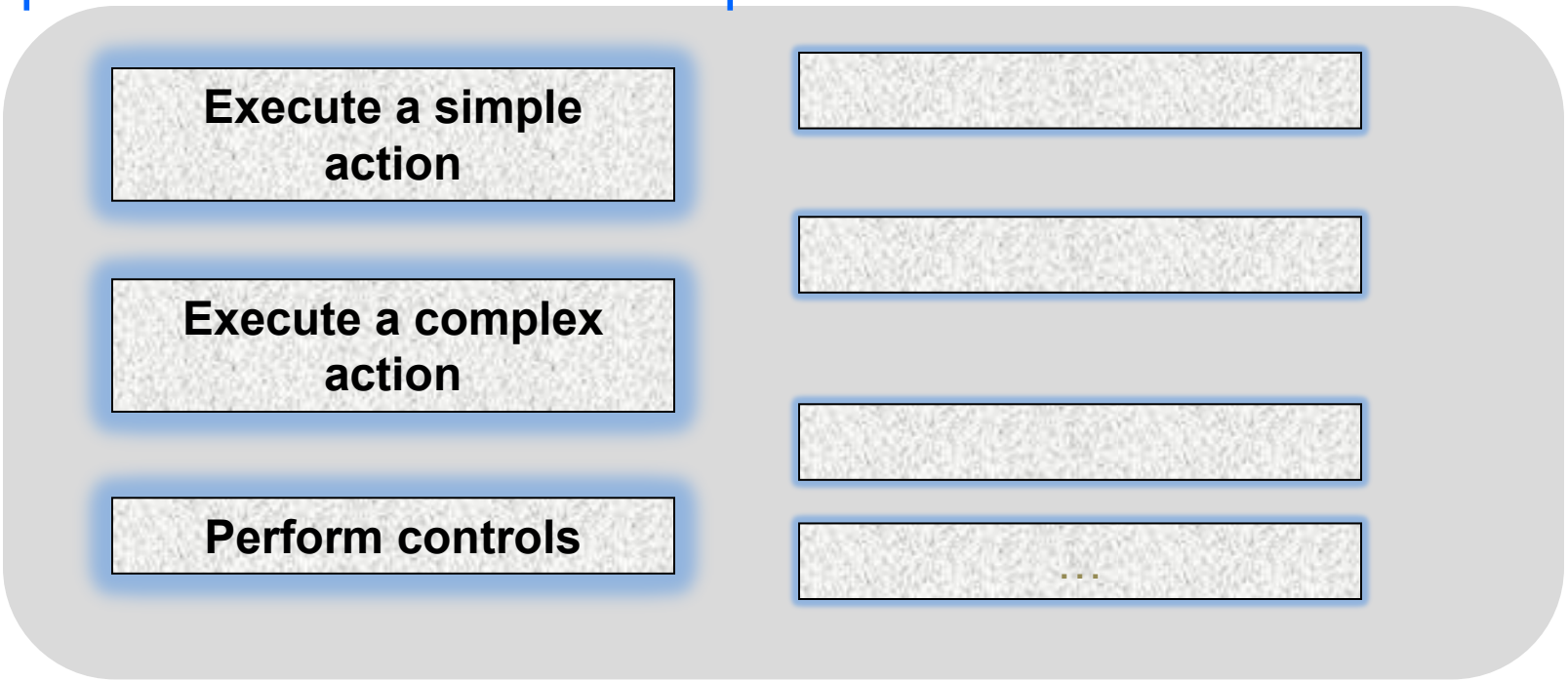
PIFs

- Task complexity
- Workload
- complexity
- Complexity
- Workload
- Training

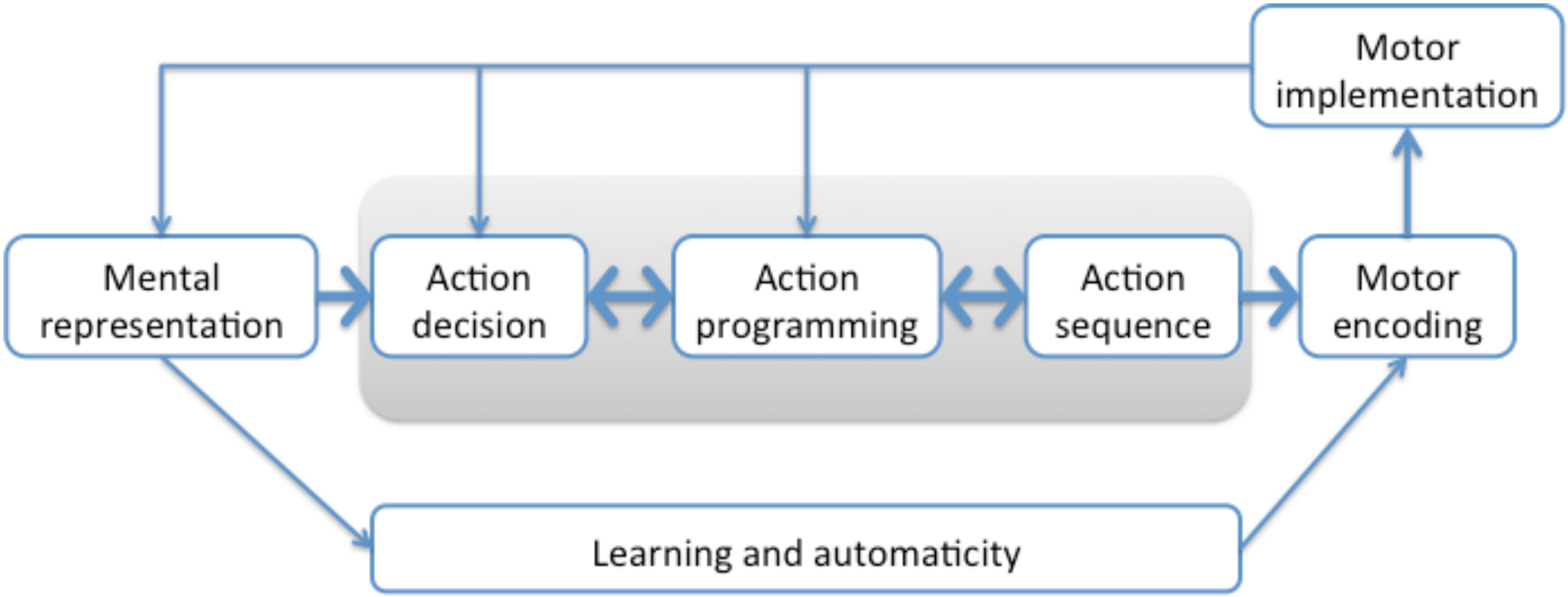
Action execution - Scope in NPP internal procedural events

Acton execution refers to executing physical control actions to achieve a particular goal. Execution is implementation of an action on the level of a single manual action or a predetermined sequence of manual actions. The action(s) must involve the manipulation of the human-system interfaces of the plant and would consequently alter plant status.

Scope of *DM* in NPP internal procedural events



Action execution – How the objectives are achieved



Hierarchy Pathway - The hierarchy pathway involves movement programming, storing, and sequencing, and movement execution.

Automaticity Pathway - Action automaticity is the ability to implement actions without occupying the brain with the low-level details required, allowing it to become an automatic response pattern.

Sensory Feedback - Human goal-directed behavior depends on multiple neural systems that monitor and correct for different types of errors.

Action execution – What makes the function reliable

Cognitive Control of execution - Cognitive system must be capable of running mental processes that virtually simulate action sequences aimed at achieving a goal.

Cognitive control for task switching - This process reconfigures mental resources for task switching.

Sensory feedback in execution - Precise and continuous sensory inputs make adjustments to physical movement to enhance action correctness and accuracy.

Error-monitoring and correction - Goal-directed actions depend on multiple neural systems that monitor and correct for different types of errors, especially errors in delayed or sequences of actions.

Motor learning and automaticity - Routine sequences of actions are executed automatically for the scope of the learning and training environment.

Action execution – Error causes and proximate causes

Proximate Cause - *Failed to take required action (did not attempt action)*.

- Action not initiated
- Action initiated too late

Proximate Cause - *Executed desired action incorrectly*

- Omitted one or more steps
- Incorrect order of steps
- Incorrect position (e.g., turn switch to wrong position)
- Action prevented because of interlock

Executed undesired action

- Blocked a needed function from initiation (e.g., an engineered safety system)
- Stopped or turned off a needed function (e.g., an engineered safety system)
- Unnecessary initiation of a function (e.g., manual trip)

Action execution – Error causes and proximate causes

Proximate Cause - *Failed to take required action (did not attempt action)*

- Action not initiated
- Action initiated too late

PIFs

- Workload
- Procedures

Proximate Cause - *Executed desired action incorrectly*

- Omitted one or more steps
- Incorrect order of steps
- Incorrect position (e.g., turn switch to wrong position)
- Action prevented because of interlock

- Workload
- Complexity
- HSI
- Training
- Procedure

Executed undesired action

- Blocked a needed function from initiation (e.g., an engineered safety system)
- Stopped or turned off a needed function (e.g., an engineered safety system)
- Unnecessary initiation of a function (e.g., manual trip)

Outline

I. Goals, limitations, and process of developing the cognitive basis

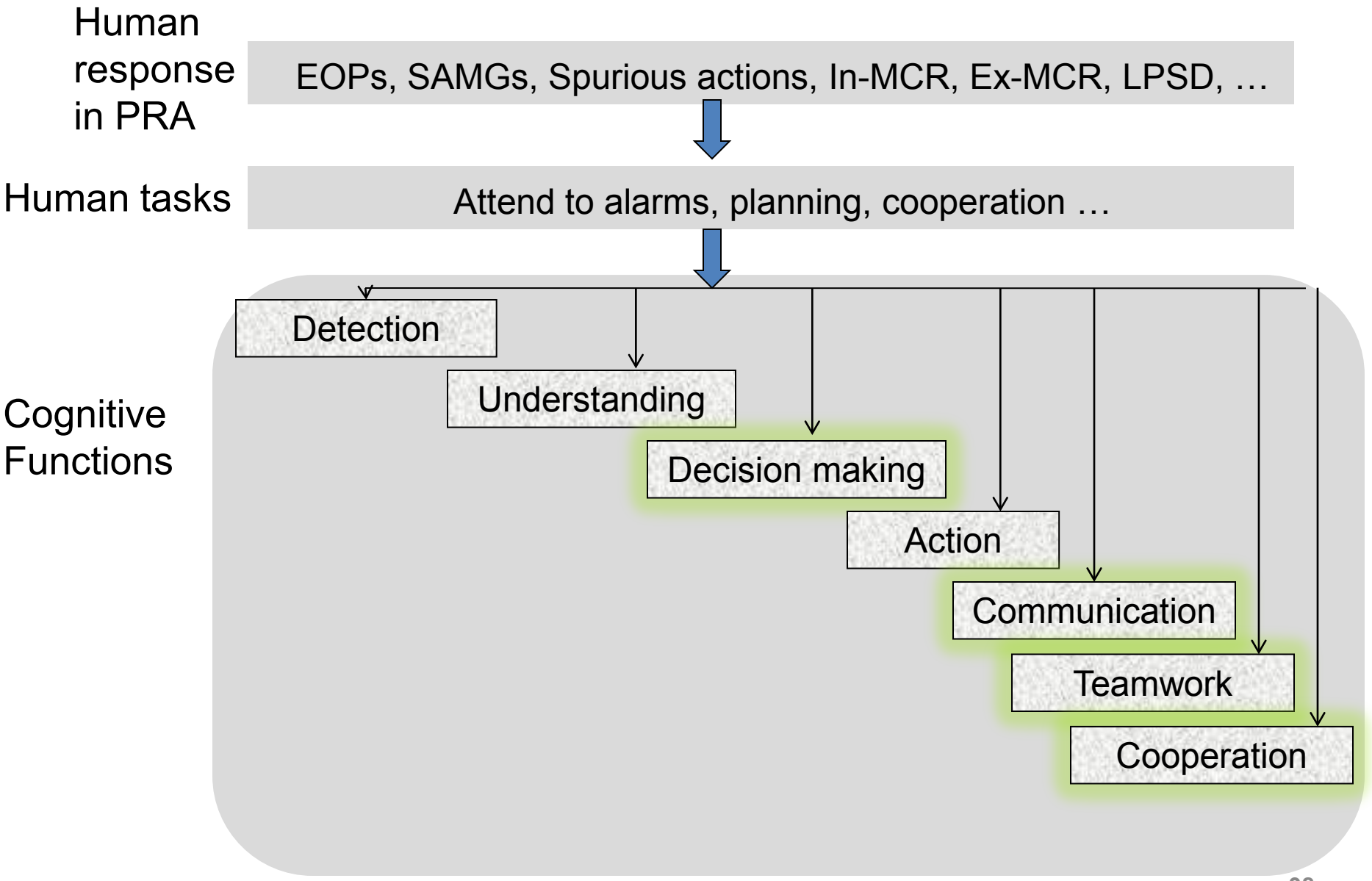
II. The cognitive basis – five cognitive functions

III. Additional study of literature and operational experience

Additional study of literature and operational experience

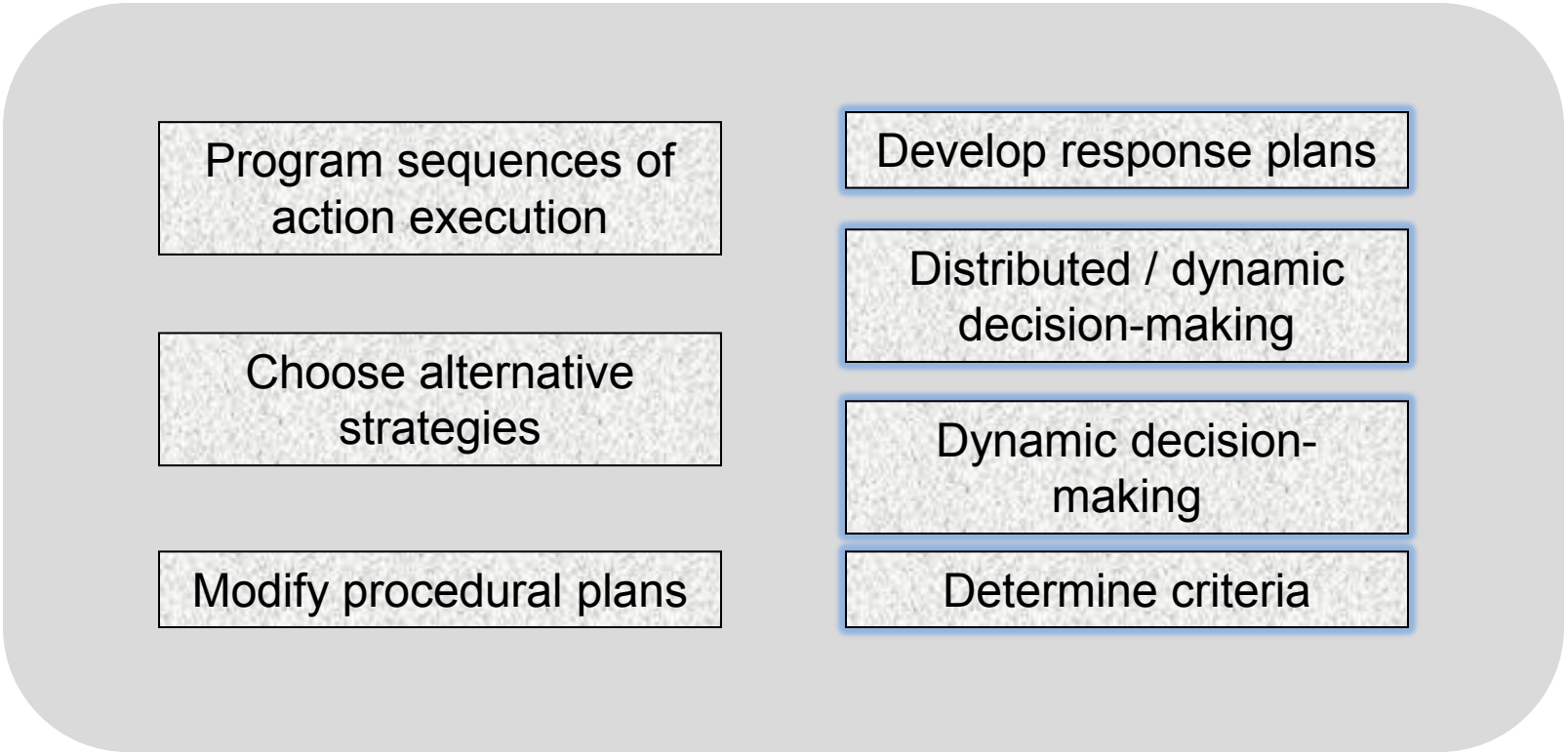
- Cognitive functions and their objectives for events in all kinds of NPP hazards
- Literature review of cognitive mechanisms and error causes for the new functions / scopes
- Inventory of PIF characteristics
- Extension of the cognitive basis – Function/objectives, mechanisms, error causes, and PIF characteristics

Cognitive functions in NPP hazards



Extend the scope of cognitive functions to human responses in all NPP hazards

Scope of *Decision-making* in human response to all NPP hazards



Develop an inventory of PIF characteristics

Three types of PIFs modeled so far -

Cognitive workload and task complexity –

demanding cognitive resources, challenging cognitive mechanisms, and leading to errors.

HSI/environment and procedures –

Aggravating the cognitive demands

Training, work process, and organizational factors –

Militating the demands and providing barriers to error causes, recovering errors

PIF Characteristics

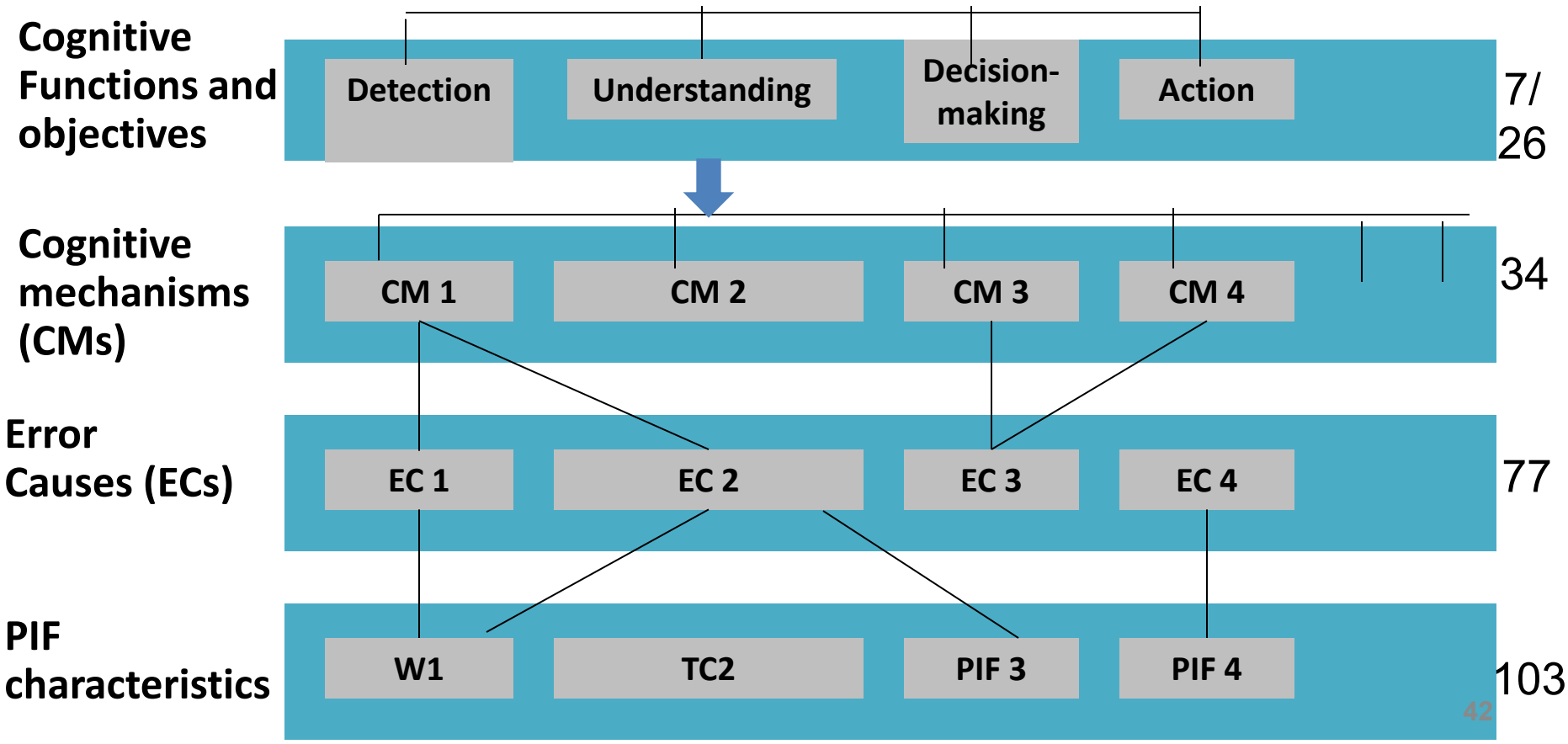
For each cognitive function, we identified the PIF characteristics that challenge the cognitive mechanisms and trigger the error causes.

Example PIF characteristics for *Understanding*

Context factor	Example challenging context character	Cognitive mechanism
Workload	Multitasking, Interruption	Integration
Task demands	Unfamiliar scenario	Mental model
HSI	System behavior is not apparent or masked	Information selection
Procedure	Criteria are ambiguous	Integration
Training	Under-trained system failure modes	Mental model

Summary of the cognitive basis for human error analysis

Each cognitive function is associated with cognitive mechanisms, error causes(or failure mechanisms), and error-prone task and barrier (or PIFs) characteristics.



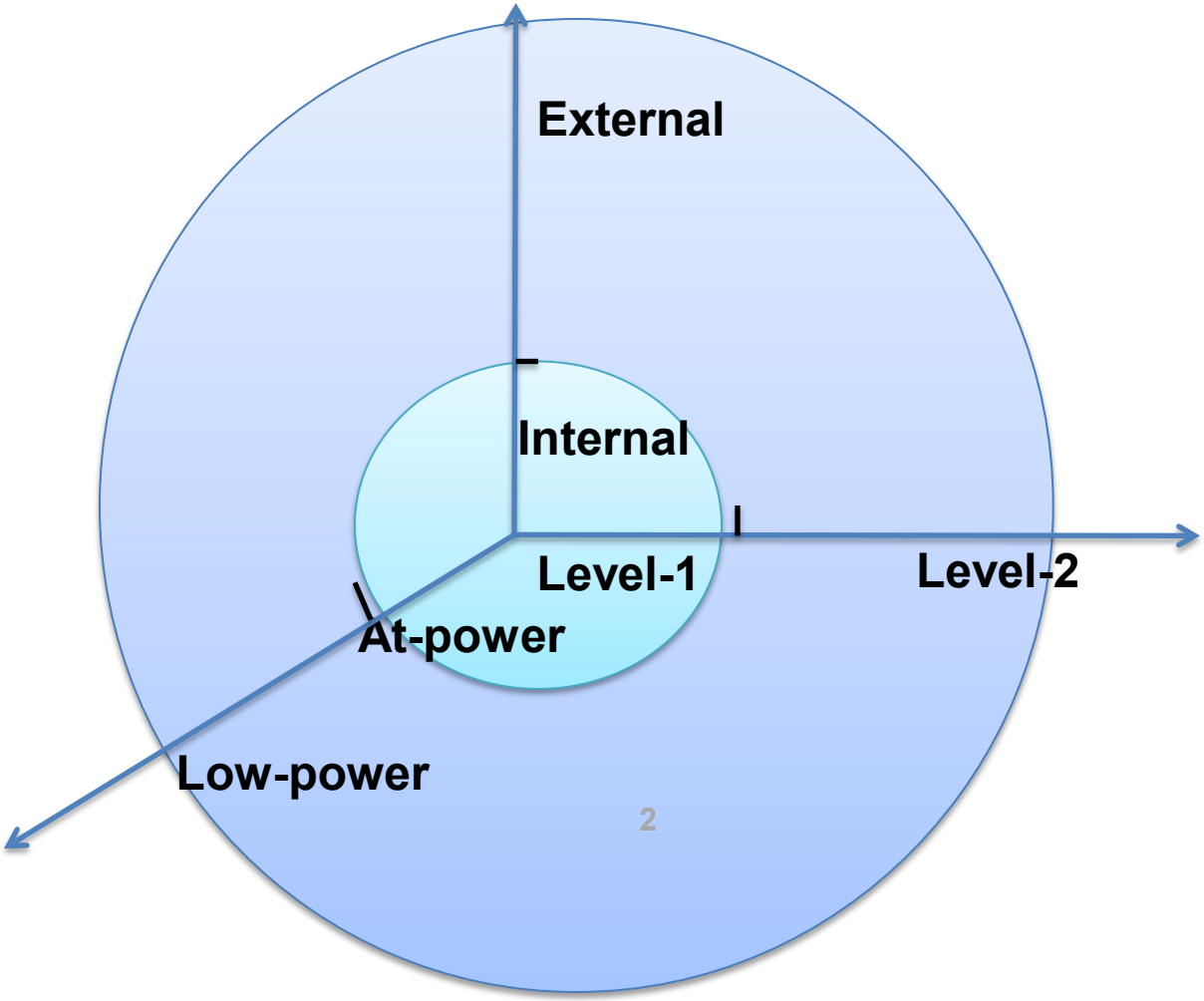

PULL
MIDVALE
SCHOOL FOR
THE GIFTED

The methodology of an Integrated Decision-tree Human Event Analysis System (IDHEAS) – A generic HRA methodology for NPP applications

Jing Xing, James Chang
RES/DRA/HFRB

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

Risk-informed HRA applications in the NRC



IDHEAS products

Product	Intended applications
Cognitive basis for human error analysis	• Technical basis for HRA • Human factors engineering
IDHEAS Generic methodology for NPP applications	• Risk-informed HRA applications of all hazards and scopes
An IDHEAS method for internal, at-power, procedural events	• Risk-informed HRA of Internal, at-power, procedural events

Outline

I. Introduction – goal, scope, and approach

II. Task analysis structure

III. Proposed methods for HEP quantification

IV. Path forward

Outline

I. Introduction – goal, scope, and approach

II. Task analysis structure

III. Proposed methods for HEP quantification

IV. Path forward

Research goal and requirements

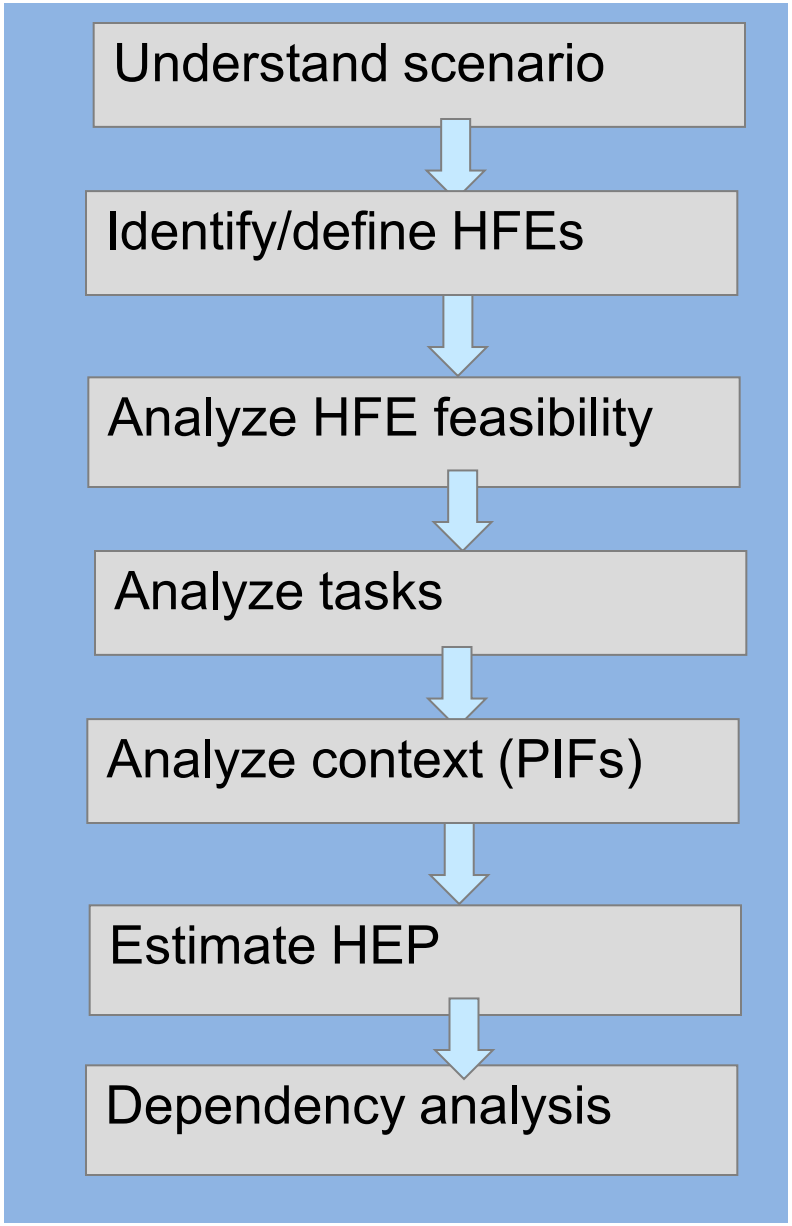
Goal –

Develop an integrated HRA methodology applicable to all HRA domains in NPP operation.

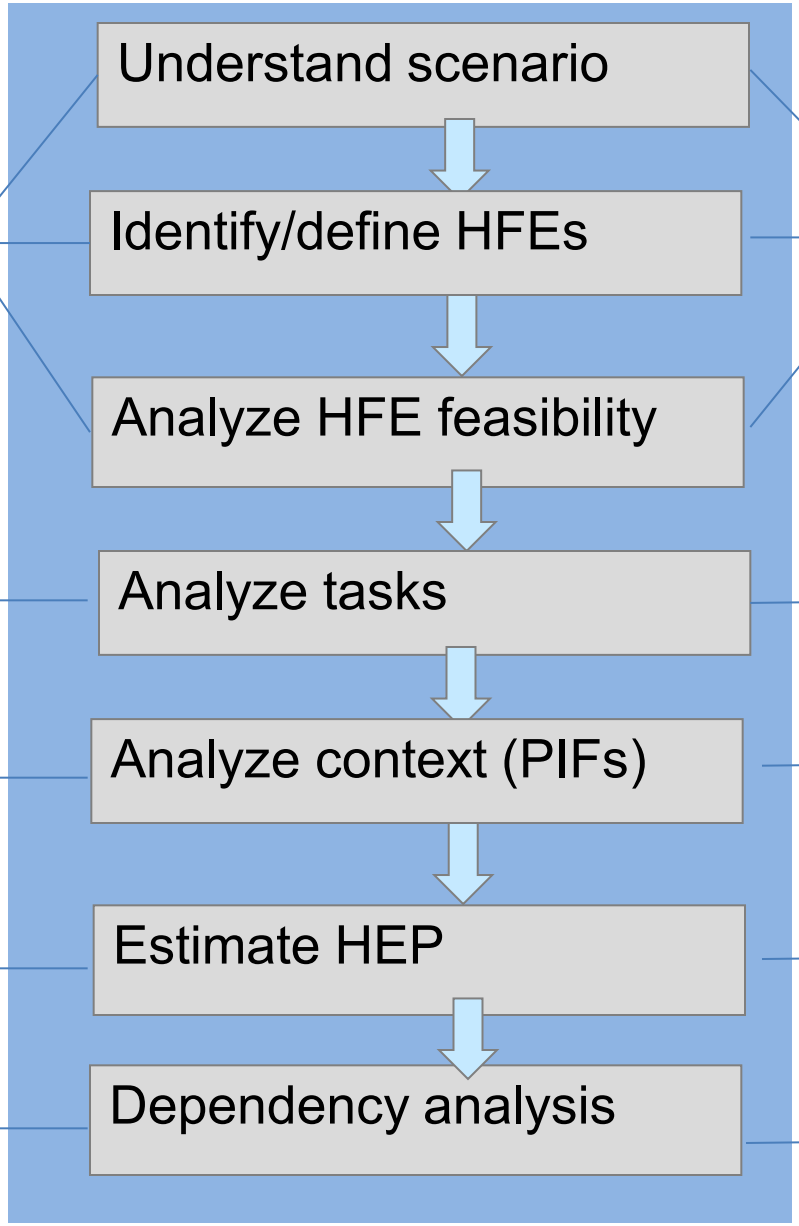
Requirements –

- Generic for all HRA applications with state-of-the-art technical basis.
- Conform to the ASME PRA/HRA standard and HRA Good Practices
- Retain and integrate the strengths of existing HRA methods
- Enhance capabilities to address the key weaknesses in state-of-practices.

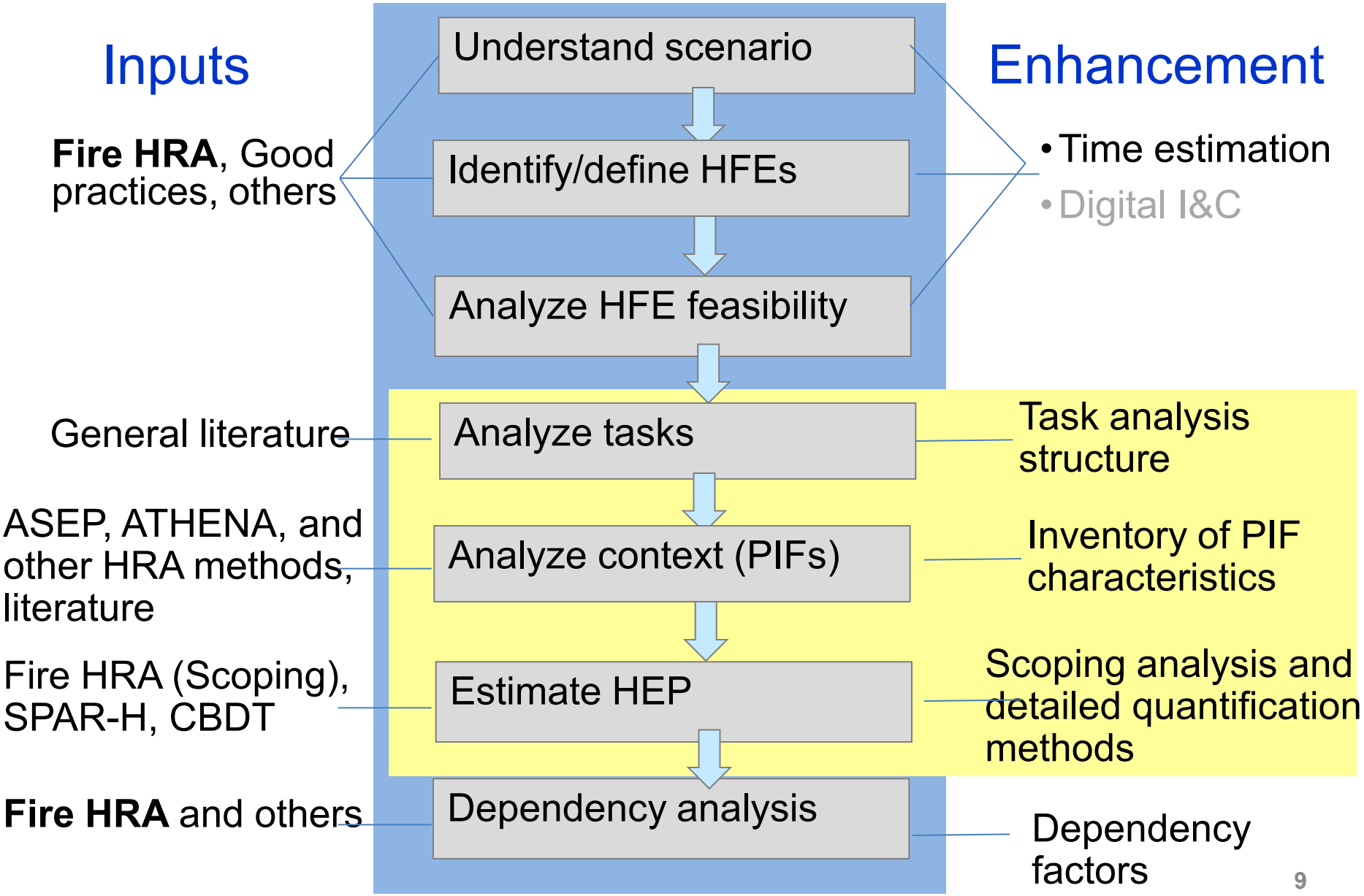
IDHEAS Generic Methodology



The scheme of the methodology development

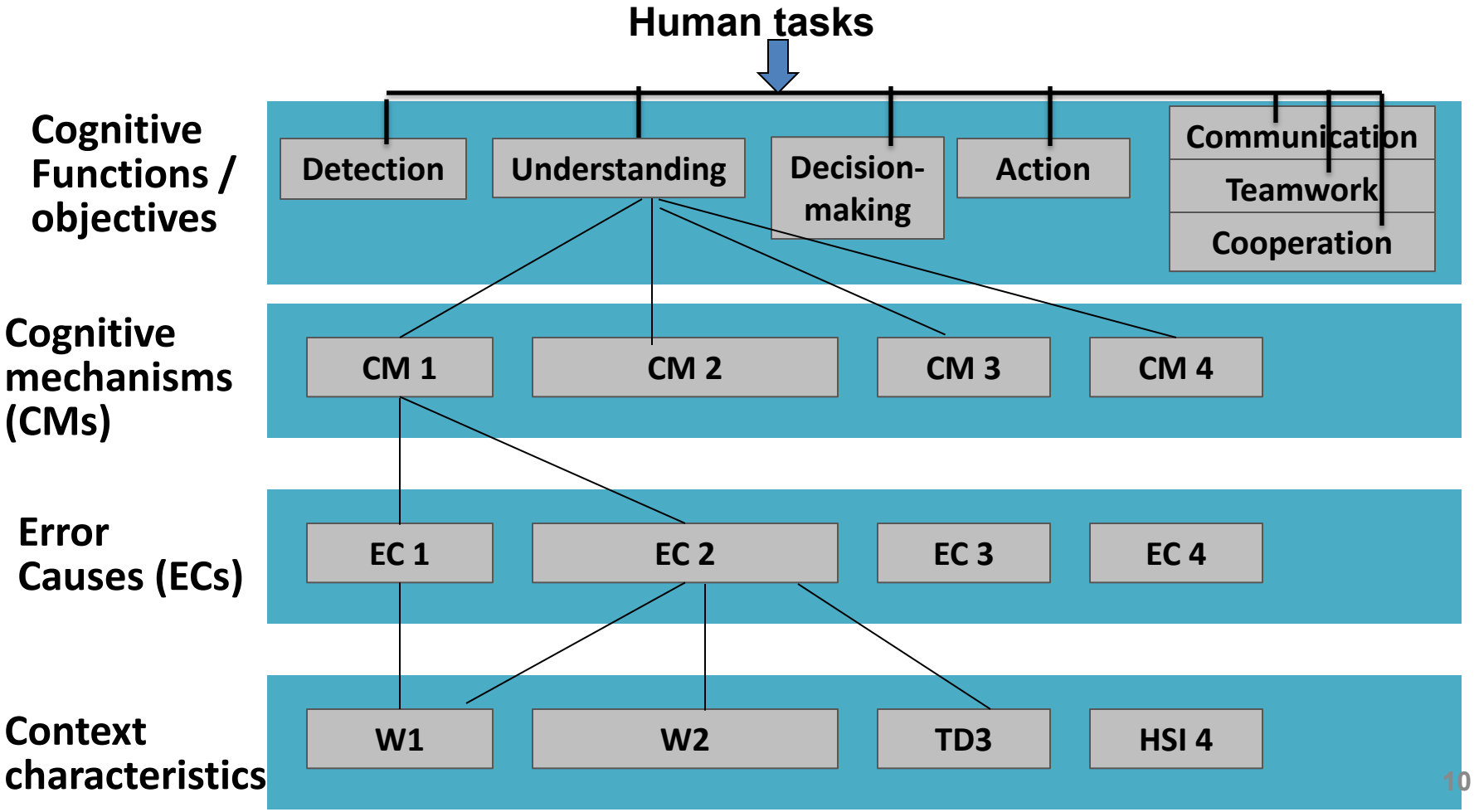


The scheme of the methodology development

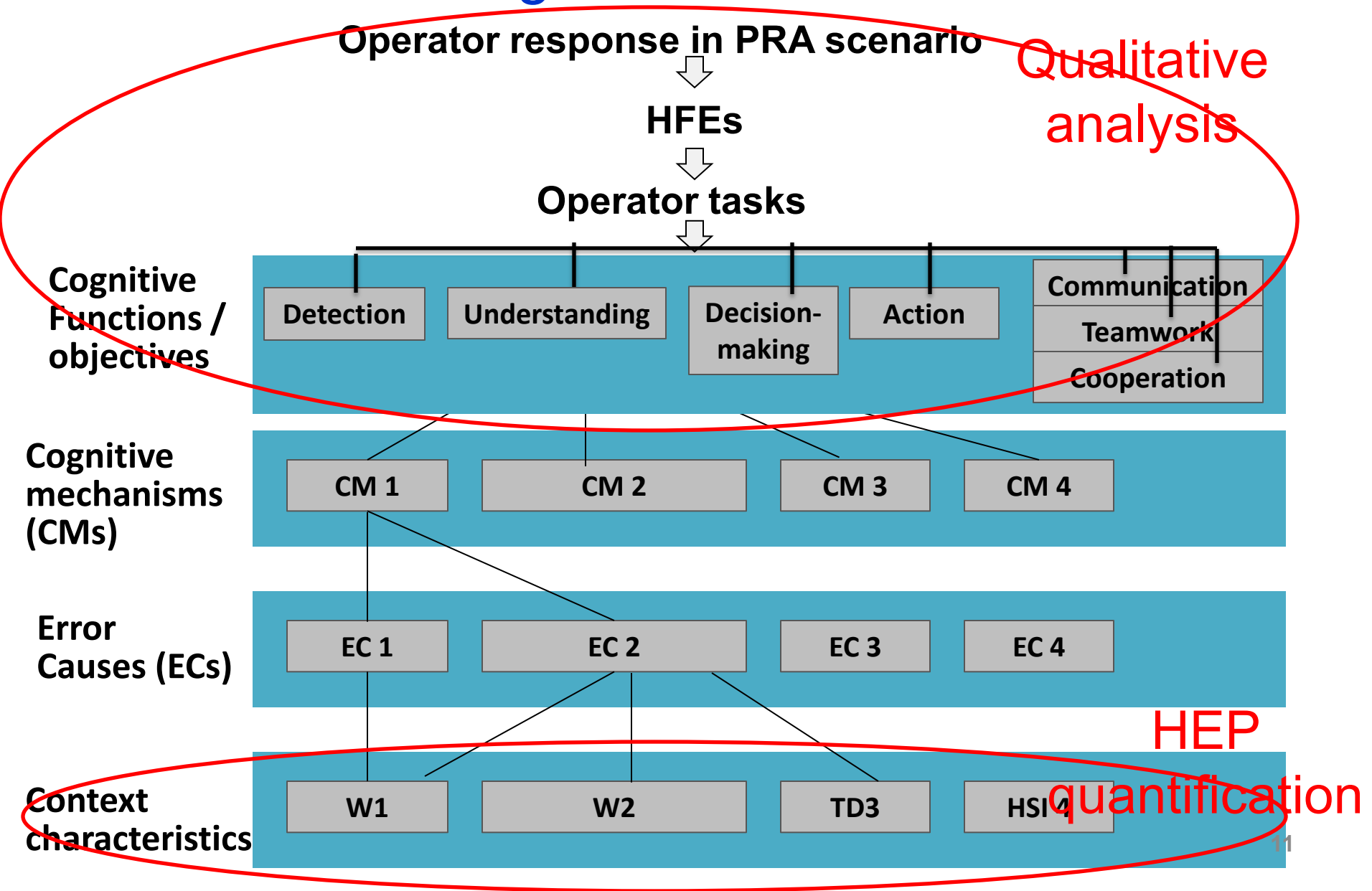


Technical approach - From the cognitive basis to a generic HRA method

The cognitive basis -



Technical approach - From the cognitive basis to a generic HRA method



Technical approach - From the cognitive basis to a generic HRA method

- **Qualitative analysis** – a procedure or guidance to represent the PRA scenario in human-centered tasks and the associated cognitive characteristics (i.e., cognitive functions, objectives).

- **Context analysis** – Realism of the PIF characteristics that challenges cognitive functions in NPP operational context

- **HEP estimation** - A method to structurally use the task and context information to estimate human error probabilities

Outline

I. Introduction – goal, scope, and approach

II. Task analysis structure

III. Proposed methods for HEP quantification

IV. Path forward

Task Analysis Structure

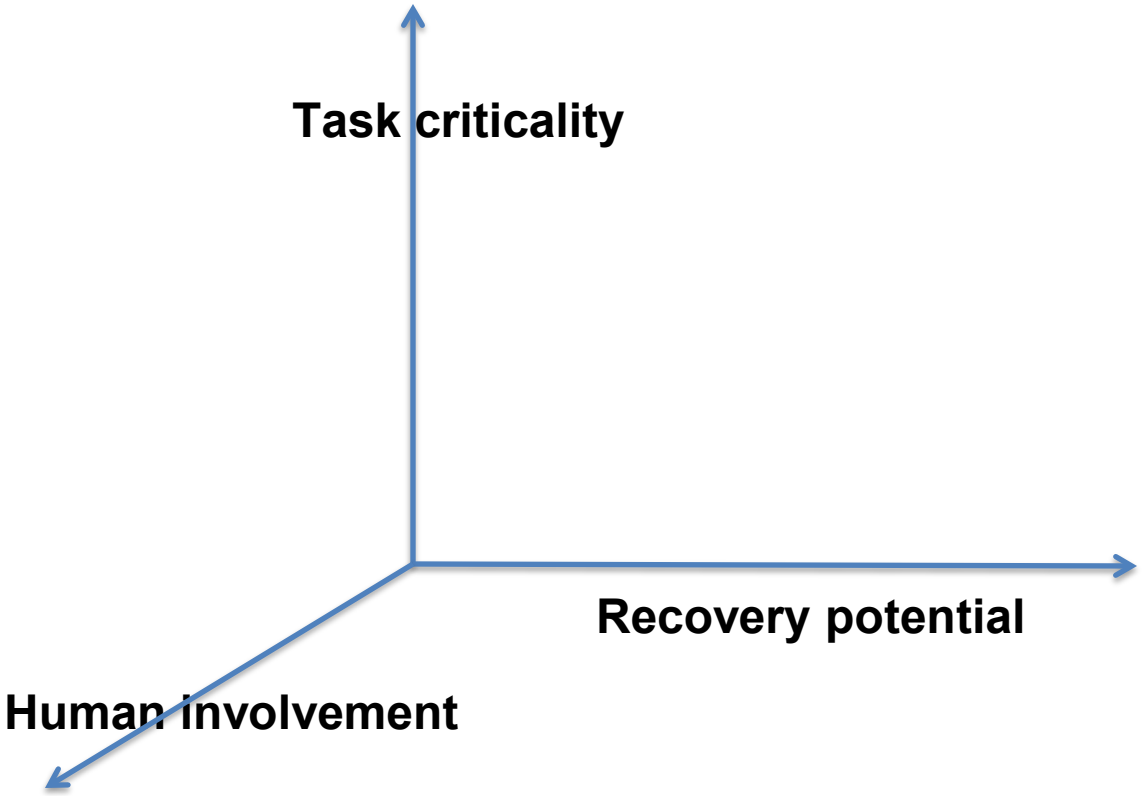
- Develop the crew response tree (CRT) and identify the tasks critical to the HFE success
- Characterize cognitive aspects of each critical task (Cognitive functions, objectives, etc)
- Perform cognitive workload analysis
- Refine the PRA operational story from the cognitive perspecitve

Develop a crew response tree for the HFE

Graphically represent crew tasks and relation between the tasks along the progression.

Identify the tasks critical to the HFE success

Identify and represent safety-critical tasks for quantification; failing each critical task leads to failure of the HFE.



Characterize cognitive aspects of critical tasks

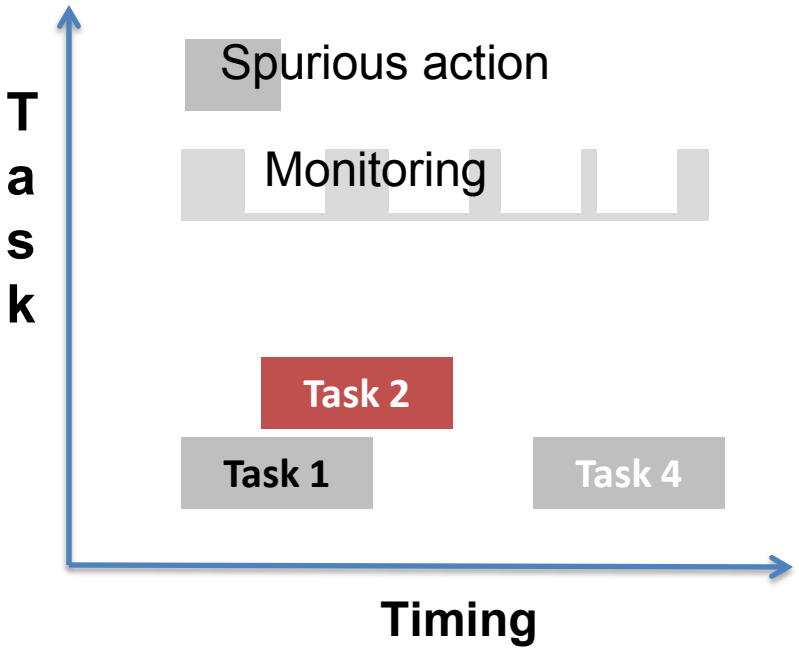
Identify cognitive characteristics of every critical task.

Cognitive features	Description
Task goal	The expected outcome of the task (e.g., reach hot shutdown within 3 hours) including the constraints of operation (e.g., cooldown RCS but not exceeding 100 ºF/hr)
Cognitive functions and objectives	Activities to achieve the goal and the desired outcome of the activities
Plant cues and supporting information	The information (i.e., cue) to initiate the task. A cue could be an alarm, an indication, a procedure instruction or others (e.g. onsite report). The supporting information is in addition to the cue and is needed to perform the task.
Procedures and guidance	Guidance used to perform the tasks.
Time available	(Performed in HFE feasibility analysis)
Personnel	Personnel who performs the task or specific task objectives.

Perform timing and workload analysis

Assess cognitive workload that challenges cognitive functions.

Timing of the tasks

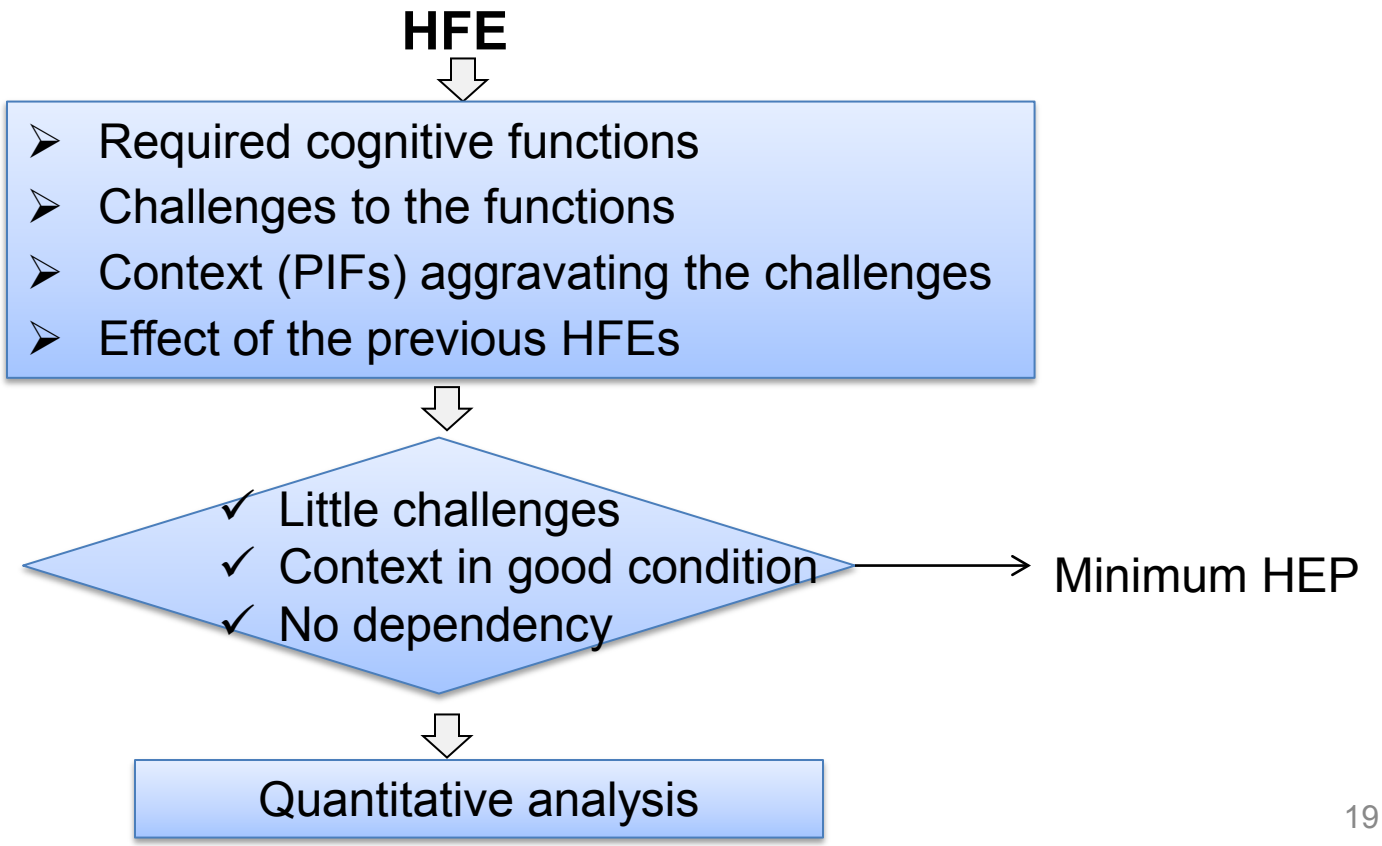


Workload characteristics

- W1 - Multitasking
- W2 – Unfamiliar scenario
- W3 - Interruption / distraction
- W4 - Complex, sustained cognitive demand
- W5 – Time demanding

Refine the operational story

1) Refine the PRA operational story to have a coherent understanding of the HFE cutset from human-centered perspective
2) Screen out very low probability HFEs (little or no challenges).



Outline

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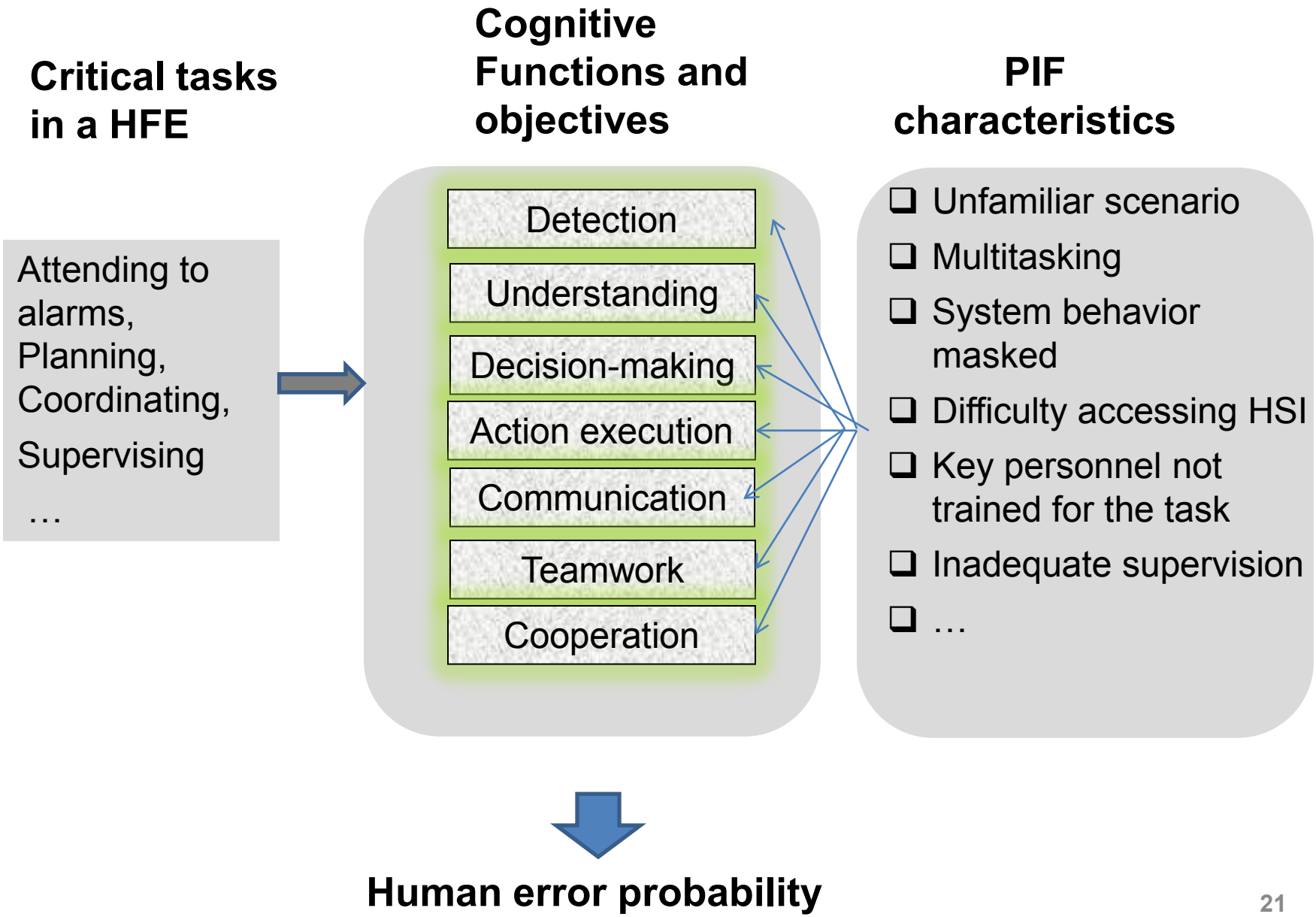
Quantification approach



Inventory of PIF characteristics

Cognitive workload

- Parallel, intermingled, cognitive tasks
- Unfamiliar scenarios
- Interruption / distraction
- Complex, and sustained cognitive activities
- Time demanding

Task complexity

HSI / environment

Procedures / guidance

Training

Work process

Organizational factors

Example PIF Characteristics for *Understanding*

Task characteristics

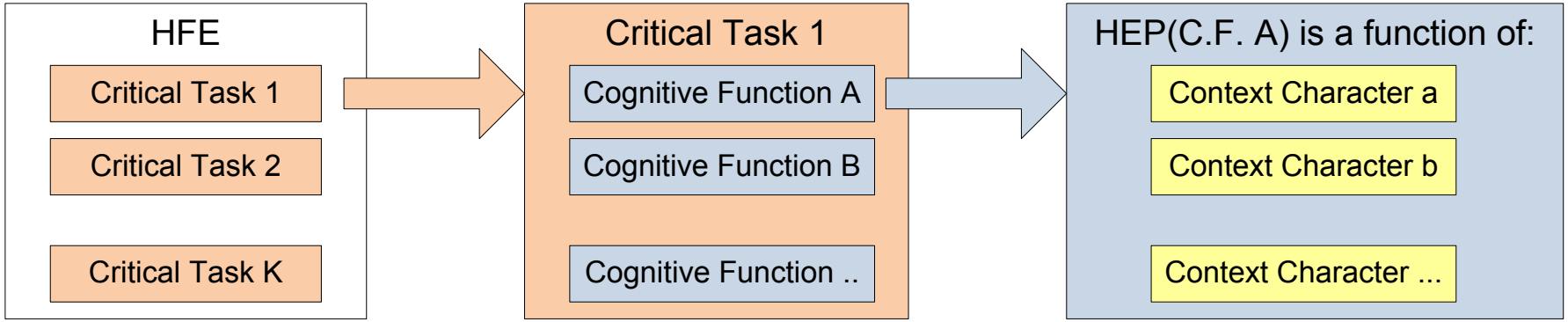
- System behavior is unexpected or unexplained
- System behavior is not apparent due to cue masked
- Distributed information across time - Situations that require integrating information over time periods

HSI / environment

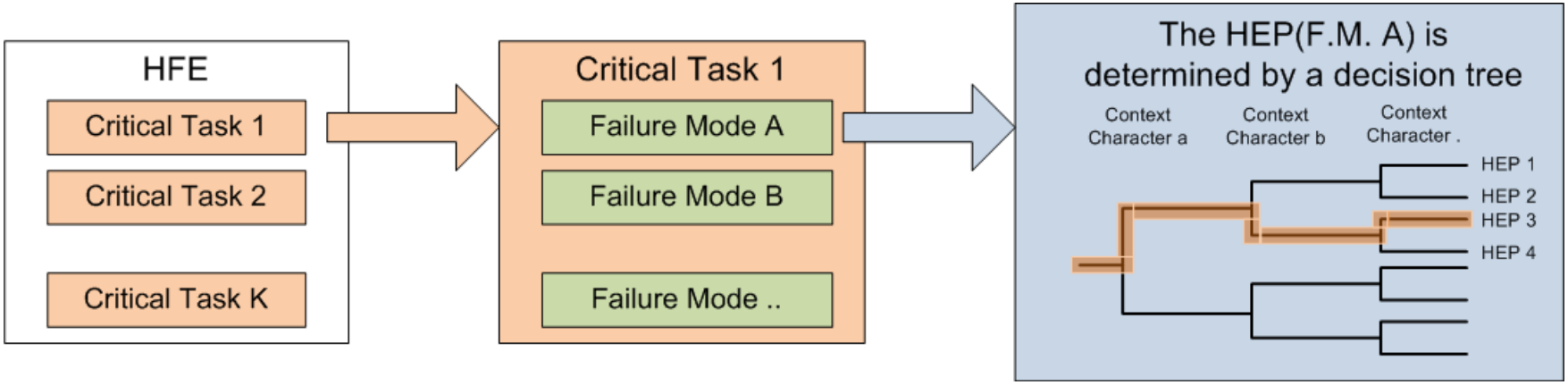
- Ambiguous / misleading information due to design (control logic) faults or I/C malfunctions
- HSI resets variables that are not known to operators
- HSI failure modes may not be anticipated by operators
- Distributed information across HSI for integration

Two methods for HEP quantification

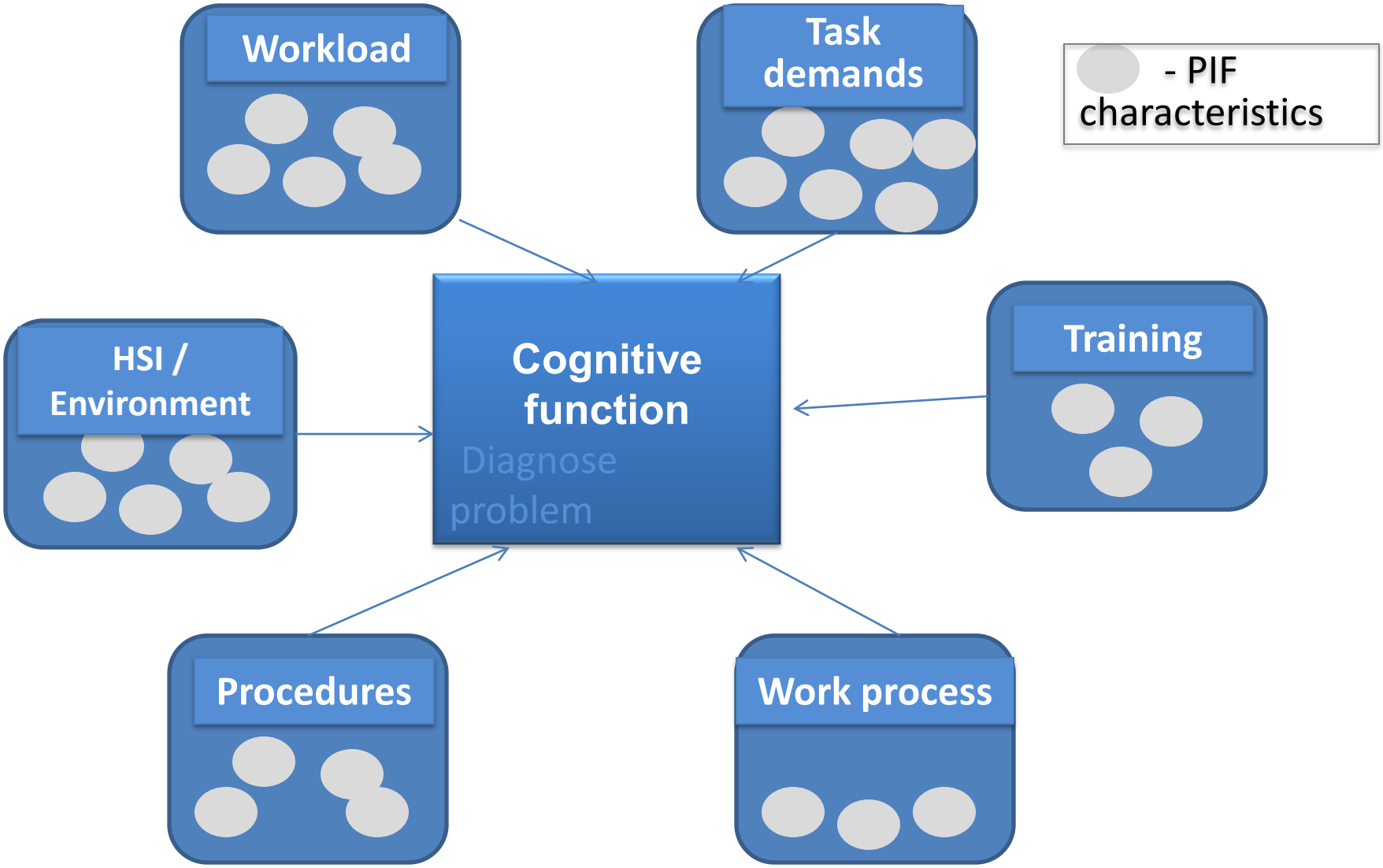
Scoping analysis – Determine the HEP range



Detailed failure-mode analysis – Estimate HEPs

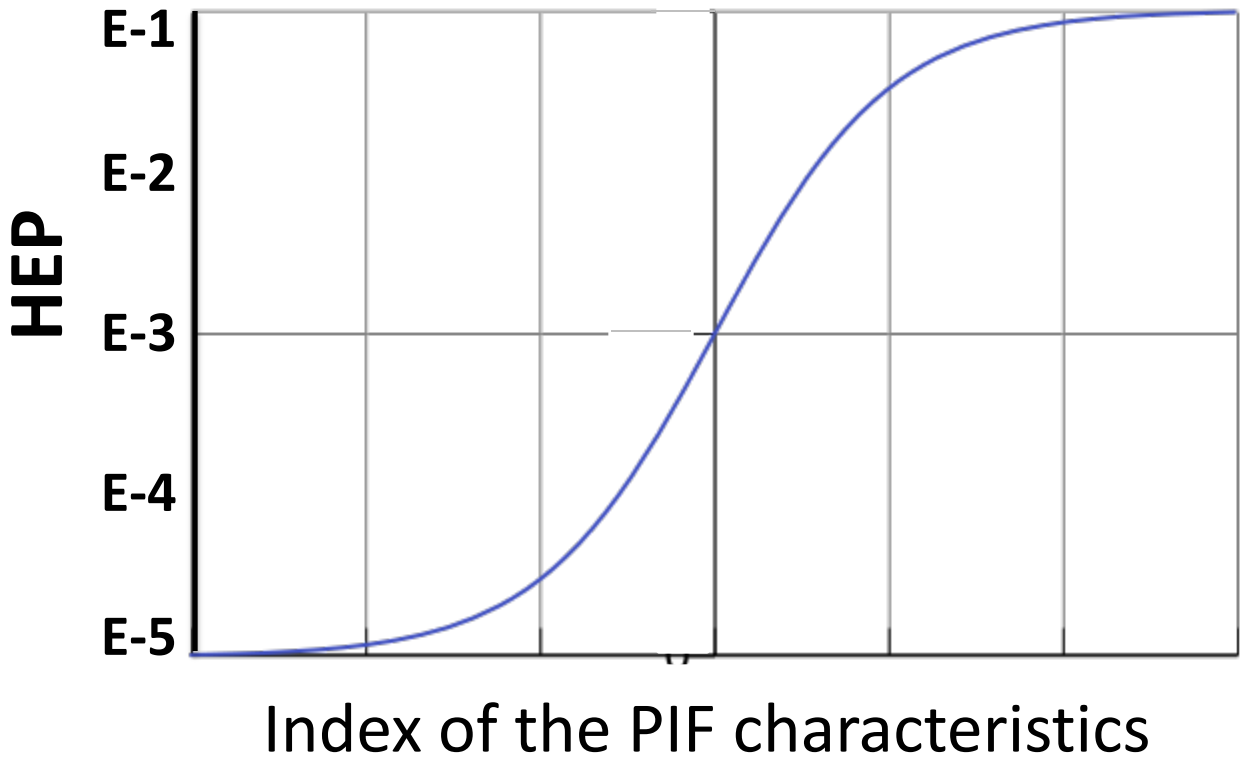


Scoping analysis



Scoping analysis

- Scoping analysis is to rank and group the failure probability of each cognitive function critical to the success of the task
- A HEP range is determined by an index of PIF characteristics



Scoping analysis – Concepts of calculating the index of PIF characteristics

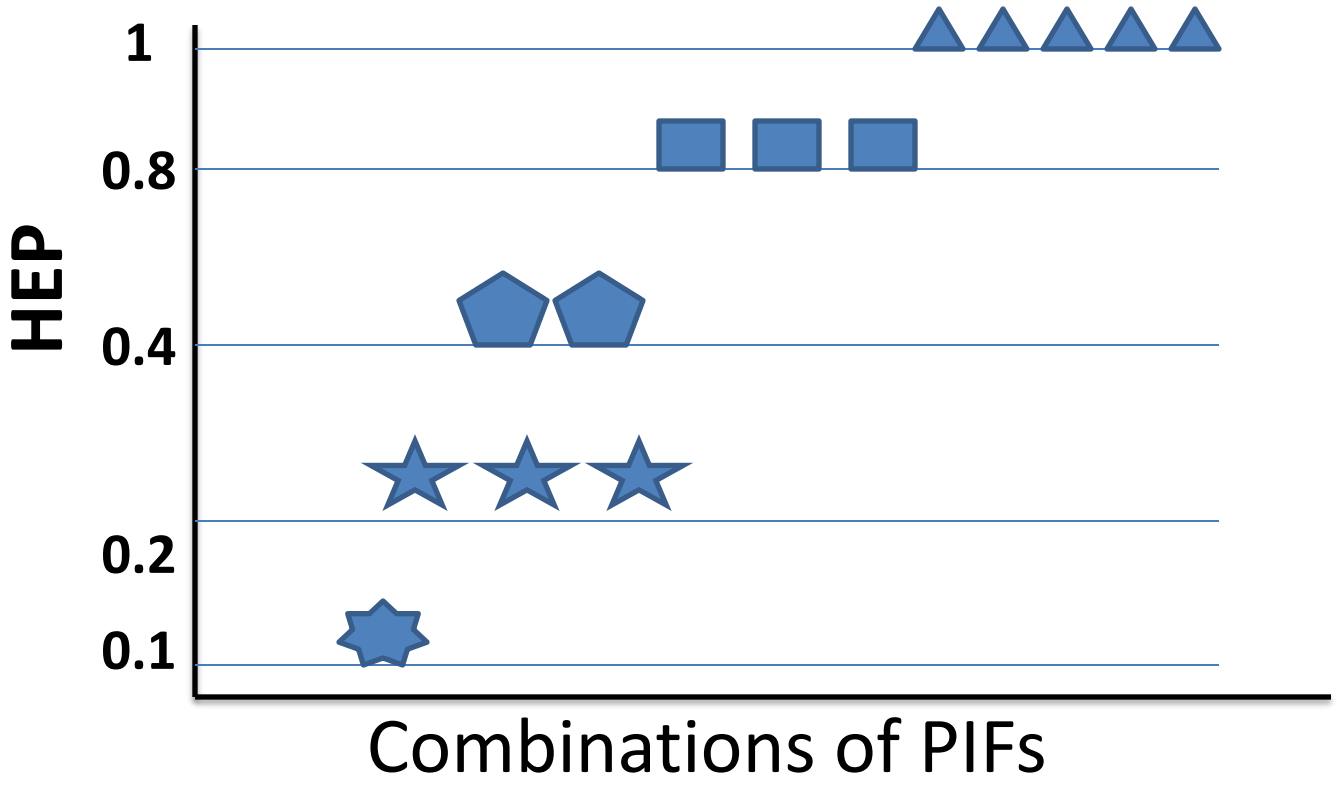
Approach - Conceptual model development, math-fitting and simulation, expert judgment

Concepts being explored –

1) Linear summation – Add the number of the PIF characteristics
2) Weighted summation – Use domain experts to assign weights to the PIF characteristics for every cognitive function
3) Winner-takes-all - Select one or several the most significant PIF characteristics for every function
4) Interaction – Consider the interaction of the PIF characteristics

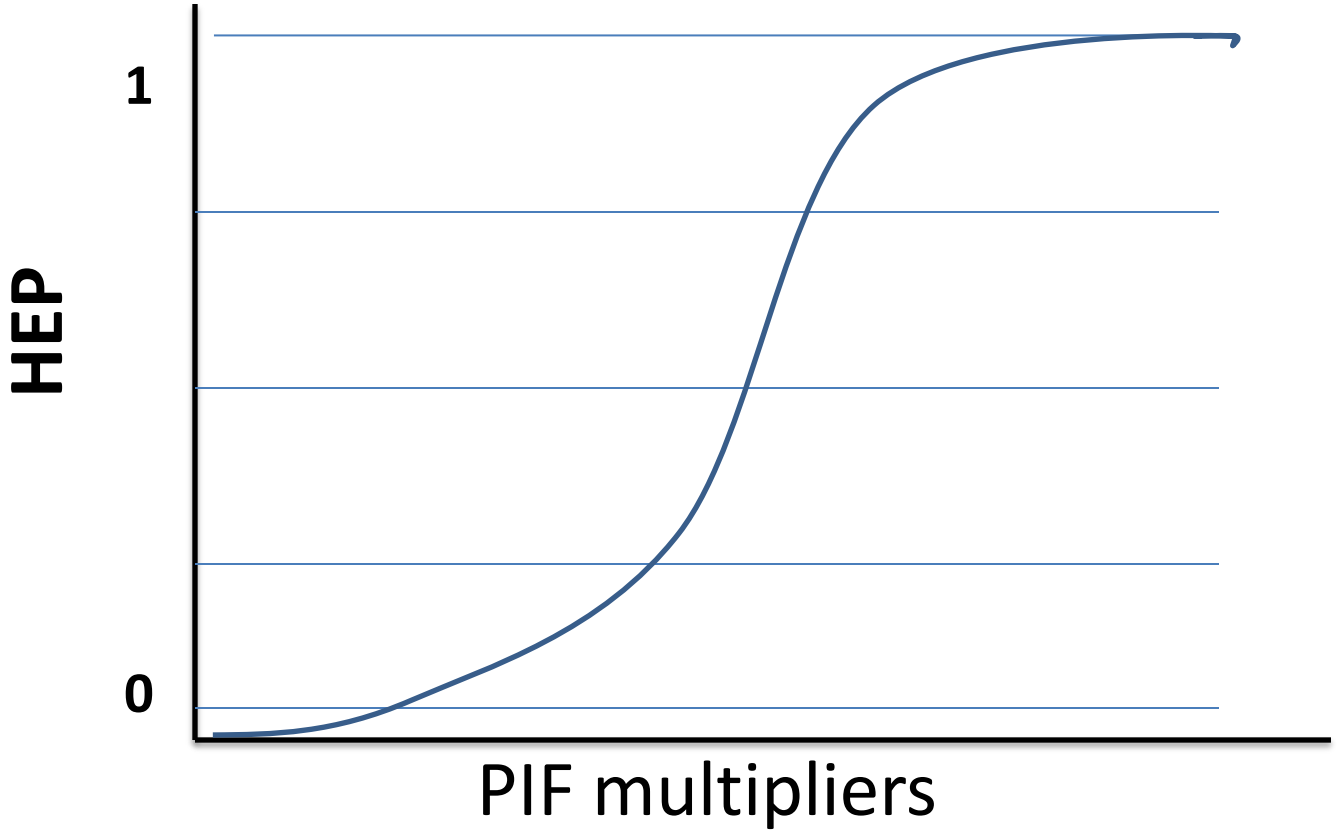
Scoping analysis in Fire HRA

- Scoping analysis is for four types of human actions: INCR, EXCR, Alternative shutdown, and spurious actions
- Five PIFs are modeled: Fire effect, time in fire, execution complexity, time available, time margin

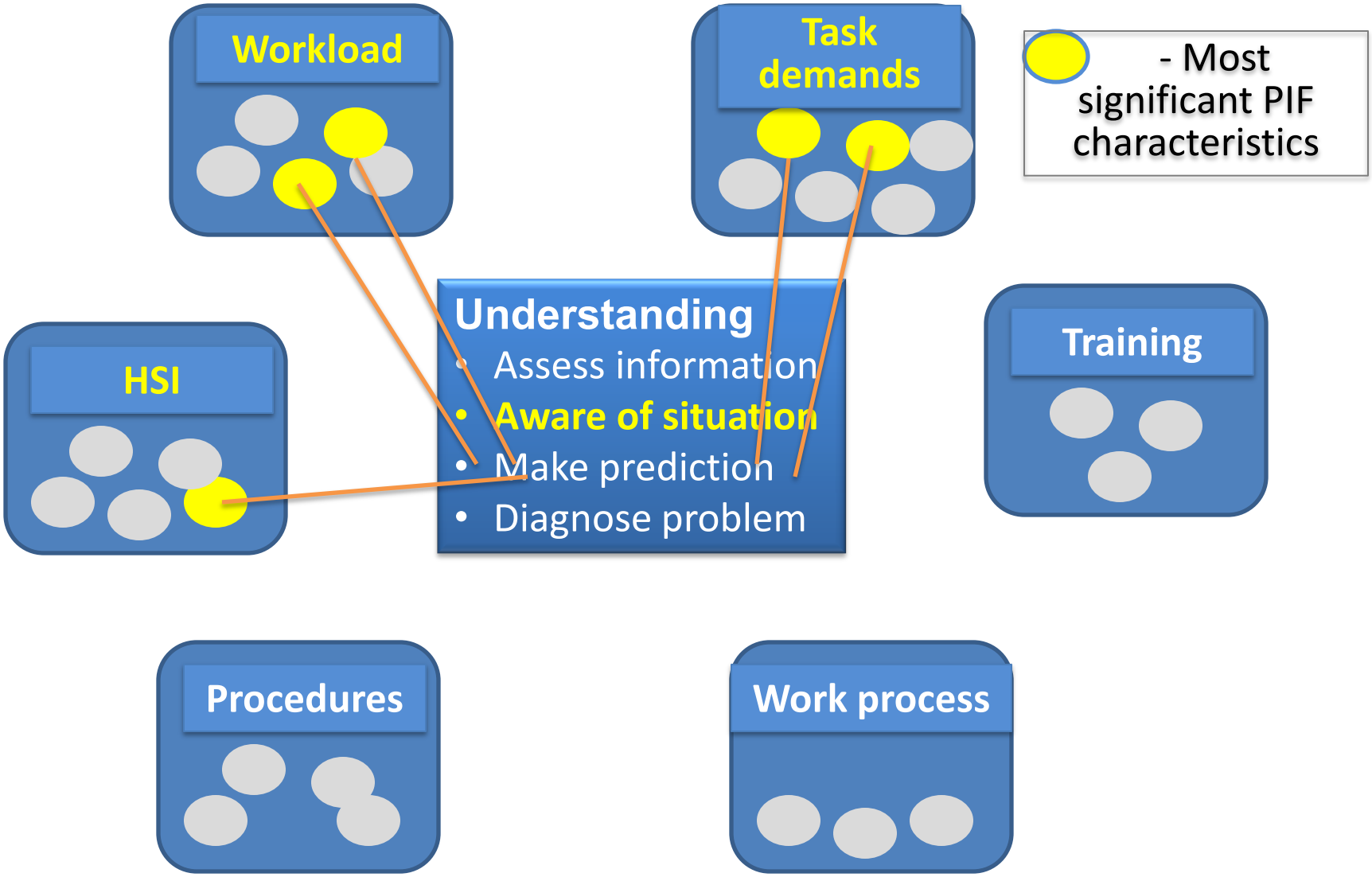


SPAR-H quantification

- SPAR-H models two cognitive functions: Cognition (Detection & Understanding & Decision-making) and execution
- HEP is determined by the multipliers of eight PIFs and the base HEP.



Detailed failure-mode analysis



Objectives of cognitive functions

Objectives of a cognitive function are the types of cognitive subtasks to achieve the function.

Objectives were identified by classifying human activities required by NPP systems into generic cognitive tasks (studied in the literature).

Example objectives for *Understanding*

- Assess and verify information
- Develop coherent understanding of the information
- Maintain situational awareness
- Make predictions and expectations for the upcoming situation
- Diagnose problems

Generic task failure modes

Generic task failure modes represent possible types of failure of cognitive task objectives.

Example task failure modes for the *Understanding* function

Objectives	**Generic failure modes**	**CFMs for internal at-power events**
Assess and verify information	Not assess / verify conflicting or ambiguous information	Critical data misperceived
Maintain situational awareness	Fail to maintain situation awareness	Critical data not checked with appropriate frequency
Diagnose problems	Diagnose the wrong causes to the problems	
	Incomplete diagnosis	

Represent a failure mode in a Decision Tree (DT)

A DT consists of branches representing the context characters that are **most relevant** to the failure mode for the specific task domain.

The internal event IDHEAS method has DTs for the 14 CFMs.

To develop DTs for task domains other than internal at-power events:

- If a failure mode is an internal CFM, use the existing DTs in the internal event IDHEAS method and modify it as needed by

1) examining the character list to identify additional significant characters,
2) adjusting the DT branches.

- If a failure mode is not an internal CFM, develop the DT by

1) examining the context character list, and
2) selecting the characters that most significantly contribute to the failure mode.

HEP estimation

Obtain the HEPs in the scoping and detailed failure mode analysis

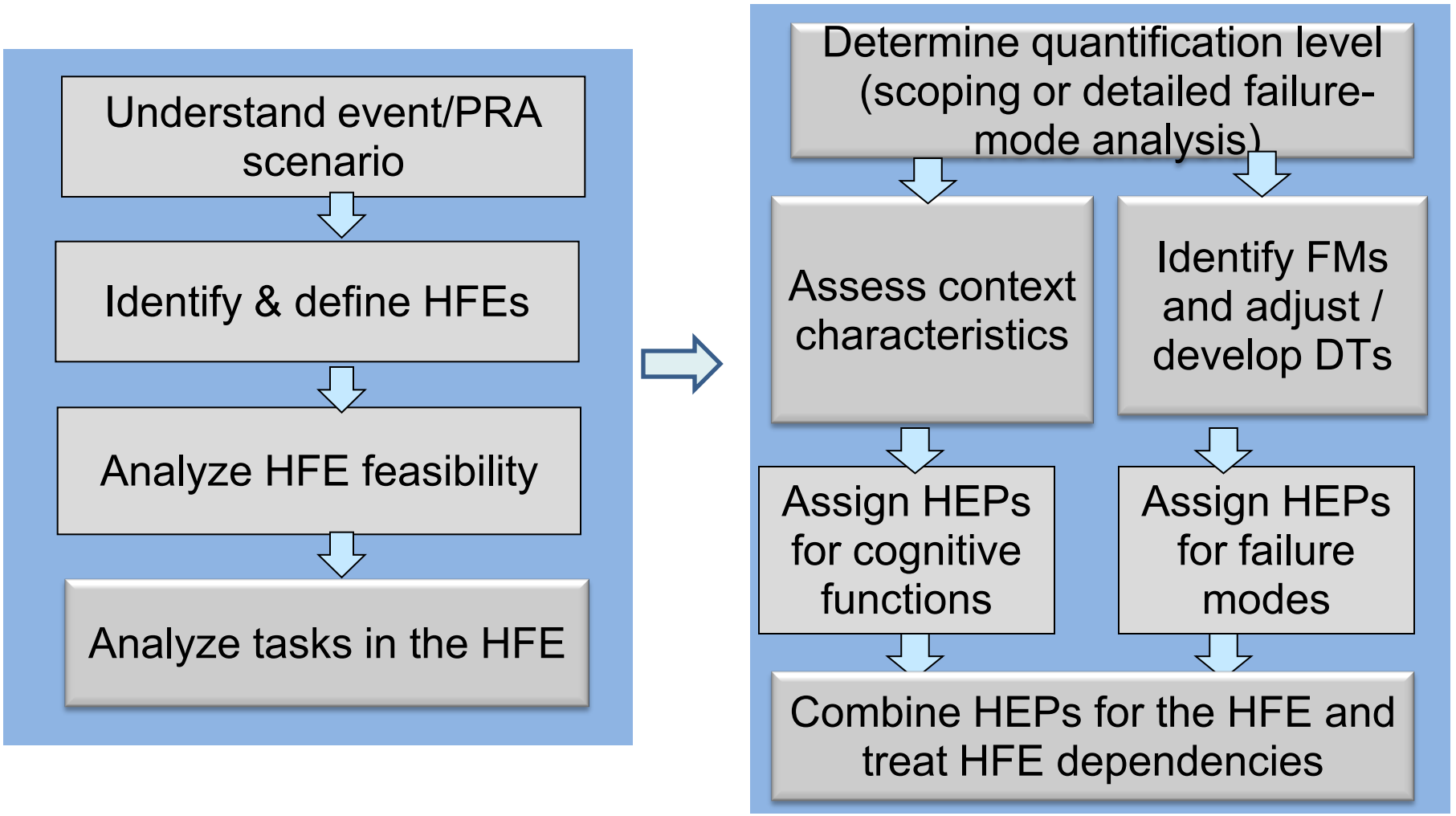
Short-term goals:

- Obtain HEP estimates through expert judgment;
- Provide guidance for expert elicitation of HEPs;

Long-term goals:

- Data-driven HEP estimation - Use the data from SACADA and other data sources to calibrate HEPs.

Implementation of the methodology



Status and path forward

2012 – Developed the basic framework

4/2013 – NRC development team formed
(HRA/PRA staff from RES, NRR, Regions)

4-7/2013 – Work out the scoping analysis method

8-12/2013 – Test the methodology in selected
elements of Level-2 PRA

Summary

- The generic IDHEAS methodology is an integration of state-of-practice HRA methods with enhancement.
- The methodology is intended to be applicable to all HRA domains in NPP.
- The methodology needs to be explored with its intended applications (e.g., LPSD, Level-2 PRA).
- Further development and refinement of the methodology will be made through exploration, piloting, and testing.