Official Transcript of Proceedings

NUCLEAR REGULATORY COMMISSION

Title:	Advisory Committee on Reactor Safeguards Reliability and Probabilistic Risk Assessment
Docket Number:	(n/a)
Location:	Rockville, Maryland
Date:	Wednesday, September 18, 2019

Work Order No.: NRC-0572 Pages 1-399

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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RELIABILITY & PROBABILISTIC RISK ASSESSMENT

SUBCOMMITTEE

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WEDNESDAY

SEPTEMBER 18, 2019

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ROCKVILLE, MARYLAND

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The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2D10, 11545 Rockville Pike, at 8:30 a.m., Dennis Bley, Chair, presiding.

COMMITTEE MEMBERS:

DENNIS BLEY, Chair
RONALD G. BALLINGER, Member
MICHAEL L. CORRADINI, Member
VESNA B. DIMITRIJEVIC, Member
WALTER L. KIRCHNER, Member
HAROLD B. RAY, Member
JOY L. REMPE, Member
MATTHEW W. SUNSERI, Member

DESIGNATED FEDERAL OFFICIAL:

CHRISTIANA LUI

C-O-N-T-E-N-T-S

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

8:31 a.m.

CHAIR BLEY: Good morning. The meeting will now come to order. This is a meeting of the Reliability and Probabilistic Risk Analysis Subcommittee of the Advisory Committee on Reactor Safeguards.

I'm Dennis Bley, Chairman of the Subcommittee meeting. ACRS members in attendance are Ron Ballinger, Joy Rempe, Vesna Dimitrijevic, Walk Kirchner, Harold Ray, and Mike Corradini. Matt Sunseri should join us this afternoon after his flight arrives.

Christiana Liu of ACRS staff is the designated federal official for this meeting. And she is, so we can go ahead.

This is the first meeting of the Reliability and PRA Subcommittee since the passing of Mary Drouin on September 5th. For many of us she's been a colleague, a friend, and well, once in awhile an antagonist.

For all of us in the PRA community she has been a moving force as an analyst, and manager of PRA projects. And later at NRC a leader in the development of many PRA related programs.

She lead the earlier HRA work on ATHEANA for awhile. And was instrumental in the development of the PRA standards. And was the leader of the Technology Neutral Framework Project more than ten years ago, which has risen again in the form of the Licensing Modernization Project.

She was awarded the Distinguished Service Award from the NRC. And I think we can say, Mary, we'll miss you. We do miss you.

The Subcommittee today will hear presentations, and hold discussions with the NRC staff on a draft NUREG report, NUREG 2198, the General Methodology of an Integrated Human Events Analysis System, referred to as IDHEAS-G.

The Subcommittee will gather information, analyze relevant issues and facts, and formulate proposed positions and actions as appropriate, for deliberation by the full Committee.

Before I get into the rest of the boiler plate, I want to give just a short history of this longstanding project. Some for new members, and some for others who just weren't around during the early part of that history.

The history of HRA really began back with WASH-1400 in early '70s, late '60s. Most of what I'm reporting here took place before many of the folks here were involved. So, there's very little overlap with the slides the staff's going to present.

In the '70s and '80s there were very early HRA methods of three different types, decomposition or database techniques. THERP, ASEP, HEART, were the leaders among them. Time reliability approaches like TRC, HCR/ORE, and expert judgment based techniques, simple judgment, direct numerical estimation, paired comparisons, SLIM, and confusion matrices.

All of these methodologies addressed questions from the PRA team in the form of, what's the probability that operator fails to do something? That's what the PRA team sent over to some PRA analysts who may or may not have been part of the real PRA team.

Some years later, primarily the '90s and early 2000s, there was an effort to try to bring cognitive basis, and understanding of the cognitive basis of human error, and the interdisciplinary nature of human performance.

And the set of methods that became known as second generation methods, ATHEANA, CREAM, CAHR, ADS-IDA, and MERMOS, one of the first. And they really took a new view of human error. Not as really a failure of humans, but as a symptom of trouble deeper inside the system. Not where people go wrong, but where the overall system sets up the people for failure.

Given the growing number of available methods, and at one point I counted about 40 of them, depending on what you call methods, the Commission in about 2006 asked the ACRS to work with the staff to propose either a single method or guidance on which models to use when. And the staff will tell us more about that, the SRM.

That SRM led to a number of international meetings. And they were coincident with the Halden and US HRA empirical studies, sort of benchmark studies. This Committee has heard from those studies along the way.

The general community agreed that a hybrid method, borrowing on qualitative and quantitative approaches for many of the others was the best path, rather than trying to develop something new from scratch. And that concept is what turned into IDHEAS. And IDHEAS-G we're hearing about today.

I'm going to depart from my usual approach in these meetings, and offer some preliminary comments. I did it primarily because of my own bits of frustration as I was reading the report, and things I've heard from other members, in the hope that it may allow us to focus better on technical details once the presentations begin.

So, I'm going to take a quick walk through the report. The structure of the report, at least from where I sat, kind of overwhelms the reader with high level philosophy.

It kind of makes it hard to believe that there's a usable method hiding inside here. You're likely to lose your readers and potential users before they get to the part that would make them feel better.

I think there's an easy way out for that problem. And I think that means expanding Chapter 1, and the beginning of Chapter 2. Perhaps with well constructed graphics to anticipate reader complaints.

Stressing why Chapters 2 and 3 are needed. To provide a basis for applications, and promising that the method will continue will come after the preliminaries are done.

In Chapter 2 you really, I think, need to explain why some new language and concepts have been chosen. And point to the appendices for additional information.

A very brief summary of the scientific

basis in 7.1.2, with a pointer to the appendix section would go a long way to calm any discomfort that people run into in Chapter 2. I think those could help a lot.

I'm going to buzz through the chapters kind of quickly, and just give you some high level comments. These are just from me.

The Introduction, subject to the caveat I just went through. I found a great improvement. It's organized top down. And I think it tells the story pretty well.

Time will tell if it really helps this deliver easy to use, and that's a quote, application specific HRAs. You haven't improved that yet. Or maybe you will this afternoon when we see your first applications.

Chapter 2, the cognition model-cognitive basis structure. I think just the title of it, Chapters 2 and 3, either you need a parallel subtitle for Chapter 3, or just call this one the cognitive basis structure. Because it's sitting there trying to figure out why you got sort of half the same name.

Because of the chapter organization, first read through this really feels very high level philosophical, rather than a useful categorization that really is, that will be helpful the rest of the time. It's kind of jargon filled and cryptic.

Figure 3, when you come to it, with all the cross connections is really not helpful without some more explanation. These new names pop up for the first time. There are lines that you don't know why they're going where they are.

Macro cognitive functions, these are the terms, processors, cognitive mechanisms, and performance influencing factors, PIFs, are introduced without really explaining the choice of language, and labels, and what they mean.

In Section 7.1.2 scientific basis, we get to that. But it's really rather late for a reader who's been struggling now for many chapters, if they made it that far, without at least some pointer back to that section, or a brief excerpt from it.

In Section 23.12345, for each of the macrocognitive functions I think if you introduced each of those with the figure that comes way at the end, people will see that structure. And then, those next Sections 1, 2 will make sense.

And the Section 3, that's really how you disrupt the cognitive mechanisms, would make more sense. At least for me, it took several readings to kind of figure out what you were doing there.

And then maybe Figure 2-3 will kind of make sense if it comes at the end. But I'm not sure if we'll need it or not. Something like it comes up again later in the report.

Chapter 3, the cognition model, had a phrase that at first put me off. It was, the PIFs model context. And I was thinking back to when we were applying ATHEANA. And what we found there was when we looked at the human, and the system level context.

Once we specified that in a qualitative analysis, the PIFs were kind of fixed from that. And on reflection I think it's the same, we're saying the same thing.

You do a good qualitative analysis. Then the PIFs model what you've already found in the context. And you can use that in the quantification. So, I think that it works well. It was just a little awkward. I'm not suggesting you change that.

The PIF criteria seemed to me a really desiderata. I am not sure there is any way to achieve orthogonal PIFs. You want to try to. But you probably can't.

And it's difficult to have no overlap.

Maybe you can. So, it's more of what you want, rather than, this is a criteria. And we won't go forward until we meet them.

In any case, in Chapter 3 you need to point to the PIF appendices, which are A and B. They're a little cryptic. But pointing them out will be helpful.

Chapter 4, the integrated process. The introduction to Chapter 4 is a little late to tell the reader that the appendices represent the guidance. I think that needs to come a little earlier, with a reference to the back.

Because you're searching for that. You've already said there's guidance. But, where is it? I'm looking all around. And when you get to Chapter 4, or you read the appendices you find it.

I think it works pretty well. But a real example would help. And maybe that's what you're going to show us this afternoon. I'm not sure if that's true of not.

Time uncertainty analysis is probably okay. I might grumble you left out a reference I though was significant there, from 1988.

The generalization of human error data, we'll hear, I assume James will be here to talk about that later? We'll hear about that. I'm not fully onboard. But I don't completely understand it yet. So, I've got to give that one some more time.

And finally, general discussion and comments. You talked about you had this reviewed by 20 experts. You don't say who they are. I'm not sure why. Maybe you can't. Or whether they're paid or volunteers. And did they all really give you comments?

You had one line I think is very cogent. Methodology is intended to be high level guidance, basic principles, not a handbook or manual for HRA practices. So, you make that clear.

You make a number of claims, like guidance is capable of producing good transparency and traceability. Some others you soften and say, it should give us a good result.

I don't know if you really can make those firm statements that you make, if you have a basis for it. If you do, it would be good to say what the basis is.

Section 7.2 is areas needing further research. Two kind of jumped out at me. And one was dependency. And when I read your appendix, I think you're really closer than it seemed that you think.

The material in the appendix gives some nice structure and context, which is the key to many of the more severe dependent events in the operating history.

I think you're pretty close on that. And you need to give yourself more credit. I don't think there's all that much more work to do. I think it's more organizing.

The combined effects of PIFs, you hint at it many times that if you want to use many PIFs there are a lot of practical problems. And there really are. And I think more emphasis on not getting into that situation

You want them available. But you need to pick out the most salient ones. Otherwise, and you do say this somewhere in one of those earlier sections. Everything washes out.

You got a middle kind of quantitative result. People aren't able to down score the ones that aren't as important, as the ones that are. And you really, it gets very awkward.

And finally, in your references, I'm not sure if you just haven't had time to clean them up. There's a lot of cases where you give all the authors of papers. There are many other cases where you just say, et al. And that's just a personal annoyance. So, I'd get rid of those.

Back to the meeting. The ACRS was established by statute, and is governed by the Federal Advisory Committee Act, FACA. The Committee can only speak through its published letter reports.

We hold these meetings to gather information, and perform preparatory work that supports our deliberations.

The rules for participation in all ACRS meetings were recently updated, and announced in the Federal Register on June 13th of this year.

The ACRS section of the NRC public website provides our Charter, By-laws, agendas, letter reports, and transcripts of all open and full Committee meetings, including slides presented there. The meeting notice and agenda for this meeting were posted on that website.

As stated in the Federal Register notice, and in the public meeting notice on the NRC website, interested parties who desire to provide written or oral comments may do so, and should contact the designated federal official five days before the meeting, as practicable.

We have received a request from Mr. John

Stetkar. The time to make oral statements is when we proceed to the public comments item on today's agenda. In addition, there will be time set aside for spur of the moment comments from other members of the public attending or listening to our meetings.

We have a bridge line established. You've heard it beep several times. For interested members, and for the public to listen in. To preclude interruption of today's meeting the phone bridge will be placed in a listen only mode during the presentations and Committee discussions. We will unmute the bridge line when we proceed to the public comments agenda.

A transcript of the meeting is being kept, and will be made available on the NRC public website. Therefore, we request that participants in this meeting use the microphones located throughout the meeting room when addressing the Subcommittee.

The speaker should first identify themselves, and speak with sufficient clarity and volume, so that they may be readily heard. Make sure, for all of us, that the green light's on when you talk. And turn it off when you're not talking. The button is the nearest point of the microphone to you, where it says push.

At this time I request that meeting attendees and participants turn off, silence their cell phones and other electronic devices. We'll now proceed with the meeting. And I'm going to call upon Sean Peters of the NRC staff to begin. Sean.

MR. PETERS: Yes. Thank you, Dennis. I would like to personally thank the ACRS Subcommittee for allowing us the opportunity to come and present our work.

I do feel a lot of the introductory presentation that I was going to give has been graciously done by Mr. Bley.

CHAIR BLEY: Come on. I don't think so.

MR. PETERS: But, and also, we have a lot of great comments to consider. So, I look forward to getting the transcripts from the meeting. We, just going through the slides real quick, we're talking about our general methodology. And these are the acronyms that we use later in the slide.

And I'm the Chief. I'm Sean Peters, Chief of the Human Factors and Reliability Branch. And this work has been part of my life for I guess about 11 years now. And I'll give you a little bit of history of why that's been a part of my life for 11 years.

So, why are we here? Dennis discussed

that, with the SRM 061020. And this is really a tasking to the ACRS Subcommittee, to choose a method or set of methods for the Agency to use.

I had the pleasure of, thanks to Jonathan DeJesus. He pulled out the meeting transcripts from the 2006 SRM. And I also got to talk to Dr. Apostolakis a few months back, and ask him a little bit about the history of this work.

In the methodology, in the Commission hearing they really talked about the NRC staff having three methods, and the industry having one. And that they were looking for some type of consolidation between us and the industry, as far as, can we kind of coalesce around a central theme, or concepts that we find acceptable.

That's kind of what they proposed to the Commission at the time. And they were talking about it in the meeting. And then they came back with this SRM, which is, kind of expands on it a little bit that, you know, we need to work with internal, external stakeholders.

And we need to at least, if we don't coalesce around particular models, we need to get guidance on particular methods, and when they can be utilized.

So, kind of a little bit of a timeframe, a timeline. So, we started a lot of this work before the 2006 SRM, by developing the HRA good practices, and evaluating those methods against the good practices.

And we have the reports. And I think we presented to the -- This was right before my time. But I think we presented to the ACRS Subcommittees on that, on those results of the HRA methods versus good practices.

I was just reading those slides yesterday. So I, just to refresh my memory. And around that same time, in the 2006 timeframe we started out international HRA empirical study, 2006, 2007 timeframe.

And coming in that international study, and looking at the best practices, what they were finding was that there really wasn't a methodology, or even a set of methodologies that really scratched the itch for all scenarios.

So, most of the methodologies that have been out there and developed were developed for a very specific context. And they simplified the human action so that it could be utilized for that particular instance.

And what was a big beef in the Commission meeting was that people were now taking these very simplified methods, and they were applying them outside of their original intent and scope.

And so, that's kind of where we were. And coming with an international study, and say in the 2008, 2009 timeframe, we were starting to get the preliminary results back from that study.

And we determined again that there wasn't just one method that really fit everything. But we found there were a lot of good pieces of all the different methodologies.

So, what the staff and our partners, including industry, what we decided at that time was that we would take what we thought were some of the best practices of each of the methodologies. And try to combine them into one method. And that's where we started in that timeframe.

And so, you got to look at in that timeframe, in the 2009 timeframe, this is pre Fukushima, the almost entirety of what we used human reliability for was internal events at power conditions. Basically modeling design basis accidents, and how we would proceed forth through those scenarios.

So, we started that. And it took a long time to get ideas that were consolidated. Because when you're working with a ton of people, we had a, basically we had a ton of cooks cooking one pot. And eventually we got down to a consensus, and were able to pull that together.

But when Fukushima hit in 2011 we had a different concept. We saw a lot of interest being sparked beyond this internal power applications methodology.

We learned that, you know, we're going to need a method that can do stuff beyond, outside of the control room, for external actions, for FLEX equipment.

And then, when we started thinking about this as a team, we determined that, well, HRA is not just going to be for nuclear power reactors in the industry in the, or in the NRC in the future.

We think that we need a methodology that can not just do power reactors, but could do like spent fuel storage transportation. Could help with security perhaps. Could help with medical events.

So, we needed something that was a little less reactor focused, but more human centered. And that's where we started down the IDHEAS-G process.

So, I'll go to the next slide.

These are just the references. So, this is just a repeat here on the bullets for IDHEAS-G. So, we evaluate all the HRA methods. And they had strengths and weaknesses.

And we wanted to integrate those strengths and weaknesses. We wanted to improve our application scope. We wanted to improve the scientific basis, with the goal of reducing variability. This is one of the big issues in the 2006 SRM.

And we wanted to try to improve the use of data. We wanted to increase the amount of data we utilize, and rely less on expert judgment. That's a long term goal for us.

So, the intended uses of IDHEAS-G. Really the concept for IDHEAS-G is to be high level guidance, so we can develop these application specific tools. So, we can do the simplified tools for the particular problem we're solving.

And we've had the distinct pleasure over the last few months of being able to do that. We had a very major push from our internal staff, and from industry, that they want to be able credit FLEX equipment in their HRA scenarios and their PRA scenarios.

And what we've been able to do is develop an IDHEAS-ECA tool in a matter of a few months, that we will be testing. So, we'll be talking about that in a little bit. But that is a simplified methodology based upon the IDHEAS-G.

Unfortunately, the timeline for delivery of that is at the end of September here, early October. So, it's a little bit, just a few weeks late for letting the ACRS Subcommittee take a look at it. But we're still working on that right now.

The other intended uses of IDHEAS-G, it can be used as a platform to generalize data from various data sources, so that we can inform our human reliabilities.

We can use this, as Dennis was indicating he saw that it might be a little cumbersome to use it as an HRA for nuclear applications. But we have utilized it for those application purposes. And we have some examples of doing that.

And you can also use it as a process identification, problem identification resolution tool. So, this would be systematically analyzing human events using that type of format.

So, there's multiple uses you can get out of this. But the real intention for this general methodology was to provide something that is all encompassing and human centered, so that we can then apply it to specific problems.

There's just a nice picture. This is, you guys have seen this in the NUREG itself. But this is just a framework. So, we developed a cognitive basis, along with literature, operational experience, and existing HRA methodologies and data.

We've formed this general methodology. And out of that general methodology, if you down select there are simplified application specific methods that come out of it.

So, that is the extent of my introduction. And I would like to pass it over to Dr. Jing if there are no questions.

CHAIR BLEY: On your last slide --

MR. PETERS: Yes.

CHAIR BLEY: Are there any other applications on your table right now that you're --

MR. PETERS: There are --

CHAIR BLEY: -- maybe going to pick up?

MR. PETERS: There are none at the moment. I actually have a kind of belief that once we have IDHEAS' ECA out, the Event Condition Assessment out, that will be utilized quite extensively for most applications that we use.

CHAIR BLEY: Okay. Thanks.

MR. PETERS: But nothing, there's no push right now to develop a new scenario. But you never know in HRA. I never knew we would be doing this beyond design basis HRA stuff back before 2011. So --

MEMBER REMPE: So, some of these documents were co-authored, or whatever, collaborative efforts with industry, right?

MR. PETERS: Yes. So, the idea is internal events had power application. So, NUREG 2199 was our original intent and scope of the IDHEAS project. And that was fully collaborated with industry.

MEMBER REMPE: But this G was not. And that was industry's decision, or --

MR. PETERS: Yes. Industry decided that it didn't need a general methodology. It already had an HRA toolbox and, or HRA calculator. And they thought that they had what they needed for that time.

The interesting part is, now within the last year or so they realize they didn't have all the pieces they needed. And they ended up developing their own approaches to handling things like FLEX equipment, external events. But --

MEMBER REMPE: So, this IDHEAS-ECA would show up under your other specific HRA applications. But it's not collaborative with industry? They did their own?

MR. PETERS: We are collaborating right now with industry. So, they didn't collaborate in the initial development, because this is a subset of IDHEAS-G.

But what they are collaborating with, and we'll talk a little bit more about it, is the actual testing and implementation. And they're providing feedback.

So, I'm missing some of my key HRA people here today. Because they're out at the Peach Bottom Site right now, with industry teams, trying to model FLEX scenarios. So, developing. And we'll talk more about that later today.

MEMBER REMPE: But they're not going, where will this IDHEAS-ECA, it's a separate document, right?

MR. PETERS: So, this will be a separate document. And there's also a computerized tool that we developed, that we'll show you guys later.

MEMBER REMPE: So, it will be a NUREG?

MR. PETERS: It will be a NUREG plus the

tool. So, an actual --

CHAIR BLEY: We have sessions on that this afternoon.

MR. PETERS: Yes, we do. We do.

MEMBER REMPE: Yes. I just was like looking at your framework, and wondering --

MR. PETERS: So, it's --

MEMBER REMPE: -- why I don't see it up there.

MR. PETERS: It's actually the middle box on the very bottom. So, IDHEAS is for event and condition assessment.

MEMBER REMPE: Oh that's, okay. You're right. It's there.

MR. PETERS: Yes.

MEMBER REMPE: And --

MR. PETERS: But it's really small print. So --

MEMBER REMPE: Okay. Yes, it's, well, I just was expecting to see that. But it's not collaborative with industry. It will be, or when you finally issue it, it will be --

MR. PETERS: Well, the development wasn't. But the actual, the feedback from industry groups about its usability and function, we will be taking them into account, to update. So it's, I would call it semi collaborative with industry.

MEMBER REMPE: Okay.

MR. PETERS: Because they are on the testing teams --

MEMBER REMPE: Okay.

MR. PETERS: -- for it.

MEMBER REMPE: Thanks.

MR. PETERS: Jing.

DR. XING: Okay. So, are we going to switch?

MR. PETERS: Yes. We can switch if you like.

DR. XING: Okay. Okay. Good morning, everyone. I'm Jing Xing, a senior human performance engineer, working for Sean. And this, today is my 12th time presenting ideas to ACRS committee over the last seven years.

And I really appreciate all the input we, our team have been received from ACRS over this long time period. And I appreciate Dr. Bley's comment on our report up front. And promise that we will address those comments, as we've been doing in the past.

So, for this to present ideas we are going to have a three part presentation. So, the first part, much like this morning, we'll present you the general methodology of IDHEAS, the IDHEAS-G.

Then followed by that I will talk about the IDHEAS-G application that Sean already mentioned, later a bit. And at the end of the day, and I'm sure we will have time, we will give you a demonstration of the IDHEAS-G application, which is IDHEAS-ECA software that we've been developing over the last three months.

So, I'll go, and the first part will be presented by me and Jonathan. But I like to thank for Jonathan made all the slides in the first part. That was a lot of work.

Okay. Just a quick view of IDHEAS-G. So, when people ask me, what is IDHEAS-G? And I will answer, IDHEAS-G has two part. It has, IDHEAS-G include a cognition model that model human performance aspect, and HRA process that implement the cognition model.

So, cognition model has two part, a cognitive basis structure that models the internal process of human cognition, and a PIF structure that model the context, which has a condition set with a factor human performance.

Then we implement the basis of cognition model in four stages, which Jonathan will give you the idea. And the little box in between is indicating the cognition model allows us to generalize the human error data from a variety of sources.

And we use that to support HEP quantification. So, that part I will talk in the afternoon.

So, start with the overview of the cognition model. And thanks for Dr. Bley's introduction. I guess I don't need to justify why we started this project about the developing the cognition model.

Mainly we want to understand the how and the why human success and failure from task. So, I'll talk the first part is cognitive basis structure.

So, this is a diagram of the cognitive basis structure. HRA models important human actions, which we call the human failure event in PRA models. A human action typically consists of one or several displays or tasks. So, sometimes actions too vague, we break down into tasks for easy analysis.

So, every human task can be modeled There's five macrocognitive functions, the red boxes you are seeing here. Macrocognitive functions are hard to come up with definition. They are the high level brain functions that accomplish a task.

So, this slide might help better what are the function. So, these five functions, just to think about you do any task. So, first function is detection, which is noticing the cues and gathering information in your working environment.

Then with that information you would come to the function understanding, which is the integration of pieces of the information in the working environment, with the person's mental model, your previous understanding of this matter. So, to make sense of the actual scenario or situation.

Then it's the decisionmaking. The decisionmaking is easy, just making decision, which would include activities like selecting strategies, planning, adapting a plan, or evaluating options, making judgment on qualitative or quantitative information.

And with all this you come to action execution, which is the implementation of your decision or plan, typically this involve make a change in some physical component or system.

And we also model teamwork. I would like to emphasize that the teamwork here is specifically to address the interaction and the collaboration among many teams, like in a complicated event such as prioritize or allocating resources, oversight all the communication between different parties. So, that's the teamwork part.

CHAIR BLEY: Jing, before you leave this, these macrocognitive functions look and smell a lot like what used to be called, at least one form of an information processing model. Is this somehow different? And if it is, what are we focusing on that makes it different?

DR. XING: Yes. The information process models in the cognition science allows the study to talk information process model. And you see lots of terminology kind of same, like detection, or understanding.

But the main difference from the microcognitive function for information process, information process model typically focus on the macroprocess. The microprocess, which is a much detailed level. In fact, my next slides will probably show you what are the focus of the information process.

CHAIR BLEY: Okay.

DR. XING: And this slides are just to Dr. Bley's early comment. It's very instructive if I just talk. This is a, this slide. This shows what is the cognitive basis structure look like.

But if we go through the bigger later on in the report it will help. So, I'll just go this. So basically, this shows our, how our cognitive basis structure look like.

For every macrocognitive functions, which on the left most box, we delineated a set of, it was shaped by a set of information processors. Yes, that's what you asked. And so --

CHAIR BLEY: Yes. It's a new term for this set of things. And --

DR. XING: Yes. I try, yes. We use for all our previous versions, for those of you who have been with us for this, yes. We used to call this as proximate causes, which means it immediately cause to the failure of the function.

And in 2017 we had, our internal staff reviewed our version of report that we never presented to ACRS. And the internal staff had a lot of the concern with the use of that term.

And say it's conflicting, or have a different, kind of causing confusion with the staff, some similar term for different meaning PRA. So, we tried to figure out a different term. It's the same thing as we've been talking proximate cause for the last, for the first five years.

CHAIR BLEY: So, these are processes that you're --

DR. XING: Yes, these are --

CHAIR BLEY: -- listing here.

DR. XING: They actually are --

CHAIR BLEY: So, it's probably a good term. But it's new for many of us here.

DR. XING: Yes. So, regardless of what we call that, what would be the best term for this, it means macrocognitive function is achieved through a series of these processes.

So, taking basis of detection as a example. Say one way to do detection information process model would just say, okay, I, you show something on the computer screen, or in my environment. I look. I see. That's it.

But in term of macrocognitive function, that to perform the task in complicated environment, you started with the, you start with initiating the detection, which means you establish a mental model for what information you're going to see.

Like, in the control room there are thousand alarms. You have to know which ones you are going to pay attention. And then you would select identify, and attend to the source of your information.

Again, a simple information process model may only have one or two source of information there. A real working environment can have thousand of pieces, source of information.

And then, these three is very much like information process model. Models that you will perceive the information, recognize what it is. And you most likely, you will categorize or classify what's this information.

This is alarm. But what type of alarm? And that's not the end. Again, think of in a control room environment. You take that, perceive that information.

You would verify the information. And you will probably modify the outcome you're detection. That verification can done by yourself, and by your peer checking or supervision.

So, when also you found information is confirmed, you want use that information. You either retain on yourself, I remember I'm going to use that for my decision making on next process.

Or you communicate with other members of your crew. Or you may record it somehow for later use. So, this whole process from D1 to D5 accomplishes the detection task.

CHAIR BLEY: So, the detection cognitive mechanisms are the, between the error stuff that either works or doesn't work. And for each of these you give us a selective list of things that might disrupt these mechanisms, and make it a source of error, if you will.

DR. XING: Yes. So, we call this the processors, and then the brain, the neuro, the neuro side of behavior subscription. They have this, what later are called mechanisms that can make this processors work, and to make sure they work reliably.

So, these mechanisms have their, only works under certain conditions. The brain is not infinitely capable. Beyond those conditions they were less effective, or not effective at all. That's when people can make a mistake, make errors in the processes.

CHAIR BLEY: Somebody on the phone line isn't muted. Please mute your phone. Go ahead.

DR. XING: Okay. So, we can look at why it's some of the mechanisms. I think we probably, most are comfortable with attention. So, attention is a brain mechanism that make the resource focus on what you need to.

Without fully attention you still can see some, can see things. But the reliability for you detecting information is dramatically reduced. You, often you will not pay attention, like somebody give you a distraction.

Or you were doing two tasks simultaneously. And you can, when you come back to your primary task you may forgot where you were. That's when you can make a mistake. So --

CHAIR BLEY: Sorry to interrupt you. You're getting very soft for in here. So, either speak more into the microphone, or speak a little louder.

DR. XING: Oh, okay.

CHAIR BLEY: Thank you.

DR. XING: Is this better?

CHAIR BLEY: Yes.

DR. XING: Okay. Thank you. Every time it's our presentation I always need to remind myself speak louder.

CHAIR BLEY: They need to get you on the record. And the folks behind me need to be able to hear you.

DR. XING: Thank you. Okay, remind me if

my voice goes soft again. And see, my attention was on the content, but not the voice. So, that's how the system works. So, cognitive mechanism, given the explanation why you can fail some task.

And on the other hand, as we state later, it will also connect to the performance influencing factors, some performance influencing factor. Kind of like, I was tired. So, I wasn't paying attention. Or I was distracted.

So, this structure allows us to have, understand in detail why a human can, how they can fail. You can fail in any of these processes if you fail detection. And why you fail. And what makes you fail. So --

MEMBER KIRCHNER: May I ask a question? How do you deal with the first category there on the right, the mental model? When I think of say being in a control room, because of training and such you have, let's pick one of the more difficult scenarios, an ATWS.

And we've watched now on plant visits how the team, the operators respond. So, obviously there's a mental model that's been trained or ingrained in --

DR. XING: Yes.

MEMBER KIRCHNER: -- the operators, that when they get this set of cues, this is telling me I have an ATWS situation. And then they start working through the scenario.

But it seems to me very difficult to generalize. I mean, the mental model, what I'm talking about is actually much like constructing the PRA. I mean --

DR. XING: Yes.

MEMBER KIRCHNER: But it's, you know, it's burned in, in short term memory for the operator. I'm having, the intention, you picked as an example attention. And I can see how one can grade that, you know, in a qualitative or quantitative sense.

The mental model strikes me as extremely difficult to build, and very complex. So, how do you, you know, perception of sensory information, that could be, you know, visual and so on.

So, some of them, now pattern recognition strikes me to be very similar to sorting through cues. So, could you elaborate on what you mean there by the mental model? Because I'm having difficulty imaging constructing that --

DR. XING: Okay.

MEMBER KIRCHNER: -- given the infinite

variety of scenarios that could be presented to an operator. And when you get out of the control room, where things aren't controlled, then it's even much more complicated. So --

DR. XING: Yes. Thank you. But I think that your question already had the answer there. But I'll elaborate on that perspective. So, very much as you said, mental model is your understanding, what you learned from training, procedure, instructions --

MEMBER KIRCHNER: Right.

DR. XING: So, how this is, and how you're going. In term of the mental model for detection, one part you already mentioned, pattern recognition. Like, typically control room operators told me they typically don't recognize a single alarm. They recognize a pattern.

MEMBER KIRCHNER: Yes.

DR. XING: How they recognize pattern, that's in their mental model that they, I say baseline of alarms. I know what that means. That's a part of mental model.

Other parts of mental model is within like, whenever you are doing some tasks, let's say you are perform a steam generator tube rupture procedure, you are not just waiting passively, waiting some indication alarm to show up. You have anticipation what's coming up. Again, that's from your training, your experience.

MEMBER KIRCHNER: Right.

DR. XING: And the look, on purpose looking for that. So, the reliability for detect information is much higher if you anticipating the information.

Of course, the down side for this is, you can have mental model introduced to your bias. You are not anticipate something. Something is not important, is not in your mental model. Therefore, you can likely just not see it.

And the other part of mental model is, when you detect something, to perform a detection test you have to have your understanding of the criteria, for example, procedure when detection tasks in the procedure tell you.

Take, it's a pressurize. The pressure has been, is greater than 2550. And it has been steadily increasing. The first part is easy. You recognize, oh, it's 2260. That's, you can say that's greater than 2250.

However, the second part, what do you mean by stabily or steadily increasing? You have to have some judgment here, to say this. Because it's vibrating. It's fluctuating. So, that's also part of the mental model.

MEMBER CORRADINI: So, can I ask a general question? This is much more in detail than I'm used to. Well, so just from a benchmarking standpoint, what does Naval Reactors do for human factors?

DR. XING: I'm sorry. I didn't get the question.

MEMBER CORRADINI: What does Naval Reactors program do for human factors training, or failure analysis?

MR. PETERS: So, we've, I'll step in here. We've only had very limited interactions with Naval Reactors. We've had a recent program where we helped them initiate human reliability analysis in some of their surface fleet.

And what they were doing was, they were taking one of our old models, SPAR-H model, and starting applying it to do a failure analysis. But before, as I understand it, the Naval Fleet has their human factors guidance.

When you're, so I guess I need to make a distinction. There's human factors, and then there's human reliability analysis. And you in fact --

MEMBER CORRADINI: Which one are we talking about today?

MR. PETERS: We're talking about human reliability analysis.

MEMBER CORRADINI: Okay.

MR. PETERS: And so, there has not been a lot done in the Naval Fleet with human reliability analysis until recent times. And this is based upon the two recent accidents that they've had in the Navy. They've instituted a new program to start looking at the --

MEMBER CORRADINI: I see.

MR. PETERS: -- reliability of their design systems. So, human factors tells you how to design a system. HRA tells you when, you know, what are the probabilities of success or failure --

MEMBER CORRADINI: Yes.

MR. PETERS: -- with that system. And so, the Navy has had human factors guidance too. But as I understand, there have been some challenges with implementing that, as evidenced by some of the changes that they've done in their surface fleet.

MEMBER CORRADINI: So, to say it in a different way, just so I understand. So, when you say human factors, there is a training program which they effectively have implemented.

MR. PETERS: Yes.

MEMBER CORRADINI: And they rely on a training program.

MR. PETERS: That's the --

MEMBER CORRADINI: The HRA, and that's human factors.

MR. PETERS: Yes.

MEMBER CORRADINI: The HRA is, given all of that, what's the chance it would go awry?

MR. PETERS: Yes.

MEMBER CORRADINI: And they historically have not done that?

MR. PETERS: Yes. There has not been a human --

MEMBER CORRADINI: Oh.

MR. PETERS: -- reliability program --

MEMBER CORRADINI: Okay.

MR. PETERS: -- in the Navy until just the last year or so.

MEMBER CORRADINI: So, this is more of a digression. The Chairman will tell me to be quiet. Is this under the assumption their training is good enough?

CHAIR BLEY: I think we shouldn't pursue

this one.

MEMBER CORRADINI: Okay. Fine.

MR. PETERS: Okay. Yes.

MEMBER CORRADINI: That's fine. First, they don't share a lot.

MR. PETERS: Yes. You know, that's a good point. I'm only speaking from what I know.

MEMBER CORRADINI: That's fine. And then, so one other one, if you'll allow me. Airlines? Training for pilots? Similar sort of breakdown? Has that been looked at in terms of a benchmark?

MR. PETERS: We have done some pilot studies. So, when we're looking at human error probabilities the airline industry is very similar to our industry.

MEMBER CORRADINI: Oh, okay.

MR. PETERS: Highly trained operators. Highly trained, highly proceduralized in how they train scenarios and systems. And as we've gotten a lot of human reliability data from the airline industry.

MEMBER CORRADINI: Okay.

MR. PETERS: And so, it's, I'm not overly familiar with what type of human reliability analysis they do. But --

MEMBER CORRADINI: I was just trying to understand similarities. Because --

MR. PETERS: There are.

MEMBER CORRADINI: As you get into the details it kind of loses me. But that's okay. Sorry.

MEMBER DIMITRIJEVIC: Yes. This is what I wanted us to comment. You know, when Dennis gave you the, his overview, he said that these first two chapters confused the people how, this is very nice, you know, detection, understanding, decision making. They all show how humans do something.

But how does this help us to get the human error probabilities? And I will, it actually it is not clear at all. You have break up to, you know, D1 to D5, and the DA to D. And this is all true.

But what does that have to do with anything? That's basically -- So, if you can connect these models to us. Is this only used, like model, mental model of cues do?

For every human action we have to evaluate what is their mental model of cues? Or do you use these to transfer to these performance indicators? What is the point of these break up?

DR. XING: Yes. The point is, just your last sentence. This last layer, the cognitive mechanisms directly tied to performance influencing factors.

In fact, there had been lots of studies, experimental data, and data from other field, like aviation data, has been done on how severe is factors different to performance influencing factors? With a factor there's cognitive mechanisms. Therefore, lead to the errors in the processors.

So, without legend, without these two layers of the processors and the cognitive mechanisms, that's where we were like seven years ago. We just say, okay, workload a heavy impact on these task performance. High workload they are more likely failure.

But we don't speak in detail what aspect of workload, to what kind of, what aspect of a task make the failure. Therefore, our modeling, the estimation for the failure probability can be largely subjective.

So, I when I was think of high workload I was thinking, oh, just too much work to do. I'm stressed. And another person would think, oh, high workload. You gave me too much, and too many. I need to do concurrent task.

So, these two will make a very different impact in term of human error probability. So, with this structure we can model to the specific aspect of the --

MEMBER DIMITRIJEVIC: If you will say, like, workload influences these attention --

DR. XING: Yes.

MEMBER DIMITRIJEVIC: -- or something. Whatever --

DR. XING: Right.

MEMBER DIMITRIJEVIC: -- how many factors. All right. Okay. Well, this is what you want to say. But, you know, if you can correct to us how the, these factor, which maybe you can even move faster than through those. It's one thing we know, how that fits in the big picture.

DR. XING: Okay. Yes. I think that that's --

(Off microphone comment)

MEMBER DIMITRIJEVIC: Right. It's that you hear me.

(Simultaneous speaking)

CHAIR BLEY: It's interfering with --

MEMBER REMPE: But it would be good for it to be on the record.

CHAIR BLEY: The record may be having

trouble.

MEMBER DIMITRIJEVIC: Okay.

DR. XING: Okay. Yes. Thanks for the question. And so, I will not go so into detail for everything --

MEMBER REMPE: Well, okay. So, I'd like to share Vesna's comment. But I don't have her background. But this thing about, don't see how it connects, I really struggled with it.

But the reason why I struggled with it, I saw a lot of examples that didn't make sense to me, to try and emphasize your point.

For example, under understanding. Assess the status based on indirect information. Assessing system status typically involves integration processing and inference from many pieces of information to interpret the situation.

For example, assessment of the nuclear power plant core damage involves many aspects of the plant's status, such as whether the core debris is relocated, whether the reactor pressure vessel is breached, and whether the containment has uncontrolled leakage.

These plant conditions don't have instruments to provide a direct indication. And the crew must integrate multiple pieces of information to determine the status.

It was three years after the Three Mile Island accident happened before they recognized half the core was gone. The crew never had that information. I mean, there was a hydrogen pressure spike.

But it's like, there were examples that I just couldn't see how you would estimate a failure probability, and use it in HRA. I mean, I ended up -- There were other things too where I think there's just typos.

Like, you talk about a steam generator tube rupture. And later then you talk about a ruptured steam generator. And I don't think those things are the same.

And so, I think, like, I don't have the perspective that Dennis and Vesna have. But boy, it would make it easier for someone who doesn't understand all the nuances, to understand where you're going.

But anyhow, I have other examples. I'll bring them. I have other examples I can bring up later that I'd like some clarification on too.

DR. XING: Thank you. So, we'll look into that to say, to import in the report. Okay.

CHAIR BLEY: Don't go past teamwork. Don't go past teamwork. This one smells different than the others. And --

DR. XING: Okay.

CHAIR BLEY: I want to ask you about a couple of things. You say that this deals with inter-team teamwork. And you talk about what that is. And then you say, the within team interactions are part of the other four macrocognitive functions.

I looked back, and they weren't directly discussed under the other four. You might want to bring out, what I'm thinking, I saw some cognitive mechanisms that could be internal teamwork related. But you might want to bring that out in the other four. Because it's not --

DR. XING: Okay.

CHAIR BLEY: When you say it --

DR. XING: Yes.

CHAIR BLEY: -- here, and the reader goes back and tries to figure out, well, where is it? I don't think you find it. At least, you don't find it directly. And just a minor comment.

MEMBER DIMITRIJEVIC: Especially because this actually can improve. All your performance indicators are negative impact on the HRA, based on your formulas you use to calculate.

So, team can actually improve performance. Because you have a multiple inputs to the decision making. So --

MEMBER KIRCHNER: And also can disimprove --

MEMBER DIMITRIJEVIC: Okay. It also can do both.

MEMBER KIRCHNER: -- at times too, which --

MEMBER DIMITRIJEVIC: Yes.

MEMBER KIRCHNER: -- is the worst --

MEMBER DIMITRIJEVIC: Yes.

MEMBER KIRCHNER: Hopefully, in general it does improve the decision making and other factors that you identified. But the teams could work at cross purposes.

MEMBER DIMITRIJEVIC: That's true. So, it's unclear how does this counts.

DR. XING: Yes. One point about the teamwork in the individual functions. It's like earlier when we talked detection. The last two processors.

After you perceived the information, it's one, probably one person perceived the information. You need to go through a verification or explanation.

That's highly rely on teamwork. And there has been lots of studies show that if one person, this peer checking, without peer checking, versus with peer checking. And the versus as supervisor feedback.

So, human error rate are dramatically different in those situations. That's how we model the teamwork aspect in individual functions.

CHAIR BLEY: Yes. And I think you identified mechanisms that either help teamwork or, do a good job or not. But then you give ways in which that can fail. And I think that's kind of the key.

This is kind of similar to Joy's comment. It, you have sort of an example. And you talk about, gee they're, when you model this for nuclear power plant control room, it always consists of three or more operators working together to perform their tasks. Well, that's normal. That's not always.

DR. XING: Yes.

CHAIR BLEY: There are, Robinson Fire. There was a fire at a couple of other plants where you ended up with really two people on the team who were doing that work. And everybody else was doing other stuff. So, that's a normal situation, and not a guaranteed situation. Anyway.

DR. XING: I saw that they have --

CHAIR BLEY: Careful.

(Simultaneous speaking)

CHAIR BLEY: Well, the rule is they got to be there. But if they get tied up doing something different --

DR. XING: Okay.

CHAIR BLEY: -- they're not participating. Go back and read the Robinson Fire story again. You'll see.

MEMBER DIMITRIJEVIC: And so, if you hadn't mentioned, I was told the power internally rise. And you into Level 2, then you have even different sensors making decisions. This becomes much more complicated.

MR. DeJESUS: And that's where we were hoping to have some of this teamwork factors help us calculate, and help us understand for these external teams that interact with the decision making processes.

MEMBER REMPE: I have a curiosity question too. Like, Figure 210 has this whole thing about the field operator detects something, and reports back to the folks in the, I guess the technical support center. He reports back to the supervisor.

Has anyone ever modeled this in a PRA in the past? And do they, I mean, it's more related to Vesna's question. And how this is really going to help doing an HRA analysis in a PRA. And do people really do that? Do we have data for it?

I mean, it goes into this nice figure, and this whole process. But has anyone used this? And what would you do with it if you had that ability to model it?

MEMBER DIMITRIJEVIC: Well, I mean, there was -- Yes. People make attempts to model that in the Level 2, you know. But everybody has a different solution. There was a couple of papers in conferences on those subjects. But, you know --

MEMBER REMPE: Because again, I don't look at this stuff. But people actually do this? And try and get data to simulate this? Because it just seems like it --

MEMBER DIMITRIJEVIC: Well, there is no data. There is no data. This is all based on the models.

MEMBER REMPE: So, you might put a 50 percent probability for failure, with plus or minus a factor of whatever on it?

MEMBER DIMITRIJEVIC: I estimate those in performance indicators, you know, what is impacting his performance.

MEMBER REMPE: Okay.

MEMBER DIMITRIJEVIC: How much time he has, and things like that.

MEMBER REMPE: Okay. So, this is a valid thing to be --

(Simultaneous speaking)

CHAIR BLEY: -- qualitatively this way lets you see where there might be problems.

MEMBER REMPE: Okay. So --

CHAIR BLEY: And then maybe you have to use judgment. And maybe it's not so funny if it's a .5, you know. Maybe it's something different because there's a lot of confidence that it ought to work. But yes. At least you can understand what's going on, and where the problems could crop up. And that's what they're trying to do here, I think.

DR. XING: Yes.

MEMBER REMPE: Okay. So, I just was surprised. Because I just have not seen that kind of stuff. Again, this is not --

CHAIR BLEY: Well, no --

MEMBER REMPE: -- my area.

CHAIR BLEY: And nobody would lay out a simulation of this with sticking numbers on all those little pieces.

MEMBER REMPE: Okay.

CHAIR BLEY: You just can't. You're right. There's no basis.

(Simultaneous speaking)

MEMBER DIMITRIJEVIC: -- to sound really like steam generators, you know, which you want to use, all right. But when you come to the mouth, you know, you want to scrub.

So, you have a contradictory Level 1 and Level 2 action. It's an interesting area. But nobody ever did the really good job in --

MEMBER REMPE: Okay.

MR. CHEOK: So, this is Mike Cheok. I want to make a comment on what Vesna said earlier, and what Dennis said. I think Dennis said it correctly. So, one reason why we have broken up all these different cognitive factors into smaller chunks, so to speak, is somewhat for us to be able to evaluate human actions. For example, in specific actions.

So, a lot of the useful HRA nowadays is in event condition analysis, ECAs. And in that sense I think a lot of the criticism of the models we have now is that, you know, the, because of the somewhat limited set of performance shaping factors. And the fact that we have very set functions for the probabilities, for the different success levels for these performance shaping factors.

The argument for more refined numbers always was, you know, we didn't have enough factors to talk about. As Dennis had said earlier. I think this allows us to at least in a qualitative sense bring up the different factors that would influence. So, in performance influencing factors.

And then that will actually provide us with a platform for discussion, as to what certain factors should be, in terms of what a probability of a failure of a certain event would be.

DR. XING: Thanks. Okay. I think we already discussed this. Like, why we like this cognitive basic structure. How it help us to understand HRA.

The main purpose for this structure is to help us, give us a systematic way to understand the failure of the human action. So, follow this process.

So, a failure of any macrocognitive function will lead to the failure of the task of human action. The next level we understand, failure of the function resulted from errors in one or more processors.

And the error in the processor may occur if one or more associated cognitive mechanisms do not work properly or reliably. And because PIFs affect the capacity limit of those mechanism, makes it not work reliably.

So, this give us a systematic interpretation, and a more concrete, concise way to model a human failure. So, we, that we move closer to what we want our HRA method. It's all, it's transparency. We can clearly see what, well, what went wrong, why, and how.

Okay. So next, any question, please? I will move to the PIF structure. So again, thanks for Dr. Bley introduce the context concept. So, context are the conditions that affect the human performance of an action. They can either have a positive or a negative context.

And that they are more, they are general descripting. Performance influencing factors, I like to say, we say performance influencing factors it's the same as the performance shaping factors in some HRA method. So, we just call them PIF.

So, performance influencing factor is

actually a model, to model the context. So, Dr. Bley commented on this.

So, as with, one lesson we learned from the International HRA Benchmark Study, one important lesson learned was the PIFs are kind of vague or confusing, say which PIF be like -- Should I use this PIF or that one? What exactly does PIF mean?

So, one direction from that study is, we do need a better PIF model. So, as we started this project we were thinking, what we mean by better? So, we develop this set of criteria. So, okay. That's what we would think. If we can achieve this, that would be great.

So, first of all, initially we put the word completeness there. Then we said, okay, that's never possible. So, it was, okay, the PIFs need to be pertinent to human error.

And they need to be comprehensive enough to address our current knowledge of human performance issues. So, and the way I, we hope they can be independent from each other.

I heard what, Dr. Bley's comment early. But we are still try to make close to this. And they need to be specific enough, so to know what you're reading into this one.

And additionally we have these three, what we decided. They should be explainable. So, if we should be able to explain this PIF. How they affect human success or failure.

And they should be assessable. If you have a PIF there, like we used to have workload in many HRA methods. You have that. People can be at least 100 different interpretation what we mean by workload. So, it should be objective. You can assess it. And --

CHAIR BLEY: IDHEAS at-power kept workload. But you gave it a structure that I thought was very useful at that point. I forgot to go back and compare that structure with the current set of performance influencing factors. You kept essentially all of them, but gave them new names, or something? They aren't called --

DR. XING: Yes.

CHAIR BLEY: -- workload anymore.

DR. XING: Okay. You want me just talk about that?

CHAIR BLEY: I want you to talk about that, yes.

DR. XING: Okay.

CHAIR BLEY: Thank you.

DR. XING: So, first example, in IDHEAS at-power application actually program wise we develop the at-power and IDHEAS-G almost in a parallel way. And earlier we had performance shaping factors there called the workload.

Then, when we come to expert elicitation to estimate how the bad, or not, for workload, a normal workload, how much that related to the human error probability.

The entire expert group spend like about half a day debating what is workload? Then the researchers keep giving example. Then the expert, like trainers, say to supervisor, no, no. That's not workload to us at all. Yes, it's more work. But doesn't mean we're going to make more error.

So, we actually did a small study, combined with what research, the comments related should talk about workload. Then I gave those, that matrix to the expert.

So, now you tell me, what, which one of this you think is workload, which will really be to human errors. So, through that interaction we actually develop a set of matrix actually. Here we call it attribute of workload. Those are --

CHAIR BLEY: Here you call what?

DR. XING: In this report they are more like attribute, PIF attribute, yes. That's when the very beginning we had this concept. Back then we just called it indicators for workload. Those are the seven ones I remember.

The first one, according to the expert, it's a scenario familiarity. If you come to a scenario you're not familiar with, you never trained on, you are doomed to fail. That's the number one, they think, that one. So, that's high workload. And whenever I come to a scenario I'm familiar, that's high workload.

The second one was multi tasking, okay. So, I don't care how much each individual tasks, how many steps I have to push, push, push. But if you want me do multi tasking, I'm going to fail.

And others like the complexity of the test, tank pressure. And they even mentioned that is, you know, at control room, physical demand, and special requirement on your physical manipulations.

So, in IDHEAS at-power we actually break down the workload into many of those indicators. So, that probably explain this, the criteria with which more objective, assessed for, and quantified for.

And this is our goal, try to make the PIF structure to what this means. And we probably never achieve the ideal status. But we are moving toward that direction.

MEMBER DIMITRIJEVIC: So, what do you mean by quantifiable?

DR. XING: Quantifiable, you, because essentially all the HRA method pretty much depend on you assess the PIF. And then either use some kind of data, or expert judgment. Say, okay, this, again use the workload as example. A high workload will make the HIP as a .1, or would increase the HEP three times.

MEMBER DIMITRIJEVIC: I know. But that's not, quantifiable means that you have some method to quantify it. It's a sort of expert judgment. It's a guess.

DR. XING: Yes. So --

MEMBER DIMITRIJEVIC: It's a educated guess.

DR. XING: Yes. So, when we mean quantifiable we hoped the PIF should connect to what we know the human performance measures or human error data.

MEMBER DIMITRIJEVIC: Okay.

DR. XING: That way it was, PIF is the

direct link to those information. Then we can quantify. We can, we're in a better position to quantify.

Okay. A starting point for us to develop this structure. First of all, we reviewed all the PIFs in existing HRA method, make sure we don't missing the ones already there.

And beyond that we also reviewed a number of human events outside the control room. So, make sure we capture the human performance issues, or PIFs, in those domains, like in severe accident, or extreme operating conditions, like a beyond the design basis event.

So, we expand the PIF scope from what we had before. And we also considered the PRA standard, which have a list of PIFs that you should consider this, in the PRA. And we made sure we covered all those ones.

And we also develop new PIFs to address the criteria we discussed in the previous slide. I can give the example, in term of a specific specificity.

Again, so like, we know from the cognitive literature that, actually lots of study, when human perform a concurrent task that will, the human error rate will increase a lot. Before the HRA analyst we observed, they used different. Because there isn't such a PIF explicitly.

So, they use different ways, and to stretch the existing PIF to model this. Some analyst modeled and stress, and say, oh, if you have me do multi task I'm stressed.

And other analyst modeled it as a complexity. There's a PIF there. However, in our SPAR-H model, and in some other HRA method, stress probably they give you a increase of your HEP like twice.

MEMBER DIMITRIJEVIC: Okay. Thank you.

DR. XING: Yes. Complexity can increase up to 50 times higher. So, they assess the same context model in different PIF. Ended up very different HEP.

So, that's the situation we see. We have data. We have a component basis, know the component mechanisms. We make a separate new PIF with concurrent tasks. You're performing concurrent multiple tasks.

(Off microphone comment)

CHAIR BLEY: Microphone.

MEMBER DIMITRIJEVIC: Oh, sorry. How did

you assess that one?

DR. XING: Yes. Okay. In order to assess that, that's actually a PIF we call the concurrent tasks. And you found interruption or distraction. So, they're different when you perform a concurrent task.

If you perform two tasks simultaneously, and both are your primary tasks, you have to do base entry that. And that's the highest impact. Some later data show that when you perform a concurrent task, in fact human errors can increase ten times higher if you're doing the model of detect information.

But if you are doing the diagnosis of problem you are simultaneous at diagnosis to cite a problem. Research data, some experiment shows the error rate can increase 30, up to 30.

One data show this error rate increase 37 times, because you're doing a concurrent diagnosis. Both have some intermingle of the prompters in between. That's the highest level of concurrent task.

The first is from other situation. You have a primary task to do. But you, there's some interruption, had take me one minute or two minute for something else. We can imagine that can happen a lot in that situation.

Or there's lots of study on that kind of multi tasking, which we define as interruption. In hospitals, doctor, nurses work. That's another attribute, effect it has.

And, a lower level on that is a distraction. So, I'm doing my job, just lots of distraction. Like we say -- You have a question?

CHAIR BLEY: I have a question and a suggestion. If I do a quantitative analysis of something I'm interested in for the PRA, some human action, my qualitative analysis ought to identify the potential macrocognitive function areas that could be troublesome.

They ought to be able to identify the processors that could be troublesome. Maybe they'll identify the cognitive mechanisms. With this really massive list of PIFs in Chapter 3, I probably can't easily connect that.

When I go back to your Appendix B I see the connections. But they're complex. I can't judge right now if you're complete there, if you've done a good job or not. But it sort of looks like it. It passes the quick test.

Two points. One, I think it would help

anybody trying to use this, before they get to Chapter 4, to have some kind of statement. Maybe it's Chapter 1, something in the introduction saying, you know, the way you do this analysis is, you do a qualitative task analysis, and identify all the key things. Those will show up in Chapters 2 and 3, and Appendix B.

If I really try to develop a method that uses the plethora of PIFs, and those linkages that I see in Appendix B, you pretty much have to have a computer program that will remind you, if this is your cognitive mechanism, here's the set of PIFs you ought to be considering, from which you could then winnow it down to the ones that are important for your qualitative analysis.

So, I think, I kind of think you need something up front to say, the real starting place is at qualitative analysis. Then you apply these things. That will get you down to maybe the cognitive mechanism level.

And then you, I guess this afternoon we'll see how you're trying to apply it. And you talk about a computer program. I'm hoping that takes me from an identified macrocognitive function processor, and cognitive mechanism, to asking me about the relevant PIFs.

Is, first question is, is that true? Because I don't know how you do it without a computer program. I mean, I can't lay all these tables out and --

DR. XING: Okay. I --

CHAIR BLEY: And I certainly can't remember them all.

DR. XING: I cannot direct say true or not true. Because there are two parts there.

CHAIR BLEY: Go ahead.

DR. XING: The first part is not true. I think that's our fault. We not saying this clearly in the introduction. The bottom layer, the cognitive mechanisms, is the way for us to understand the method.

But we never intended for HRA analyst go through that. So, HRA analyst can stop at the high level. They identify what macrocognitive functions.

CHAIR BLEY: Okay. I can do that.

DR. XING: Yes.

CHAIR BLEY: I agree with you.

DR. XING: What macrocognitive --

CHAIR BLEY: I can do that.

DR. XING: -- function this task. Then they go to, from there they can direct go to assess the PIF attribute, which task --

CHAIR BLEY: How do I get from the macrocognitive function to the relevant PIFs?

DR. XING: Okay. You can, they can just result of thinking about the link, which one link to which one. You can just, you assess the PIF, based on your context. So, I can have this PIF --

CHAIR BLEY: I can do that when I've got six or 12 PIFs.

DR. XING: Yes. Normally you don't get more than that. You were saying this after seeing James' software. Even we have probably 20 PIF, but for each, and not --

CHAIR BLEY: And each of which has many attributes. Right?

PARTICIPANT: Yes.

CHAIR BLEY: Yes.

DR. XING: Well, we, that's we worked in the IDHEAS-ECA, which there are only, we only receive one requirement in ECA from our user. Make it easy to use. Almost as simple as, no more complicated than SPAR-H.

CHAIR BLEY: Well --

MEMBER DIMITRIJEVIC: Are we, will you show this later, how he selects --

DR. XING: Yes.

MEMBER DIMITRIJEVIC: -- which PIF?

CHAIR BLEY: Okay.

MR. PETERS: And you also --

DR. XING: Yes.

MR. PETERS: -- need to understand the difference between the general methodology and an application --

DR. XING: And the specific --

MR. PETERS: -- specific methodology, is that with specific methodologies we try to initially whittle out the non important factors, the factors that wouldn't really apply in the situations this methodology supposed to be used. So, it whittled that set of performance shaping factors down to a more manageable number.

CHAIR BLEY: If we whittle it down to five or six --

MR. PETERS: That's --

CHAIR BLEY: I can readily deal with that.

MR. PETERS: Yes, yes. But then again, that's probably too few for the granularity you want. But there is, we do have a way to do that in our ECA tool. And James will --

CHAIR BLEY: Okay.

MR. PETERS: -- present that.

CHAIR BLEY: So, we'll see it then?

MR. PETERS: Yes.

CHAIR BLEY: And now we need, the reader needs some hint that they'll get help through this --

DR. XING: Okay.

CHAIR BLEY: -- massive detail. And the, you know, like I said, the linkages are hid in Appendix B. But when I start reading Chapter 3 I say, well, how do I connect these? And you do it in the appendix. But I hope you did it well.

DR. XING: Yes. Well, we had a massive set of reviewers that reviewed the early versions of report. Several reviewers suggested, can you just eliminate all your discussion of cognitive mechanisms? Because the PRA analysts don't need to know that to do their job.

MEMBER DIMITRIJEVIC: Yes. That's because well, that is so true. Because for me this is, I have, I'm a new member. So, I will just --

You are all been around. And you think that's a useful matter here. That's what you wanted all the time. And you reading there. Because then you just sort of go with fate. That's what I decide. I'm going to believe that it is a useful matter here.

But I couldn't prove that to myself.

DR. XING: Yes. And that's so true. That's, I think is a, that's the set of, you are be the first set here. And we also had a same comment, similar comment on the same issue but just the opposite.

Say, oh, the company can. Great. And now I understand why they are previously, when I assess the PIF I have always not sure if it's really have a impact on this action. But now, by knowing the mechanism, I know.

So, we've been struggling in this last version, in this recent re-writing. So, we still decide to keep them. But because this is a general methodology.

But in the, in application specific method, like IDHEAS-ECA, you will not see this. This terminology not even appeared in our ECA before the analysts -- That's just the substrate to help us establish the connection.

CHAIR BLEY: I, this is personal opinion. I think the connections you make in Chapter 2 across the processors to the mechanisms are pretty clear, and make sense.

And I think it is a help for people to

understand. And if you want to use any HRA method, you really ought to understand what's behind it, and what's in peoples' heads, you know, that you're trying to model.

The Chapter 3 discussion of the PIFs has, yes, makes sense. But maybe you need, maybe you have the list. Once we get to the tables -- Yes, I don't -- The link from the text to the tables, I'm not sure how good that is.

Maybe I just wasn't reading carefully enough. Maybe it links it. But, you know, the tables have loads of information. And they're good to go through.

But then you wonder, oh, how am I going to use this? Because any one of these could potentially affect any of the key attributes, the processors, and mechanisms, and macrocognitive functions.

So, I think you just need some hints for people, of what it's for. But in any case, I wouldn't get rid of --

DR. XING: Okay.

CHAIR BLEY: -- the concepts in Chapter 2. I think they're pretty important. And after I start using --

DR. XING: Okay.

CHAIR BLEY: -- this I'll go back and study that some more. My worry about HRA methods is, we want something that's fast, easy to use, and you don't have to think. And that leads you into really bad analysis. Go ahead.

DR. XING: Okay. So, we have discussed the most part of what we want to say on PIF structure. So basically, PIF structure we have these four layers. On the top are the four where you categorize the context in four categories.

So, the context can be addressing environment and situation, systems, your working base, personnel, who does the job, and the tasks, what actually you're doing.

So, for each category we have a set of PIF describe them. Then for each PIF we, again to make the objective specific assessable, we develop a set of what we call the PIF attributes, or characterization of this PIF.

And this PIF attribute actually, as Dr. Bley just said, they direct link to the cognitive mechanisms, which showed in Appendix B.

So, we are like look at the, break down the models of context in progressively two levels. The first is the high level PIF, then the PIF attributes. So, if we want to take a look of the PIFs we have. So, these are the --

CHAIR BLEY: Can I --

DR. XING: Yes.

CHAIR BLEY: -- toss in another idea? The table you just had up there, which is Figure 3-2 in the document. If you somehow, in the headings to the tables carried over that, which of those contextual elements that PIF table is about, I think it would help. So, you know, the first four or five are environmental and situational. And that's there. Go ahead.

DR. XING: And then for the, I realize I should practice the requirement, which you need a caption. And for that paper, diagram, for me to explain what each item means. We will do that. Thank you.

Okay. So, I will quickly go through this PIF. This, unless you want me explicitly explain somewhat. So, for the environment and situation context we have five PIFs to model.

So, the accessibility or habitability of a workplace, including the travel path, workplace visibility, and the noise in the workplace, and the communication pathway, like in the, if you use several communication.

And cold, heat, or humidity, and the resistance to physical movement, such as the rain, water on the, still water also same. So, based on that --

CHAIR BLEY: You know, I'm sorry to interrupt you again. But even at this level and these little tables you made, are kind of nice. And maybe, well, you kind of have that in paragraphs in the report.

But, you know, if I'm a user, right here I can look through the environment and situation context, given my qualitative analysis, and I can say, workplace visibility's no problem. There's no noise problem here. There's no resistance to physical movement.

You know, I might have one of these I shall keep. I might not even have any, depending on my qualitative analysis. So then, it clarifies much more quickly which ones you ought to be using. I think some tools, the bigger tables have so much detail it's kind of hard to see the forest through the trees.

DR. XING: Yes. That's exactly the way we hope user to use. Like, IDHEAS-ECA --

CHAIR BLEY: Yes.

DR. XING: We have the, you do the up front qualitative analysis, assess the context, and you quickly narrow down a set of PIF that you want model this, or take a detailed log, a detail. Okay.

Everything happen in the control room, not this going to use. You will not consider this again. But then you say, okay, test the complexity. That's something I need to -- I'm not sure it has impact or not. But I want to know the detail that --

CHAIR BLEY: I'm going to say again, I really like this structure of linking the PIFs to elements of context. And back when we did ATHEANA we saw this sort of thing, that once we specified the context, and we saw we were, you know, that locked in the PIFs.

Why do we even need the PIFs? We've, but you need those for thinking about quantification. I'll give you that. So, this idea that, you know, they are an image of the context is really a good one. Go ahead.

DR. XING: Thank you. And as you can see the structure is highly influenced from ATHEANA. I read ATHEANA report many times, to keep our team try to. Honestly, I know more ATHEANA lines than the original author did.

But it really, we think this is a great concept look at the overall context. That's what really determine the performance. But --

CHAIR BLEY: And that's what you're getting from, you ought to be getting from the qualitative analysis.

DR. XING: Yes. But the one HRA benchmark study, last one was, ATHEANA is the best, you know, help guiding people analyze the context. The problem was how to model the context for quantification. That's why we try to do it here, using this PIF structure.

In the system context, the system is the optics of the actions. So, which the work may take. So, the three PIFs are system and instrument and control transparency to personnel. PRA models reliability of the system and the I&C.

But for the transparency to human operators it's not clearly modeled. And the traditional PIF is a human system interface. And equipment and the tools, which can be more impacting in, at the control side, control room actions, then control room actions.

And the PIFs for Personnel context.

Personnel are the people who do the job, like this, including individuals, teams, and organizations. So, five PIFs are staffing, Procedure, Training, Teamwork and organization factors, and work process.

So, the last category is task context, which, as I said, many of these factors previously were lump into one grandfather factor, which called workload.

Now we model them separately, which including information availability and reliability, and scenario familiarity, multitasking, complexity, mental fatigue at the time you perform the task, and time pressure and stress, and physical demand.

Yes. So, we can look at in a -- Then for each of these PIFs, as we say, we actually, still is hard to judge, to quantify them. How you quantify a good versus a poor human system interface?

That's, we went down first in there to characterize each of these PIF. Use what we called attribute. So, I think it's, we can just look at this example, see what attribute is --

CHAIR BLEY: Can I reinforce my last comment? I think in your tables in the report, and in these examples, if you included kind of a heading here of the contextual element that this PIF is modeling, if that's your word, I think it would help.

DR. XING: Okay. Thank you.

CHAIR BLEY: And I think it would help --

DR. XING: Is that your comment? Otherwise, Jonathan is right behind --

PARTICIPANT: Well, when we get on the --

DR. XING: Oh, we have transcript.

PARTICIPANT: When we get on the --

DR. XING: Yes.

PARTICIPANT: Eventually we'll get it.

DR. XING: Okay. Thank you.

CHAIR BLEY: But who knows what it will say, but you'll remember.

MEMBER DIMITRIJEVIC: You said that you had the, actually I read some of the, you had plenty.

CHAIR BLEY: Microphone, please. So, the guys --

MEMBER DIMITRIJEVIC: I press it and nothing happens.

CHAIR BLEY: We'll have a training session at PNP.

(Simultaneous speaking)

MEMBER DIMITRIJEVIC: You, I noticed actually, and I read in your slide there is 20 PIFs, right?

DR. XING: Yes.

MEMBER DIMITRIJEVIC: But you actually only have tables for 17, right? And now, in the report. And I notice, actually when you talk about environment that you talk about two.

But actual it's five. But there's only two in those detailed tables. So, there is some discrepancy of the numbers you mention, and what I was --

DR. XING: Okay.

MEMBER DIMITRIJEVIC: -- you know, following.

DR. XING: Yes. I can explain the fact we have 17 tables. Because they're, two is repeats. I think those are about, those PIFs are the environmental one.

MEMBER DIMITRIJEVIC: Right.

DR. XING: Each of them only have two or three attributes. So, try to save some papers I just lump them in that table.

CHAIR BLEY: Bad idea.

DR. XING: Okay.

MEMBER DIMITRIJEVIC: Okay. I notice that you have two instead of five. So, I asked if those are three missing. And --

DR. XING: Yes. I just, okay, let's save some pages, papers. So, Jonathan, we, that was a bad idea we did.

PARTICIPANT: I, yes.

MEMBER DIMITRIJEVIC: I think is a good idea to save the pages.

DR. XING: Paper. But it causing a lot more confusion with the missing three. And again, that's actually a good example of the interface. You presenting the confused, the information, not presented consistently.

MEMBER DIMITRIJEVIC: Well, the quality of procedures, which is not one of your PIFs, right, quality of procedures? Is that the --

DR. XING: That's one of the, it's not one of the attributes. And, but we have other indicators. So, instead of just say quality, because we can't say this one is a quality five, that one's a quality ten. We break down several --

CHAIR BLEY: Wait a minute.

DR. XING: -- for quality.

CHAIR BLEY: Quality's maybe a tough word. You have the procedures under personnel context. But always remember, when I go to this, I've done my qualitative analysis.

And the question isn't, is this a good procedure or a bad one. Given the scenario of interest, and the contact of that scenario, does this procedure work well? And that's a place we get into trouble.

The procedure works well almost all the time, except under this unusual condition. Damn, it doesn't quite work right anymore. And that's a really great thing to learn.

And if you own the plan, and you own the procedures, you probably want to fix that, unless it's an extremely rare situation. Then you just want to be aware of it. But you can't call procedures good or bad, absent the context.

DR. XING: Yes. That's the, actually you said the same thing as what our user said. She said, for something like a procedure you can't pre-eliminate it based on your analysis of context.

Because normally we would think procedures are good. For a particular situation it may not fit. Therefore, you always need to look at as, actually be able to look at every attribute to make sure, okay.

Because each attribute is perhaps one bad way. So, you look through the attribute, and make sure, okay, there's no problem with this.

CHAIR BLEY: Could you explain this though? These attributes are all negatives.

DR. XING: Yes. Attributes --

CHAIR BLEY: So --

DR. XING: -- are all negatives. We describe PIF in the neutral manner. But all the attributes are negatives. Each attribute represent one way this PIF can negatively impact the performance.

MEMBER DIMITRIJEVIC: Now, previously we discuss that there can be negative and positive. So, what happens with positive?

CHAIR BLEY: Yes.

DR. XING: That's a touch question. We had lots of discussion on that.

MEMBER DIMITRIJEVIC: This is smaller than what?

CHAIR BLEY: Well, you know --

DR. XING: Yes.

CHAIR BLEY: I'd just say, sometimes you introduce new technologies to reduce these problems, not to increase the number of problems.

DR. XING: So earlier, one thing we been struggled, because, you know, our current SPAR-H method, it does have positive PIF. So, we have extremely good training, which mitigate a lot of problem.

So, we took a set of example where people can say that we have positive PIF. Ended up every, because each PIF we already assume is good enough status, I wouldn't say ideal, but is good enough. It's an honest average.

CHAIR BLEY: So, average?

DR. XING: Yes. Average, good enough. If what you mean you are better than good enough, we look at those. Typically when you have a positive PIF you are in reduce negative attribute in another PIF. Say, this is a, I have a complex task.

However, my procedure really clear, gave me step by step guidance on how to go through this complex diagnosis. So, we wouldn't give extra credit to procedure, other than it's already good.

But we would give credit when you assess PIF, the complexity. You want to even base the appearance as a complex task. But this procedure, this current procedure is not complex. So, that's how the positive PIF.

MEMBER DIMITRIJEVIC: I mean, there is no reason for you, I mean, negative PIF means just smaller than one, right? Because only a PIF is -- So, why didn't you include the, you know, the beneficial PIFs, not to call them positive? Because it's not plus, minus. Is, why didn't you include them? Especially for the things like teamwork or --

DR. XING: Yes. Like, for the things like teamwork, with teamwork it's already included in the PIF. Assume that you already have the base assumption when you have PIF. Teamwork you would assume they have, you have peer checking. And you have cross verification.

Those are actually the PIFs, the attributes in the teamwork, which means, if you don't, you have base, means you have good teamwork. If you don't have it your performance would be drop. So --

MEMBER DIMITRIJEVIC: Well, but that's assume that your average one you're starting for these then for optimum, and not average conditions. And that's mean they have, everything is superb. And then, you know, you're measuring. So, it should be done for average, not for the optimum --

DR. XING: Yes. That's --

MEMBER DIMITRIJEVIC: -- conditions. So, that will imply that you could have a, you know, the smaller than one piece. And I don't see why would be the reason not to have this.

DR. XING: Yes. Well, the --

MEMBER DIMITRIJEVIC: And I like how extremely low stress situations, especially, I mean, you may have them.

DR. XING: Yes. And another part --

CHAIR BLEY: I kind of get that, especially if you're doing a formulaic kind of quantification with the --

MEMBER DIMITRIJEVIC: Right.

CHAIR BLEY: -- PIFs. If you're using the PIFs to essentially evaluate the context, then if your context doesn't challenge any of the PIFs, you're good. I mean, you -- I can see both approaches. But I --

DR. XING: Yes.

CHAIR BLEY: I think if I'm --

DR. XING: Well --

CHAIR BLEY: If I'm developing a qualitative analysis and a context, then I use the PIFs to say, is this context going to challenge the operators? And then you could say, could it make the operators better? Is there something about this context that makes it less likely for failure? I'm, I think it's okay they way they've done it.

MEMBER DIMITRIJEVIC: Well, from

qualitative evaluation I have no issue. And then you have, you know, one plus with duplication of PIFs, which multiplies your average.

CHAIR BLEY: I don't know how they're going to handle the PIFs. We'll get, I'll wait to see that.

DR. XING: Yes. James can comment on this.

(Off microphone comment)

MR. CHANG: James Chang, Human Reliability Engineer in Office of Research. I think this, if the, in the, we are talking about the optimum context for, about for our peer performance. In this thing that Jing, even the situation is optimal.

Humans still make mistake. That was we call the residual human error probability. That thinks somehow that you couldn't talk to at that level. That's one thing.

The second thing that you mention about the teamwork, this thing that make reduce the entire human error probability lower. In IDHEAS-ECA implementation it has a separate factor with don't cause a PIF. But we cause recovery.

Recovery, that means that you have a outside overseer or the independent checker that stands, able to spot you make mistake, and correct it. That's what we model in recovery, not in the PIF.

DR. XING: Yes. Thanks, James. Actually, the recovery factor, lots of the factors we credit recovery, such as team. So, the teamwork through the work process, and even plenty of time, have more than extra time you need. Those are all the things we credit in recovery, when we come to quantification. Thanks, James. Yes.

CHAIR BLEY: You have half a dozen more slides before we finish Chapter 3. I'd like to take a break, unless you really want to push ahead to get that.

DR. XING: Yes. To your choice. To keep our schedule I think all this discussion pretty much covers rest of the slides.

CHAIR BLEY: Do you? Okay.

DR. XING: We don't have to --

CHAIR BLEY: Well, let's see how that goes.

DR. XING: Otherwise, we can back. I'll keep talking after the break.

CHAIR BLEY: So, these are just PIFs for other, other specific PIFs? Yes. You want to jump to conclusions?

MR. PETERS: Scroll through your slides.

PARTICIPANT: Can you just show another one, or two?

DR. XING: Okay. So, this explain --

CHAIR BLEY: And example.

DR. XING: -- how the PIF work. We already talk how the attributes work. We already talk. And well, we may want talk this. This what, then you are here to how we model the PIF effect on the HEPs. So, maybe we talk this when we come back.

CHAIR BLEY: Okay. We're going to recess for 15 minutes. Be back at 25 until 11:00 a.m.

(Whereupon, the above-entitled matter went off the record at 10:20 a.m. and resumed at 10:36 a.m.)

DR. XING: -- How we look at PIF affect HEPs. That's what we really wanted. Okay. So again, the lesson learned from HRA defense models is basis error for improvement.

Because the quantitative relationship between PIF and the HEPs has been ambiguous. So, we started to address this. We said, okay, then we need to look at data to explain these three aspect regarding quantification.

How you, assessment of a PIF attributes.

Now you we have attributes we are in a much better position before, than just assess the PIF, however. And the quantification of the change in the HEP, even the attribute change.

And the most headache one is a combination of multiple PIFs on HEP. Somehow we have to address it. So what, with data we performed the metadata analysis from the literature.

I would say, I never count how many literature we went through. I would give a minimum, maybe 1,000 research articles. Each of these article actually have a explicit human error rate in the report.

So we, to gain insight on these three aspect -- Oh, by the way, that metadata analysis, that's, Sean will talk at the end of day. We plan to document all those we did, in the next two years.

CHAIR BLEY: That would be grand. We've talked about this for a long, long, long, long time.

DR. XING: I always say, well, I finish that. You see, I will move on the documentation of that. Now we finally, I think we come to the end of the turn there.

And so, talk about assessment of PIF attribute. Some HRA method use discrete levels, like low, medium, high, to model the state of PIF. For example, we can say complexity can be low, medium, high.

I think two person can argue forever what is medium versus a high level complexity. So, in the cognitive studies, actually when we look at the data we had, they don't say complexity low or high.

They, the experiment to perform specific PIF attribute, like how many items you need to integrate them together to get an answer. That's what they look.

And quantification of the HEP should be based on the PIF. So, from there we draw the insight. Okay. Quantification of HEP should be based on PIF attributes, and how they change from a baseline where there's no impact on HEP.

So, this one, this is how we approach to quantification. So, we try to, quantifications are changing in HEP when the PIF attribute change. So, the cognitive studies of data we have, they measure human error rates when you systematically change an attribute.

You know, you can change one or more attribute, or change around the attribute you want more PIFs. Then the measurement typically reported is no impacts, or lower impact versus high impact on the error rate.

Say, okay, we have no more. All the information needed are available. Then experiment and manipulation of some operation data will show, with some information missing, or even misleading. How much change in the reported or observed error.

So, if we use this measurement we call the PIF weight, or PIF weight factor, which is a change in the error rate between the impact state, between the impact versus no impact state. So, that's --

CHAIR BLEY: What you're doing here is a lot similar, I think, to what Jerry Williams and the later folks did with HEART, CAHR, and NARA.

DR. XING: Very much the same.

CHAIR BLEY: Although, they never showed us their data either.

DR. XING: Okay. I --

(Simultaneous speaking)

CHAIR BLEY: But it is similar. Okay. Go ahead.

DR. XING: Actually, a lot of the data already in IDHEAS-ECA. So, IDHEAS-ECA has generalized data, which I will talk on this afternoon. Does not have all the original data. But we documented those on computer.

MEMBER KIRCHNER: Let me, can I test you on this? So, I'm still thinking back to the one PIF you showed us, where among, it was the human system interface.

If I go through this example mentally, with the mislabeled, Dennis and I were talking about this during the break, a mislabeled control, a button. You think you're pushing this button to reduce the level. And it actually is doing something else.

So that, I mean, the error, it's one. I don't know what rate. I mean, by demand the error is one. So, how, versus the base. I'm a little -- So, you have this PIF with that in there.

DR. XING: Yes.

MEMBER KIRCHNER: I'm just trying to mentally work through an exercise. And I don't know what the base is. The base is --

DR. XING: Okay, yes.

MEMBER KIRCHNER: If it's mislabeled it's wrong. So, you would have an error to begin with in the baseline of the PIF. So, I'm having trouble working this formula to any practical use, in terms of weighting.

DR. XING: Okay.

MEMBER KIRCHNER: Can you give me, can you elaborate --

DR. XING: Yes. That's a very --

MEMBER KIRCHNER: -- and give me an example.

DR. XING: -- good example we can talk about. First of all, think about if the label is really clear. And if the label's really clear, and all your test is just push this button. So, that's a very simple task. No other bad PIF.

MEMBER KIRCHNER: Yes.

DR. XING: You would get, you still not get a zero HEP. And actually early, in later '60s Army did lots of research on this, try to, over 10,000 peoples study on this if how much, the chance of errors you can make just push a button.

So, they have this baseline study. Okay, if they just push, press a button, the error rate I think is 0.9998, which there's chance of you still have three-tenths of one out of 10,000 to try out. That's a baseline error.

And then they have manipulation. They didn't say it's entirely mislabeled. But they tested. The label is ambiguous. It's unclear. So, the -- And in that case I cannot exactly recall the error rate.

But it was something like 0.95, something like that.

So, which is like, you can have five times wrong out of 100 time. So, if they put it an entirely mislabeled one in the experiment section, you're right. You probably get a error rate as one.

However, we have, when we look at our data, especially they have lost such data in aviation. And this, there's sometimes there are mislabel in the, in cockpit. Still, pilot doesn't get 100 percent of error. Because they have other source of the information help them verify that.

So, one study I saw, they make like 20, 30 percent of, like over population. Twenty to 30 percent of people would make a mistake.

MEMBER KIRCHNER: Yes.

DR. XING: But not entirely. So, but that were case to case dependent. If you don't have any other information, or if you don't, the system doesn't give you feedback.

MEMBER KIRCHNER: Yes.

DR. XING: Tell you your data wrong. You press the wrong button. Then you entirely wrong. But because it have these other things to help you avoid a completely failure, that's, we come to the probability domain.

MEMBER DIMITRIJEVIC: Well, I have to correct what we discussed before. Because the way how you define the weighting factor you did it having negative. And you would have a negative, positive.

Because if there is no impact you are zero. Your weighting factor is zero. And if that is, you double your rate, then is one. So, you said is two. So, the different --

DR. XING: Yes.

MEMBER DIMITRIJEVIC: -- there is no smaller than one. It's smaller than zero.

DR. XING: Yes.

MEMBER DIMITRIJEVIC: So, how I define before. However, what I wanted brought -- well first, what is the rate? Where you said rate instead of probability, you meaning what --

DR. XING: Percent.

MEMBER DIMITRIJEVIC: -- percentage of it?

DR. XING: Percent of, correct, yes.

MEMBER DIMITRIJEVIC: So, let's say that you have 100 percent rate --

DR. XING: Yes.

MEMBER DIMITRIJEVIC: And your expectation was ten percent, right? I mean, your base case is ten percent. What would your base case --

DR. XING: Yes. My base case is 0.001 percent, yes.

MEMBER DIMITRIJEVIC: Is it all --

DR. XING: That isn't perfect.

MEMBER DIMITRIJEVIC: Well, let's say ten percent, just for --

DR. XING: Okay.

MEMBER DIMITRIJEVIC: -- simplicity of the math.

DR. XING: Yes. Okay.

MEMBER DIMITRIJEVIC: So, you have a 90 minus ten, which is 80 percent, divided by ten percent, which would be 80. So, that would be like their weight factor, or something.

DR. XING: Yes. Say, in my base case --

MEMBER DIMITRIJEVIC: Okay.

DR. XING: Our base is ten, or .1. And you are have a bad PIF, the indicator unclear, it's a .3 then or better. So, weight would be --

MEMBER DIMITRIJEVIC: Well, this rate is much more difficult to understand than other performance factors, which are just multiply HEP. Because that tell you exactly how many times you expect this to increase. This is a little more --

DR. XING: Yes.

MEMBER DIMITRIJEVIC: -- convoluted, this is.

DR. XING: That's a very good point actually. We did try that. And of course, the two is is just the dividers. The other way is the minus one. We had a reason for minus one. Because it make the formula to calculate each easier. Much less --

MEMBER DIMITRIJEVIC: Well, that's, and I'm not sure. But okay. I mean, my opinion had the one weakened. All right.

DR. XING: Okay. Well, we think about that later on, yes. We might get same feedback from the ECA test team on this. See if much more easier just think of dividing than --

MEMBER DIMITRIJEVIC: Right. Yes.

DR. XING: -- the platform baseline. I agree with you on that.

CHAIR BLEY: Jing, we're losing your voice again.

DR. XING: Okay. I will raise my voice. Thank you. Keep reminding me that. Yes. Okay. I wish I can avoid the, talking about this slide. Combine the multiple PIFs.

So, in the later trend, the existing HRA method we can, while we can keep or try to avoid it by doing a holistic approach, without thinking about each individual PIF as a factor.

I will just make a combination. Okay. Given the fact that you have a high workload, bad interface, and poor training, what is the probability for people fail this task?

So, that's actually how we did our expert elicitation in IDHEAS-at power. So, that way we avoid a thing called individual factor. However, the problem with that approach is when you have many PIFs, many possible combination.

All the combination you didn't have in your expert elicitation, you would have no way to approach to this, to better -- You can't afford it instantly overnight to have an expert elicitation vetting your number.

So, then the other approach, which often used in HRA method, is a combination of individual factors. So, we estimate the individual factor, like weight, defined earlier, then combine them together.

For this one we look into data. So, we want to search the studies which showed people actually measured this error rate of reporting, when a individual factor tend to, versus they have data of several, two or more factor change at the same time.

So, we, under the preliminary result we find there was a factor for combination marked for PIFs can be roughly estimated by adding the effect of the individual weight. So, if one factor, let's say if workload, let's say if --

CHAIR BLEY: Without seeing the source of your data though, that leaves me wondering what happens when there's a higher degree of dependence between these two PIFs, and where, in experiment you were citing.

DR. XING: Yes, true. So, in the data I used for the, actually we published the data on this in 2015, PSA conference. And when we looked for the data to support our analysis I specifically looked into the dependency between the factors.

So, I tried to preliminarily rely on the lab studies which people really tried to isolate the factors. I was being very cautious in using the operational data, because of dependency.

In fact, I had a conversation at the career people, HRA folks. He said, oh, we see the factors are really multiplied in here, not adding together.

I said, okay, let's look at your data. And it turned out that the two factors that they analyzed are highly dependent on each other.

So, but nevertheless, this is a area really we would like to do future research, including more extensive metadata analysis, to establish a good cognitive basis of how to combine them. And even now we have more data than we had time to analyze them all. So --

CHAIR BLEY: So, if you, I'm just wondering if you might have a user need. Or if this is more in making the distinction that Sean did earlier in human factors, or HRA. Are you going to be able to pursue this as future research? Do you have any idea? And if so, under which of those approaches?

DR. XING: Yes. We would have to do this anyway. But we would love to have a user need to do this.

MR. CHEOK: So, I think, this is Mike Cheok again. This is, the staff would have in our, longer to implant in the medium, to implants that we would do this.

But then we would like to get support from our user offices. And we'll ask for that. But if the ACRS would like to weigh in on that, it would also be, we would also take that advice into how we go forward.

CHAIR BLEY: Thank you, Mike.

DR. XING: Thank you. So, having said that, concluding the PIF structure. On this slide you can mainly look at the last bullet, which we feel in this PIF structure we tried to make the improvement according to the criterias we set forth earlier.

And, but big takeaway from this, we think about sharing the PIF. Because right now every HRA method have their own PIF, set of PIF. And even for the same PIF they different definitions and different way.

So, we think a shared PIF structure in the overall HRA community should increase the consistency of different HRA methods, and allow the comparison of HRA quantification results from different methods.

CHAIR BLEY: I want to go back to your multiple PIFs. Is that something you think documenting your many sources of data could let you address? Or is that something you need to sponsor experiments? Or have you thought about how you would actually try to improve that situation, get better understanding?

DR. XING: Yes. Two ways. So, currently, as I said amount over 1,000 paper, research paper I collected. There are probably several hundred of studies. People studies more than one factor, and show the effect.

I only analyzed like 30 of them. Basically because it's very time consuming. You really need to read through the paper to address what Dr. Bley said, whether there's a dependency between those factors, if those, how the attribute manipulating the factor.

So, we could, first we continue to go through more data. And also, we've been closely working with the Halden Reactor Project. And earlier we recommend them use our PIF structure in their experiment design.

So, in their experiment design they can actually say, we are testing factor A, B, and the combination of them. They already, they the ones started like that on information.

CHAIR BLEY: Have the published anything?

DR. XING: This is preliminary report ready. I will check with Andreas for the final report. I think for, yes. So, you must --

CHAIR BLEY: Yes. I'd like to see it.

DR. XING: -- study base concept. They tested the, for people in the SBO scenarios. They need shut down the reactor. They have, information is incomplete. Some information indicators missing.

And indicator misleading versus both. So, that's a very good data point for us to look at the combined factor. So, we are planning, so, the short answer to your question is, we try both existing data, and more experiment data.

CHAIR BLEY: Well, the Halden idea's a good one. I'll, be interesting to see if they -- Have you had a chance to read that preliminary report, or --

DR. XING: Yes.

CHAIR BLEY: Is there good information in this area in it?

DR. XING: Yes.

CHAIR BLEY: Okay. Thanks.

DR. XING: In that study, because I practically participate in the baseline. Okay. So, if no more question I would like to give to Jonathon. We finish the combination model. Jonathan will talk about implementing the combination model in HRA process.

CHAIR BLEY: Great. Jonathan. I think this is your first time to visit with us. Is that right?

DR. XING: Okay, Jonathan.

MR. DeJESUS: Good morning. Yes. This

would be my first time on this topic. Actually, this is my second time. I did it a few years ago. I think you were there, in the field cycle oversight process, when we were trying to --

CHAIR BLEY: Oh, yes.

MR. DeJESUS: -- revise it back in 2011. So, yes. I was there.

CHAIR BLEY: Well, we probably asked you at the time. But I'm going to ask you again. A little voir dire, you know, what's your history, and how did you end up coming to this role?

MR. DeJESUS: Okay. So, I'm Jonathan DeJesus. I've been with the, I'm a liability and risk analyst. And I've been with the NRC since 2006. I started with research, moved to NMSS data, and year plus in NRR. And I got into the Grow-Your-Own PRA Analyst Program.

So, and I, what got me to research was actually the graduate fellowship program. I did the graduate fellowship program for NRC at the University of Maryland. And that's something I'm still working on, on my own time.

So, I was assigned to the Human Factors Reliability branch. And when I came back, then I got assigned to this project. And --

CHAIR BLEY: Yes. Very good.

MR. DeJESUS: And here's my reward for helping the, what we --

(Laughter)

CHAIR BLEY: Congratulations.

DR. XING: And we couldn't get the report down without Jonathan. Because he's new to the project he brought a fresh view of what we're doing. So, that really helps with reliability and usability. If you see the improvement of this version's report compared to our previous versions, a big credit goes to Jonathan.

MR. DeJESUS: And if I may quickly respond to your comment earlier about the references. It's the, this personal preference of yours of addressing all authors, and one author, et al. The thing is, that was, I did it with software. So, a software manager that helped us manage those 130 references.

CHAIR BLEY: So, if there's greater than two authors it --

MR. DeJESUS: If there's greater than three authors --

CHAIR BLEY: Three authors.

MR. DeJESUS: -- then it adds the et al. So, that's why. It wasn't intentional that we were trying to left out anything and anybody. But anyway --

CHAIR BLEY: A bunch of enemies with authors four through ten.

MR. DeJESUS: But it can be fixed.

DR. XING: Okay, Jonathon, you want to start from here?

MR. DeJESUS: I got the mouse. I think I'm good to go.

DR. XING: Okay.

MR. DeJESUS: All right. So, moving onto --

CHAIR BLEY: Are you leaving, Jing? Are you leaving?

DR. XING: I'm sitting here.

CHAIR BLEY: Okay.

MR. DeJESUS: So, for those people on the phone, we are Slide number 40. So, hopefully this, I guess --

DR. XING: Yes, right.

MR. DeJESUS: So, in here the, I was expecting some animations. But they're not there. Anyway, so in, my intent of this presentation is to give you, put the whole process together.

And essentially this Slide number 40 gives more detail on what Jing showed on Slide 11, regarding the stages of the HRA, of the IDHEAS-G HRA process.

So, starting with Stage 1, the purpose of that stage is to understand the scenario, and collect information that would help in the quantification of the human error probability.

So, that includes developing the operational narrative, identifying the scenario context, and identifying what we call the important human actions.

And the reason we use that terminology is because of, important human action, is because IDHEAS-G is a general methodology, applicable to multiple nuclear applications. So, if you think about it from a PRA perspective, it's the same as a human failure event, or HFE. So, they're the same.

So, on Stage 2 of the process, the purpose of that stage is to model the important human actions for structure and analysis, for a structure analysis, and for HEP quantification.

And as shown in the slide it includes the identifying and analyzing the critical tasks, identifying the applicable cognitive failure modes, and assessing the PIFs.

And hopefully in this part we'll be able to answer your questions regarding the PIFs, on how to assess those.

And then moving on to Stage 3, it's the HEP quantification stage. And essentially its name gives away its purpose. And IDHEAS-G does the HEP in two parts.

There's the error probability attributed to the uncertainty in time available and time required. So, that's what we call PT. And the error probability attributed to the cognitive failure modes, which we call PC.

And the, Stage 4 essentially includes the, it's the integrative analysis. And essentially what it does is document the uncertainties throughout the analysis, and assess the dependencies between the human failure event.

CHAIR BLEY: Jonathan?

MR. DeJESUS: Yes, sir.

CHAIR BLEY: I'm not sure, but I don't think this figure is in the report.

MR. DeJESUS: It is. It's I think --

CHAIR BLEY: Or somewhere --

MR. DeJESUS: -- Figure 4 --

CHAIR BLEY: That's all right.

MR. DeJESUS: It's at the end.

CHAIR BLEY: That's all right.

MR. DeJESUS: Figure 4-9.

CHAIR BLEY: Oh, it's toward the end. Okay.

MR. DeJESUS: 4-9.

CHAIR BLEY: But what I wanted to ask you, we now go from macrocognitive functions to crew failure modes.

MR. DeJESUS: Cognitive failure modes.

CHAIR BLEY: Cognitive failure modes. And those aren't the processors, or the cognitive mechanisms, or the PIFs, or their attributes. They're something different?

MR. DeJESUS: They are related to the macrocognitive functions. They're related to the processors, and the cognitive mechanisms. And I'll talk about it when I talk in more detail --

CHAIR BLEY: Okay.

MR. DeJESUS: -- about Stage 2.

CHAIR BLEY: Thank you.

MR. DeJESUS: So, that's an overview of the entire process. So, going to Stage 1, it talks, the objective of the operational narrative is to develop an in depth understanding on how the scenario progresses from the initiating event to the end state.

The baseline scenario describes the expected scenario progression, and if available, it is recommended to include operating experience into developing that baseline scenario.

The operational narrative has two parts. It's, as shown in the slide, the scenario narrative, and the timeline. So, the timeline is a story telling style documentation that provides an overview of the event, the initiating event, the initial conditions, the boundary conditions, and the end state.

So, essentially a PRA model provides this information. If you look at the, if you're modeling an HFE through the, using the event trees in the PRA, you should be able to get that information.

So, the scenario progression should emphasize the, involving important human actions, and describe the expected responses from personnel and the systems. So --

CHAIR BLEY: Can I jump ahead a little? Maybe it's ahead or behind. When, this is the qualitative analysis --

MR. DeJESUS: Right.

CHAIR BLEY: -- essentially, the operational narrative. It's a good idea. For an event, and the same beginning status, progression could change.

There could be many different contexts. Are you going to get to when you include the context or multiple contexts, and how you come up with those?

MR. DeJESUS: That has to do with how the PIF attribute changes throughout the context. And that, initially the baseline scenario is developed. And if something changes from that, then what we have in the slide, showing like additional scenarios. There are deviations from that baseline.

CHAIR BLEY: Okay. That's what I want to hear about. And that could include multiple contexts?

MR. DeJESUS: Correct. Certainly.

CHAIR BLEY: Okay. Go ahead.

MR. DeJESUS: So, and the timeline documents the important human actions, and the responses in chronological order. So, we're back in talking about the baseline scenario.

And as I mentioned, well, we just discussed, the additional scenario can be identified asking what if questions. For example, the change in the context.

So, that's the first part of the Stage 1. Moving on to the identification of the scenario context. And what that means is, the search for conditions that challenge or facilitate the human performance in the scenario.

So, as mentioned before, the context provides a basis for estimating the HEPs, and is represented by the PIF attributes. And that search process focuses on the macrocognitive functions.

And it is documented in the four context criteria shown in the slide, which are the same, if you look at the PIF structure, the top level, the environmental --

CHAIR BLEY: I think we're on a different slide.

(Off microphone comments)

MR. DeJESUS: Yes, sorry. Yes, Slide 42 for those on the phone. That's what I was talking about. Forgot to click the slide.

So, there are the four environmental, the four PIF context categories. The same as we show before, environment and situation, systems, personnel, and task.

And the environmental conditions can affect human performance. And examples of that include fire, smoke, earthquake, extreme temperatures, and radiation.

So, the environmental conditions can

change throughout the scenario. And they may vary in different locations where the actions are performed.

The systems, well we, that term, it's a broad term used to refer to structures, systems, and components, sensors, equipment, and the human system interface.

The identification of the system context focuses on conditions that create conflicting priorities, confusions, and distractions. For example, operators may be concerned with the equipment that is not directly related to the scenario. Or they may turn off automatic systems based on well intention, but on incorrect belief.

The personnel context considers the framework in which personnel work, that is, individuals, teams, and organizations. Examples of considerations in the personnel context include the availability of personnel, lines of communication, and chain of command.

Finally, the task context includes the conditions that affect how the tasks are performed, which are specified by the characterization of the human system interface, and the conduct of operations.

The conditions in the task context should be evaluated against the five macrocognitive functions to determine if any of them are challenged.

MEMBER KIRCHNER: So, how do you narrow down the scenarios that you're actually going to examine? Do you use the PRAs? Say you're looking at a plant, just to make it simple, just the full power.

Do you go through the PRA as the, a means to pick the scenarios that are of interest? Or, how do you bound this problem starting?

It seems like a rather daunting task to search through all the scenarios that would challenge, or facilitate human performance. I mean, how do you begin selecting scenarios? Do you use the PRA? Or --

MR. DeJESUS: That would be the starting point, yes.

MEMBER KIRCHNER: Yes.

MR. DeJESUS: Starting with what actual HEP human failure event that the PRA is trying to model.

MEMBER KIRCHNER: So then, you would go through the PRA, and look for those junctures where a human interaction could change significantly the course of the outcome? Or, I'm just trying to get a feeling for how you do a completeness test in identifying the scenarios.

MR. CHEOK: So, this is Mike Cheok. I

think what we would do, as you say it's through the PRA. The event trees in the PRA would define the event sequences that are important, given different initiating events.

Once we have those event sequences we will have fault trees for those events that the different branch points for the event trees. In those fault trees you would have equipment --

MEMBER KIRCHNER: Right.

MR. CHEOK: -- reliability, and human reliability. And so, in places where an event sequence is asked for, we would depend on operator action. That's where we would model these events that Jonathan --

MEMBER KIRCHNER: Okay.

MR. CHEOK: -- called the HFEs, the human failure events. That's how they would be defined.

CHAIR BLEY: I want to hit on that a little bit. I'm not sure, and even though I've read this a couple of times I might have missed things.

I hate to keep bringing up ATHEANA. But for the last 20 years there's been a kind of consensus among people who do this kind of work in PRAs, that you really shouldn't have a bunch of HRA analysts sitting in a room and, you know, give them events to analyze.

But they are to be integrated with the PRA team, and experts on the plant, and operators. And together, through the PRA, the PRA would have identified those places in the procedures where human action is required.

But also, there are techniques for looking, and saying do the gray areas here, if you get to a point where there's a decision to be made, but maybe the scenario hasn't caught up to the procedure, could this come up later, you know, identifying more places?

I'm not sure you have laid out that kind of a search for these things in this document. Maybe that comes in the specific application documents.

I have one comment though on Table 4-1. You've introduced a term that's anathema to many people doing PRAs. And that's credible. What are the credible cues? What are the credible information? It's not a word that goes with probabilistic analysis. Come up with something else.

MR. DeJESUS: Okay.

MEMBER REMPE: So, while we're doing nits. On Page, it's 100 out of 334. But you talk about, and you had this actually in an appendix too. The

Fukushima event provides multiple examples of performance delays and performance failures, resulting from miscommunications, lack of clear understanding of roles and responsibility, and complex chains of command and control.

Could you elaborate what you mean? And then probably the next thing I'm going to ask is, what's your reference for that?

MR. DeJESUS: So, what page are you quoting?

MEMBER KIRCHNER: At the bottom of the page it will give you the real page.

MEMBER REMPE: Well then, I have to use my touchscreen. Hold on. Is the problem here. Hold on. If you're in the report it is Page 411.

MR. DeJESUS: I got that.

MEMBER REMPE: That's the only thing you say. And you say it twice, the exact same words. But I don't know what examples you're citing. Could you tell me?

MR. DeJESUS: The bottom of 411?

MEMBER REMPE: It's in the middle of 411.

MR. DeJESUS: Okay. Here it is, second, I guess --

MEMBER REMPE: Yes. End of the --

MR. DeJESUS: Third paragraph after --

MEMBER REMPE: -- first full paragraph, after the bullets.

DR. XING: Okay. So, for your --

CHAIR BLEY: You've failed now, the interprobability of getting --

DR. XING: I don't know which button I should press --

(Simultaneous speaking)

CHAIR BLEY: Push.

MR. DeJESUS: It says push. Green light is your cue.

CHAIR BLEY: I think it's that end of the table.

DR. XING: Yes.

MEMBER REMPE: It's catching.

DR. XING: So, your question is asking the references?

MEMBER REMPE: No. I want to know what is it, when those failures. Tell me what happened at Fukushima that substantiates that statement. Because you've said it twice in this report.

DR. XING: Okay. We did recover, it's important, this last sentence. Do you have any preference which one you would like we talk?

MEMBER REMPE: No. Tell me what happened at Fukushima. I can read the whole paragraph to you. But that doesn't tell me what happened at Fukushima to say that it provides multiple examples of performance -- And I can read that sentence again.

DR. XING: The performance, yes.

MEMBER REMPE: But what happened? Give me some examples.

DR. XING: Okay.

MEMBER REMPE: Where did the operators --

DR. XING: Yes.

MEMBER REMPE: -- do that?

(Off microphone comment)

MEMBER REMPE: 411.

DR. XING: Yes. Well, in some part I can talk as, in Fukushima, when the isolation condenser was actually not working, it took the peoples long time to figure out it's not working.

MEMBER REMPE: And how is that due to lack of communication, and those things --

DR. XING: Yes.

MEMBER REMPE: -- that you say there?

DR. XING: When they finally figure out it's not working they gave that information to their emergency, the command center, the tech.

MEMBER REMPE: Okay. So --

DR. XING: However, it took, I don't remember exact number for hours. Nathan may know. I think my recollection is took about ten hours for the people in the command center --

MEMBER REMPE: Okay. So --

DR. XING: -- realize, oh, it's not working. For that entire ten hours they had been under the assumption of the isolation condenser was working. So, they made the decisions based on that assumption.

MEMBER REMPE: So, I suggest you go look at some more recent evaluations by TEPCO. Because they spent a lot of time looking at the isolation condenser.

DR. XING: Yes.

MEMBER REMPE: When the earthquake happened they followed procedures and turned it off.

DR. XING: Yes.

MEMBER REMPE: Because they didn't want to worry about over cooling. They didn't expect, and this was a procedure that came from --

DR. XING: Yes.

MEMBER REMPE: -- General Electric input, okay. But anyway, they didn't expect the tsunami was going to happen. And they wouldn't be able to restart it. They didn't have instrumentation. I don't know.

And then they actually, because they were concerned. They went and had some people outside. But look at, make sure you really have good references that are up to date of what happened.

DR. XING: Yes.

MEMBER REMPE: There was a lot of misinformation that came out.

DR. XING: Yes. I appreciate that part. Actually, when I observed the Fukushima report of the, I have documentation on all the human performance related Fukushima.

And that is, I did see, as you said, people had the conclusion on that, or the suspicion on that has been changed. Initially they thought it because this. Later on they find it's a different reason why it wasn't it working.

For the particular example, I was talking in term of related delayed action, and the miscommunication. I was talking, regardless whatever reason, it wasn't working.

From the moment that the site people was, confirmed it wasn't working, to the time that the people in the emergency operating center realized, that is -- Okay.

There probably information, just stayed in their room, or the person heard of that. But they didn't thought that important. That part I haven't see clear analysis why it's, for ten hours they didn't.

MEMBER REMPE: I looked at some, there's a whole unresolved, unconfirmed issues report that TEPCO has issued in the last several years. And they have like five volumes. I suggest you go back and look --

DR. XING: Yes. I'll --

MEMBER REMPE: -- at more recent things --

DR. XING: -- definitely look.

MEMBER REMPE: -- to make sure you really can support this statement. Because I think maybe it's, early on a lot of people did say things. But I think that they've tried to spend a lot of time looking into --

DR. XING: Okay.

MEMBER REMPE: -- what really occurred.

DR. XING: Yes.

MEMBER REMPE: And, yes, okay, it's from TEPCO. But I think was an honest effort, in my evaluation. And there's been folks who have looked, and reviewed those reports. And they believe it's an honest evaluation too. And let's make sure it's factual, okay?

CHAIR BLEY: There's --

DR. XING: Thank you. I appreciate that.

CHAIR BLEY: There's a associated problem there. And Joy's touched on it. And that is, the truth may be really hard to dig out. And I, you know, this is such a controversial event. The examples form there are probably going to get you into trouble, no matter --

MEMBER REMPE: Yes.

DR. XING: Yes. Okay.

CHAIR BLEY: -- what you say. There were extensive reports, and even a book came out, of people who were actually hands on there. And they have a different view than engineers who analyze later.

And I just, it's a touchy area. And I'm not completely sure, you know. The truth about physically what happened, and when it happened, is probably, not probably, is much clarified.

But the hows and whys, and what was going on for the people, by now that's probably even lost, except for the people who wrote it down at the time.

MEMBER DIMITRIJEVIC: Yes.

DR. XING: Thanks. I --

MEMBER DIMITRIJEVIC: I would not reference --

DR. XING: Yes.

MEMBER DIMITRIJEVIC: -- that.

DR. XING: I definitely see --

MEMBER DIMITRIJEVIC: You know, not because the P factors are out of the range, you know, stress, the worry, you know, about the lack of instrumention, you know, after the DC batteries failed.

I mean, only listed in positive way, when they have to be inventive and bring batteries from the car to start to get instrumentation. There is absolutely no need to use those examples I think. I would --

DR. XING: Yes. Very, I agree with you. We'll work on, we have other good examples to replace this one uncertainty. Thank you.

MR. DeJESUS: So, and I guess the takeaway from this slide, Slide 42, is that these four context categories are not intended to be an exhaustive classification system. Sorry.

And so, the four context categories are not intended to be an exhaustive classification system. Rather, they guide the search for the context.

And as mentioned before, if the action takes place in the control room, then there may not be a need to consider the environment and situation context.

Next in Stage 1 is the identification of important human actions. So, an important human action is the unit of analysis of an HRA.

In general important human actions are identified as actions that are required in the scenario progression to achieve the goal of the event. For example, that we provide on the slide, they achieve a safe and stable state.

CHAIR BLEY: Now, that would be true for our so called areas of omission.

MR. DeJESUS: Correct.

CHAIR BLEY: Which is really a figment of the analyst's imagination. The so called errors of commission don't quite fit that definition.

MR. DeJESUS: I agree. So, the search for the baseline, in the baseline and deviation scenarios should consider the interaction of humans with mission critical and non critical systems. And identify errors of commission that impact mission critical systems if they are errors of commission.

The important human actions are defined at a level that describes the human failure of the action, and linking it to the affected systems. The definition should include the success criteria of the action, the consequence of the failure, the cues and indications and their timing, the relevant procedure guidance, and the time available for the action.

MEMBER DIMITRIJEVIC: Well, how did you define, to be begin with importantly, human actions?

Every human action, everything will always have important action associated with. So defining important human action doesn't reduce a number of the human actions that you have to look in.

Because for every human action there is a task associated with it. So there is always action to accomplish the task, right?

MR. DEJESUS: Yes. And I think in a couple of slides I make that differentiation between human action and important human action. Yes, in the next couple of slides, if you --

MEMBER DIMITRIJEVIC: All right. Okay.

MR. DEJESUS: Yes.

MEMBER KIRCHNER: Where is it defined? Or is it defined there by default?

I mean, obviously you're looking through your scenarios. By default, I agree with Vesna, it's just, those things to realize the interface of the human with that scenario that you defined. And then they're all important. Or I'm missing something.

MEMBER DIMITRIJEVIC: Right. That's how I see it.

MEMBER KIRCHNER: Yes.

DR. XING: Yes, we have, I've got the appendix number. One of the appendix identification of important human actions.

MEMBER DIMITRIJEVIC: Right. He said he's going to talk --

DR. XING: Yes. Okay.

MEMBER DIMITRIJEVIC: Are you going to have examples?

MR. DEJESUS: Well, at least let me get there and you can ask again.

So, the identification -- and the next step is to identify and analyze critical task. And we'll go back to the top level in a minute.

So, the objective of that part of the process is to identify the critical task in an important human action. Oh, Slide 44 everybody.

So, the objective is to identify the

critical task and characterize them. And a critical task is an essential, it's essential to a success criteria of the important human action and is the basic unit for the HEP quantification.

And the failure of any critical task is the same as, will give the failure of the important human action. So I think about it like a series system, if you will.

So, the next slide, 45, to provide more insights of what we mean by important human action and critical task, the figure shown on Slide 45 provides a little bit more detail then what was shown on Slide 13. Essentially a human event or a scenario has one or more human actions.

So, the important human actions, I don't know, are divided into task and critical tasks. So the, with respect to the important human action, it's what the HRA, that's what it models. There may be other actions.

I don't know if you can help me out here, Jing, on differentiating the important human action and the human action. There may be things like confirming that something, that a parameter reach a certain state, that may not be a important so it doesn't get modeled into the HRA.

DR. XING: Yes. I think technically we started this important human actions from a PRA model. A PRA model already identified those human failure event. That's our starting point.

And in many PRA models, a lot of like operator actions, now safety critical system are not included in the PRA model. However, in some particular scenarios, those actions can be important.

The failure of those action on the non-safety critical system can have a direct impact on the safety stability of the reactor.

So, those what we also call the important human actions into the LOCA. And at some part it's in our agency, NRC staff's, STP analysis for Robinson event.

For Robinson fire event, there is already PRA model there. So they analyze the HFEs that was already defined in the PRA model. I believe there was eight HFEs, I could be wrong.

But again, the staff also identified two or three additional human actions that was not included in the PRA model. However, they were critical to the success or failure in that event.

But I don't remember what other, those three additional actions.

MR. DEJESUS: Thank you, Jing.

CHAIR BLEY: I'm just a little confused. You coined a new term with the important human actions, which seems a common everyday term.

But in at least some design certifications, maybe all, in the human factors engineering, the same words are used to mean something a little bit different. Just so you know that.

DR. XING: Yes.

CHAIR BLEY: You've defined what you mean by them here.

DR. XING: Yes. For that we had actually, we had several staff meeting based on HRA, PRA folks on that. We would initially, earlier, would just call them HFEs, to be consistent with our PRA model.

However, we realized as say IDHEAS-G is for all HRA are risking from the nuclear applications.

In some application areas, such as dry cask handling, nuclear waste material handling, there isn't a PRA model, clear PRA model exists. But they want to use this analysis, that's why we say regardless --

CHAIR BLEY: I wouldn't really see a problem with using HFE over there. I'm just worried you'll get some confusion because important --

DR. XING: Yes.

CHAIR BLEY: -- human actions are already defined. You might never run into those people who are doing that work, but you might.

DR. XING: Yes. We had a sentence up front in the --

CHAIR BLEY: HFEs is pretty --

DR. XING: -- however, I think we should clearly cut out or reconsidered this in the report. Thanks for the comment.

MEMBER KIRCHNER: Let me just, I'm looking at the team work box and I'm thinking, normally what you would hope, say the control room scenarios, the team work actually helps understand, helps decision-making, helps execute.

So, isn't that an attribute almost or all those other four boxes rather than, I'm just trying to think how you would, if you're going to go and quantify this, how having a separate box, is it a positive factor or is it a negative factor?

Because team work, you know, it could work at cross purposes or there could be confusion, which would result in a delay in decision-making, et cetera, et cetera. There's all kinds of complexity in that box.

So, if you're trying to get to something that's quantifiable, I'm just trying to think about the math of how that is included with the other four boxes there for critical task.

MR. DEJESUS: So, if I understand your question correctly, I don't know if this was mentioned before, but the first four macrocognitive functions, it can be used for an individual or a single team.

MEMBER KIRCHNER: All right. That wasn't clear because --

MR. DEJESUS: First four.

MEMBER KIRCHNER: -- you had this box called team work and I'm thinking --

CHAIR BLEY: But they specified that that box is for teams interaction of separate teams.

MEMBER KIRCHNER: Yes. And there's that dimension too. No, I understand, the control room may know what it's doing, but someone may be out in the plant doing something else at the same time that the event is happening and that could cause all kinds of complexity.

So that part, yes, I did understand. But, Jing, while I think of the teamwork as, okay. Okay.

MEMBER DIMITRIJEVIC: So, there is some actual events from the previous discussion, they assume optimum situation. Everybody is in control room, they work as a team, and that's your base case.

Now, if anything preserve that, some of these outside, there is that, they only add the negative. So optimum case, yes.

DR. XING: Thank you.

MR. DEJESUS: Okay. Okay. So, in the third level of this figure on Slide 45, there is the distinction between a critical task and a task.

So, why, the reason we define it that way because task may compete for resources or interfere with critical task. Therefore they should be identified as part of the characterization of the critical task.

They're not necessarily analyzed at the macrocognitive function level, but they are, they're there. So it's just part of getting the entire context, if you will.

So, and then the critical task consists of the cognitive activities with our, achieved through the macrocognitive function. And the failure of a critical task is represented by the cognitive, by the applicable cognitive failure modes.

Next in Stage 2 is the identification of the analysis of a critical task. And the identification is a, the identification of the critical task is usually done, or it's essentially done using a task analysis.

And the, an essential element of a task analysis is a task diagram. And what a task diagram does is help identify the critical task, their relations, cues and time information.

And they show the success path and order of the task. And what I'm showing here on Slide 46 is an example of a task diagram.

Moving on.

MEMBER DIMITRIJEVIC: So, in this task diagram, are those analyzed as a separate task or is that one task?

MR. DEJESUS: Well, each of those would be one critical task on the, what, the rectangles.

MEMBER DIMITRIJEVIC: And each one of those tasks will have their own HFEs associated with those?

MR. DEJESUS: Correct.

MEMBER DIMITRIJEVIC: So this task is to, you know, the RCP, the shield failure assumes so.

MR. DEJESUS: Yes.

MEMBER DIMITRIJEVIC: It's actually broken now into three tasks. And each one of those tasks it has it's own analysis of cognitive --

MR. DEJESUS: Activities.

MEMBER DIMITRIJEVIC: Man.

DR. XING: Yes. Yes, just to, I'd like to make a comment on that.

So, once, when performing an HRA, analysts have been troubled with, to what level of detail you break the action or HFE into tasks.

MR. DEJESUS: That's the next slide.

DR. XING: What I heard from the HRA analyst is you cannot specify a universal applicable rule to what level of detail breakdown the action into tasks. But when we come there we know where we should have stopped.

But for us, we gave the general guidance breakdown task. It's breakdown the critical task. You breakdown when you need it. When you need it is because you're going to assess the PIF.

If the PIF change between these two tasks, then you should break it down.

MEMBER DIMITRIJEVIC: But every task has detection and a procedure as a pathway.

DR. XING: Yes.

MEMBER DIMITRIJEVIC: So, what I conduct, no, because these are part of the tasks.

DR. XING: Yes. So, you can actually if you break, in the past, in our exercise, we saw people, some people would take, oh, I'm taking the detection as a separate task because you have to collect all this information then we'll decide whether you're going to into E0 or E3.

MEMBER DIMITRIJEVIC: Okay.

DR. XING: I bet people will say, I will just take this as a whole task.

MEMBER DIMITRIJEVIC: I know. But then when you come to opening the valve, or whatever, or the tripping the pump, you don't have detection anymore in there.

DR. XING: Yes, you don't have --

MEMBER DIMITRIJEVIC: Because you separate it.

DR. XING: Yes. So --

MEMBER DIMITRIJEVIC: And you don't have a procedure and you don't have training and you have taken all of these cognitive parts because they came from the, in the other tasks.

DR. XING: You probably still have procedure. I mean, even you just to --

MEMBER DIMITRIJEVIC: Protection.

DR. XING: -- open a valve, you need to

check a bunch of parameters. The procedure will tell you which parameters you need to check.

MEMBER DIMITRIJEVIC: This will be part of the, AOP training. Okay.

DR. XING: Yes.

MEMBER DIMITRIJEVIC: All right, let's see how it works. We cannot wait for examples.

DR. XING: Thank you.

MR. DEJESUS: And the next slide we sort of touch on it a little bit. It's the how, the guidance we provide on breaking down the HFE into critical task.

And we understand that this is an important aspect of the process, so that's why we included the guidance. And I'm on slide 47.

The first guideline is to use as few critical tasks as possible. And then further breakdown the HFE, only with the PIF attributes, vary for different portions of the action.

And next, the important human action should be broken down into critical tasks at a level that retains the context. And that can be represented by the macrocognitive functions.

And then last, the breakdown of the action stops at the level where there is performance indications or data available to support the quantification of the human error probability.

So it's not, we're not telling the analyst, yes, go crazy and, yes. We understand this tedious process.

MEMBER DIMITRIJEVIC: There was several methods because you went to a procedure break every task and everything, I mean --

DR. XING: Yes.

MR. DEJESUS: Next is the character, the first part was to identify the critical task, and them breaking them down. And now we're in the characterization of those critical tasks that are identified.

So, the characterization, what it does is defines, refines the scenario context in the PIFs. And I'll show in the next slide what I mean by that.

And also identifies the cognitive activities involved in the critical task using a taxonomy of cognitive activities, which you have seen before. It's those first boxes in the, each of the macrocognitive function elements in Chapter 2.

So, once you have the cognitive activities required by the critical task, you determine which macrocognitive function and processor require that critical task. And if the characterization is the basis for identifying the cognitive failure modes that are applicable to the task.

So, on the next slide, this table, it's in the report. So the, specifying the task goal, the specific requirements, the cues and supporting information, procedures, personnel, task support, that has to do with the context of the action.

And one of the characteristics of the task is the cognitive activities, as I mentioned before. And one of the other aspects is concurrent task and teamwork considerations.

MEMBER DIMITRIJEVIC: Well, example of what you had before about this reactor coolant pump, when you came to the last step, let's say trip the pump instead of restoring cooling, there is not anymore cognitive activities. All cognitive activities in the procedures has to perform physical action.

MR. DEJESUS: Well, that executing the action, we consider that a macrocognitive function. We consider that, at least a part of cognition, if you will.

MEMBER DIMITRIJEVIC: All right.

MR. DEJESUS: So it's sort of like a

different way of seeing it.

MEMBER DIMITRIJEVIC: Okay.

DR. XING: Yes.

MR. DEJESUS: Okay, moving on, on Stage 2, Slide 50, for those on the phone. It's the identification of the applicable cognitive failure modes.

And in here I want to step back a little bit and bring, I guess, a philosophical view on how the cognitive failure modes were developed. And so, we developed several criteria for the cognitive failure modes in HRA.

And with respect to completeness, the cognitive failure modes should adequately represent the ways in which a task might fail. The non-overlapping, again, this is a, I guess a criteria we intend to do that, I'm not sure if it's possible.

The scope of the individual cognitive failure mode should not overlap with the, should not overlap with each other. So that is a human failure represented by one cognitive failure mode, it's not represented by other cognitive failure modes.

The specificity on sensitivity, that refers to the cognitive failure modes should be specific enough to differentiate the failures caused by different context. That is, cognitive failure mode should specifically link to a limited set of PIF attributes. And be sensitive to changes in those attributes.

And the observability is to estimate the human error probability of a cognitive failure modes. It should be done using available data or evidence. Or evidence. And the cognitive failure mode should be observable. And related to data.

And since IDHEAS-G is a general methodology, the cognitive failure modes that are provided in the IDHEAS-G should be independent of HRA application.

MEMBER DIMITRIJEVIC: How are the cognitive failure modes connected to cognitive macrocognitive tasks we've discussed before? Are they direct?

MR. DEJESUS: That's the next slide. Thank you for the segue.

So the, I didn't find the applicable failure modes. IDHEAS-G has this basic set of cognitive failure modes, and there is three levels.

There is the high level cognitive failure modes. The high level, it's the failure of the macrocognitive function.

Then there is the middle level, which is the failure of the processor. Of the macrocognitive function.

And then below that is the detailed cognitive failure mode, which is the behaviorally observable failure of the processor. So there is three levels.

And we developed a reference set of the detail cognitive failure modes. They're provided in Chapter 4.

And so, for a specific HRA applications, the developers may develop its own set of the detailed cognitive failure modes or from the middle cognitive failure modes or adapt what we provided as the reference set.

Moving on, Slide 52. The assessment of the performance influencing factors. The PIF have a baseline. I think we discussed that before, where there is no or low impact to the human error rates.

So they are determined based on the context in the scenario analysis, which is from Stage 1, the development of the operational narrative, and the task characterization, which I discussed a few slides ago.

And when the context, having this baseline where there is no impact, and I think this goes back to the discussion before, having a PIF attributes being all negative, so when the context challenges the task performance, it maps to the PIF attributes, which was discussed before.

But the key point I want to make here, I guess add to that, I guess it's when the context facilitates the task performance, it moves PIF attribute to the baseline. So that's, I guess, the positive impact how IDHEAS-G models that.

MEMBER DIMITRIJEVIC: Zero baseline.

(Off microphone comment.)

MR. DEJESUS: Base, I wouldn't zero, it's a minimum. I don't know what that minimum HEP would be.

MEMBER DIMITRIJEVIC: Not HEP, but PIF is zero.

MR. DEJESUS: Oh, the WI, yes, the impact --

MEMBER DIMITRIJEVIC: Yes.

MR. DEJESUS: -- yes.

MEMBER DIMITRIJEVIC: Okay.

MR. DEJESUS: So, moving on to Stage 3, which is the quantification of the HEP, on Slide 53. So, the estimation of the HEP is based on the modeling of the important human actions in Stage 2.

And the HEP has two parts, as I mentioned before. The Pt, the error attributed to the uncertainty in the time available and time required. And Pc, which is the error probability attributed to the cognitive failure modes of the critical task.

The overall HEP is calculated as the probabilistic sum of Pt MPC and is the equations shown in the slide. And as you can tell, this calculation assumes that Pt and MPC are independent. That's an assumption.

Pt is calculated as the convolution of the probability distributions of time available and time required. The equation is shown in the slide.

And Pc is the probabilistic sum of the error probability of each critical task. Which is the equation I'm showing in the bottom.

And then the probability of the error of the critical task is calculated as also the probabilistic sum of the error probability of the cognitive failure modes.

MEMBER DIMITRIJEVIC: And if the, because the time Pt is zero?

MR. DEJESUS: I'm sorry?

MEMBER DIMITRIJEVIC: For the reconsider

Pts cross section within to distribution, if they don't cross that, it's zero.

MR. DEJESUS: So, Pt doesn't make a contribution to the overall human error probability.

MEMBER DIMITRIJEVIC: So, if that's a matter, does he had a four to six hours, that doesn't have an impact on anything?

MR. DEJESUS: Yes. It would not have a contribution, yes.

MEMBER DIMITRIJEVIC: No, it has to have contribution survey, at least very low stress or something? You have plenty available time, that doesn't have a contribution?

MR. DEJESUS: Jing.

DR. XING: To plenty of time would be modeled, will be considered in recovery. So you have, we have a good collection of experimental data shown, which is a little bit against our previous blame.

So, when you have more than adequate time you needed, extra time doesn't really reduce your chance of error. Because you still make error due to those cognitive failure mode.

However, the extra time would reduce the overall chance of error because that give you more opportunity to recover. Provided if the error was recoverable. So that's it.

CHAIR BLEY: Yes, but you're built into the cognitive failure mode probability. If there isn't much time, and I know I don't have much time, then that effects my performance separate from the time calculation.

That's just a real world, this is --

DR. XING: Yes.

CHAIR BLEY: -- you can either get it done or you can't.

DR. XING: We have a PIF there from --

MR. DEJESUS: Oh, there is a PIF about time pressure --

CHAIR BLEY: Right.

MR. DEJESUS: -- in the task. I think it's in the task context category.

CHAIR BLEY: Yes. Not only is there, if you know you have time pressure. Yes.

MR. DEJESUS: Yes.

MEMBER DIMITRIJEVIC: And also, if you have too much time then you get bored and you may forget.

CHAIR BLEY: That's true too.

(Laughter.)

MEMBER DIMITRIJEVIC: Do you have a PIF

for that?

DR. XING: Yes. Yes, we actually have a PIF for that for execution. If you have too much time and you don't need to immediately perform the exclusion, then that increases the change of error.

MR. DEJESUS: Okay. So let's talk about, on Slide 54, start on Pc. Get that, explain that component.

So, the probability of a cognitive failure mode can be estimated in one or a combination of following three ways. The database estimation is essentially calculating the error, the error as a ratio of the number of cognitive failure modes to the number of times the task --

MEMBER DIMITRIJEVIC: Can I get you back to the previous slide --

MR. DEJESUS: Sure.

MEMBER DIMITRIJEVIC: -- because I have a question that I missed to ask.

MR. DEJESUS: Slide 53.

MEMBER DIMITRIJEVIC: You release different PIF for every CFM. Is there some importance of that, that you said go to aid in 17 then 317 then 710?

MR. DEJESUS: Oh, thank you for bringing

me back to that. Yes.

The probability of a cognitive failure mode is essentially, I think we have touched on it but I guess I'll put it in concise terms. It's a function of the PIF attributes. That's what it's meant by the different CFM 1, 2, 3, 4 shown in the slide.

So it's a function of, for example, Pcfm 1 is a function of the attribute of PIF2 and PIF8, et cetera. Whatever, and we'll get into how we quantify that in a moment. That's CFM.

MEMBER DIMITRIJEVIC: So, CFM, you already have idea what that CFM is going to be critical failure mode, you already have in mind which one is that?

Okay, that's --

MR. DEJESUS: Well, that's not in the qualitative part of the analysis identified, which are the cognitive failure modes. And we'll talk about this when we talk, in the IDHEAS-ECA.

In that specific application, the cognitive failure modes are, we left that at the high level. Failure of the macrocognitive function.

MEMBER DIMITRIJEVIC: Right. But how do you know which PIFs will be applicable because that's a selection of analyst, whatever he's going to define as a critical failure mode.

MR. DEJESUS: That's part of the task characterization. When the critical task is characterized, correct me if I'm wrong, Jing --

DR. XING: Yes.

MR. DEJESUS: -- there's this scenario analysis where, for example, where the action is taking place. That's part of the PIF and the environmental situation context.

And then there is the attributes of, with respect, what tools are needed, essentially what the table shown on, if I get it correctly, Slide 49. That's how, when that's done as part of the qualitative analysis, that's where those failure modes and critical task are identified.

So, the cognitive failure modes are identified based on the task characterization.

MEMBER DIMITRIJEVIC: Okay.

MR. DEJESUS: Hope that helps. Okay. So, Slide 54.

We were talking about the probability of the cognitive failure modes being estimated when one, or a combination of the three ways, shown in this slide. The database estimation is made, determined or estimated as the ratio of the number of cognitive failure modes to the number of times the task involving the cognitive failure modes is performed for a given set of PIF attributes.

And this provided that there are adequate human error data. However, human, as we all know I think, human error data are scarce, so IDHEAS-G provides a framework to generalize and integrate various sources of human error data, which will be, Jing will discuss later.

Then there is the expert judgment. Given the scarcity of data, then there is the use of experts. The experts, what they provide is a distribution of the HEP.

And it represents their best knowledge. However, using expert judgment usually requires a lot of resources.

Then that leads us to the HEP quantification model, which is a, I would say a trade off between, okay, not having enough data and the substantial resources that would be required for a --

CHAIR BLEY: And this is what Jing showed us before with the weight functions?

MR. DEJESUS: It is there.

CHAIR BLEY: Okay.

MEMBER DIMITRIJEVIC: Well, no, but you

still haven't made the base case. So, what is actually HEP quantification?

DR. XING: Yes.

MR. DEJESUS: That's in two slides from now.

DR. XING: That's what I will talk in the afternoon, the data. We needed this base data to, we need the data to establish the base case.

MEMBER DIMITRIJEVIC: This equation, but this equation there is many, I mean, just mentioned, but there is not any inputs to --

DR. XING: Yes. So we use the existing data as the base.

MEMBER DIMITRIJEVIC: Because you don't want to tell us you're using all of the existing HEP model by the base, to quantify base --

DR. XING: Yes.

MEMBER DIMITRIJEVIC: -- then that will be all right.

DR. XING: In this case we tried to not use the base HEP existing HRA model because we already collected a generalized substantial cite of real performance data. So we used those.

But I still looked at based numbers. Other HRA measured, trying to get a sense of where we are compared to other ones.

MEMBER DIMITRIJEVIC: Okay.

DR. XING: Yes. So we didn't use them, we used them for verification. Go ahead, Jonathan.

MR. DEJESUS: And this HEP quantification model was based on the cognitive literature research that Jing performed.

So, going to the next Slide, 55. So this HEP quantification model has two assumptions. This slide describes the first one.

Is, the first assumption is the use of base performance influencing factors and their respective base human error probabilities.

A review of the cognitive literature performed by Jing found that three of those 20 PIFs have the ability to change the HEP from a minimum value, whichever that is, to one. Which is represented in the slide by the blue curve.

So, those three PIFs are information availability and reliability, task complexity and scenario familiarity.

Then the remaining PIFs are shown, the remaining 17 PIFs are what we call in the report the modification PIFs. So, how to show this in the slide is essentially, you are in a, and that's where the PIF weight factor enters.

And what it does essentially is moves the blue curve to the right or to the left, depending on what, well, in this case would be to the left. Which, if you take for example this, the very line in the middle of this slide, you're in the blue curve and that's your HEP from the base PIFs.

So, if you include the modification PIFs, what it does is it moves that curve to the right, to the left in this case, which increases the HEP. So that's represented by the orange and red curves in this slide. And --

CHAIR BLEY: Explain your x-axis, the attribute of base case scenarios.

MR. DEJESUS: Oh. The x-axis, it's the attributes of the base PIFs. And --

CHAIR BLEY: That's a label, that's not an explanation.

(Laughter.)

MR. DEJESUS: I know.

DR. XING: The three show there information, reliability, types of complexity and the scenario familiarity.

MEMBER DIMITRIJEVIC: Those are you're PIFs?

DR. XING: Yes, those are --

MEMBER DIMITRIJEVIC: But this is, I think this is just there substantive to the solution for base case.

DR. XING: Yes. So, let's --

CHAIR BLEY: Is that what this is?

DR. XING: Yes, that is. Let's take an example. Supposed we, out of the three, we only have an issue, information reliability in the SPO, some indicators is not reliable, stuck there. So what it shows is, was a half hour ago. So that is giving misleading information.

And the third were site map base failure rate. Let's say .1. I have a ten percent chance I will fail if I get this misleading information.

CHAIR BLEY: Okay.

DR. XING: So, I will gather this, what we called a base HEP because of this factor. Then, in performing the task, if I have some other PIFs attribute to appear to like, I didn't have peer checking or I have concurrent task distraction.

Those are the two, PIF1, PIF2, move me from .1 versus up, maybe multiple by five or multiple by whatever number. That's what --

MEMBER DIMITRIJEVIC: It's actually some

--

DR. XING: Yes. Right.

MEMBER DIMITRIJEVIC: So, if you have a nine multiplier, two and one multiplier or three, you're actually getting four, four times --

DR. XING: Right. That's what we did. That's based on all the data we looked at. Bases reached, have really pushed the full range of the probability.

Example we had earlier, the HSI is human system interference. We can say that it's modified.

But what if the example you gave me earlier, like if the indicator is mislabeled, that will set you to one. Yes, that is a case, but in the data we have, that's a very rare case because, one, when we perform a PRA we are in the assumption, base HFE is physical.

If it's completely, entirely mislabeled, there is no way you recognize it's mislabeled. You already determined this is a physical action, we don't even go to quantify it.

MEMBER DIMITRIJEVIC: Is this line in the middle --

DR. XING: I will say the baseline.

MEMBER DIMITRIJEVIC: Do you have that

graph in the report?

CHAIR BLEY: Yes.

MR. DEJESUS: Figure 4-8.

MEMBER DIMITRIJEVIC: I mean, this is total lack of the definition you guys should remember. I mean, what it is. I mean, you know, you have to give it the good title and then to define what is the, what type of decision, this line, things like that.

DR. XING: We need the right figure. We need the right figure captions, that's our --

CHAIR BLEY: Right now, at least to me, that section in the report, and looking at these slides, is not transparent. Your blue curve is accounting for the three most important PIFs, I think. But are they at their worst condition, are they at the, I don't know how to use this curve and I don't understand how to carry this out.

Maybe this is a good time to break for lunch and after lunch you can be refreshed, we'll all be refreshed, and you can explain to me how you use this thing.

MEMBER DIMITRIJEVIC: You have, up to the Slide 60, right, before you enter the new --

CHAIR BLEY: Yes. Just a couple more, but --

MEMBER DIMITRIJEVIC: Yes. You want to finished up to 60 then? I say let's go to 60 so we can have more problems to --

CHAIR BLEY: Yes, go ahead. But I don't --

MR. DEJESUS: Okay.

CHAIR BLEY: -- the picture is pretty. I see one curve is higher than the other. I don't see anything that's relating how you do this quantification to the status of the PIFs.

It might be along that baseline but I don't know what that is, except something that says, attribute to the base PIFs. Are they in a base condition?

DR. XING: Yes.

CHAIR BLEY: I don't know quite what to do with this.

DR. XING: I just realized, it was my fault, I used the same word for two different meaning. When you say, earlier when we talked about the PIFs, we said each PIF start from the baseline attribute wherein to the bad situations.

Now, the base here have an entirely different meaning. We just classified the PIFs into these two types.

One type we call it base PIF, the other type we call it modification PIFs. So, I think if your mental model now, if you replace the word, base PIF, with something like dominating PIF or important PIF, that might work better.

MEMBER KIRCHNER: And that's determined by human judgement or which base PIFs?

DR. XING: Yes. So, prime example would better in this case. Previously when we use the SPAR-H model, primarily it's not all, most of the HRA we used it for control room actions using EOP, which are well proceduralized.

In SPAR-H, there is minimum HEP value. For execution, it's e minus 3 I think. And for understanding, or a combination for understanding a decision making is e minus 2.

So, that's an assumption made. Assuming you have all the information you need. And the scenarios you are familiar with because already in your training. So, SPAR-H does not model those two factors adding more.

But they do model complexity. But that's assumption without complexities that all these three factors are good, your HEP is generally minimal e minus 3.

However, when we move to action, control room action, for example, in 2016 NEI's guideline, HRA for crediting flags, they didn't have much information on how to give a detailed model. But at that time they thought, okay, because this action, control room action, they are saying things like scenarios not familiar, you may not have all the information.

Let's just assess the base HET as Code 1. So, all the actual control room action, if no other thing is bad, the HET will be .1. If anything else comes up, then you will multiple that .1.

CHAIR BLEY: So, if I just look at the blue curve --

MR. PETERS: Dennis, can I do my layman's interpretation since I'm not an HRA expert?

If I want to look at this graph, the blue curve would be a distribution function of, let's pretend the blue curve or modeling tasks complexity.

So, in a low task complexity we would look at that blue curve, when there's very low complexity, our error rates would be around e to the minus 4. As complexity increases, it would move up that curve all the way up to, trending towards the value of one.

So that's what we would see for those three tasks that you are modeling for.

CHAIR BLEY: So this isn't a curve one uses for quantification, it's just an illustration that as the PIFs get worse, the probability of failure gets higher?

MR. PETERS: Absolutely correct.

CHAIR BLEY: If that's how it showing, okay.

MR. PETERS: Yes.

CHAIR BLEY: It looks like it's trying to show me something quantitative, how I could use this to pick off a number.

MR. PETERS: No, no. We're not picking numbers off this curve.

DR. XING: Sorry, I never realized that's --

CHAIR BLEY: Okay.

DR. XING: I apologize for that.

MR. PETERS: The only thing it's trying to illustrate is for those three curves. That's how the distribution function will work.

And if you have the 17 other curves, it would move your curve left and right --

CHAIR BLEY: Okay.

MR. PETERS: -- based upon that infancy factor. Yes.

DR. XING: Yes.

MEMBER DIMITRIJEVIC: Well, okay, well, that's different what your slide puts. Because it just says, 17 factors move your, I mean, if this presents just PIF and not basic HEP then the factors, they'll have to be parallel, they all can relate and go on the different level, they can be identical. There will not be 17 curves.

DR. XING: Yes, there will not be 17 curves. Because you combine them. That's early we measure --

MEMBER DIMITRIJEVIC: Because, in my understanding, blue curve is your HEP, your base case HEP multiplied, that gets multiplied, or some with the different PIF.

This is very confusing and you should definitely --

MR. PETERS: Yes, so the blue curve is just representing the human error probabilities for those three --

MEMBER DIMITRIJEVIC: Yes.

MR. PETERS: -- performance implementing factors. And you would move it, so they calculate it in a different way. This is just trying to illustrate how those function.

CHAIR BLEY: Maybe if we go to the next couple of slides.

MEMBER DIMITRIJEVIC: But it's not 10 to minus 4 performance in the --

CHAIR BLEY: I think they're just trying to show us that --

MEMBER DIMITRIJEVIC: Performance indicators --

CHAIR BLEY: -- the HEP goes up as the PIFs get worse. If that's all you're trying to show me, I didn't need the curve.

(Laughter.)

MR. DEJESUS: Got it.

MEMBER DIMITRIJEVIC: Well, it's showing that there is parallels, but because they're all going to come to one, they're little --

MR. DEJESUS: Yes, the point of this slide is show that first assumption of the, I guess the differentiation of the different PIFs.

MR. PETERS: Let's move as quickly as we can to the next slide.

MR. DEJESUS: Yes, that's the point.

(Laughter.)

MR. DEJESUS: So, here is the second assumption. And here you have Slide 56.

The second assumption is that the linear combination of the PIF effects. So, this is the equation we use to calculation the probability of the cognitive failure modes, and that first term, the Pcfm base, I guess we'll change that term, base, it's based on, it's related to the three PIFs.

The information reliability, unavailability, task complexity and scenario familiarity. So those three go there in that first term.

The second, the one plus the summation, that's where the other 17 PIFs come in to modify the probability, the --

MEMBER DIMITRIJEVIC: Wait, wait, wait.

MR. DEJESUS: -- error probability.

MEMBER DIMITRIJEVIC: Where does three go?

MR. DEJESUS: The first three, in the first term. The Pcfm base. They go there.

MEMBER DIMITRIJEVIC: Why?

MR. DEJESUS: Because that's, according to the cognitive literature search, that's what can change the HEP, in this case, the probability of a cognitive failure mode from the minimum value to one.

That's how, I guess that first assumption is implemented into a quantification model. Which is what we're showing here on Slide 56.

MEMBER DIMITRIJEVIC: So your base case already has the three PIFs in, that's what you're saying?

DR. XING: Yes. So, put it in base way. If a task is not complex at all, it's very simple, it's the same as just press a button.

And the HEP for that would be e minus 4. So very unlikely you will get it wrong. Therefore, even you have a bad procedure, that's a bad procedure, even the procedure is not good, the training is not good. So you have some W there.

You will have, you're over or the HEP will still be very low. Your HEP will be e minus 4 multiplied probably 1.1 or 1.2.

So that, however, if you have very complex, the task, if you have this task, let's see, still using example, you don't have the right information because your indicator gave you the wrong information. That alone will set your HEP failure rate at .3.

So, in this case, even if you have the ideal procedure, you would still end up in the error probably, .3. So that's why we said, these three factor based on the data, the metadata analysis, there's really dominate which range of HEP you are.

CHAIR BLEY: You know, that paper that won't be here for two years I guess is the key to this.

DR. XING: Yes. Okay.

MR. DEJESUS: Okay.

DR. XING: Yes, go ahead.

MR. DEJESUS: So, the third factor, the C factor, is the PIF interaction factor. And it's set to one, with the linear combination of PIF effects.

And then there is one over the recovery factor, which is set to one, unless there is data suggesting otherwise.

And the reason we choose to do the division is to have that recovery factor be an integer rather than be like, you can say, oh, recovery factor of ten. So instead of recovery factor of only one. So sort of like, that's why there is a division there.

And with respect to the, I just recall that what Jing talked about before, the PIF weight factor, which is given by the equation in the slide.

CHAIR BLEY: Okay. If you go back to Slide 54.

MR. DEJESUS: No, I'm not that far. Okay, one more.

CHAIR BLEY: You have three different ways to quantify. Which one are we looking at here?

MR. DEJESUS: HEP quantification model.

CHAIR BLEY: Okay. And this is the, Jing, where you start?

MR. DEJESUS: Correct.

CHAIR BLEY: Are you going to talk about the other two?

MR. DEJESUS: Well, the data-base estimation, I think Jing will talk about with respect to generalizing data from other domains into HRA --

CHAIR BLEY: That's in the data?

MR. DEJESUS: Yes, that's in the data part. The expert judgment is, you probably know this better than me, getting experts and getting into a distribution of HEPs.

CHAIR BLEY: Is that right, okay.

MR. DEJESUS: So that, I think the point in this slide, 54, was to how we got to the HEP quantification model.

CHAIR BLEY: Okay.

MR. DEJESUS: So given that there is not much data, no expert judgment and --

CHAIR BLEY: Yes. So --

MR. DEJESUS: -- and so on.

CHAIR BLEY: -- if we believe this stuff, we might be comfortable using HEP quantification model. But getting comfortable with that and this linear combination of those weights, really requires getting comfortable with the database, so we can't really do that now.

DR. XING: Yes.

CHAIR BLEY: And maybe you're comfortable with it. I think you've been comfortable with it for several years, but it's still, there's nothing there yet for us to see.

Okay, so maybe the equation works great. And we've got the data to show that this is a reasonable model. Why don't you go on to the next slide.

MR. DEJESUS: Okay. So next we go into Pt, or the time uncertainty analysis. And this model was developed in response to ACRS comments.

And actual events have, so the PET, as I mentioned before, is composed of time available and time required. So, in actual events there are inherent uncertainties in those quantities.

And the best, the mathematical way, I'm not sure, to show that, is through a probability distribution. And I apologize that the slide is not showing the time available distribution. Maybe the color I chose was gray, so, you can see it on my slide.

MEMBER DIMITRIJEVIC: Yes, we can see it too.

DR. XING: There is another line, you just go like this.

CHAIR BLEY: It's in the book.

MR. DEJESUS: I don't know if this is a PDF version of the slides, but yes.

DR. XING: No, it's on the computer screen that's okay, it's just --

MR. DEJESUS: Oh, okay, not on the screen --

DR. XING: -- not on the projector screen.

MR. DEJESUS: -- okay, sorry. So, because of those inherent uncertainties in what goes into time available and time required, the best way to represent it mathematically is through a probability distribution.

So it's, the Pt is the convolution of the time available and time required distributions and is the probability that the time required is greater than the time. Time required is greater than the time available.

And Pt is proportional to the area where the two tails of the probability distributions overlap.

MEMBER DIMITRIJEVIC: So, I assume the available time comes from the success rate failure, thermal hydraulic analysis?

MR. DEJESUS: Yes.

MEMBER DIMITRIJEVIC: And where does required time come from?

MR. DEJESUS: Required, that's my next couple of slides.

MEMBER DIMITRIJEVIC: All right.

MEMBER BALLINGER: Is this just a calcium distribution?

MR. DEJESUS: In the example shown --

CHAIR BLEY: No.

MEMBER BALLINGER: It can't be. Okay.

CHAIR BLEY: Well, go ahead, make your bid.

MR. DEJESUS: In the example shown, yes.

MEMBER BALLINGER: Okay.

MR. DEJESUS: But that's for illustration purposes.

MEMBER BALLINGER: Okay.

CHAIR BLEY: In most cases, Ron, this

would be from an expert elicitation essentially.

MEMBER KIRCHNER: Well, there's certain scenarios, I'll throw up the hypothetical, ATWS in the BWR again, there is some distribution on the calculations where oscillations would, the onset of oscillations would start. And you could put, I guess, some spread on the time required.

CHAIR BLEY: That would be taking thermal hydraulic calculations and applying expert judgment to a distribution on hand. Unless you do a whole bunch of cases.

MEMBER KIRCHNER: Yes. Well, often they do.

CHAIR BLEY: Yes.

MEMBER KIRCHNER: So you have an uncertainty --

CHAIR BLEY: So you could.

MEMBER KIRCHNER: -- kind of analysis on the --

CHAIR BLEY: So you base it on as much quantification, calculation as you can. But the time required is really a judgment call. It's not a stopwatch thing, you can go out and do a --

MEMBER KIRCHNER: No, no, not at all.

CHAIR BLEY: -- acknowledge that other

things will make them take a little longer or a little less.

MEMBER KIRCHNER: Well, if they don't drop the level then they're going to be in serious trouble, so --

CHAIR BLEY: On that particular scenario.

MEMBER KIRCHNER: -- on that particular scenario, yes.

MR. DEJESUS: Okay. So, for the time available, there is the quantification model for Pt does not credit situations where there is excessive time available, and that's because there are studies that show that it doesn't have an impact on the error rates in the task performance.

However, having the extra time available makes recovery possible but does not guarantee it. And if I recall correctly, the IDHEAS at-power application, having extra time, it's one of the factors contributing to making a decision that recovery is possible.

The factors that affect the distribution of time available, as mentioned, as touched before, the thermal hydraulic calculations, the system time window and time delay for the cue, and I took HRA training recently and I asked, hey, do those thermal hydraulic calculations give a distribution and I was told no. So --

(Laughter.)

MR. DEJESUS: And there were people started talking about, oh yes, but you got this, you got that. This could change, this could, that. Well, exactly, you're making my point, it should be a distribution.

But we take what we get and try to make it better. And another --

MEMBER KIRCHNER: If they're best estimate calculations, and with uncertainty, then they will have a distribution. Yes. The answer is yes.

MR. DEJESUS: Okay. And the other factor that effect the distribution of time available, it's the crew-to-crew variability in performing the action.

And that is because the, one crew may take a little bit more time in one action and that effects the time available for subsequent actions. So that's another factor that effects the variability.

And this is my last slide I believe. So, this is the, for time required or needed. So, it assumes that the action is performed at a normal work pace.

And includes the time to attend the cue, understand the situation, diagnose the problem. Essentially the, going through the macrocognitive functions, the time that it takes to go through that process.

And also includes the time to travel to the location if it's something outside the control room. It's there in the time required.

And as we mentioned before, the time pressure is accounted for in Pc. And the factors affecting the distribution of time required, I summarize it as the PIFs.

If you look at, I think it's Table 5-2 of the report, essentially talks about the different facts. So, environmental factors, plant condition, work site accessibility, information availability. So, that's I guess my summary bullet.

And also, we talk about the crew-to-crew variability affecting the distribution of time required.

MEMBER DIMITRIJEVIC: So, how did you get distributions for your examples?

MR. DEJESUS: We're going to talk about that.

DR. XING: We actually recently had some exercise with our users at NRR. We talked how to do this estimation.

So, the best way, if you have all personal data, have loss of the simulator role, so you can get a distribution for the action.

In the case that, like our user say, well, we know those data exist but we don't have access, so still, we encourage them to estimate this. I can estimate a single number but I cannot estimate distribution.

But we did some exercise to show, when you estimate a single number of time needed, you already mentally estimated distribution. So you are estimating what's worst case, the maximum time within 30 minutes.

Ninety-five percent, if I have a crew of 100 people, 95 of them will definitely complete this task within 30 minutes. Or, you also estimate as a lower bound.

Like, if you gave me 15 minutes, I am confident I will have no more than five member can complete this task. So you gradually approach to the most likely by, actually, you say a model, a Jim is going to show you, we recommend them.

You can use this five point estimation. The best and worst case approach to the middle, then you get a distribution.

MEMBER DIMITRIJEVIC: I can give a very good distribution time required to run Boston marathon.

(Laughter.)

CHAIR BLEY: All right.

MEMBER DIMITRIJEVIC: A thousand people running, you can feed them and all. But I don't really know time required to the ease of a steam generator.

CHAIR BLEY: If you run, I'll come watch.

(Laughter.)

MR. DEJESUS: I want to get there some day.

CHAIR BLEY: When we come back from lunch, the slide show, we're moving into applications. You haven't quite talked about Chapter 6 and 7. Will they come up as part of the applications?

DR. XING: Yes. Chapter 6 actually belonged to application. The reason we add that chapter to the report is because our staff feel that's a very important aspect of this methods ability of generalized data, used data being performed HEP.

So we're going to talk about that in the afternoon, in Part III.

CHAIR BLEY: Okay, that's good.

MEMBER DIMITRIJEVIC: And 7 is uncertainty and we will definitely have many questions about that.

CHAIR BLEY: 7 is general discussion.

MEMBER DIMITRIJEVIC: Oh. 5 was uncertainty.

CHAIR BLEY: Okay. We're running behind. We'll hope the applications go faster. We're going to recess for lunch, and let's be back at 1:30. See you then.

(Whereupon, the above-entitled matter went off the record at 12:25 p.m. and resumed at 1:31 p.m.)

A-F-T-E-R-N-O-O-N S-E-S-S-I-O-N

(1:31 p.m.)

CHAIR BLEY: We're back. Jing.

DR. XING: Yes.

CHAIR BLEY: Back in session.

DR. XING: Okay, thanks. I just realized over the lunch that this was the first time we actually stayed on scheduled.

Because, for those of you on the phone, in the agenda we said afternoon part would begin with the gentleman's continued talk about the last part of IDHEAS-G, the time uncertainty analysis. He actually finished that before lunch. So, we are --

CHAIR BLEY: Caught us up, that's good.

DR. XING: Yes. So, we will start Slide Number 60, the IDHEAS-G applications.

So, just a little bit of background on the application. We finished most part of IDHEAS, the cognitive matter and the IDHEAS-G, HRA process in 2016.

And for the last two years we've been working on improving the report. We made a lot of changes in the report from one version to another.

And also, at the meantime, we tried different applications of using IDHEAS-G to the areas that we won't intended to use that Sean talked this morning.

So, for the next how many minutes I'm going to talk about the three applications that we've had so far.

MEMBER REMPE: Jing? Jing?

DR. XING: Yes.

MEMBER REMPE: This slide brought to mind a question that I forgot to mention earlier. At the introduction of the report you had something similar to these three bullets that talks about the IDHEAS as a method. And then it says it's a methodology for developing guidance later.

And is it a method or is guidance for developing tools? What is it?

I mean, sometimes it goes back and forth throughout that report --

DR. XING: Yes.

MEMBER REMPE: -- and what was the intent and what is it nowadays?

DR. XING: Okay. James is smiling because we, our team has been struggling on this many times.

So, the answer is, it's false. By itself it is HRA. It can be used as a HRA method for event analysis.

However, as we already seen this morning, it's too, you can use it but it's too complicated. Not user friendly for people to use.

So, it also can be used as a general methodology from which you can develop applications, specific method. That's what I'm going to talk in --

MEMBER REMPE: So, then --

DR. XING: -- Bullet 1 to 3.

MEMBER REMPE: I have follow-on questions then. I don't know if you saw, truly someone saw our biennial research review from, I don't know, 2017, 2018. But in there the Committee had put, we look forward to a coherent articulation of the general methodology that provides a unifying concept for HRA and meets the need of the SRM.

And we struggle when we put that sentence in, but did you ever see that and do you think you've met this or been addressing this recommendation and the work that's been, and maybe this is a question for Sean. Did you understand what we were trying to convey there?

MR. PETERS: Yes, I think we understand what you're trying to convey. And when we think we are meeting the intent of a statement, the general methodology we're looking at as that kind of unifying context for how we understand HRA.

And I think some of the intent was based upon previous versions of the report were less comprehensible then this version right now. So we're making strives to make it more, at least understandable to the users.

And I think once you'll see, when we have derived the applications out with the IDHEAS-ECA, you will see a user friendly methodology for implementing IDHEAS.

MEMBER REMPE: So, I might get the guidance and the need, I get the, again, I'm not a HRA person but from a distance, my understanding is I can understand that you need to start delving down to the weeds and have a consistent way, forcing people to document what they're doing by asking questions. But that's a methodology and guidance that could be used to other, with other applications.

But when you start talking about, you have the HRA method and it's so complicated, difficult for people to use, I'm not sure that really helps meet what we wanted when we wrote that recommendation.

MR. PETERS: Yes.

MEMBER REMPE: And, again, this is from afar, you can disagree with me. But I still struggle with this.

MR. PETERS: What I think you'll see is the easy to use version is IDHEAS-ECA. The challenge we had with IDHEAS-G is we also had to capture all the scientific basis behind the methodologies in general.

And so, you can make something very simply if you kind of leave that scientific basis information out and the basis and the technology behind it. But if you keep it in there, then it becomes a little bit more cumbersome and hard to use as a standalone guidance document.

And so, we're kind of making that balancing act here, that we have this comprehensiveness in IDHEAS-G. But we have the simplified methods that come out in the other methodologies. So, that's kind of how we're trying to juggle it with this report.

MEMBER REMPE: But if you're trying to help reduce variability with predictions for HRA, it seems that the guidance is the most effective way to go there more than the tools, since the tool takes some intelligence and, it takes a lot of user training to make users and like to use it, so it seems like the guidance is more important.

MR. PETERS: Yes, yes. And what you will

see, hopefully the next meeting we're having with the HRS we'll be able to share the IDHEAS-ECA methodology with you.

What you're seeing is that's a simplified implementation of the IDHEAS-G guidance. And you'll be able to look through that. It will be a step-by-step process.

And so, if the user of that has questions about the technical basis or what was truly met by one step or another, this IDHEAS-G document is kind of this reference library to go back and look at, to evaluate versus that.

MEMBER REMPE: Okay.

MR. PETERS: So, our goal is to make it more scientifically robust, but yet more user friendly. And so, we can get that repeatability.

So it's a tough balancing act because I feel this whole project here has been, we want everything. We want it to be scientifically robust, we want it to have data, we want to have improvements in X, Y and X, in the methodologies, oh yes, but we also need to make it user friendly so our users will want to do it.

Oh, and by the way, we want you to work with industry to come up with some kind of consolidated mind set around it. Oh, and by the way, industry does HRA differently than you do, industry, 90 percent of the time they do perspective HRA whereas 90 percent of the time we do retrospective HRA.

So, it's been a big challenge in this program to try to consolidate all of those concepts and IDHEAS into one report. And so, what we're, I think we've gotten to somewhere relative good with respect to where we are with a general framework.

And I hear what the Committee is telling us that there is still some confusion about, when reading through the report. And I think we can make that a little bit better.

MEMBER REMPE: Well, again --

MR. PETERS: Yes.

MEMBER REMPE: -- I don't think we're trying, it wasn't in my vision, and I'm just one member of the Committee, that we're not only trying to tell you to correct the words in the report so it's easy to understand, we're trying to say, get somewhere where you've met the intent of the SRM, which was to reduce variability.

MR. PETERS: Yes. And so, we've done some, and this will be more at the at-power methodology. So the SRM was written for the at-power methodology, right?

It was written prior to Fukushima in 2011. And we went through that process, and we actually tested that at-power methodology and its ability to reduce variability.

We saw some reduction in variability with that at-power methodology. And so, that was kind of that, one of the intents of the SRM. And we think we tried to drive down variability a much as we could through that process.

We're trying to keep that intent as we expand upon the SRM into realms outside of the, outside at-power applications.

MEMBER REMPE: Okay. The other comment I wanted to follow-up with before lunch was, early, again, in the introduction of the report, I believe you said you had applied this methodology to the evaluations at Fukushima.

And as you heard earlier this morning, I had some concerns about that statement, about Fukushima. Is that document where you applied it?

Because, I mean, that's what's in your report. It says, and I can draw you to the sentence if I need to and look it up, you've applied it to Fukushima. Is that a document you've issued or published?

MR. PETERS: Jing, do you want to --

DR. XING: Yes, I can answer that question. The answer is, we documented but not published.

MEMBER REMPE: Okay. So now your NUREG says, we've done this, somebody can ask. I'd like to see that. And before you --

DR. XING: I actually, over the last two years, I have sent it to many people who want to see it. And what started was, initially I, I don't think we explicitly say evaluated, I saw we analyzed and documented Fukushima events.

Initially I made a collection of all the reports and talks I can find on Fukushima related to human performance. Quickly, I got a folder over 300,000 papers from the patients.

Then I tried to consolidate all of this information into one place organized them. I first tried to use some human factors taxonomy to consolidate those information. It wasn't going to work well, so I was, okay, let me try IDHEAS-G because IDHEAS-G actually give you a layered out structure.

So I ended up, I documented all the information from those various reports in this one single report in the format of IDHEAS-G.

MEMBER REMPE: So it is a report? Because I mean, your last bullet says, the NRC Staff has used IDHEAS-G to analyze the documents, including the Fukushima Daiichi Nuclear Power Plant accident in 2011 to test this methodology.

DR. XING: So, the whole entire, I wouldn't call it a report, the manuscripts. The entire manuscripts is in my computer, I can email you at any time.

MEMBER REMPE: If it's every going to be, again, I'm not particularly interested in seeing this, I'm more concerned that if you document it as the last bullet then the NRC should be ready to issue this. And if you're going to issue it, then I would like to see it before it comes out. Okay?

DR. XING: Okay.

MEMBER REMPE: And so, that's where I'm at. Either take the bullet out or let's make this public is where I'm going, okay?

DR. XING: Okay.

MR. PETERS: Yes. And I think Jing also has some of that. If you want to continue, you have a shortened version that you --

DR. XING: Yes, I have a shorter version

published in a conference paper.

MEMBER REMPE: Okay.

MR. PETERS: So she has published some of this --

MEMBER REMPE: Okay. So, yes, then you should cite that reference.

MR. PETERS: Okay.

MEMBER REMPE: But I would be interested in seeing that reference. Maybe not what's in your computer that's not --

(Simultaneously speaking.)

MEMBER REMPE: -- if the public were to ask for this, I would like to see what your going to put in and make some comments on it.

MR. PETERS: Absolutely.

MEMBER REMPE: Okay.

MR. PETERS: And what you'll see when I am doing the wrap-up slides is we have a lot of, what I call post-cleanup work. Getting all the technical basis documents and all these analyses of the staff done.

We have to get all that published. But it's our secondary priority, given our primary priority is to get a tool right now for our staff and industry to use for document FLEX actions.

So, it's one of those things that we will be getting done, it's just not done prior to the publication of --

MEMBER REMPE: Okay.

MR. PETERS: -- the initiation reports.

MEMBER REMPE: Okay.

MR. PETERS: Yes.

MEMBER REMPE: Thank you for your tolerance of my back up questions. Go ahead.

DR. XING: Yes. And a little bit, go back, adding to Sean's comment on your earlier question, on the 2017 ACRS recommendation, I think in the 2017, I believe it was May 1st, that ACRS meeting we discussed how we going to use IDHEAS-G.

I think the recommendation were not rated, but just the comment from ACRS committee was. When we developed application specific method, which resulted in hours of qualitative analysis guidance in IDHEAS-G. Because that's really important for analyst to truly understand the operation narrative document as a context.

And the simplification will come to the quantification part as far as the estimated HEP. It could be really tedious for an HR analyst if we use the detailed failure mode. It could be really tedious when you go through all the failure modes.

So, at some point it would be in IDHEAS at-power, we had 14, we used the 14 detail failure mode instead of the whole set that was about 15. So, I think to address your question, even any application specific method, we resolve all the up front qualitative analysis guidance.

MEMBER REMPE: Again, I really want to emphasize that in my opinion I was looking for something that would reduce variability. And I can get that documenting how, if there's a disagreement between industry and the NRC on what should be credited, having that documentation helps reduce variability --

DR. XING: Yes.

MEMBER REMPE: -- in the guidance is important.

It's just, when you produce a tool that's so complicated most people don't want to use it, I'm not sure if that helps.

DR. XING: Yes. Actually when, in the later slide, even your IDHEAS-ECA, we had two part. The first part we did, we laid out five worksheets which asks our analysts to document all their analysis from the operation of their team to task analysis to context. Document all those things in the standardized format. That's not a part of the total.

After you document all these analysis you can take the outcome of your analysis as the input to the total. Get an HEP.

If you get two different HEP, which is most likely, you can go back to your documentation analysis say, oh, my assumption, in my context I assume they have all the information you assume in this scenario. They can have indication failure.

MEMBER REMPE: That's why I think the guidance might be more important than the tool. But that's just from a distance.

DR. XING: Yes.

MR. PETERS: And one of the things that we're finding, by trying to, go in all these years trying to reduce variability is, the one variability that's tough for us to tackle is the variability of what an analyst perceives as an important human actions based upon on how they interviewed and how they analyzed a scenario versus another analyst.

If they have competing mental models of where they think scenarios are going, you're never going to get agreement until they get down to those, that base assumptions of what they're trying to model.

And I think that's why it's important to have that documentation step.

And that's what our benchmarking study show, that if you can truly document what you were modeling, that's where the different analyst can go back and then compare notes and say, okay, we'll, let's come to some common agreement about what we're modeling. And hence, that reduces the variability.

MEMBER REMPE: I think we're all in agreement.

MR. PETERS: Yes.

MEMBER REMPE: The guidance, the documentation is important.

MR. PETERS: Yes.

MEMBER REMPE: It's just the other parts may be, we'll have to, that's now on Dennis to decide, okay?

MR. PETERS: Absolutely. Absolutely. No problem.

MEMBER DIMITRIJEVIC: Well, on that note actually, when you say simplify model, right, there is a tiered and there is a simplified model. And you just mentioned something which had 35 failure modes, cognitive failure modes, and then we'll simplify to, I don't know, two or three, right?

Well, if 35 in a row, failure modes will produce complete different number. I mean, is that a simplified model?

Simplified model should produce the same similar closed model --

DR. XING: Yes.

MEMBER DIMITRIJEVIC: -- to the full model, right?

DR. XING: Yes.

MEMBER DIMITRIJEVIC: It's not just different analyst, it's --

DR. XING: Right.

MEMBER DIMITRIJEVIC: -- just simplification, right?

MR. PETERS: Yes. I think you guys are going to see a practical application of the simplification in the later slides. And it will show you how a lot of these shaping factors are removed through the process.

And I think that would be relatively repeatable based upon the context that they're analyzing. Because the contexts that they're analyzing won't change much, so those same shaping factors should come out of each analysis.

DR. XING: Yes. In line of that, where

I'm coming from, the Subcommittee, our 2015 or '16 version of the report. And that Dr. Bley asks us, explicitly stated, when you use a simplified subset of the failure mode, even if you think this is good enough, let's say for control room at-power action, there may be particular scenario.

Some failure mode you eliminated become important here. So you should always visit as a full set of failure mode, if needed, to bring back to your simple model.

MR. PETERS: And I think, just to beat a dead horse, I have one other thought that I'm not certain variability and analysis is a bad thing.

If I have two analyst that come to a same situation and analyze and come up and say, hey, I think human errors in this fashion or these context are important and another analyst goes and analysis the same thing and says, well no, I think these are the important actions and context that are associated with, I think what you'll find is a richer understanding of the possibilities of the scenario.

So, there's, if we start centralizing everything around, and this is one of my big disagreements with the SRM, if we start centralizing everything around one model, you know, models are not reality, right, they're a simplification, they're a wave course to try to comprehend as close to reality as we can.

But if we all centralize around just one model and one method, they're might be missing context that the model and method aren't good with.

MEMBER REMPE: If you have good guidance though, wouldn't that take care of this?

So, you might not take care of it for that example, but you look at the differences and you say, oh, the guidance should be expanded, right?

CHAIR BLEY: Or, you look at them and you figure out what they're different and you revise the analysis. You know, maybe there were two context hiding there and maybe when you find those two you look and you find another one too.

So you ought to use that to expand and refine the analysis. Not just as good that we got different results.

MR. PETERS: Yes, I mean, I agree. It gives you that insight that you have missed with one type of modeling technic.

MEMBER DIMITRIJEVIC: The main problem, and I completely agree with you, that it is a value. But how do you express it?

How do you, when you give somebody number, you know, 40 minus two, how do you express your variability in that number because it doesn't come through the uncertainty analysis, it never comes through any uncertainty analysis.

So when we have these huge variability, how does that reflect the numbers to provide to the users? That's what you cannot do.

DR. XING: Yes. Thanks for this discussion. I actually like deviated a little bit from the slides to talk about an example related to this.

In 2008, NRC had a expert elicitation for FLEX HRA, estimated HEP for several FLEX human actions. EPRI also had a parallel activity. Not expert elicitation but use their current HRA measure to stretch it to model FLEX.

We've got a huge difference in the HEP. For example, we had a, our expert elicitation forward, declare ELAP other use FLEX equipment.

We had a HEP .2 from our expert elicitation. EPRI had HEP E minus 4. So that's a huge difference.

So, I compared our documentation in the EPRIs report. So, the assumption or the boundary condition that we asked people to document are performed.

We assumed, so the guideline was, so the instruction for declare ELAP is you need to declare ELAP, within six minutes you lost power and you are constant the power is not coming back in the next four years.

However, our experts said, in that pace we would have first perform the, to use our generated diagnosis if we can recover it. Except these generated diagnosis procedure takes 90 minutes. So it's impossible.

We have the information we needed to make that decision by 60 minutes. That's why they credit, that's the reason they were higher HEP.

Look at EPRI's document on the same human action. They say, okay, this is a simply human action. EPRI there is no, they're cut to perform this.

And this action, all it needs is to judge the time within 60 minutes. There is a clock on the wall.

They can, either you are in the SBO or LOOP saturation, you also have, you always can see the clock is low on battery. You look at the clock before

60 minutes you declare ELAP.

So, in that context, E minus 4 is not bad. Same in our context. We have justification. This is not, I mean, I don't know how we can have one HR method completely reduce this kind of variability.

But IDHEAS-G have the capability to document it all your justification, all the way like from up front, your boundary condition, your contest, your PIFs, all the way while you get this number. We say our assumption was, assumptions in the two analysis are dramatically different.

I think that's the way we consider, we wouldn't reduce the variability, but we make the variability truthful and transparent.

MEMBER REMPE: So, the current applications, of whether this would be used and what's important, you may have different numbers. But if you document it and you have appropriate guidance for documenting it, that would still be important.

Maybe we shouldn't, do we really need a new method at this point or would it not have been appropriate to have just said, make sure you have good documentation for what you're doing and have some guidance?

Again, the ship has already sailed. We've been doing this for a long time.

MR. PETERS: Yes, we've been doing it for a long time. But I personally think we do need a new method because of the scope creep over the last 20 or 30 years, that the methods have been built for particular application purposes and they're starting to stretch them beyond what they're originally intended and using them outside the context.

And even the Commission was worried about that back in 2006. So, I think that improving that technical basis beyond the methods and allowing that scope to be encompassed by the method is important.

And so, I just wanted to finish something that Jing was just saying there, that it sounds like the variability may not be able to change, is our two analyst's opinion about if something is an easy thing or a hard thing.

But what we think we've done is if the analyst agreed to the context and agree if a task is easy or hard, we have repeatability in our HRA numbers with this methodology. So, if you can get analysts, analysts to agree on the context, then we can repeat those numbers very well.

But just getting one analyst to use a methodology and describe if this is difficult, this medium is hard, it's hard to get different analysts to agree to those particular things.

MEMBER REMPE: But then the staff has to go with an owner/operator, making an assumption in their particular PRA, if the staff can understand why they did it.

MR. PETERS: Yes.

MEMBER REMPE: -- guidance.

MR. PETERS: Absolutely. Yes, we think we have that down relatively well. Just the interpretation of the context.

DR. XING: Okay. So, I will only very briefly talk about the first application. Actually, we already talked.

So, when we see bases being used as a HRA method for human event analysis, because it can provide the outcome. If we figure human event into the IDHEAS-G process, we can have the output systematically documented event context. Which are the conditions, challenge of facility performance.

And we also got human, important human actions, the critical test. This tells us what are the potential failures and the consequence with the test or diagram.

And that by going through, say which

failure mode applicable to the test, and what are the PIFs, which PIF attribute applicable are relevant. So, base tells us how the human action may fail and what contribute to the failure. So it's like a systematic root cause analysis.

So, we did several, I call it piloting study, as we caught some of them not officially documented yet. So, we said earlier, I tried to use this to document all the Fukushima accident reports relevant to human performance. That was the short version of it published in your conference paper.

And early this year, Mason should lead a group of research staff locate a set of seismic event. I was looking at the human performance aspect, so I used the IDHEAS-G culminating functions and the performance shaping factors to went through all, I think seven events. Seven seismic events.

That was also published in the conference paper.

The third one, we worked with our data instrumental control staff. Located, together located several data instruments in the control event.

In their reviews they find a lot of the event has been reviewed. At the end, come to, it's a human performance issue, not just simply an instrument or control failure.

So it's, okay, you did your instrument control part there. We use IDHEAS-G to go through the analysis, to document as a failure mode and the contributing factors.

That one is not in any official documentation. It was just a piloting study. We want to see how it's applicable.

And the last one was interesting is that pilot study we did this year. This actually as had a conference paper published.

Halden performed the last of the human performance experiments for 30 years. That's a very valuable resource for our research.

And we tried to consolidate those information in one place that our staff can easily find the information, use it. So we use the IDHEAS-G to document it as they are experimental.

What are the initiating event as a boundary condition. Everything like we talked this morning.

And by the end we show, okay, this is our analysis, if you want, we can actually give you a prediction. Not an HEP number, but which is more likely fair and to compare our analysis with actual experimental result.

So, and Halden and also the conference audience, were very interested in this trial and the way we're going to do more work on the base line.

So, that's a summary of what we did use HRA, use IDHEAS-HRA method. The result give you a HEP number. Everything before the HEP number.

So, normally I would like spend this part of the talk focused, using IDHEAS-G as a platform to generalize and integrate a human error data. So, HEP, human error probability, normally we do it, it's probability of failure and the specific context.

Theoretically it's important number for errors you made divided by the number of occurrence you performing this task. And the identical, same context.

Therefore, in the ideal world, if I want HR data for HRA, I would want the same task for in a failure model. If repeated 1,000 times with the same people and the same context, that will allow me to get to a very low number of HEPs.

And to do this and all the combinations of possible for context. That's the ideal world, I hope for.

And when we look at reality, what kind of a human error data we have in the real world. The good news is, that there's a whole lot of human error data in human error analysis, operational database and the culminating human factor studies. So, it's not we don't have data.

And some not so good news is, across all these sorts of data, in some cases the failure mode is not analyzed at all. Coming with greater variety. Or the context we talked earlier, were not documented or not repeated.

So we see this number but we don't know if it was performed and what kind of context. And the limited coverage, we don't have sufficient data for every failure mode and every context.

The worst problem is this data sources are not talking to each other. I think this effort started, at least what I know, started ten years ago. There was a workshop on HRA data, people part of different sources, are a common, different formats, different purpose, different domains, how you can use them together.

So that's, we try to address that using IDHEAS-G.

So, our approach is like this. We have different source of information. They talk in different terminologies, different level of detail.

But if we can interpret a data source in the common taxonomy, locate whether tasks in the context, embedded data source, and analyze what are the failure modes in the PIFs. Basically not a regional situation to our taxonomy of failure mode in the PIF.

We do this to every data source. Then we will have the data for failure mode. And as a given combination or a big single PIF. That's our approach.

Then we think IDHEAS-G is suited for this purpose. Because for this taxonomy, it has to be generic enough if you only talk about changing the failure mode arch.

It starts as a pump, align something or connect something, it may not talk to another source of data. So you have to use a generic term.

And also, the data can come at a different level of details. So, the generic taxonomy should be able to address the different taxonomy.

So, in Jonathan's presentation you have, we have the failure mode defined at three levels of detail. And the PIFs, we also define in multiple levels of detail.

So, in that way we basically use our

IDHEAS-G process to document the data. So this diagram shows the IDHEAS-G process.

So up front you document as an event. In the middle we model the failure as a failure mode in the PIF. So we use the same weight due for the data.

So when we say we're generalizing data, we take three steps. The first step, we evaluate the data source, which one criteria, I use this and we have to use original paper, at least three times before you see anything bothered or truly understand what they were doing, what was the task, any dependent state between the factors that they tested. What was the uncertainties.

So, we identified the human actions, a task, and the context there.

Then, the next stage we call the interpret and the represented data. That's what we said, you have a task there where you say in the task you have people perform what was the failure, culminating failure mode you got there and what was the PIFs.

Once we're done with this interpretation, the third stage is consolidated data into three, we call the human error data tables.

These three tables, the first table is the HEP table. So it gave us the error rate. Sometimes it's probably, we can find the very baseline or minimal HEP.

For example, we have this data source from NASA in command center, which is a highly controlled everything. They claim that they make sure all the PIFs are positive. So ideal situation. That's what gave us the minimal number of error rate as probably representable.

The best HEP, the best human performance that you could possibly get. So we document that line of information.

And we also document the PIF have a second table, it's a PIF weight table, which we talked this morning. We calculated it.

If a study or the presentator showed us the human error rate in the good or not impact status versus you have some bad PIF attribute, we can calculate it as a weight. There's a difference between the human errors.

And the third paper we also discussed it this morning. We try to capture the inter, called the PIF interaction table.

This study gave the data about the human error. And the individual PIF. They also gave the data performed by the same set of people but when two more PIF were presented at same time. So, we also have this table documenting that data.

CHAIR BLEY: So, in the first one on the right, the HEP table, you have failure rates for similar activities under the same PIFs?

DR. XING: Yes and no. Same activities, which means same failure mode. But PIF sometimes the same, sometimes different. We document those. This is error --

CHAIR BLEY: But that's in the table. So if I want to find all the cases of particular failure mode with particular PIFs, I can pull --

DR. XING: Then you go to the --

CHAIR BLEY: -- those out of the table?

DR. XING: -- second table.

CHAIR BLEY: What?

DR. XING: Then you go to the second table, PIF weight. Yes.

The first table mostly documents the data that you people did not change the status of a PIF. Like in the NASA command center data, they said, we have all the PIFs perfect.

CHAIR BLEY: Was that true for all of the data in that in table or is it mixed?

DR. XING: It's a mix. But we were

clearly documented. This way it's a PIF reported, these three PIF.

This one we have the error rate, but the PIF wasn't reported. It doesn't mean that they are good. So we try to document all this. Also, in the table, we documented uncertainties.

MEMBER DIMITRIJEVIC: Those tables?

DR. XING: I think in Chapter 6 I gave an example for these tables. Yes, we actually already talked about the first tables. HEP tables.

It will have the information for each data point. We have the information about what failure mode, the CFM. And human error rate, or HEP.

In the table, whenever we see it's HEP, most likely that was obtained by expert judgement. And otherwise, it's just experimental data or operations data we're reporting human error rate. Which means the percent of error of the data.

And the PIF attribute applicable to the data point. Time and information, whether the task goals perform, these are results of time-constraints.

And we put a brief narrative of the task and the types of human failures in the original data source. And finally, we got asked to document the uncertainties in the data source. Not just in the data source, also in our interpretation.

Again, using the example of NASA command center data, they reported error rate of astronaut, trainer astronaut, error in diagnosis task. Which was very low. Like, between E minus 3, E minus 4.

I never saw diagnosis error like that low. So I read through their report. There was, in the appendix, there was a discussion about the task performed.

Really, once this is diagnosed, it wasn't diagnosed at all. They don't need to relate multiple pieces of information together. It's more like a pattern of recognition.

So, if your data, if the saturation match this parameter, you go to A. Your conclusion is A. If they match another set of parameter, you go to conclusion B.

So, the real challenge in that task is really, is that they tag team the information and they gather information rather than diagnosis. So, in the uncertainty part I made a note, just as I said, we believe this is detection, not diagnosis. So that's how we worked on this paper.

CHAIR BLEY: I'm having a cross connection problem here. Do you have the report with you?

DR. XING: The NASA report?

CHAIR BLEY: No, your report. IDHEAS-G.

DR. XING: No, I don't have it with me but I probably can recollect.

CHAIR BLEY: Table 6-2 is mapping the HEPs and IDHEAS at-power, to IDHEAS-G HEP table.

DR. XING: Okay.

CHAIR BLEY: Now, I assume the HEP table is the first table we were talking about. But this has different failure rates for different kinds of PIFs. Or is this the --

DR. XING: Yes.

CHAIR BLEY: -- second kind of table?

DR. XING: Yes, this table, the reason I mapped the IDHEAS at-power expert elicitation, expert judgment of HEPs to the HEP table, because in that, so, HEP was obtained with an assumption like holistically.

You have these three poor PIFs like documented. It's the first line. You have high distraction, confusing indications, lack of detail in the procedure.

CHAIR BLEY: Which gives you a pretty high failure rate.

DR. XING: Yes, they give a pretty high

failure rate.

CHAIR BLEY: Now, the 3, 4E minus 3, is that --

DR. XING: That's, everything, all these three factors are perfect phenomena.

CHAIR BLEY: And that's what's in --

DR. XING: Yes. So I cannot put this in the PIF table because I cannot differentiate. That high failure rate is 3.6E minus 1.

It's hard to tell which factor contribute how much. So I can only give you the HEP for when they, all these three factors together, at this much.

CHAIR BLEY: Right.

DR. XING: Yes.

CHAIR BLEY: In your previous slide, 67, you said I have three different data tables.

DR. XING: Yes.

CHAIR BLEY: But this one you're looking at in the report, table 6-2, is not one of those three, it's something else.

DR. XING: This table, it belongs to the first, when we say the HEP table, it's a crazy long table.

CHAIR BLEY: So, this is part of the HEP table?

DR. XING: Yes, this is just a very small portion of the whole table.

CHAIR BLEY: So it does include PIFs?

DR. XING: Yes, it does have PIF --

CHAIR BLEY: When they were there.

DR. XING: -- but just not --

CHAIR BLEY: I'm sorry, I thought you told me it didn't.

DR. XING: Oh, I'm sorry, I didn't explain. We said we have a --

CHAIR BLEY: Okay.

DR. XING: -- column.

CHAIR BLEY: So this set of tables --

DR. XING: Yes, you see the third --

CHAIR BLEY: -- are extracts from that HEP table, okay. Go ahead. No, they're not.

DR. XING: No.

MEMBER DIMITRIJEVIC: Like, example, your table 6-3 includes task complexity.

DR. XING: Yes.

CHAIR BLEY: Vesna, put your mic on because the poor guy behind you can't understand you.

MEMBER DIMITRIJEVIC: Well, I want to say, in the 6-3 you state simply that that's the tax complexity where the Table 6-2 you don't say it's with anything, you just discuss PIFs.

DR. XING: Yes. So, test the complexity one is that table was extracted from the very long HEP table. I pick up all the data point that the failure mode is task complexity. I'm sorry, has a task of complexity there.

MEMBER DIMITRIJEVIC: And then there is a distraction in 6-4. So what is the 6-2? 6-3 is task complexity and the 6-4 is --

DR. XING: 6-4 is not for any specific PIF. It's --

MEMBER DIMITRIJEVIC: Don't we make it to those three PIFs, which you involve, in the diagram, which we had a problem?

DR. XING: Okay, so we're talking, okay. Oh my, we have to table 6, oh, continue. Okay.

So, Table 6.2 is the data, Table 6.2, in the report is a part of the long table of, the HEP table. So, because we met this table there.

MEMBER DIMITRIJEVIC: All right.

DR. XING: And then the next one, the complexity table, I said, okay, I won't look at, all the data that have the type of complexity PIF there.

So, I generalized the, except, this is not all, just several examples. If I want to look at that particular PIF, I can extract it from the big table.

MEMBER DIMITRIJEVIC: So, this is not those PIFs you discuss in these graphs?

DR. XING: Yes, it's not. So --

MEMBER DIMITRIJEVIC: So it's not, 6-2 is blue line?

DR. XING: You are very right. The 6-2 actually is the blue line.

MEMBER DIMITRIJEVIC: All right. And then --

DR. XING: Yes. And then the next table is multi-testing. You can think that's the orange or red line.

MEMBER DIMITRIJEVIC: Yes.

DR. XING: Thank you. That's really helpful.

CHAIR BLEY: So when you did the table, which was probably before you did some of the other word, you were still using PIFs that you no longer use, like workload and stress?

DR. XING: I was trying, in this table, I tried to document if there is, if this is from another HRA method, they have a different term for their PIF, I tried to document with them.

That was the first, because this, in this first paper, my main focus was on the HEP values. And the PIF status what the impact column, what I showed in this particular example. I used the original term in the data source. I didn't show --

CHAIR BLEY: No, I'm talking about the PIFs. So, if you went to IDHEAS at-power --

DR. XING: Yes.

CHAIR BLEY: -- application and you picked up one and it had high workload, that analysis, also as I recall, would have said it was high workload because of task, multitasking.

DR. XING: Yes.

CHAIR BLEY: So you could have then --

DR. XING: Yes, I --

CHAIR BLEY: -- put in here multitasking so it was not your current --

DR. XING: Yes.

CHAIR BLEY: -- arrangement.

DR. XING: You're right, I --

CHAIR BLEY: But you haven't done that --

DR. XING: Yes.

CHAIR BLEY: -- or you haven't done it.

DR. XING: I could have done that. I actually state that. The only reason I want to keep this original term, so we can see the, easy to trace where it was. That was only, so this table was only for demonstration.

CHAIR BLEY: It was for illustration?

DR. XING: Yes, for illustration.

CHAIR BLEY: But now, somewhere in the world here at NRC, you have a real data table.

DR. XING: Yes.

CHAIR BLEY: And in that real data table, did you leave it the way it is here or did you put it in the terms of the current PIFs?

DR. XING: Yes. That's, on this slide you see Bullet 3 is the PIF attribute. That means we incorporated on that for the IDHEAS-G.

But in the second, which is the last bullet, was a brief narrative of the original information. That's more like what you see here.

CHAIR BLEY: That's here, okay.

DR. XING: Yes.

CHAIR BLEY: Just --

DR. XING: Yes.

CHAIR BLEY: -- clearly for my questions I'm not seeing things --

DR. XING: Yes.

CHAIR BLEY: -- absolutely clearly, but then I haven't seen --

DR. XING: Yes.

CHAIR BLEY: -- your three big tables or what supports it.

DR. XING: You see, in the actual table --

CHAIR BLEY: Is there, right now, is there really a real table, HEP table and a real PIF weight table and a real PIF interaction table?

DR. XING: Yes.

CHAIR BLEY: So they're somewhere on somebody's computer, you do have these tables?

DR. XING: My computer in the SharePoint.

CHAIR BLEY: Okay.

MEMBER DIMITRIJEVIC: And they're huge?

DR. XING: Not that pretty huge. It's a software of information. Like the original paper document, that was huge. So it was really scared to me early this year when we upgraded our agency --

MEMBER DIMITRIJEVIC: So, if they're not huge, why didn't you involve them in the presentation or in the report?

DR. XING: In that sense it's huge. For example, the table 6-2, the HEP table, it actually, I think it has nine columns. That's too much of a spread. So I only demonstrated four columns here.

The more you, like, the uncertainties,

original data source, the reference ID, all these are not in the table.

CHAIR BLEY: Anyway, you have a SharePoint cite where analyst can go and get this information?

DR. XING: Yes.

CHAIR BLEY: Are you intending to make that a public SharePoint cite so anybody can use this or is it just for internal use?

MR. PETERS: She's looking to phone a friend here. So, yes, the point is to make all of our data publicly available. And a lot of this will be documented when we have these last steps of cleanup.

So the point is to have all those nine columns established in a particular report. But for, we're already at 320 something pages and the IDHEAS-G, general methodology.

And given that this is, we don't go into a lot of detail on quantification and the IDHEAS-G methodology, it doesn't seem like the right place for us to put all this data --

CHAIR BLEY: No, I'm not saying to print out all that stuff, I understand. I would hope when you're done you'd have a place on the public website where people can go and have access to those tables.

MR. PETERS: Well, our long-term goal was to have a robust data program where we show where we have weaknesses and strengths in our data tables, and that will help guide us to where to go forward.

CHAIR BLEY: Yes.

MR. PETERS: And we're also trying to work together on SACADA data available to the general public so that we can get free resources out there, analyzing that data and feeding that out into the general scientific literature.

So, we absolutely do want to do what Dennis says. We want to get the data out there and for people to analyze and scrutinize and see its capability.

The issue we're having is, we're still trying to build a model here. Because one of the uses we have with, from the NRC perspective of using an HRA tool is, expert elicitation is not a valid way for us to do our SEP announcement analyses, it's a primary tools of what we use at the NRC.

We don't have the kind of resources to do that. We need some type of quantification methodology that they can utilize, that we're hoping to improve on the current SPAR-H methodology quantification.

And so, this is our attempt to actually incorporate that data from these multiple data sources. And we do want to get that out there for the public to see so we can create that more simplified quantification capability.

DR. XING: Yes. So --

CHAIR BLEY: You may not be surprised, but at least one member of this Committee would have trouble endorsing this data approach without having seen the data.

MR. PETERS: Yes, absolutely. I totally understand that, yes.

DR. XING: So, I think we can walk through one example, we talk of data points. So this is actually a research paper published in Human Factors Journal.

So, it's about a human errors in flight simulator study. So, the task is to, for the pilots make a decision on de-icing in flight simulator under icing weather.

So, the context was the pilots were provided with either incomplete information or inaccurate information for handling icing and whether information they received was 20 minutes ago.

Now, they have three different sources of weather, about weather. There's different weather sources that don't completely agree with each other.

Situations like that. And that this is a time critical decision-making, they cannot wait forever to make a decision. So even they were given -- Okay.

The failure mode, here we just use a high-level failure mode. It's a failure for decision-making.

They didn't make the right decision for de-icing. Either they didn't do de-icing at all, or de-icing too later or over.

So, the PIFs we state in Phase 1 is incomplete or unreliable information, they manipulate in the major 30 percent of information. Or I could be wrong.

And the last thing, in my part uncertainty, I wasn't sure this was a time pressure or inadequate time. I couldn't tell from their research paper. Because they said that you have to do this position as quick as you can. But what they did in that position.

So, I actually know the author of this report. I talked with her. She couldn't answer either. She was, oh, we don't know, we just tell them do it as quick as they can.

So, this is a certainty part in the data.

But nonetheless, so, the table is what's actually recorded in the report.

So, each column shows one manipulation. The first one is the baseline accurate and the complete information. They have 18 percent of error.

So this gave me the sense that probably they were not given enough time. Otherwise the error wouldn't be this high.

And the second column, they manipulate, the information is accurate but incomplete.

The third situation was inaccurate, but had the complete information. You get all information but 30 percent is incorrect but they don't know which part was incorrect.

So, as --

MEMBER DIMITRIJEVIC: Is this de-icing, that's not in flight, they usually de-ice on ground?

DR. XING: Both. This particular simulation is in-round, it's en route. Yes, supposedly you are flying and you are flying through bad weather and you should make a decision, should I de-ice or not.

The transcript says, ground people tell them, you have a line of five miles of weather, they were trying to decide how this five mile weather look like. So, a lot of information is inaccurate they put in.

So the chance of error was actually pretty bad with 30 percent of uncertain, misleading information or inaccurate information. They have 89 percent of error.

So, that's the way we documented this in the table as a failure mode. It's a failure of decision-making.

The PIFs we put in the adequate information plus inadequate time for the first case. But I make a note, it's a experiment, they didn't specify adequate or inadequate time.

MEMBER DIMITRIJEVIC: And how many trials they held there?

DR. XING: I don't remember exactly. I think these study was a test. They did multiple tests on this over several years of period.

The one test they reported was about 40 pilots. Each pilots work three different scenarios. And I think they repeated at least once. But between the repeat they didn't place identical scenario, they made changes in scenario.

So, that was one data point looked like. And, again, we cannot use this single, one single data point for our HEP calculation, we're also looking for as many sources that we can to pull them together for the information.

So, we already talked the second paper, the PIF impact the table. Again, it's has multiple, more dimensions of information than I presented in the report for simplification purposes.

But we can look at the second example showing what goes into the PIF table. This is a study done by VISN, I think it's VISN Military subject. Studies the effect of long working hours, which in our PIF it's mental fatigue.

So, the test was a team, have a team make a judgement of threat on Military surveillance task. So, it's a situation assessment.

So, the failure mode, we mapped it into incorrect failure of understanding, which the process is a incorrect situation assessment. And several PIFs have been tested here.

Long working hours, which goes to mental fatigue. No feedback information, that's one way of the teamwork. So, you made an assessment and your supervisor didn't say a single word.

Give you some feedback about cause like or no supervision peer-checking at all. So basically it was like, you have one single person do the task or you have to people, another person, do the peer-checking for you.

So basically it's three manipulations. And their conclusion is the result of sleep loss affects assessment, accuracy and the time needed to make assessment.

So, if we look at this table, if we only look at the first rule, that's basically four feet back. That means after your dates assessment the supervisor will tell you your assessment was right or wrong. Where you were wrong.

And the numbers there shows the percent or error. So, result of sleep loss, the error was 4.2 percent. Based on sleep loss, I think that's the second they did for not getting sleep. That 5.5.

In fact, a little bit of surprise on third day, they're performance was slightly better than second day. So this is their second data.

And then you look at the bottom two rows, that's the difference if you look at it vertically in the first.

The bottom two rows, the first, the column, that's the situation, no sleep loss. You will performed by one single person versus two person as a team. So, the percent for error is the difference was one, is six percent as others, 4.5 percent.

So, we're calculating the, with this information we can calculate in the W of PIF with, between those three. Between no fatigue and with mental fatigue, between base peer-check and the result of peer-check. That's another way we, so basically the table you are looking at actually went to the PIF table.

And within this table you already see the result also goes to the PIF interaction table. Because you actually have the information, no sleep loss versus sleep loss, combined of a single person or a team. So, we can see the interaction of that.

So, that's what we talked about, the interaction table.

So, this is the, again, it's a demonstration, a part of the extraction from the low PIF impact table. I look at that long paper, I don't know how many pages, it's probably around 50 pages.

Then I extract them by different PIFs. So, all the data I have related to multitasking, I make a sub-table there. So this is a sub-table above the effect of multitasking.

So, the columns, again, I only show four columns, and you stand all the column in the table. The first one is a task and macrocognitive function.

The second column are the context in the original data, how they're manipulated. And the third column was the actual error rate reported in the report. The last column is a PIF, which I calculated.

So, then we can look at this first rule. Vesna studied on multitasking. The two tasks are intermingled, are kind of related.

So, the failure mode, the macrocognitive function required in this test, two activities like you're missing the cue. That's a failure of detection.

Or you're missing the changes because you were supposed to look at the cue, you were also supposed to look at the change in the cue. So, that's called a change of detection. So you manipulate a single task versus dual task.

So, if we look at the last column, the PIF with, for the true detection failure, one is seven times more increase, other is four times more increase. But for the diagnosis, it was reported as 37 times more increase because error rate went from one percent to 37 percent.

So, this is what the data shows. In the

uncertainty part I documented I have a question on that one percent. Maybe because, maybe they didn't, they ripped the piece and not big enough.

If they repeat it with more subjects you'd probably get a higher diagnosis rate than the one percent. But we don't know, so I documented that as uncertainty. Yes.

So, James, you come. So, I showed you the two example, both from the experiment study, but we now have a really good data source, which is SACADA, human operator performance database that James is the evaluator, so I'll have James talk this.

MR. CHANG: My name is James Chang, I briefed the committee on all SACADA data twice in the past few years. Jing asked me to talk about SACADA so I'll briefly talk.

This we've been studying about a decade ago that every reactor unit has a fire operating crew, one step crew. That each crew, that in one year, they go through five to six weeks, a training week.

And within this training week that they would do at least two or three simulator scenario. And that's rush data source for us. But before that time NRC did not systematically to correct this information to inform HRA.

So that was the motivation that we are, data that we work with STP, that is a two unit plant down in South Texas that we do work with them to defer a similar that they can use for the routine operator training. For them it's a one, two operating training department, they want to improve their training.

But deferring the methodology, we are able to design the system, that corrected information, that help HRA portion. So this portion here that I would like to talk about is the data that we use for HRA.

I think we don't need these two slides. Yes, that's a slide --

CHAIR BLEY: James, I just want to remind you --

MR. CHANG: Yes.

CHAIR BLEY: -- we are a public meeting and we might have people listening on the phone. So, I don't know if that makes a difference on anything you might talk about here --

MR. CHANG: Okay. So I should not talk about plants identification. We spoke with one plant. Thank you.

So, now that it was, we originally were there for the simulator, SACADA simulator training data and now it is decided that we have a plant to work with, and now it's expanding, trying to correct the emergency preparedness human performance information.

This was, back to a few years ago that I presented to a committee. The data we collected at one point, there's a different portion of data. The one is, we called it contextual factors.

So this contextual factor, the data was okay. In the simulation, simulator training scenario, start from the beginning that they have initial condition. Either is 100 full power operation or that you are down power, increase power or that you have a certain component that's not available. That's all things initial condition.

And given that scenarios start, the instructor will inject malfunction into the scenario. And the crew need to respond to the malfunction.

The malfunction could be simple instrumentation failed that need to respond. Or it could be something big like design basis if any tube rupture or LOCA, that they need to respond.

So, the scenario to defer this scenario, and then let the crew respond to each malfunction, once the mal, the instructor see that the crew successfully respond to the malfunction and then the initial, the next malfunction for the crew to respond.

So, scenario that, the training scenario for the crews are identical. But the crew performance responds to these scenarios could be different.

So that we correct two type of information. One is contextual information that's shown here. That for each, the crew responds here that we watch the context crew responding.

The crew responds here. I'll give you an example. For example, like I say, I lost the essential cooling water pump in Train 8. The pump lost, once the training went to see the important operating action respond to that.

So, in the scenario training they identify each of these crew responds item, they call it the training objective element. We call it element.

The typical element would be, the first thing is detection. You detect the loss of the ACW A pump. And then the second you correct, make a diagnosis, that typically represent that you follow the correct procedure to solve the problem.

And then that has a action. Now, what's a physical action that the operator take to manipulate a plant to resolve the issue that we are relying the past.

And there is additional activity, like a shift manager, need to declare the emergency action label, or the other thing. So this thing, from the training objective that the trainer want to see crew perform this. And then that's the crew performance evaluator based on the information.

And the information, even though that's for training purpose, but we think, well, that's super for the HRA. And the other unit resolution is very similar of the two events we are looking for.

And we characterize this information, detection, diagnosis, understanding of decision-making action. And then there is team work. Team work, but it separated lines in the data correction.

This is because, when we designed this that, every crew take about one and a half to two hours to learn the scenario. After that they have 30 minutes to debrief their performance.

And we want to get this, lots of information within this 30 minutes, as much as possible. It's very possible.

So, we define methodology that tool that are needing, okay, that's a practical method they could use in the simulator training environment.

So, one of these character here that, the first column here that this is the fourth, I think it's the fourth diagnosis, type of activity. If the training, unduly these diagnosis and that that software will pop up coming to the action of the trainer input this information.

And then the person, okay, response planning, sorry. So that's a, the first action is asking, what's the basis of this response planning is that there we have a three option for them. The skill-based, procedure-base or knowledge-base.

Skill-base means there is a table that you don't, it's based on the what, the incident ran that it can use or it can reliably perform.

And procedure-base means this test take a little bit longer without procedure assistance. That task cannot be reliable performed.

And knowledge-based in the nuclear power plant context, they typically have procedure. But because the way the scenario design. This malfunction, it plays in the very beginning of scenario.

And the placing of in the very end of the scenario that before the things that already, as things happen. Now the system already unavailable in the, happen in the earlier malfunction.

That operator may need to interpret procedure too based on the context. So there is just some knowledge that is in, even the operator superficial, is following procedure. But there is knowledge, element to interpret the procedure that, according to the context, would implement.

So that's a, we asked the trainer, okay, you give that to, look at the entire crew perform this training objective, and what do you think that this response. What type of response, is it skill-based, procedure-based or be knowledge-based.

And the second thing are familiarity. More recruit for when familiar with this task. Maybe this just updated procedure, that the crew was training on the updated, renewed, revised procedure.

So there is a different familiarity on this. And so, this thing on the right that we have this, asking this question, that workload for example, normal or concurrent or the multiple concurrent task, this language here is the trainer gave a, STP trainer gave, okay, so they used a concurrence of multiple concurrence and they know what they meant. Okay, let's take a --

MEMBER DIMITRIJEVIC: Is --

MR. CHANG: Yes.

MEMBER DIMITRIJEVIC: -- what you're saying is, let's say that you have 2,000 data points, like for example, 1,200 of them have information on that, on these skilled, procedure or knowledge-based. Is that what you are saying?

MR. CHANG: Yes. That's, I'm very glad you said that. Okay, here, within that, this was a, within this, this is about five years ago that we have 7,000 data points. Given these data 1,000 data points, some of the detection, some are diagnosis, some are response training, some are action.

So, given that we spend time that we have 1,990 data points is characterized as the response training type.

MEMBER DIMITRIJEVIC: So, if every, a data point can only belong in one of those rows?

MR. CHANG: Well, actually, it's a combination. Let me explain to you. So, within this 1,990 data points in the response training, and then how many of them is characterized, I think you have, okay, procedure-based, is 1,282 data points is the response training, this procedure.

And then when we go down more and more, context fracture, so that's, I have response training and then the procedure-based and the standard uncertainty is clear, there is no uncertainty. And workload is concurrent to the end, and says will come to the end, I have a 201 data points. They have the same context. I have the same context.

And given that, given this 2,001 data points, I have a performance, how many data points is graded with respect to performance. We use a four scale and satisfactory. Except that means that is, performance is satisfactory but there is a data, a group, performance to be better.

And satisfactory means that performance is normal. And then surpass, that means super. So that we have a grading. Within this 201 data points we have rating.

So, this was using, come back to the IDHEAS, the data points here, we have denominator. And then given in this specific context and then what's the ratio that the crew failed a task.

MEMBER DIMITRIJEVIC: So, where do you have a number? Well, yes or no? Satisfactory, not satisfactory?

So every square has both number --

MR. CHANG: Yes.

MEMBER DIMITRIJEVIC: -- times satisfactory?

MR. CHANG: Yes. Yes. Okay, back to you.

DR. XING: Okay, thanks, James. I don't believe we have any questions. More questions for James? Okay, I consider none. You might just stay here.

MEMBER REMPE: Can I interrupt for a second? I just want to make sure I understand because, again, this isn't my area.

But in an earlier slide you talk, you have, SACADA is a database for HRA and there's plant specific data as well as generic data. So, when I look at this table, how many plants are involved in this?

The underlying reason I'm asking this question, are you being, if you use this data for something, are you being unduly influenced because it's not generic, it's very much affected by one or two plants or three?

How many plants are in this database?

MR. CHANG: I cannot say.

MEMBER REMPE: Just one, okay.

MR. CHANG: Correct.

MEMBER REMPE: And then, so, I just am wondering is --

MR. CHANG: Yes.

MEMBER REMPE: -- the database is --

MR. CHANG: Yes, exactly. That's the one thing, so we tried to diverse. That's --

MEMBER REMPE: But you haven't done it yet?

MR. CHANG: Now we have a second plant doing the same thing.

MR. PETERS: Well, we have two units and we'll have two more units coming onboard.

MEMBER REMPE: So, without talking about which plants are in or out, are they all BWRs, PWRs, are they representative of the fleet, I man, are you getting stuff that's really generic yet?

MR. PETERS: We're just two units from one facility, we're not representative of the fleet.

MEMBER REMPE: Okay.

MR. PETERS: But what this is, is a human centered context. So, what we're trying to find out is, if you put a human in a particular context, how well do they respond to that or not, do they detect the cues, do they perform the functions when they have multiple demands or fewer demands, how different does their performance change.

So, we try not to break it down by like, say, how well the plant performs, but how does human respond to an environment. So, we think from that perspective it's a little more generalizable than saying, okay, this is a boiling water reactor and they're, or this is a pressurized water reactor and they're going through a steam generator tube rupture.

We're not kind of related it to the plant context, we're putting it back to the personal cognition context.

MEMBER REMPE: But this, again --

MR. PETERS: This is --

MEMBER REMPE: -- it came from one --

MR. CHANG: Yes.

MEMBER REMPE: -- place so they've had similar training, they have had --

MR. PETERS: Yes.

MEMBER REMPE: -- you said there's some maybe undue influences from locations --

MR. CHANG: Yes.

MR. PETERS: And trust me, we would love to have every plant --

MEMBER REMPE: I know.

MR. PETERS: -- in the United States onboard here. We were only able to get one to, or one utility onboard. And the reason being is, because there's not a lot of trust of the NRC to scrutinize all their human performance --

MEMBER REMPE: I get all that, but I just want to bring up a point that might be relevant.

MR. CHANG: Yes.

MEMBER REMPE: Or not relevant --

MR. PETERS: No --

MEMBER REMPE: -- from what I know on this.

MR. PETERS: -- we truly understand. We know that relevance. But where we are on the human performance role, we're just trying to take any data we can get and try and see if it's utilizable.

So yes, there is some challenge there that it might not be all the facilities and representative of all the types of crews that are out there in their context.

MEMBER REMPE: Representative.

MR. PETERS: Yes.

MEMBER SUNSERI: But I would add though, my experience with the whole fleet is that all of the plants try to break down their human performance into skill procedure and knowledge-based error modes, or performance modes they call them.

I mean, all of the plants had adopted that philosophy, so I would think then that there wouldn't be too much variation --

MR. PETERS: I hope not.

MEMBER SUNSERI: -- from a specific plant.

MR. PETERS: We have these standard approaches to training that are kind of industry-wide. We hope the utilities have at least a minimum standard that they're setting.

But again, we have a very proactive licensee. We may be sampling from the cream of the crop, we don't know. We assume that they're not the worst, but yes, your, these are very valid points.

MR. CHANG: Yes, so, one thing that I want to add. A few months ago, that we have evolved, that's more than 10,000 data points and then has all these data that's cast, grouped into the detection, detection subgroup, detection indicator movement. Or the detected alarm. That's a separate, two separate group of data.

And then there's a diagnosis response training and action. So, each of these that has information like this, give this specific context, what's the, in a manner, that's how many responses we have. And then how many unsatisfactory performance here.

And that was, that we put in the public

domain back a few months ago.

DR. XING: As you see in the report, we were able to map in the IDHEAS-G and the SACADA taxonomy to each other. Mainly because they share the same cognitive framework.

So we can do this mapping. Not necessarily a one-to-one mapping, but we know how to map them.

And like James said, it's the error modes that test take off of SACADA can be generalized for IDHEAS-G HEP table. And the table gathered has a different context factor, like those columns he showed you earlier, can be generalized into the PIF impact table and the PIF interaction table.

And in this mapping process we find that the scope of the functions in the current SACADA. Because it was designed specifically for control room actions performed by the licensed operating crew.

So, the SACADA error mode and the context factors only map the two, a subset of IDHEAS-G failure mode in the PIFs. But as we said, a SACADA-2 will collect operators, will collect emergency response data that will provide a data in the broad scope.

So, for the reason --

CHAIR BLEY: SACADA --

DR. XING: -- discussed, because we now only have a very small number of plants contributing to --

CHAIR BLEY: What's SACADA-2?

MR. CHANG: It's a --

CHAIR BLEY: Is this a revision to SACADA or is it --

(Simultaneously speaking.)

DR. XING: -- methodology, but it's more like in the IT profile to make it easy to use. And then the two subs, some of this software issue that was have there.

But then the other thing is that it explains the scope. In SACADA-1 that's all we, we only designed for, collecting the crew performance information in the simulator training.

And during the outreach there is a couple companies, include Duke and Entergy, tells us, you're performance for them, that you're performance only track to the crew level. And at that time, when we worked with this particular plant, that crew performance is shift managers --

CHAIR BLEY: Right.

DR. XING: But the, Duke and Entergy, they want to track the performance to individual operator.

Also work, did not design in that way.

And the second thing they want too, Duke and Entergy want, they are not only interested in simulator training, they want to have all operator performance in single place. Then when the operator job performance measure in this data space and then a simulator in this data space, we're going to get exempt in this data space.

So, they want a single place that putting together able is able to track individual operator performance in all these area. So that was more efficient with, because the limitation, the structure limit in the SACADA-1 would come to the different, instead of modifying it, it's easier to defer new ones.

CHAIR BLEY: Is that under development or is it out there now?

MR. CHANG: Currently it's deferred for, able to track individual. That's already deferred. That's where it is, yes.

And now we are looking for a different area that's emergency training. For this particular plant, because the crew for the, in the control room and emergency planning is a different crew, they prefer to be separate.

I think we will borrow a lot of code that we have issued in the second one, component here. But build a separate software for emergency training. But a lot of things are, I think it will be very similar.

CHAIR BLEY: Is the original plan to be picking up SACADA-2 or --

MR. CHANG: They will use a SACADA-2 for simulator training, but their emergency program that are not interested.

CHAIR BLEY: Not interested --

(Off microphone comment.)

MR. CHANG: Not interested in use, correct.

CHAIR BLEY: So that's going to be a problem trying to get to more and more plants, is everybody has got their own needs and desires.

MR. CHANG: Back to a few years when I did the outreach, the information I got is, if we put all these crew performance information in one bucket and then single stop able track individual crew for bringing these, and they will go ahead.

And the problem now is this plant management changes so fast. When we come to the developing, okay, we think we're ready to start, and sorry, manager changing, new manager is not so interesting in pursuing. That's a chance that we face.

CHAIR BLEY: Wow. Let me ask one other thing. When you're merging SACADA data with the other data, most of the data sources you've collected, Jing, are looking at actual failures.

As you said, James, the SACADA data is unsatisfactory performance on a task. It might not equate to failure really. How are you dealing with that?

MR. CHANG: Not, as far as the data, are classified unsatisfactory. That means it's typical the procedure has stuck, you need to do this within a certain time, certain point.

And failure means that you failed to let, explicitly explain the point.

If the crew is just doing the slow sluggish, okay, that was, set data is not unset. So, given the human error, I think that's a way that we define because it express procedure. Even the step, okay.

You need to perform this and complete within two minutes, three minutes, or the certain step won't be for a certain setpoint. That, I think, is equivalent to the human error probability we use in

Jing's numbers.

CHAIR BLEY: But it's clearer to somebody using the SACADA data that that was the criteria for the unset?

MR. CHANG: Yes. Before employees do this we provide training. That we ensure the message is carried over.

CHAIR BLEY: No, I understand that. But now you've posted the data on the website or something, so I can go use it to do my HRA.

MR. CHANG: Yes.

CHAIR BLEY: Is it clear to me what unset meant to the people to the plant?

MR. CHANG: I need to check where we provide the explanation --

CHAIR BLEY: Okay.

MR. CHANG: -- for unset, yes. Yes.

MEMBER SUNSERI: I think you're hitting on something there, Dennis, with the SACADA-2. SACADA-2.

Because, at least as I'm looking at this, I think you're going to be introducing more uncertainty in the analysis in the SACADA-2 and here is why.

I mean, if you look at just SACADA-1, there is a small group of very focused simulator instructors, probably just a handful at most, looking at all the crews and making all the decisions on what the error actually was, right?

But if you go out to like job performance measures, which are usually distributed by the crews to implement out in the field, there could be any number of people trying to make that judgment. And so, Dennis' point becomes more valid then, how are they doing it. And let me give you an example.

So, when you're thinking about procedures, right, you can have a procedure error by either failure to implement the procedure correctly or implementing the wrong procedure.

Well, you know, if you don't have a lot of experience with that, you could put failure or implementing the wrong procedure in the knowledge bucket versus the procedure bucket, right? And so, I think that could introduce some uncertainty in your analysis for the SACADA-2, that you might want to think about --

MR. CHANG: Yes. SACADA-2 is current, that we haven't really do a chapter from the measure because the company withdrawal from one intention.

For the emergency preparedness, we'll work with this 2 and to first understand what, how they conduct the emergency preparedness drill that, what information is current and correct and what's the practical way that we can correct the information for HRA purpose.

CHAIR BLEY: Okay.

DR. XING: Okay, thanks, James.

MEMBER RAY: Just a second, let me ask Dennis a question. Dennis, I had assumed that the data that we're talking about here, actual operating plant crew performance data --

CHAIR BLEY: The SACADA data. Yes.

MEMBER RAY: -- was, that all of the data that we used to develop and validate models is so we can apply it in the future.

It sounded to me like in this last exchanged it was also being, expected to be applied --

CHAIR BLEY: I can tell you a little because I was involved with them when they did this. The plants have held on to this kind of data and never shared it.

MEMBER RAY: Absolutely.

CHAIR BLEY: They got a good relationship with one utility who said, well, it was proposed by James, we can help you develop a computer tool that will you give you help in setting up your scenarios for drills and evaluating your crews. And we can give you a lot of free work if you share the data with us afterwards.

So it's, they spent a lot of time getting the language just right for the training people in the plant so it was good for them. And then they effectively had to translate from one to the other, if you're going to pull out data to use for PRA/HRA kind of work.

So, my impression watching that project was, 80 percent, 90 percent of the work was really getting the software into a form that was very useful to the utility so that the training people got what they needed. And as a benefit, and now you're up to 50,000 data points or something, I don't know.

MR. CHANG: More than 20,000. I didn't keep following --

CHAIR BLEY: Okay. But yes, so you're right. It was a --

MEMBER RAY: But I still thought that it was a way of developing a tool that we would use for future plants rather than something that would be factored into the ongoing management of an existing plant. And I'm just asking --

CHAIR BLEY: I think that was their goal.

They were hoping this would show up in lots of plants because there's this gigantic database of simulator drills and exercises that nobody is collecting or using.

MEMBER RAY: Well, right, but again, looking at it from the standpoint of the managers that are constantly turning over, he's talking about, I would think participation would be a contribution toward developing a model that's useful in the future rather than helping me manage my crew at the plant.

CHAIR BLEY: Well, in an ideal world I think that's right. What they did here was put a lot of effort into making it useful at the plant so that the data could come out.

Now, they're going to use the data too because they have PRA work.

MR. PETERS: Yes. I think one of the challenges is how plants are managed. There is an operations department and then there is like engineering groups, and they're out of different management structures and they have different purposes.

MEMBER RAY: Well, I know, but again, I'm looking at it from a standpoint of the agency and what are we doing.

MR. PETERS: Yes.

MEMBER RAY: And, again, I thought this was a part of the building the model that we need in order to cite and improve future plants. And this is one compliment of the --

MR. PETERS: I would be --

MEMBER RAY: -- risk analysis.

MR. PETERS: Yes, yes. So we're using this data here at the NRC and we're going to be building these risk analysis tools that we think utilities and plants can go out and utilize.

MEMBER RAY: Okay. Well, that's the difference then.

MR. PETERS: Yes.

MEMBER RAY: I didn't realize we were expecting existing plant to benefit from ultimately what we're doing here. I'm surprised by that as a long time CNO.

MR. PETERS: Yes, yes. The main, we've actually had our utility partner out there advertising our work. They thought they were benefitting such much from an operations standpoint.

MEMBER RAY: Okay.

MR. PETERS: From a SACADA program that they were advertising all the utilities to join along.

And that's the primary benefit they see, but from us we see it as this way to build up a more robust tool with real data that utilities and the NRC could utilize in the future for performing PRAs and HRAs.

The big challenge right now is I don't think industry does a, they don't do the same amount of work in PRA/HRA that they did when they originally initiated the programs, right? There were these huge massive programs to put in the first PRAs and associated with that, analyzing human actions.

MEMBER RAY: Yes, absolutely. I have been there.

MR. PETERS: Yes, yes.

MEMBER RAY: I know --

MR. PETERS: Yes.

MEMBER RAY: -- you only do things like this where you can see a benefit that is worth the effort required.

MR. PETERS: Absolutely.

MR. CHANG: Yes.

MR. PETERS: And so, what you will see is --

MEMBER RAY: Okay then.

MR. PETERS: -- we're representing later today, you'll see that the industry is really gung-ho right now about our FLEX work and using this new tool to model FLEX applications. So that's where they're seeing the return for the investment.

MEMBER RAY: I see.

MR. CHANG: Just a supplement point. The training, operating training that work with the NRC on the SACADA, they assume that, they use this to demonstrate to INPO, to get INPO's positive feedback on it. On their training program.

MEMBER SUNSERI: At the risk of extending this conversation just a little longer, and building on Harold's kind of thought there, I thought that what we were doing here is developing factual, if I can, maybe information, credible information growing human reliability that could be used in these PRAs so we could build like a NUREG or something, similar to the one on components that said that if I have a valve, this is it's failure rate, if I have a motor this is the failure rate.

So if I have a human doing these kind of things, this is their likelihood of having an error, if you will. Is that --

CHAIR BLEY: That was the driving force --

MEMBER SUNSERI: Okay.

CHAIR BLEY: -- from one end.

MEMBER SUNSERI: So if you have that then, whether it's a new plant, old plant, whatever, it wouldn't matter, right, it would be just useful if you decide to use it.

MR. PETERS: As long as we have the right context.

MEMBER SUNSERI: PRA or whatever.

MR. PETERS: Yes. Yes. Our hope is they can put a data --

MEMBER SUNSERI: Okay.

MR. PETERS: -- NUREG out there. Something similar to a data NUREG that would show the error rate with these particular context.

MEMBER SUNSERI: Okay, thanks.

CHAIR BLEY: I'm looking for a good place to take a break.

DR. XING: This is --

CHAIR BLEY: This is like, two more slides?

MR. CHANG: This is a perfect place --

CHAIR BLEY: You're sure?

MR. CHANG: My last slide is pretty much we just discussed. SACADA data and we are able to generalize them when we have more data from more plants.

The only thing I want to mention in these slides, as we all realize, the data generalization is the ongoing continued effort. So we should, in the down role, like periodically, look at what data we have and update them, generalize them, integrate them so the update has HEP numbers. That's down the road.

MR. PETERS: So this is a good place.

CHAIR BLEY: We're going to recess for 15 minutes. Be back at 25 after please.

(Whereupon, the above-entitled matter went off the record at 3:11 p.m. and resumed at 3:25 p.m.)

CHAIR BLEY: We are back in session. Jing's still up, or who's up now? Jing?

DR. XING: Yes, interface. Okay, so we come to talk the third IDHEAS-G application which we've been looking forward to for this whole day, IDHEAS-ECA. So I will first talk about the philosophy in developing IDHEAS-ECA which luckily, early this afternoon, we already pretty much discussed everything. And then James will give you a demo of the software.

So we already talked about everything in this slide which talk why we want to develop application specific HRA method from IDHEAS-G. That's on the top, the three reasons. And on the lower portion, the table, which speaking at a very high level, what's the delta between IDHEAS-G and an application specific method?

So look at the right column. From specific application method, of course we want it to be more specific for the application. And we want it be concise and easy to use.

The most important is the last item. IDHEAS-G we can reference to human error data tables, get a sense what is likely the human error where the probability probably is. In the application-specific method, mostly I think that the people who want this method, it wants a way to get HEP of the human actions.

CHAIR BLEY: Jing, what makes IDHEAS-G specific to nuclear applications?

DR. XING: Honestly, not much.

MR. PETERS: I don't think, you know, it's just specific to nuclear applications. What we were trying to do is make it specific to all things that we would do at the NRC. And so that was our entire context. But almost all things we do at the NRC are applicable in the real world also.

DR. XING: Yes.

CHAIR BLEY: Yes, I agree with you. But

it does cover all of our applications to --

MR. PETERS: But we never went through that delta analysis to go look at all possible applications of HRA out in the real world. And so we're sticking with what we know. We know we were encompassing what's in the nuclear domain.

DR. XING: Yes. It's more of speaking to the public, a way data work for where our paycheck comes from, just kidding.

Back to two years ago, I talked with my previous co-worker at the Federal Aviation, FAA, and say are you doing anything HRA? Maybe you can share your human error data with us. And FAA's project manager answer was, oh, we rely on NRC to develop the method. Then we just take it to use.

MEMBER DIMITRIJEVIC: But this division here actually answered to one of Joy's comments which was is this guidance a methodology? Because this IDHEAS-G is methodology, and then application to be presented is a guidance. And maybe they can be either separated as appendixes --

DR. XING: Yes.

MEMBER DIMITRIJEVIC: -- in a main report or something. Because here ---

DR. XING: I think that's a much better

way. Otherwise, we are playing this word game of methodology versus method. It can be many different interpretations. Thank you.

So the general approach with development application-specific guidance, IDHEAS guidance, we first define the scope of the application requirements, typically from the people who want to use it, and available sources of the intended use.

And this comes to where we discussed earlier this morning and back to the ACRS recommendation in 2016. We want to keep all the qualitative analysis the same as in IDHEAS-G. The guidelines should be the same. And we developed application-specific sets of failure mode PIFs and HEP model, so we preserve all the --

So the table in the bottom actually explains this, spells this out. So left column's for IDHEAS-G, right column is for an application-specific guidance. So all the guidance for scenario analysis is going to be the same. But you can make some specifications, for example, to identify deviation scenario to identify context.

IDHEAS-G provided some general questions to help you search for context. You may adapt to those questions be more specific for your application, same for human actions and identify HFEs and the task analysis. Use the same guidance and you may give some specifications on how to develop a test diagram.

For example, in our IDHEAS as power guideline, we actually had a very detailed guideline on how to develop accrual response diagram for task analysis. Because presumably, the tasks are all performed based on procedures. And procedure allows you to go line by line to delineate how they perform a task. What are the possible paths, what are the recovery possibilities if you have that? So that's a specification. But the general guideline's the same.

Okay, the text in blue really shows the difference. So we come to this specific application. We probably only want to use a set of the failure modes instead of everything. And we probably use a subset, or the full set with some adaptive set of PIF and the attribute. And we should provide some base HEP values and PIF weights for calculating HEP. And the time and certainty analysis stays the same.

So come to IDHEAS-ECA, so to define what we want in this application by our NRR users, the scope is they wanted this ECA tool or ECA method for all the nuclear HRA applications. In this sense, there's no fundamental difference from IDHEAS-G.

Specifically, they want to use it for FLEX-HRA. But they also want to use it for any other control room action involved, a lower power shutdown, which action lasts for days.

And the requirement was really simple. When we got one requirement, easy to use, as simple as SPAR-H. And the resources we have available at that time back to a couple of months ago, we have some IDHEAS-G HEP tables, well sorry, not just HEP tables, IDHEAS-G human error data tables, the three tables.

And we also have some HEP numbers from our 2018 FLEX-HRA expert elicitation. And the users want a way use those numbers, those HEP numbers, at least as a benchmark of validating the HEP calculation in this method.

So the bottom portion specifically listed what's the delta between IDHEAS-G and the IDHEAS-ECA. We already said that the qualitative analyses up front are the same, no change. So it's only in the quantification part.

IDHEAS-G provides a basic set of failure mode in three levels details. When we come to ECA because we want to model a broad set of defense, and the user wants to keep it simple, so the compromisation is that we will only use the five high level failure modes, which is those short-worded, the failure of detection, failure of understanding, failure of decision making. So we only quantify them at this level.

CHAIR BLEY: So the macrocognitive function?

DR. XING: Yes, macrocognitive functions. That's where we also have data for. And IDHEAS-G has 20 PIFs. Each PIF has an extensive set of attributes. We preserved all the 20 PIFs, but we have a compressed set of PIF attributes. And that compression is based on the human error data available.

See, we see several attributes. Their impacts, the W, the PIF width, on the same failure mode are the same. So there's no reason we have them separate here. And also, user wants a relatively shorter list, not an extensively long list, quite interesting --

CHAIR BLEY: Do you remember how many attributes there are altogether? There's a lot of them.

DR. XING: Okay, I would say the shortest attribute in the environmental PIF, they probably only, like, around anywhere from three to five. The longest one is a test complexity, which we didn't get really many of them. Because each one modeled a different aspect.

So we have about totally, for past complexity, we actually really break down the specific attribute for each macro company to function. Each macro company detection function has anywhere from, like, eight to ten attributes.

CHAIR BLEY: I thought there were seven, based on my count. So I think it was --

DR. XING: Oh, okay. That's probably --

CHAIR BLEY: I'm trying to keep track of those --

DR. XING: Oh, I actually put some examples here. Again, that's for demo, not the whole set. Otherwise, you would have to read a very small sized font.

And from our human error data table, we actually integrated the numbers for the base HEPs we need and the PIF width. So this will allow the HEP calculation for any given failure mode and PIF attribute.

Because it was very clear we got from our users. We couldn't afford of keep doing the expert elicitation. Each expert elicitation would take, like, the one with data, they did it in six months.

They said, well, that was too fast.

MEMBER DIMITRIJEVIC: So how many data failure mechanisms and how many PIFs do you have in the data?

DR. XING: Failure, how many? For this level, as we said this morning, the analyst, when they look at this IDHEAS-ECA user guide on that report, they don't even say the word accommodating mechanisms. Because they don't want to go to that level of detail.

But we just tell them if you want really understand why this PIF attribute would impact the detection but not understanding, you can go to IDHEAS-G report where we explain there.

MEMBER DIMITRIJEVIC: So basically, you have a five times twenty, 100 inputs?

DR. XING: Oh, that's --

MEMBER DIMITRIJEVIC: Some are empty, I assume, I'm not sure.

DR. XING: Yes. I think at one point, see, we need to get something around, okay, let's say, we have 20 PIF. If each PIF on the average you have 10 attributes, that's 20 times 10. And then you have five failure modes. So it's 20 times 10, times 5 to solve that.

MEMBER DIMITRIJEVIC: Yes.

DR. XING: So that's the numbers we struggled with in the whole summer to get those numbers. But luckily, we probably only need a half of that many numbers. Because some PIF attribute only affect one or two macro companies to function but not the other ones.

MEMBER DIMITRIJEVIC: So you do micro-cognitive. I just heard you discussing that you only do it on macro level, but you do it actually on micro level.

DR. XING: We do micro-cognitive functions at the highest level, but we don't do it at the detail level in this method.

MEMBER DIMITRIJEVIC: So you do more than five. For every five you have a ten micro ones.

DR. XING: Oh.

MEMBER DIMITRIJEVIC: In addition to D, U, DM, you know, the --

DR. XING: Yes. We do at least five.

MEMBER DIMITRIJEVIC: Five, and then under that you go further?

DR. XING: We don't do the end, but for each one we needed the --

(Simultaneous speaking.)

MEMBER DIMITRIJEVIC: PF.

DR. XING: Yes.

MEMBER DIMITRIJEVIC: Okay. All right. Well, once when we see some example I will understand too.

DR. XING: Yes. Because if we go one layer down, the number we need to get would be tremendous, ten times the increase than we have now.

Okay. And again, this morning IDHEAS-G introduced us with three different ways of the combinations of quantify HEP. In this particular method, we use HEP quantification models that Jonathan talked this morning.

And this is example you said you want to see. Again, this is probably the full table of, the HEP table for information, availability, and the reliability. As we said, for this PIF, we get the number, they write the HEP number, not the weight.

So this one actually only you can say have two attribute. The first attribute, INF1 is for information incomplete or information availability. The second one is for information reliability. But for each one, for the top one we have these three anchors which show the different level of this attribute.

So the lightest level is the information is temporarily incomplete or not readily available which means that you probably can recover the data later on or you have the memory from early data can make some compensation.

And the second case is somewhere like in the middle. Yes, you do miss some information.

And third benchmark will be the worst case. The information is largely incomplete, say the key information is the mask or indicator of missing, like, for example, in the talk this morning. The indicator label is wrong. So that was the three situations.

Because we define this PIF specifically, say it's information, you need it for understanding the situation and making decisions, therefore in the five columns there's no number we have not applicable for the three functions, the detection, execution, and team interaction. We only have the number for understanding and decision making.

So each individual number represented the data point from multiple sources. I would say basic generalization but, like, I have five research papers of all the data sources can fit into one of these box.

And these five numbers are not necessarily the same. If I have enough numbers, they will bring me a good distribution, the most likely, the middle point, and the wrench which eventually, when do HRA, we won't get the uncertainty. So if there's uncertainty wrench in the data we were in. But for this project specifically, because right now we only present the most likely wrench.

MEMBER DIMITRIJEVIC: Okay. I forget that you going too many details, I don't understand it on the high level. Why you are only looking in understanding and decision making and not in detection?

DR. XING: That is in the definition of this PIF. The detection means that you give, assumption is the information is there. What is the failure probability you didn't detect them or you detect them incorrectly? So it was already in the assumption for detection.

MEMBER DIMITRIJEVIC: But it says that, okay. All right, let's look in the stuff which you show on the shutting the pump down which you broke on detecting problem, entering right procedure and shutting the pump down

DR. XING: Yes.

MEMBER DIMITRIJEVIC: So let's look, I want to calculate that decision making to shut the pump down. So what do I do? How do I go about that?

DR. XING: James, can you elaborate on that?

MR. CHANG: I would defer this question to later. It's simple how we do this. It's we look at, in short, looking at the task you were describing that what's the macro-cognitive function involved there, and then that's a good, in the ECA, looking at the macro-cognitive function say that your diagnosis doesn't show anything. That information in diagnosis situation.

And then look into that these are PIF affecting diagnosis. And then each PIF has these PIF attributes. What attribute applies to this diagnosis situation. That's one. And then based on the ---

MEMBER DIMITRIJEVIC: Well, so give me some example, I mean, than just I'm going to trip the pump. What attributes? Was my information complete? Yes, let's say. I mean, I don't know what we want to ask. If you ask me, I will know what's happened in the plant, and I can answer to you. But I don't know what attributes you want to look in.

MR. CHANG: Okay. So in this case, that when we say talking about detection, that's a mixed -- .

MEMBER DIMITRIJEVIC: Yes.

MR. CHANG: Yes. And now this, if I say that, given this situation, I should follow procedure ---

MEMBER DIMITRIJEVIC: Right.

MR. CHANG: -- whatever procedure to there. And then the procedure will ---

(Simultaneous speaking.)

MR. CHANG: -- guide me to trip the pump.

MEMBER DIMITRIJEVIC: Got it, okay.

MR. CHANG: The detection portion says that's all the key permitted I have detect, assume that is correct.

MEMBER DIMITRIJEVIC: Right.

MR. CHANG: Now I follow this procedure. Is there anything that I still need to diagnose, integrate information that's in that aspect, that will lead me to go to a direct action stat to trip the pump? And then we are looking at that diagnosis, that type of condition, and looking at the PIF and attributes. What are the attributes applying to that operator working at that task in that condition?

MEMBER DIMITRIJEVIC: What are advantages? So we already diagnosis ---

MR. CHANG: Yes.

MEMBER DIMITRIJEVIC: -- where he has a problem.

MR. CHANG: Oh. Okay, sorry, I misunderstood. So that question is the prior diagnosis that now the problem.

MEMBER DIMITRIJEVIC: Right.

MR. CHANG: And now it's following the procedure, that procedure, if that's only one way that operator would lead into trip the pump.

MEMBER DIMITRIJEVIC: Right.

MR. CHANG: The decision portion, there's no alternative of how we'll make the decision --

MEMBER DIMITRIJEVIC: Or is there anything from this table he will use? That's what I'm asking. So I don't understand how this table works.

MR. PETERS: I think some of the confusion comes from this table is only from the HEP for information availability and reliability.

DR. XING: I actually have ---

MR. PETERS: So there are other tables that are ---

(Simultaneous speaking.)

MR. PETERS: -- are for other types of human error probabilities.

MEMBER DIMITRIJEVIC: So what I mean, this could be in case the information is not how available or something. Maybe, you know, breaker for the pump is not well, you know, identified, things like that. I mean, what does it mean HEP for information availability? Every HEP needs ---

MR. PETERS: So detection would be there's an alarm that goes off in the plant, right?

MEMBER DIMITRIJEVIC: Right.

MR. PETERS: So information availability doesn't matter, because it's the alarm or not the alarm. So from an information availability it would be, say your procedures say you have a particular set point that, by that set point, you need to trip the pump.

So you already got the alarm. Now you're through the procedure, and you're looking for that particular set point. If that set point's not displayed on your panels or you can't get that information, that means that's not really available. I don't know if I'm coming close to that parameter.

MEMBER DIMITRIJEVIC: All right. Okay, so if the, let's say data is displayed on the panel, okay.

MR. PETERS: Yes.

MEMBER DIMITRIJEVIC: Everything is fine.

DR. XING: Yes.

MEMBER DIMITRIJEVIC: Set point displayed. Then what do I use from this table?

MR. PETERS: So let's see if I can read this far.

DR. XING: I actually have an example of ---

MEMBER DIMITRIJEVIC: Yes. I would love to see that, some example. Because for me this is just tables. I don't know what to do. I don't know why don't you have a case when everything is all right. I mean, how do numbers fit?

DR. XING: So in the U.S. benchmark study, four crews performed the three scenarios in one of the U.S. plants. And then a bunch of HRA analysts used a different HRA method to analyze those scenarios. So the three scenarios, one is a simple, standard steam generator tube rupture?

MEMBER DIMITRIJEVIC: Excellent. That's good.

DR. XING: Yes, assuming you have everything, have good procedure and have all the information you needed. And also, of course, state data correctly success. And all the HRA analyst team, even if they had variabilities, they all get the HEP very low for that one.

And then they also have a comparison scenario which is also steam generated tube rupture. But they purposely introduced many complications. One complication is make the information misleading. They manipulate it.

I think that was a small, that was actually two deep. Therefore, you only say that, people only say the information think that's a big deal, because they didn't realize that actually two deep are the same indication.

So that would affect, when I go through this table, I would go to that category. Key information is masked. You should have the indication for the leaking, but the information about the leaking for the second, for the LOCA was masked in the information for ---

MEMBER DIMITRIJEVIC: So you would go to the third one?

DR. XING: Yes. I would take the key information is masked.

MEMBER DIMITRIJEVIC: Okay, then the ---

DR. XING: In that case, base HEP is supposed, for understanding, for the diagnosis, the two cases, If everything else perfect, the HEP is already pretty high. Like, they would, that's Point 2 which means you have a good 20 percent chance of failure. But that scenario, there are several other complications. The results, I think, is three.

MEMBER DIMITRIJEVIC: There is a, I mean, like in the steam plant, the tube rupture, there will be multiple indication. He does not rely only on one, I mean --

DR. XING: Yes. So at the end of all the four crews' failure, not the crew identified that LOCA, that masked by the steam generator table --

MEMBER DIMITRIJEVIC: Are you today going to present to us something you take from the beginning, and then you come with HEP in that?

MR. CHANG: Yes.

MEMBER DIMITRIJEVIC: You will present something for us, what is here, what does the, you know, the cognitive failure mode, how did he select task? What cognitive modes are related? What PC selected? Then what was HEP on the them, and where did he get the data to answer that?

DR. XING: Yes. James had prepared an example.

MR. CHANG: One example.

DR. XING: So that means --

(Simultaneous speaking.)

DR. XING: Yes. I will finish my part, talk quickly. I think you all looking forward to hear what he's going to show.

MEMBER DIMITRIJEVIC: Okay.

DR. XING: Okay. This is another demo for the PIF weight tables, but let's skip this unless you want to see the detail.

So this is summarized. This is a diagram we are going to give to the analyst. This is from the IDHEAS-ECA report that we are in progress writing. So Jonathan prepared this diagram and laid out so each box is a step of activity you need to do to use the IDHEAS-ECA.

We don't need to go through every box here, because he already went through this morning. But look at the three, we call that orange color, that's the difference between IDHEAS-G and ECA. IDHEAS-G can be all those white boxes up front, qualitative analysis.

Then IDHEAS-ECA, this is the software. But without software, you have to do it manually by hand which I already heard analysts say they don't want to do math, even if it's a simple math.

So IDHEAS-ECA provided you the way to

calculate in the PC, calculate in PT, and calculate in the overall HEP. And in the IDHEAS-ECA ---

MEMBER KIRCHNER: Can I make an observation? It's seeming to me that that figure you just showed, the previous view graph, we didn't really see that earlier. We saw it in words and multiple view graphs. But this figure simplified, like, you might remember, I asked where are you getting this narrative from? So you show here that you're taking the PRA model as the input to start developing the narratives.

Some stylized version of this much earlier would be much useful, because now we're just getting to the point of putting all the pieces together in some coherent manner that suggests you can actually use this. I think it almost goes back to Dennis' opening comments, that at the end of going through all this, there's some utility to what you're presenting, just an observation.

DR. XING: Thank you. We'll definitely take that.

CHAIR BLEY: I mean, when you say here it's the same process as IDHEAS-G, that's great. But it would have made sense then to have this at least in Chapter 4, or some simplified version of it maybe way up front.

MEMBER REMPE: How does this differ from other methods. I mean, you come down and say, well, you really just have the three orange boxes. Is it because you documented the scenario narrative and all that? How does this differ from other methods that existed before IDHEAS-G?

DR. XING: I would say it depends on each different method. Pretty much every HRA method explicitly or implicitly asks you to analyze a scenario, identify the context, do a task analysis.

But as I said, some methods doing this implicit. For example, you know, NRC's method, SPAR-H, a lot of people just read the SPAR-H report would think, oh, you started from only this end part, identify the PIFs, then get a HEP number.

But our NRC staff, when they use SPAR-H, they always do a lot of similar up front analysis. But the main difference in IDHEAS-G, compare others, it will make this very explicit.

So other than, because SPAH-H does not have this guideline, so it very much depends on individual analysts, what I want to analyze up front and what I want documented. So in the HRA benchmark study, two teams used the SPAR-H. So I was in the NRC

SPAR-H team.

Our reports were very different. So our report, NRC staff's report using SPAR-H, we documented a lot of upfront information. And the SPAR-H performed by a different team, they barely documented any information. It's just a, oh, here's my selection of PIF. That's not HEP --

CHAIR BLEY: Jing, I disagree with you. Before ATHEANA, the only methodology that laid out a process for doing HRA was the EPRI thing, SHARP1. And then ATHEANA did. Most of the other methods left this up to the analyst to figure out what to do.

And many of them, the analysts didn't figure out, they just went to tables of performance shaping factors, and grabbed numbers off, and used them. So, you know, SHARP1, ATHEANA, and then this, have a process. And I think that's pretty important.

Now, if you ask me how much different is this from some of the others, I don't know, one thing I'd say is the approach here has documented the cognitive basis probably more thoroughly than anybody else has done. And I won't try to think beyond that. Because my brain's not working great.

MR. PETERS: So just to --

DR. XING: Thank you, Dr. Bley.

MR. PETERS: -- just to elaborate a little bit, I just wanted to make one correction. So our process is the entire sheet, so the white part and the orange part. The orange part is just going to be the tool that James is presenting.

CHAIR BLEY: And all the methods had some kind of orange part to them. And in fact, mostly that's all they were, were quantification set of tables or some such thing.

DR. XING: Okay. Thank you, Dr. Bley. I completely agree with your disagreement. And that give us more credit than I would dare to claim, ha, ha. I don't want to criticize other methods for not having it. They will immediately say, oh, we don't have it written, but we will do it. Okay, so ---

CHAIR BLEY: I think you're right. The empirical study showed that, yes, maybe they do. But mostly they don't.

DR. XING: Yes. They don't, or they do it very differently. So it's hard to compare between them. Because they documented this information not in any systematic way.

MR. PETERS: And that makes it hard to repeat. And that affects the variability, so ---

DR. XING: Yes. So one thing, in 2016 we

did a test IDHEAS at-power which is a qualitative part, pretty much the same. And the two outcomes, one was the testers complain, oh, this takes too much more time than it did before, because I have to spend so much time documenting analysis.

Then at the end, they say the advantage was when we compare the differences between the different teams, it was crystal clear to see where they make a difference. Because they said, oh, we are in that box.

You and I have a disagreement in the context assumption. Like I assumed indicator would be unreliable. You assumed all the indicator perfect. So that was an advantage with this documentation process.

Okay, so I'll quickly turn you to James. Yes, so we said earlier we want to make sure that users in ECA will document all the information systematically. So we have IDHEAS-ECA report which included guidelines, worksheet, and all the HEP and the PIF tables, and three or four examples. Two of them, we applied the method to U.S. benchmark study.

And these five worksheets are documented information in the boxes in the previous page. So only after you finish these five boxes, document has information, then you can turn into the two boxes of software which will help you do the math.

MEMBER KIRCHNER: May I just point out just something that you might check for consistency? On the previous view graph, you used different nomenclature. You were using HFE.

DR. XING: Oh.

MEMBER KIRCHNER: On the next one, you're calling it --- I'm not a practitioner in this, so the more acronyms makes for more confusion for me. If the practitioners know that an IHA equals and HFE, fine. But I notice you call it one thing there, and now you're calling it something else. So you ---

DR. XING: Thank you.

MEMBER KIRCHNER: -- you might look at ---

DR. XING: Yes. It was in ---

MEMBER KIRCHNER: -- whether your nomenclature ---

(Simultaneous speaking.)

MEMBER KIRCHNER: -- is consistent.

DR. XING: -- because the analysts started the analysis with HFE data.

So that was a recommended use if you need to analyze the event or document them in the worksheet. And then use the HRA tool box for calculating HEP. Having said that, I'll turn to James to show the software.

CHAIR BLEY: I'm sorry. Back up one. The NRC HRA tool box?

DR. XING: That's a new term.

CHAIR BLEY: You haven't explained that.

MR. CHANG: Yes, I'm going to explain.

DR. XING: He's going to explain. We took the software for ECA, but James actually developed the software, not just ECA, it also has a dependency there and has other ---

CHAIR BLEY: And it's up on the NRC web for people to use here at NRC?

MR. CHANG: Not yet.

CHAIR BLEY: Not yet?

MR. CHANG: The software installation package is now with NRC IT, that's what, no ---

(Simultaneous speaking.)

MR. CHANG: And then after that we will exercise it with EPRI in the project. And then, if everything goes well, that will release. That's the time to release to public.

CHAIR BLEY: Okay. We'd like to be kept informed of that process, if you don't mind.

MR. PETERS: Absolutely.

CHAIR BLEY: It's a good thing. So this is kind of like the PRA tool box that's up already? It's a place to go to get tools, or just one tool?

MR. CHANG: It's most equivalent to the EPRI's calculator.

CHAIR BLEY: The what?

MR. CHANG: For use in the EPRI HRA calculator, but equivalent to that kind of level of software. But it's for implement ECA method at the dependency and SPAR-H.

DR. XING: SPAR-H.

CHAIR BLEY: Okay. You're going to show us what's in there now?

MR. CHANG: Yes.

DR. XING: Okay, James. I think everybody wishing for your turn, ha, ha.

MR. CHANG: Chairman and the other committee members, correctly state this morning that the event on the HRA, NRC to implement ECA, that there's 28 performance influencing factor. Each factor has a number of the PIF attributes. That's the memory, the mental note, to remember all these methods, these items, and then also the math involved in calculation, especially convolution, math in the calculating the PT, that will be quite correction to the HRA analyst to implement the method.

Without the software to implement the method that we envision that software, this method will be only implemented in probably research projects, not go through, be practical to apply for NRC day-to-day operation.

So staff has this variation that we want to develop a software to take a capacity out of the analysts' hands. And then that analyst folks put their efforts, the folks doing the good qualitative analysis, the good documentation, and then that has a good tool for them to implement. And then the tool itself serve a good guidance.

And then the data that Jing talked today that we implement in the tool, that's a five data point come to the one recommendation vary where we want to use, we implement in the tool.

That's here that the user can, once analyzed that highest documentation, that the tool can operate all the factors that the user check and then watch the factor's effect, individual factor effect, so that the user coming to that has all the clear documentation. And then it was a detail coming in to the HEP calculation.

So the screen shown here is that the

software that's up on the screen that on the top it's HRA calculator. And the bottom one is you can use, the one below it is the user that wants the analysis will we able to save in the file. And then we treat them and then inspect later all the codes.

Underneath is actually HFE identification, that this is a typical identification we use in the PRA model, why this H-A-S-D-T-R-whatever. And beneath it is the description that describes that the user will be able to provide more description about what's this HFE about.

On the top, on the right, that you see that, there's a blue background, that's a white text, this LCA, ECA, oh, that's HEP, the number here that is the -- Yes?

CHAIR BLEY: Would you use the pointer, and --

MEMBER REMPE: The mouse.

CHAIR BLEY: The mouse. Once you move it it'll light up.

MR. CHANG: Oh, okay.

CHAIR BLEY: And you can show us where you're talking about.

MR. CHANG: Okay, thank you.

CHAIR BLEY: Thank you. It goes away

after you rest, but --

MR. CHANG: That is a much helpful tool. Okay.

CHAIR BLEY: Thank you.

MR. CHANG: So this a final HEP, we took it from in the ECA method. And then it has two elements. One is a PC and a PT. The PC here that we, okay, let me come back to this data.

This is only the independent, but we also implement the dependency model that's documented in the NUREG 1921 fire HRA method that NRC jointly developed with EPRI. That's the dependency model. We implement in this software that user could use that dependency model and then the software will take the independent HEP to calculate dependence, HEP --

CHAIR BLEY: I'm sorry, NUREG 1921?

MR. CHANG: 1921.

CHAIR BLEY: And that's a dependency?

MR. CHANG: No, fire HRA method. Within it has a --

CHAIR BLEY: Oh, it's the fire HRA.

MR. CHANG: Yes, fire HRA. And within it has a dependency that meant a flow chart.

CHAIR BLEY: Now, you have an appendix in IDHEAS-G on dependency. Are those two related, or are they just randomly different?

DR. XING: Not related, I would say the appendix dependency, because we put all the source there, how dependency should be addressed.

CHAIR BLEY: Are you lit up?

DR. XING: Yes. So the appendix in IDHEAS-G report on dependency, I would consider that's not finished. The development hasn't finished. We only laid out our source on how dependency should be created. And the dependency HEP should be calculated if we use IDHEAS-G.

However, we haven't completely finished that part. And meanwhile, our branch already has a project further give a better guidance on dependency. So we gave that IDHEAS-G dependency software to our other project. Hopefully, they will take some source there.

CHAIR BLEY: Okay. Are you bringing the fire HRA dependency ---

DR. XING: Yes, so ---

CHAIR BLEY: -- into IDHEAS-G, or just into this example?

DR. XING: Only in the ECA. We didn't bring that to IDHEAS-G.

CHAIR BLEY: Okay, you didn't refer to it either, I don't think.

MR. CHANG: But there's a tool box.

MR. PETERS: Same thing in the IDHEAS-G document.

DR. XING: Yes. In the IDHEAS-G report, we said we didn't do our own development of dependency. We only have some source documented.

CHAIR BLEY: Yes, and you documented some, I thought, kind of useful thoughts. But it sounds as if you didn't link to the other work that had been done so that these things are kind of dangling again and not hooked together where they could be.

MEMBER KIRCHNER: Just to point out in your previous flow chart where dependency enters into your -- because now you've introduced something else.

DR. XING: Yes.

MEMBER KIRCHNER: So I thought I understood this calculation, but where is the dependency coming into this flow chart?

DR. XING: Yes. This flow chart, because we didn't specifically address dependency, the method will say if you need to address dependency use whatever you choose as the current method. So it's not included in the flow chart.

MEMBER DIMITRIJEVIC: Plus, if you understood method, you well, because I am not even close yet. And we are moving in that direction.

MR. CHANG: Thank you. So these are the previous information that will constantly show on the top screen of this software. And underneath it, we have the seven tabs. Each tab that's allowed a user to do different functions.

The three root tab we implement here, the critical task, that's to calculate cognitive error probability. So this software just now allowed the user to calculate up to three critical tasks.

One thing I didn't mention, this software that, it's intentioned use that Jing already mentioned, the HRA is the first dual qualitative analysis that understands that the human failure event want to analyze and then do a qualitative analysis. So this is two estimates of this error probability of these human failure events.

So given that we have the three, so we allowed the user to have maximum of three critical tasks. In our conversation with the understanding of what the HFE we're using, the PI model it seems that we expect most of that, we only use the one critical task.

And the reason that's coming to the three critical tasks is that when you have detection, understanding, and implementation, that could deploy FLEX and component, that type of scenario, that the context was quite different that we may come to the multiple critical task.

Okay, the brown tab is still calculated. I have a slide to talk about this. And then there's a gray slide, the documentation, and then dependency and SPAR-H.

MEMBER DIMITRIJEVIC: So this 3.2 minus three is just for Critical Task 1.

MR. CHANG: Yes.

MEMBER DIMITRIJEVIC: It's not for the human error which you have there, there were ID myHFE. It's not for myHFE, just for critical task identified for myHFE.

MR. CHANG: Yes. But I want to clarify. So 3.2 is for this critical task. In this critical task that you see that I have a check for each macro, failure mechanical --

DR. XING: Macro.

MR. CHANG: Right. So this critical task involved all five macrocognitive functions. And then underneath this blank box means that if that has any performance influencing or PIF attribute, that means negative ins, that will show on here. And without showing anything here, that means that I did not identify any negative factor or factor performance. So --

CHAIR BLEY: I want to stop you right there.

MR. CHANG: Yes.

CHAIR BLEY: You've done your qualitative analysis, you've identified that all of the macrocognitive functions are involved in Critical Task 1.

MR. CHANG: Yes.

CHAIR BLEY: Now, does the software then let me go in and search for what the important PIFs would be or --

MR. CHANG: Yes.

CHAIR BLEY: Can you show us that?

MR. CHANG: Yes. Later screen that will show that. But now I just provide a high level overview of it.

MR. PETERS: It's much easier to see when you actually have a working tool to click buttons ---

MR. CHANG: Yes, but I was --

(Simultaneous speaking.)

MR. CHANG: -- the device, but not to do a demo in this place so --

(Laughter.)

MR. PETERS: So what we're going to try to show is pretend that James is clicking through the screens as we're going.

CHAIR BLEY: So if you had gone through that process and identified some PIFs that were important ---

MR. CHANG: Yes.

CHAIR BLEY: -- you would have found them, and they would be showing up on this screen?

MR. CHANG: Showing at the top, yes, in the corresponding ---

CHAIR BLEY: So since they aren't there, that means this was quantified assuming all the PIFs were good.

MR. CHANG: Yes.

MEMBER DIMITRIJEVIC: Why does the MFC selection on your left, it only has a detection line?

MR. CHANG: Yes. Because this is a, we have limited space ---

CHAIR BLEY: I can't see that.

MR. CHANG: -- that you switch the form of detection to understanding, to deciding, and then when you switch, the user switch on the site, the tree will change correspondingly.

The tree, PIF tree for each macrocognitive mode are different. So that will change correspondingly.

CHAIR BLEY: Have we seen the PIF tree today?

MR. CHANG: I'll show of them. That's a later slide, we'll show some of them ---

CHAIR BLEY: Okay, because I'm not sure exactly what you're talking about.

MR. CHANG: Yes. It is mentioned here that, given this thing, so this critical task involved detection, understanding, deciding, action, teamwork. And each of them checked means that this critical task involving this macrocognitive function. But underneath it there's no item means that that has a HEP. This is the minimum HEP we apply for this cognitive function.

MEMBER KIRCHNER: What's your basis for that then, for each of the numbers that are entered?

MR. CHANG: Yes.

MEMBER KIRCHNER: And you're saying for, let me just pick one. For detection it's the nominal error or the mean error, whatever it is, one times ten to the minus four.

MR. CHANG: Yes. This is another user in there. This is a program already put in there. This is the minimum HEP for detection we put in there.

MEMBER DIMITRIJEVIC: So does this come from those 6.2, 3, 4 tables that ---

MEMBER KIRCHNER: Yes, that's where I was going. This comes from the tables.

DR. XING: From the original table that make ---

MEMBER KIRCHNER: But how does it know the complexity of, I'm a little concerned. I know you will have understanding next and such, but the set of inputs you need to detect some of the more extreme events, maybe very low probability, but extreme and complicated events, would have a much higher value.

MR. CHANG: Yes. But that means that you likely will have a negative PIF attribute involved. Now we are just talking about, at a minimum, the best quality that, without recovery, what's the HEP at lowest without ---

MR. PETERS: James, could you skip ahead to Slide 97? That might clarify things a lot.

(Simultaneous speaking.)

MEMBER SUNSERI: One more down.

MR. CHANG: One more down.

MR. PETERS: No, no, go up two.

PARTICIPANT: There you go.

MR. PETERS: Yes. This one will show where particular performance --

DR. XING: That would be in your handout.

MR. PETERS: It doesn't show as well on the screen as it does in the handout.

MEMBER DIMITRIJEVIC: On this we have, it identifies some, we have identified some of those issues. Understanding information is temporary and incorrect.

MEMBER KIRCHNER: So I noticed standing up and looking at --

PARTICIPANT: Walt doesn't have it.

MEMBER KIRCHNER: That's all right. I looked at the screen up there. There seems to be now a precision, now the numbers changed, right. So now --

MR. CHANG: Yes. Once they're selected in, so ultimately using the equation that Jing has shown to calculate all of that into the --

MEMBER KIRCHNER: So now it's increased, the error probability is increased to 7.2.

MR. CHANG: Yes.

DR. XING: Because you have many in the middle, those big white box. You have many PIF --

MEMBER KIRCHNER: Yes, so I looked at that.

DR. XING: -- actually selected.

MEMBER KIRCHNER: Geez, the precision of those numbers, I guess maybe it's the computer model. Thanks.

MR. PETERS: We were trying to get more decimal points but, you know ---

MEMBER KIRCHNER: Yes. I guess the computer doesn't care, but as an engineer, as I do.

CHAIR BLEY: They should round off for us.

MR. PETERS: Fully noted.

DR. XING: Yes. As an analyst, they can actually hold the ECA report which has all the numbers there. They can see if I changed the complexity for detection from Attribute A to B. They can see a factor there. But for computer part, it only shows the final number.

CHAIR BLEY: Yes.

MEMBER DIMITRIJEVIC: And where did you enter those?

MR. CHANG: When?

MEMBER DIMITRIJEVIC: Where did you enter, on the screen, did you enter those.

MR. CHANG: So this screen that I use, see at the bottom left there has, we call it radio button. Now it's lacking in action. Once the user selects action that's on the right, this will show the PIF and their attribute corresponding to action. That user, using this tree to select which PIF attribute applied to performing the action.

MR. PETERS: So again, you check box the applicable performance influencing factors, and that will affect your overall calculation?

MEMBER REMPE: Well, I hate to ask this, but I'm a little confused. Because under detection, you have SF1.

MR. CHANG: Yes.

MEMBER REMPE: But under scenario familiarity, you have SF2. Well, how did it get, under detection, I mean, if you look at the bottom screen, what's checked is not consistent with what's in the box in the far left under detection. Why is that?

MR. CHANG: Because, okay, we omitted the two slide. Let me come here. Since you're already here.

MEMBER REMPE: Which slide is it, 99?

MR. CHANG: Yes.

MEMBER REMPE: Okay.

DR. XING: Yes, 99.

MEMBER REMPE: Okay, I'm there.

MR. CHANG: So in IDHEAS has identified 20 performance influencing factors. But not all these performance influencing factors affect all macrocognitive ---

(Simultaneous speaking.)

CHAIR BLEY: Macrocognitive, ha, ha, ha.

DR. XING: Just say cognitive function.

MR. CHANG: Okay function, okay. So this software only implement the PIF relevant to less specific cognitive function. So here you see that, in the detection PIF, that these are PIF affecting detection. Understanding, that's a subset of this PIF affecting the understanding. Each cognitive function has a different set of the PIF of this, under these 20 master lists.

MEMBER REMPE: So maybe to be a little more specific, am I looking in the bottom screen under action, and that's why I see SF2, and SIC1 checked.

MR. CHANG: That's right.

MEMBER REMPE: It's not the detection one, what you have in the lower screen right now.

MR. CHANG: Yes.

MEMBER REMPE: Okay. I was curious on that, but I just was wondering why is it not highlighted so you know which one you're on or something. How do I know I'm am on the action one instead of the detection?

(Simultaneous speaking.)

MEMBER REMPE: Oh, the far left, okay. I see it now. Thank you.

MR. CHANG: And since we are here, the screen here, even this imagined complexity, this PIF in all macrocognitive functions, but underneath the attributes are different. So here, we see this text complexity sphere for detection that's only C12, C6. These are the attributes. For understanding, there's different list, decision making, different list.

CHAIR BLEY: How did we get from this you just showed us to this smaller list?

MR. CHANG: You said that I go to the task complexity that says now I'm in detection. I'll go to the check, click the text complexity. It was automated, showed me what's relevant.

CHAIR BLEY: So you pick the ones that would apply?

MR. CHANG: Yes.

CHAIR BLEY: Okay.

MR. CHANG: Yes, sir.

CHAIR BLEY: And that's what the next screen was then?

MR. CHANG: Yes.

CHAIR BLEY: What's left.

MR. CHANG: Yes.

DR. XING: One feedback we have from users and from our users, they would like this software, they kind of want to make the analyst go through this PIF attribute list. So if they probably think, oh, this is simple, no complexity at all. But when they are forced to go through each of these attributes, maybe one attribute is applicable that wasn't in their initial software.

CHAIR BLEY: So when you're using this, and I guess this is kind of what the screen looks like, or part of it is, do I put, like, a number in that box, or is it just a check mark?

MR. CHANG: Check mark. But the number is in the software. We can measure once the effect of these factors.

CHAIR BLEY: So you don't give a measure of how bad this thing is, it's just bad.

DR. XING: We can check the report. The report has that.

MR. PETERS: So go back and look at Slide 97 real quick.

MR. CHANG: Which one?

MR. PETERS: I was saying 97.

MEMBER DIMITRIJEVIC: Before you do that, I have this question before. I was wondering how come detection doesn't have this information completeness and reliability? Because I would assume that's the thing most important for detection.

DR. XING: Okay. How about we let James finish with the software, then we come back to that question. Would that be okay?

MEMBER DIMITRIJEVIC: All right.

MR. CHANG: Yes. So unless I hear this, that the user selected which cognitive function I am analyzing. And then that once clicked, on this slide that's the worst corresponding with this. This is a cognitive function ---

CHAIR BLEY: Do those one at a time.

MR. CHANG: Yes, one at a time. And the item, PIF in red is the basic PIF that's mentioned in Jing. And all the blue is the one that has a weight factor attributed. That's just important too for the user to manipulate the tree.

Okay. That I already talked. So that if you look at a high level structure here that's over, it's to calculate human error probability of human failure event. This human failure event contained two elements, time and completed portion, completed portion here that is a critical task.

Each critical task is based on contribution from the five cognitive functions. And then each cognitive function, that's how they affect the top is based on that performance influencing factor attribute.

The directions that are in the software that the check box user can check off it, is this a critical task involved in this actuality or this macrocognitive function involved in this critical task? So that's a lot. So we'll only take the practical cognitive function and the critical task into the calculation.

Okay, the first probable calculation of PT, as mentioned this morning that the PT, it's not an influencing factor. This simply is just under, crew was doing the task based on their normal pace. And then too is titled, given the time available for completing the task, whether there's a possibility of crew not able to complete a task.

So the software implements, in this thing it's based on two distribution. One is time required. That means how much time the crew takes to perform this task. So if say that, one, the operator in the event say that, one, the operator go onsite to open the valve.

So taking from the if a symptom occur, that's a control and detected information, and then go through the procedure step to the point the call say, okay, we're needed onsite operator coming in, and then give him the procedure attachment, go to that place to manipulate valve. And then until the valve's manipulated, the time it takes, that's time required.

The second parameter is the time available, how much time from the symptom, that before depend on my success criteria, how much time that I have for these tasks need to be completed in order call it a success.

So we represent this thing in the two parameters. Both of them is a distribution. We possess several distribution folders and we, I'll come to this, but likely it's that in this case there are, for the user into the time required, it's a blue line, that the user choose the method to enter the 25 points or 50 percentile. That's what the time. If you have quite a number of operators doing the action, what's the time that it's in this distribution?

And we implement the number that the user entered into the step function you see on the graph. That's a step function. So the zero percent to five percentile, because user did not enter, I simply take the probability density function between five percent and 25 percent, divide by two. That's the PDF you see. And this arrow, that represents zero percent to five percent. And then that's based on the numbers here.

So the user enter that PDF we simply take, even for distribution, that's a five percent based on the number here, five percent to 25 percent, what's the probability density function that's here, so the software property, the distribution step function.

MEMBER DIMITRIJEVIC: So that's usually, that is, like, how many points they want to do this type of functioning?

MR. CHANG: Currently, we only ask them to enter five data points.

MEMBER DIMITRIJEVIC: All right. And where does the red thing come from?

MR. CHANG: Where does this 5/25?

MEMBER DIMITRIJEVIC: No, the time available come from?

MR. CHANG: Well, this typical face on the thermal hydraulic analysis, that's what's the time available before something happen if operator didn't do any action. That's typically what we do in PRA. Yes?

MEMBER DIMITRIJEVIC: That doesn't come as a distribution, so the ---

MR. CHANG: Yes. So in this case, we also implement as one constant user can enter a single value. Yes, I just said that, okay. Well, showing that the distribution that the user entered into this Weibull distribution and then provide an safe and escape.

And the software takes these two distributions, usually a Monte Carlo simulation to calculate the probability less the time required --

MEMBER DIMITRIJEVIC: Yes. But this is pretty straightforward, the inputs --

MR. CHANG: Yes. So when you take one million data sample, and the Monte Carlo took care of the PT, it's showing that we implement the different distribution for time required and time available. Both of them have them had the normal distribution, gamma distribution, Weibull distribution, and then provided the five data points, the percentile. For the time available, we added one option for user, simply enter a constant number.

MEMBER DIMITRIJEVIC: Well, if you enter distribution, then this software will calculate convolution, right?

DR. XING: Yes.

MR. CHANG: Yes. But it's implement convolution the way inference is among the Monte Carlo simulation.

MEMBER DIMITRIJEVIC: Oh, okay, well, if you know other way, that will be interesting.

(Laughter.)

MR. CHANG: Yes. Well, now we have computer, we don't need, that will be harassing for the HRA user to calculate that convolution.

Okay, so we already talked that on the left-hand side that analyst goes through, apply the practicable macrocognitive function are practicable to the situation and then select, no, come into the tree here to select what's the PIF attribute apply.

Committee Member Joy, that you earlier this, you mentioned about this, the purpose of this SRM is to reduce variability. My viewpoint is that, in the earlier letter, they tried benchmarking project, that we upload one thing, is the gap between the qualitative analysis and quantitative analysis.

But something did a really good qualitative analysis. But the way that the inside, they were not able to apply to the method they selected for analysis.

And my fear was that we've got to have a straight line from the qualitative analysis to the quantintative analysis that guides you not only to a good qualitative analysis but also the analysis result that you can carry to the quantification.

I see that things here, the ECA, the way it implement, the number of the PIF and the attributes, that's very much a different level than the current HRA method is.

And there are, one thing I want to mention is specific of this PIF. If you see that the GS report is not, each PIF attribute is not just this short description, there is some additional information. That additional information was implemented in the software when the user hovered the mouse on the top of this item. Now the screen has shifted description.

I have example of that basic question for the user that will kind of remind the user to say, okay, now the first thing you check at the high level which PRA that is more, no, that applies. And then they go into the detail. That's a PRA, give you each attribute that you check where they're practicable.

I think that the information at this level were able to carry the qualitative information coming to the quantitative result. That reduce the probability. That's my personal two cents.

Okay. So this simply just say that we implement whatever the equation that you see in the report, in the software. We talk these --

DR. XING: Maybe you can go to the example.

MEMBER DIMITRIJEVIC: Yes. I was on 97 going to the what's happening here. Because I note you're already in the hundred one.

MR. CHANG: Before going to the example, let me talk one thing. Among these, I think, one morning, 160 PIF attributes despite macrocognitive function, there's a PIF that most of PIF we simply infer into a point effect. Say that you check this one, that one will increase the ten percent of the HEP or that would, you check these attributes in the task capacity that the HEP will increase this amount.

There is some PIF has a range of, in fact, and then most of them that the uncertainty, the range is more than one order of difference. So in this case that's here, that the software provided that reference point.

As you see here, this was implemented in the C1. I'm sorry, I cannot read that either. That's a two-starter there that's provided. That two-start in one item means that the user needs to specify which, given the scale that for user to spend a point, when to apply for this PIF attribute effect.

I was, user created this attribute that this screen will pop op. Let me show you that, okay, these are the things you were analyzing. And then this allows the user to, we use the scale from one to ten, and then underneath that provider, we provide information. Say okay, one, we present that you have have information at seven. You know, three is this, this, this. This gives you the reference value for user to choose the number.

And what user need to do is simply adjust this number, so that's okay. The software will take this number, that two, use a linear, that slope and then to calculate whatever that HEP or the effect on HEP into the equation. And then that eventually shows on the top, that HEP number.

MEMBER KIRCHNER: For clarification, you can't do multiple choice?

MR. CHANG: For this one?

MEMBER KIRCHNER: Can you, well, I'm just looking at the box. Can you check C1, C4, and C6?

MR. CHANG: Yes.

MEMBER KIRCHNER: Okay.

MR. CHANG: Now this one just for C1, once I click okay, then I can go to check C4. And another pop-up screen for C4 will show to me that I checked it, wherever that I want to use for C4.

MEMBER KIRCHNER: But doesn't that contradict your claim about the variability? I thought it would force you to say this is a complex problem or it's not, so to speak. You know, but if you pick many, and then a different user can pick a different set, then you're going to get a lot of variability.

MR. CHANG: Well, I think this is a detail that, when you say the complex or not, that's everyone can ---

MEMBER KIRCHNER: Yes.

MR. CHANG: But now we come to here. The complex, what's the level of complexity? This, I feel this should give you an attribute, different aspect of complexity, at least the part that will apply, that user check more. That kind of implies that all this is more complicated. If you check less, that simply is not so complicated.

MEMBER KIRCHNER: Well, I just worry or wonder whether the system double-counts things in multiple places.

DR. XING: Yes. That's one reason I would use, actually we had, probably every other week, a user come to evaluate the software. He want us to add those boxes, what you clicked.

MEMBER KIRCHNER: Yes.

DR. XING: So when everything you clicked showed on the box, they will say, oh, I already counted this context at this. I shouldn't double count it.

MEMBER KIRCHNER: Yes.

DR. XING: So they can look at everything you clicked, you selected, and detect the double counting.

MEMBER KIRCHNER: It might be interesting in some kind of data-like test to have multiple users attack the same problem and see how convergent the answers are.

DR. XING: I will ---

(Simultaneous speaking.)

MEMBER KIRCHNER: Are you doing that?

DR. XING: -- talk that. That's our ongoing project.

MR. PETERS: Yes, we're doing that now.

MEMBER KIRCHNER: Okay.

MR. CHANG: Okay, fine. In documentation, once the user does all the checking and then that's got documentation, that will load this information shown at the time. And then the HFE was, the calculation was that the PIF attribute for each different cognitive function there.

And then the time analysis, what's the parameter entered, what's the HEP for PT information so that the user can save this information to Microsoft Word to add additional information to justify why the attribute is selected, you know, that type of information that provides documentation.

CHAIR BLEY: Two related questions. One, have you written up a short report on using the software, or a conference, or journal paper on it?

MR. CHANG: Not yet.

MR. PETERS: We just finished the software a couple of weeks ago.

CHAIR BLEY: Okay.

MR. PETERS: Yes. We're just not to that stage yet.

CHAIR BLEY: And the other related one was, although you didn't bring it for the meeting, would you be willing to come some lunchtime and demo the software?

MR. CHANG: Yes.

CHAIR BLEY: Okay. Maybe we can find a time for us to do that for anybody who's interested. Okay, thanks. I think it would be helpful.

MR. CHANG: Okay. So now --

CHAIR BLEY: And when you write it up, we'd like to see your paper.

MR. CHANG: Oh, paper, okay.

The example, the example is simple, that we took this example from the U.S. HRA benchmark study that is a very straight forward steam generator tube rupture event of the 500 GPM, because its purpose is demonstrated how we implement software in this analysis.

The HFE we analyzed was, given the steam generator rupture, then from a PI perspective, the interest thing of the human actions, operator is able to identify which steam generator has tube rupture and correctly isolate broken steam generator, and then depressurize and cool down to prevent that steam generator pilot operating valve release. Because that release, that will, radioactivity would release to the outside environment. So even here later, we have a clear, what's our reaction, and then what's the success criteria?

Given this here that you see in the ECA that was, at the beginning we talked about what's the initial condition, it's a full power, under power operation. And then we have the fire operating crew operator that's inside the control room, one shift supervisor, two reactor operators, they are men, crew to respond to the event.

And then we have a shift technical advisor, STA, during the event here will perform independent check to see that these three crew that they are running to the right direction. And then we have shift managers that stay on there as overseer of the scenario. That's the crew, that aspect, condition we have.

The initial event is very straightforward, just 500 GP and steam tube rupture. That is not beginning has a leak, okay, it's just rupture. And then find the condition that, we all assume that there's no component, no instrumentation failure. So everything responds as designed.

And then, as we all know, that simulator training, because this is a steam generator rupture event, design basis event crew is trained, at least once a year, or even twice a year, with a variation of the steam generator rupture if or in combination with different components of instrumentation failure that's for them to respond to the situation.

So from the symptom-wise, that the crew, we expect the crew is quite familiar with the symptom occurred in the steam generator rupture event. Given that, for this particular plant, if the chief rupture that occurred did not manually trip the reactor, then four minutes after the event that reactor will be automatically tripped.

So that we talk about HFE, and there's a scenario context briefly talk through.

MEMBER KIRCHNER: Isn't that really two events, two HFEs?

MR. CHANG: Depends on how you model it. That's ---

MEMBER KIRCHNER: We do get a different answer with your software if you modeled it differently. I would separate these two personally, but ---

MR. CHANG: Two means --

MEMBER KIRCHNER: So if you lump them together it doesn't matter.

MR. CHANG: Two means that when you say the two --

MEMBER DIMITRIJEVIC: They isolate and depressurize.

MEMBER KIRCHNER: Isolate the steam generator is different than controlling the RCS pressure.

MR. CHANG: Yes.

DR. XING: We can try that in the U.S. empirical study. This was given to analyst as one HFE.

MEMBER KIRCHNER: All right. Well, you're leading the witnesses when you do that. Because you're telling them to do two important steps, and you're putting them together.

MR. CHANG: Let me come to that --

MEMBER KIRCHNER: Okay.

MR. CHANG: -- when we come to address the issue.

MEMBER REMPE: Would the results differ if you did the other way?

MEMBER KIRCHNER: Yes. Well, that's what I would want to know, yes.

CHAIR BLEY: We'd had earlier meetings on the empirical studies. But when they were done, I was part of them, there were separate groups. There were a group of analysts who didn't get to see what went on. And then there were a number of crews who went through. And the crews did them as you'd expect in the simulator. They just, they didn't know what was coming.

MEMBER KIRCHNER: Yes.

CHAIR BLEY: And they'd get events as they occurred. The other folks were asked to quantify, I think, both of these events. So they did them separately. But, you know, that was compared with what really happened in the simulator.

Of course, there are only four of five data points in the simulator, so it's a limited kind of comparison. But you learned a lot of things from it. It was useful. Anyway, that's the way they did it.

MEMBER KIRCHNER: Okay.

CHAIR BLEY: So the crews weren't told they're being judged on two different things. The analysts were told to evaluate two different things.

I think that's right. Go ahead.

MR. CHANG: So now this is where I start to talk about how we calculated the PT that's given this action. In the U.S. HRA benchmark that has three crew run through the scenario, and then we got the three data points, there's 30 minutes, 36 minutes, 40 minutes, ten seconds, 43 minutes, ten seconds. This is a time that these three crew completed the cool down and isolation at the time.

So I simply took these things and turned these three data points within 33 percentile, 67 percentile, and 95 percentile. And then that using a linear tube, come out to the five percent, 25, 50, 75, 95 percentile. That was the time used for the time required.

And in the HRA benchmark report also say that the success criteria typically was between two and three hours. It's only one sentence, so I took the normal distribution that pick a mean number, 2 and 3, and then gone through the software, that's the distribution. And then come to the FPT is equal to zero. So that's for PT.

Now we come to a calculated --

MEMBER DIMITRIJEVIC: Back up.

MR. CHANG: Yes?

MEMBER DIMITRIJEVIC: Well, you're talking here about pressurizer pore which I don't know really why, I mean what is your measure for that, to prevent what? I mean, you know ---

MR. CHANG: If they ask, reactor coolant system, they are up, depressurize RCS system. The RCS system, now eventually that will pressurize steam generator and then push the pump open.

MEMBER DIMITRIJEVIC: Yes, but that's not bypassed for the inside containment. You worry about releases outside.

MR. CHANG: Some of that pore that go to the steam line, steam line may directly go to ---

MEMBER DIMITRIJEVIC: But that's, well, here you said pressurizer pore which is in, that's why I say here. There you say steam generator pore, whatever that is. But I think it's like you are mixing little apples and oranges in this.

MR. CHANG: Okay. So given this, the human action, that's HFE. We talked on that operator successfully isolated a broken steam generator and then depressurize RCS and cooled down RCS to prevent the pump open. This slide ---

CHAIR BLEY: It should be the steam generator.

MR. CHANG: Oh, steam ---

(Simultaneous speaking.)

MR. CHANG: Yes.

MR. PETERS: We didn't catch that when we were putting the slides together. Thank you.

CHAIR BLEY: And I think when you weren't here it came up that, you know, we're talking about a steam generator tube rupture. A steam generator rupture is a different thing. That's a primary rupture. And I don't know what a broken steam generator is. So you're talking about old tube ruptures. And you ought be consistent.

MR. CHANG: The steam generator has the tube rupture. Yes, that's what we talk that.

CHAIR BLEY: But you've also got a broken steam generator up there too, on the fourth bullet.

MR. CHANG: Yes. There are two successfully acute to decide the action. Isolate broken steam generator and depressurize RCS, yes. So your question --

CHAIR BLEY: Broken steam generator's odd language for this sort of thing. It would be the steam generator with a tube rupture.

MR. CHANG: That's a common term I heard from the NRC staff. I just used it.

CHAIR BLEY: There you go.

(Laughter.)

MR. CHANG: Ruptured steam generator, that talks about the ---

MEMBER DIMITRIJEVIC: Failed, usually it fails.

MR. PETERS: So we should use the word ruptured, obviously it's a ruptured steam generator event.

MEMBER DIMITRIJEVIC: Or you could say failed steam generator.

(Simultaneous speaking.)

MR. PETERS: The slides aren't quite --

MR. CHANG: Sorry, my NRC ---

MEMBER REMPE: It's in the report.

MR. CHANG: Ruptured steam generator means that the main steam line of this corresponding steam generator has a rupture. And the broken steam generator is the tube of that steam generator.

CHAIR BLEY: That's new language to me.

MR. CHANG: Oh, okay.

CHAIR BLEY: I'd call them both broken, ha, ha, ha.

MR. CHANG: Okay. So given this task, the detection, looking at the, given this condition that what's the key information that operator needs to observe in order for the operating crew able to succeed to the action.

Okay. So these, including that information, then you could be aware, okay, there's something wrong. And then the main immediate path for them is to, they will need to be able to enter E zero, and enter from E zero transfer to the E-3, and then cut power to E-3 to perform that required action.

The key information helping operator to go to this path, there is key information. What's the likelihood that the operator is not able to detect this information that would lead into how the action is not performed or not performed on time.

The probability of doing this was going to the detection CFM, that tree there, to check what are the PIF attributes practicable to this context. So that's a detection.

Understanding here is that, given the crew identify all able to detect all the critical key information, and operator is able to follow the right procedure path, and then some of them, they might need to make sudden judgements, or information integration, and then follow that next is logical, whatever, that the two come out, two correct analysis. Okay, this is a steam generator rupture event, and then identify what's the broken steam generator. That's the diagnosis we talk here.

MEMBER DIMITRIJEVIC: But that's for isolation. That's the indication for isolation.

MR. CHANG: Yes.

MEMBER DIMITRIJEVIC: Under pressurization, any steam generator broken will lead to that pressurized primary by opening usually for something. So that's two different indications depending what action you're doing which was discussed before.

MR. CHANG: Right. So our push here, I note the key information that's able, for our ability to do this, that not only the secondary radiation alarms are also disabled, to check what's the steam generator water level and incident pressure that's all, the different steam generator come out to the understanding that that's okay, that the other probable steam generator has an issue. Now, this is key information, and then it's able to make the diagnosis.

Issues you're making here, let's assume operator has correct analysis of a steam generator bubble has problem. That's only one procedure, doing isolating, this thing to isolate that broken steam generator, and then follow the procedure to cool it down and depressurize it. So that decision making within this context procedure only provide one path. So there's no alternative.

So in this case, that the decision is not applicable, because the procedure just only one path to make the decision. And the action execution here is now we are talking about action, yes, isolate broken steam generator. And now I understand I need to isolate the steam generator bubble, I need to turn this flow closed, and then the other things. How reliable I can perform that task?

And then I need to depressurize and cool down RCS in a proper manner that this thing, how reliable. We are looking at this activity as a whole, going to the action CFM there, the three, to check what are the PIF attributes we applied for doing this action.

And teamwork, because in the ECA is talking about different team. That mostly this activity is performed inside the, action that a complication has happened within the main control room. That might be something to talk about, that the outside operator to close a LOCA steam generator rod that's a mechanical test and to check.

But within this context, we think that inter-team activity is not contributing to that defense, so that we did not include the teamwork in this HEP estimate.

MEMBER DIMITRIJEVIC: You know, just to be picky, you know, E-0 is not a number.

MR. CHANG: It's EOP-0.

MEMBER DIMITRIJEVIC: Oh. EOP-0?

MR. CHANG: Yes. Emergency Operating Procedure 0. And Emergency Operating Procedure is reactor safety procedure. That's once the reactor operator forced go into that procedure. And then from E-0, in the steam generator event, will lead them to jump into E-3, EOP-3, that's a steam generator block for ---

MEMBER DIMITRIJEVIC: To be honest with you, I thought you were talking one minus, you know, one minus three. Because in the previous tables you have a similar ---

MR. CHANG: Okay, thank you for pointing that out. Yes?

DR. XING: That's a lower probability.

MEMBER SUNSERI: Is that a cognitive error, I don't know.

MEMBER DIMITRIJEVIC: Yes, well.

MR. CHANG: Okay. So the way with the understanding we come to the software to calculate HEP. So the user here, let's simply go to each one of them going to a decision detection. And then in the detection we didn't identify any negative PIF attributes.

And each tree, the first one of attributes has no impact. And then the user has to check every PIF and then to check no impact. That's just demonstrated that the user, you know, goes through each PIF to check were there any PIF attributes.

And then the same thing here about understanding, given the context that a user will take the understanding this radial pattern and then, within the tree here, to check what's the PIF attribute applied. In this case it's also now and then.

So we said that the decision and teamwork is not applicable. So that's unchecked. The user unchecked that, will make grade. It's just human factors, consideration make it more apparent that ---

MEMBER KIRCHNER: I might observe something, and I don't know how you would how you would factor this in.

MR. CHANG: Yes.

MEMBER KIRCHNER: This is all true in

simulator space. This is not true if you're in the control room of a real reactor and the blank hits the fan. And this is a really serious event.

And so I wouldn't have some blanks in some of these categories, because if this actually happens, this is, you know, the tension level, there are a lot of dynamics that change from a well rehearsed simulator scenario. Just an observation.

MR. PETERS: Absolutely.

MEMBER KIRCHNER: And I don't know how you factor that in.

MR. PETERS: Well, it's easy to factor in if the analyst knows if they're mulling a real scenario. They would go and select the challenging context that they see in the real scenario. So I think it's a good comment.

DR. XING: And we picked this example just like in the U.S. study. We won't have a baseline example. This is suppose everything is perfect --

MEMBER KIRCHNER: No, I understand.

DR. XING: -- how we go. But we know in reality --

MR. CHANG: Yes, with the information ---

DR. XING: -- we probably never have that perfect.

(Simultaneous speaking.)

MEMBER KIRCHNER: There is another aspect that occurs to me.

MEMBER BALLINGER: It has happened, and you can get data on that.

MEMBER KIRCHNER: Yes.

MR. PETERS: Well, the interesting part is ---

MEMBER DIMITRIJEVIC: It's happened in Japan.

MR. PETERS: This is a retrospective analysis ---

MEMBER BALLINGER: Well, there's one in the U.S. for sure that I know of.

MEMBER DIMITRIJEVIC: Yes. Right, the Japan decision making was the most important factor which is here blackened at the top.

MEMBER BALLINGER: Yes. They have, what, two in the U.S. and one in Japan, right.

MR. PETERS: So the nice thing about this --

MEMBER BALLINGER: North Anna, Indian Point, and I don't know about Japan.

MEMBER KIRCHNER: No, I'm just trying to add something.

MEMBER BALLINGER: No problem.

MR. PETERS: You know, I was just going to say, the nice thing about this tool is the intent of this tool is for a retrospective analysis use at the NRC. So what we will have going into the scenarios, we will know the contextual information, what actually happened at control.

And we'd be using this tool to help us do our, submit a determination process, enhanced analyses. So that would give us basically this contribution of human error probability on the known conditions.

So if we wanted to apply it to a prospective analysis, it's a little bit different. And that's where you would kind of get these vanilla sunny day scenarios. But our original intent is for staff use. And like I was saying earlier, highly scientific number, 90 percent of what we do is retrospective, that we would have that context to fill in.

MEMBER KIRCHNER: Yes. I guess the other thing that I'm maybe jumping ahead of you a little bit, in this particular example, the PT calculation makes a contribution of zero.

But again, in such a real life scenario, although the time required to do it, this distribution that you show, it probably broadens and moves out because of delays and such. So I was just curious.

Do you have a sense for when the PT might, for this scenario, it's a zero contribution, but when you get into situations where the time for detection, the time for understanding, the decision making, the execution and such, is different than the clean, we've done this drill before. We know it takes 20 minutes. But now you've got all those variables. Am I ---

MR. CHANG: Let's come back to the definition of PT.

MEMBER KIRCHNER: Yes.

MR. CHANG: PT is that known capacity they followed in the, you know, just the way the team ---

MEMBER KIRCHNER: Yes.

MR. CHANG: It's what's the reason that ---

MEMBER KIRCHNER: Exactly, you gave us. You know, you gave a nice example.

MR. CHANG: Fine.

MEMBER KIRCHNER: You had a bunch of teams, you had data, it took him this long.

MR. CHANG: Yes.

MEMBER KIRCHNER: I'm just thinking of

when the situation gets real and complicated, the time required probably dilates.

MR. CHANG: Yes, but that's a ---

MEMBER KIRCHNER: And you could then, I guess, explore it by changing this percentile on times to something that would reflect the delay in response because of either detection, whatever. You see where I'm going? I am trying to --

MEMBER DIMITRIJEVIC: This is a very complex action response. Because you're going to, in 150 minutes you're going to lose 75,000 gallons, I'd say, we found that. And you're going to get the LOCA signal. Your interaction systems are going to come in.

MEMBER KIRCHNER: Exactly.

MEMBER DIMITRIJEVIC: It's going to be difficult to depressurize. You have to look, you have a small LOCA read, the high pressure injection bumping in, you have to shut the charging before you start. This is very complex thing, just as the action itself.

And the thing is, to say the time doesn't really, you have competing factors, you know, LOCA signal, systems coming in.

DR. XING: Well, we have a table we had given --

CHAIR BLEY: They started this, and they had thermal hydraulics to back it up for the plant that was involved. But if you isolated the steam generator within 40 minutes, I forgot what the time was, you'd get it done before you had the small LOCA. And it's an unusual plant, I think, in that regard.

MEMBER DIMITRIJEVIC: You can at least, on, the primary side, there were rooms --

CHAIR BLEY: I'm sorry?

MEMBER DIMITRIJEVIC: Nobody has, you know, LOOP isolation valves. I mean, you cannot isolate primary side of the steam generator. You cannot easily treat water and steam like that.

CHAIR BLEY: Yes. And you have to, hum, I forget what time they gave you to isolate it.

MR. CHANG: Around 40 minutes.

CHAIR BLEY: Yes, which, for most of the plants ---

MR. CHANG: Yes, from the beginning of the --

CHAIR BLEY: -- here in the U.S., you get much less time than that before you get a LOCA.

MEMBER DIMITRIJEVIC: But that will not stop the loss of coolant until you depressurize. Insolation itself will not stop loss of coolant.

CHAIR BLEY: Yes. That goes ---

MR. CHANG: Sorry, the time was a quarter and depressurize. That's isolated, that's all happened earlier. So that did not ---

(Simultaneous speaking.)

CHAIR BLEY: There we go, that's better.

DR. XING: This is everything now. They actually, in the study, they listed the detail, the time for every major activity. So that was already ---

MEMBER KIRCHNER: No, I was just curious that there is some interplay. Even though this one was a nice clean example, based on the data and the analyses, once they start overlapping and making a contribution, implicit in some of the CFMs, is a time element as well.

DR. XING: Yes. In fact, in the ---

MEMBER DIMITRIJEVIC: And in a sense, those two actions are completely different now, isolating and depressurize.

DR. XING: Yes.

MEMBER DIMITRIJEVIC: So, I mean, they should not be analyzed as one. I mean, it's easy for you to separate. It seems like you are analyzing this relation not the categorization.

DR. XING: Yes. I can talk an example. In the another scenario in the U.S. benchmark study, the loss of CCW, that one, operator needed to do two actions. They need the instructions. They need to stop the RCS within one minute of you detect the loss of the --

CHAIR BLEY: The pumps.

MEMBER DIMITRIJEVIC: The pumps, yes.

DR. XING: Yes. And then start the PDP within, you start the PDP before temperature exceeded 230 degree F. And the estimate, it will take, after you lost the ECW, it would take seven to nine minutes for the temperature to reach that level. However, for all the four crews, it took them average, I think the shortest one was four minutes, the longest was eight or nine minutes. It took them that long to detect the loss of the symptom.

So none of them started. I mean, all of them eventually started the RCP, I'm sorry, stopped the RCP. But they all exceeded the one minute criteria. So you can see the failure. Worse than that, because they spent so much time doing the detection diagnosis up front, they have the procedure to start a PDP. But by the time they ---

MEMBER DIMITRIJEVIC: What's a PDP?

CHAIR BLEY: Positive displacement charging from ---

(Simultaneous speaking.)

CHAIR BLEY: -- that that plant used and ---

MEMBER DIMITRIJEVIC: What is that going to do ---

CHAIR BLEY: This is an abnormal procedure. It's not an emergency procedure.

DR. XING: Yes. It's abnormal procedure. But they followed the procedure, but they have seven to nine minutes before they do that. But they spent all this time in up front information detection. So they all failed that second action too, because of that complication in time.

MEMBER DIMITRIJEVIC: Well, for us this a complicated action, and we are not calculating HEP, and we can question your HEP until, like, you know, the, we are just trying to see how your method works.

DR. XING: Yes. So this example, we just want to, let's just make hypothetics in our --

MEMBER DIMITRIJEVIC: Right.

DR. XING: -- you know, perfect world.

MR. CHANG: Yes. That is actually the things about it that reduce variability. Now they use the check located action that I only have one negative PIF attribute here. And this is very specific, that everyone can argue that while a specific attribute may play in the action this year, that, I think, is one mechanism to improve the consistency.

Okay. So what done is that they simply selected a document that's all, and in this report was load into this place that user can either add it here, that the provided location why I select it. There's no impact, otherwise why I check this performance attribute, et cetera, this information.

I want to let the committee, that each bullet, it's a performance PIF attribute checked. And then underneath, below that, that bullet is the effect. But in this case, there's no effect. So you see that the basic HEP is zero, and then that the weight factor is zero.

But in the earlier slide we see that here. You see that while the detection, that C2 was checked, that it provided a basic HPOs, Y minus three. And then that C3 was checked. That has a contribution of HEP, basic HEP of 1E minus three.

For detection, that SIC information was checked. That it has the weight factor of 0.1. So this they come to ---

MEMBER DIMITRIJEVIC: What page is this?

MR. CHANG: Huh?

CHAIR BLEY: I'm trying to find it.

MR. CHANG: It's 103, Page 103. Okay, I see that on the upper right.

CHAIR BLEY: Oh, yes.

MR. CHANG: Yes. This is just the information we provided once the user's done the analysis. The complex math and the data that's software to manage it. But to come to the end, the user has all this information that he can -- This PIF actually did this type of contribution. Is that the right contribution that, no.

CHAIR BLEY: This is a completely different example than the one we ---

(Simultaneous speaking.)

MR. CHANG: Yes, yes.

(Simultaneous speaking.)

MEMBER DIMITRIJEVIC: It's myHFE.

MR. CHANG: Yes, myHFE.

MEMBER DIMITRIJEVIC: Is it yours? It's myHFE, but it's the steam generator. Well, do you have page for steam generator and have the time? But there is not too much on that page.

MR. CHANG: Yes.

MEMBER DIMITRIJEVIC: Because everything is zero, and you don't have that one.

MR. CHANG: Right. The purpose that I'll try to show was that user check every PIF and then make sure that none of the attribute applies on the check, that they're not applicable for each PIF.

MEMBER DIMITRIJEVIC: But the active here you have the one applicable, didn't you, like for the action?

MR. CHANG: Yes. But it was too, under part and it didn't show up on the screen.

MEMBER DIMITRIJEVIC: But you have the page that you passed out.

MR. CHANG: Yes. This is partial screen shot. Okay, that's all I have.

DR. XING: We turn to our boss.

MR. PETERS: Thank you, this is Sean Peters again, Chief of Human Factors and Reliability Branch. And I'm going to go very quick to try to make up time. My DeLorean is broken right now, so I won't be able to get us back on schedule. But we'll move as quick as we can.

So I'm going to tell you a little bit about the testing that's going on right now. We have an NRC and industry joint team. This is a team of us and EPRI. This is wholly supported by the BWR and PWR owners groups who have volunteered members to members to be part of this team and volunteered their plants for us to go and do modeling.

The purpose of our testing is to model FLEX scenarios using our IDHEAS-ECA tool to help our future regulatory decision making. This includes license amendments, NOEDS, credit, and like termination processes and analyses, things like that.

And it's basically because industry would like to get credit for the installed equipment. They spent all these millions of dollars installing FLEX, and training on it. They want to get some PRA credit for that.

What we're going to be getting out of this testing is a better understanding of the human challenges and flexible mentation. So we're actually going to go through the plants and see how they implement FLEX tools and see where there are challenges of implementing those.

And we hope to get feedback for our method improvement. So as users click through our buttons, as they use this qualitative analysis process, we want to get feedback from them on how it went.

So there are two sets of teams. We have

scenario developers out there helping us define, clearly define the scenario. And we have teams of HRA practitioners. Both teams are roughly 50/50 split. The scenario developers have half NRC folks, half industry folks, same with the HRA teams, half industry, half NRC.

We're doing two sites so ---

CHAIR BLEY: Any operators from the industry on your teams?

MR. PETERS: Any operators, I think there are. I'm trying to remember the specific background. Most of the people have, from the implementors, they are the people that actually implemented FLEX at their various plants. But what they're not modeling, is they're not modeling their plant. They're modeling Peach Bottom and Surry. So these are people that have installed, and operated, and trained on FLEX equipment.

CHAIR BLEY: I hope you've got some real operators involved on your teams.

MR. PETERS: That's what I'm understanding on the scenario development team especially. HRA team's, obviously not necessarily operators on the HRA team but for the scenario development. And then we also have a bank of experts that we draw on if we have questions associated with when we're doing the modeling of HRA, which are the people that are plant familiarity.

CHAIR BLEY: We've a long history of, one, saying we absolutely have to have operators on our HRA teams and, two, knowing that if we don't, we get funny results.

MR. PETERS: I think, so somebody has worked with you a long time. Dr. Susan Cooper is leading the team, and she's probably the person I've heard say we need operators more than anybody ever in the history of HRA. So she is leading this program and our staff. So we, but I have to go back and specifically get you the expertise.

The site visits are right now. I'm missing Dr. Cooper here to answer that question. Because she is currently at Peach Bottom running down FLEX equipment today. They'll be there until tomorrow. And they're starting Surry the first week of October. So I think it's October 2nd and 3rd we'll be at Surry looking at their facility.

Scenario modeling, so they're going to be taking information we've got through the run downs, and developing our scenario models in this October, November timeframe and then testing those models in the November, December timeframe with the HRA teams.

And then we'll be documenting the results of that testing and finalizing our ECA tool based upon that feedback. I don't like to put exact dates on that. It just depends on how extensive the feedback is and what changes we want to make. But we're shooting for the summer of 2020.

But in the interim, our tool will be out there for public use and consumption in the next few months. And so we'll give the, we can give our ACRS counterparts a demonstration of the tool, even access to it, once we get it acceptable to be put on the NRC network.

CHAIR BLEY: Great, okay.

MEMBER REMPE: So out of curiosity, is this effort part of a user need for IDHEAS, or is it for a different user need that you're addressing?

MR. PETERS: We're faster than the user need process. So inevitably, we have, as part of the SRM, it was creating a set of methods for the Agency to use. We actually don't have a user need for this, but we have users who have expressed need, shall I say.

(Laughter.)

MEMBER REMPE: So it's a part of the user need for the SRM is why you're ---

MR. PETERS: It's basically part of the SRM ---

MEMBER REMPE: A mission directive ---

MR. PETERS: Yes. Our users are full onboard. They want this thing done. They're actually a part of our team. Well, we already take their, yes, I know, it's a good joke. We already do take their money, and we're already developing this out of their pile of money. So they're directing us.

This is the highest importance to our NRR counterparts at the office level and the staff level. And it's very high importance to the industry. So everybody's onboard. We just don't have the formal documentation calling this a user need, long story short.

So that takes care of the testing, and we'd love to get back with you and tell you what we've gotten out of this in the near future.

CHAIR BLEY: That'll probably be next fall though, given what you just had on the last slide.

MR. PETERS: Yes. If you want us towards showing you what the finalized tool is, that would be a good timeframe.

CHAIR BLEY: And the analyses, right?

MR. PETERS: Yes.

CHAIR BLEY: The test cases, yes.

MR. PETERS: Absolutely.

CHAIR BLEY: Okay.

MR. PETERS: So just a real fast recap to try to minimize the time. So we've developed a general methodology. All the white parts and the orange parts of the previous slide that you thought was informative, it models our underlying, the cognitive processes underlying our human actions. And it's application independent, so it's user-centered under the general methodology.

We've enhanced the scientific basis. We based it on the state of the art cognitive sciences. We model activities in a teamwork and organizational environment which is lacking in some of the HRA models out there.

And our cognitive mechanisms are built-in, and they explain why humans fail in these actions. But we've developed enhanced guidance to help reduce HRA variability. As we discussed, you're not going to be able to completely eliminate variability based upon inherent biases in the modelers themselves.

But you can help guide them down a path where at least they can discuss why they have different results from different analysts and specifically point to where that variation exists.

And that's what we find helpful in the NRC process, that if we talk with licenses about where our differences are, we can then come to a common agreement at that point and make those changes. And here's our agreed upon consensus result.

And then we also have a built-in interface with HRA data. That's where we saw a lot of lacking in some of the other methodologies where they have very highly structured qualitative analysis or maybe not structured at all, just a kind of implicit qualitative analysis, and have data capabilities. So we've developed this interface between the qualitative analysis and the data.

And I just want to express, we're not, I can't say we're building anything new. Like I said, the whole intent was to try to take pieces that already exist out there. And we are enhancing those in some way, but these concepts that we have are not just magically thought up by our HRA team. This is off of years and years of development and walking on the backs of people who've made such great strides in development earlier.

Other specific improvements, we talked

about qualitative analysis, operational narrative, description of scenarios, progression and context. We have guidance for searching, and documenting context, and how to model that context with PIFs. We model human failures.

You know, I guess I don't want to go through these slides too much more. It's just taking a lot of time. We talked a lot about time and certainly analysis in our HEP quantification tool. And then we have guidance for how to perform HRA practice.

But I guess what I really want to get to is the closure of SRM-M061020. And from a development point in the Office of Research, what we think our end point for development, from our perspective, will be a successful completion of IDHEAS-G and IDHEAS-ECA.

These are the primary tools that we see the NRC will be utilizing. So IDHEAS-G primarily utilized by the Office of Research for building new tools, IDHEAS-ECA is what's going to be primarily used by our NRR and region-based customers, and even some of our research customers who do ASP analyses.

We think this tool will be robust enough, and we think the software tool will be robust enough and liked enough that we'll want to look towards the replacement of SPAR-H.

I may be putting my personal hope out there. It's sometimes hard to get ingrained users to use a new method and model. But the FLEX scenarios will require them to use a new model, because SPAR is not specifically built for that. It doesn't have that capability. And this tool will.

What that puts us towards is what's the future. And this is where I get throw the ACRS under the bus. I think we've done over a decade of research and work trying to move this path forward, answering kind of what's on the SRM.

But at some point, the SRM is really directed to the ACRS. And the ACRS will need to go back and decide what does it want to do. Does it want to endorse a method or set of methods for the Agency to use? My hope is that the ACRS will choose to endorse at least this general framework of IDHEAS and say yes, we think this is a way to go forth with doing that, doing HRA modeling for the future.

From our perspective, from an NRC staff perspective, where we would go forth is a possibility of issuing a regulatory guide. We've done all this work on the HRA best practices, comparison, and methods to best practices, benchmarking with respect to international and U.S.. And some of the thoughts around that are we have a lot of information about the capabilities of the various HRA methods out there.

Where I personally think a regulatory guide could be useful is where we could then spell out, yes, this method is good here, this method is good here, specifying clearly where the methods are applicable and where they're not applicable, and then stating how IDHEAS-G, we think, is applicable in these scenarios. And ECA and our at-power applications are good in most places.

So our concept is this is a possibility. I understand that the Agency is not really big on creating regulatory guides, but regulatory guides is a way to tell our staff we think these are acceptable methods to use in these scenarios.

CHAIR BLEY: Two things. You've said what you'd like our letter to address. Do you see it coming after you get IDHEAS-ECA in a state that you've got something written down on paper about it?

And the second question is do you think IDHEAS-G, as in the version we got, is all done? Or are there some things you'd like to fix up before we get to a full committee in a letter that would address it?

MR. PETERS: Yes. I think the staff has heard, I don't think ECA needs to be fully complete before we could get a letter of endorsement from the ACRS. Because inevitably, it's a down selection of IDHEAS-G. If the ACRS says that IDHEAS-G is a way we think is a good path forward for future method and model development, we'll have that common framework that the Commission has kind of directed us to have.

Now, the second question, do we want to take IDHEAS-G and work on it a little bit more, I think the staff does, based upon some of the feedback that I've heard in the hallway conversations, that there may be a couple little changes that we want to make. And even the dependency comments might be something we want to put into the report.

I've also heard in the back rooms that our meeting has already been postponed from November to a later date, so feasibly a February full committee time. So that could give us some time to make the final changes.

CHAIR BLEY: That would be enough time to ---

MR. PETERS: I think so.

CHAIR BLEY: Because it's kind of hard --

(Simultaneous speaking.)

MR. PETERS: -- we also have a concurrent deadline to get this ECA tool ready for use here in the next, you know, next month or so. And so I don't like to overload Jing too much.

CHAIR BLEY: The holiday's coming up.

MR. PETERS: Yes, Jing hasn't had a Christmas in about ten years so it's, but I can work with the ACRS staff and determine how far along we are here in the near future.

CHAIR BLEY: Well, if you do that, I think that'll be good, and keep us informed. The reg guide, I'm not exactly sure what you're going to focus on there, but ---

MR. PETERS: It's just a thought I'm throwing out there. Because it's not, I'm not saying a well thought out thought, but if we want guidance on which methodologies to use, and which scenarios for situations, it might be good, something coming from the NRC staff versus, I guess, versus not having something.

CHAIR BLEY: Okay. Well, we'll talk among the members later. I think one thing that makes me a little, two things that make me a little uncomfortable are, one, we've got the historical data and the analysis that Jing's put together that's now part of

IDHEAS-G, and as part of it, as a quantification tool. And we just haven't seen much about that.

MR. PETERS: Yes.

CHAIR BLEY: And I'm not sure what you can give us when that would boost our confidence in what's there, because it's kind of amorphous. You know, I've heard about it for years. Most of the members probably haven't heard about it before. So that one kind of lets me hang a little bit.

Seeing IDHEAS-ECA carried through to a point that gives confidence that, yes, the spinoff from IDHEAS-G into ECA is actually working, is another thing that I think would give members more confidence. And, you know, it sounds like you're not going to have scenarios ready until the end of the year.

MR. PETERS: Yes, until November. I mean, they're on a very tight time crunch for this thing.

CHAIR BLEY: And do we have anything done in, you know, roughly that same timeframe that would be a little more complete on IDHEAS-ECA?

MR. PETERS: The ECA tool has to be ready in November also, kind of --

CHAIR BLEY: In November, okay.

MR. PETERS: -- when we start doing the testing. Yes. So we would have a complete draft of the user's manual, how to --

CHAIR BLEY: You would, okay.

MR. PETERS: Oh, yes. Yes, this is to say I have a ---

CHAIR BLEY: And it would be available to play with and see how ---

MR. PETERS: Absolutely.

CHAIR BLEY: Yes.

MR. PETERS: Yes, for the testing teams.

CHAIR BLEY: That helps me. We'll let the other members chime in later.

MEMBER REMPE: So I have a question in saying, well, the full committee meeting's been delayed until February. Are we going to have another subcommittee meeting, is the vision, before we go to full committee? Because I think that might be helpful.

CHAIR BLEY: Let's talk about that when we go around the table. It's not in the plan right now. And I'm not sure what it would do.

MEMBER REMPE: Having a manual for ECA just discussed at the full committee meeting, and there were a lot of questions raised today just all brought up at a full committee meeting, knowing how many years we've interacted, I would, again, we can go around and talk about it at the closing comments, but I just kind of thought maybe that was something that you'd already thought, oh, we probably should have one. But you're saying no, we haven't thought about that at all?

CHAIR BLEY: I've looked at a lot of computer manuals, and I'm not sure --

MEMBER REMPE: If you're going to bring up that data --

CHAIR BLEY: -- any of them are worth a committee meeting.

MEMBER REMPE: You've talked about the data, and again, you're ---

CHAIR BLEY: But they're not going have a data report until another couple of years.

MR. PETERS: I mean, when do you think, Jing? I mean, Jing's always optimistic, so add about six months to whatever she says.

CHAIR BLEY: I know. This was done about ten years ago, ha, ha, ha.

DR. XING: Well, if we didn't completely revise the IDHEAS-G report for five times, we would have it done in 2014.

CHAIR BLEY: You had to revise IDHEAS-G.

DR. XING: Yes. For the data report, it's going to take a lot of time to, like, I showed you two examples today. For one big point I explained each item. So you can imagine if I had a thousand of that kind of paper, documented them to that level of detail, it's going to take a lot of time.

CHAIR BLEY: Yes. That's not coming up soon.

DR. XING: Yes, it's not.

(Simultaneous speaking.)

MEMBER DIMITRIJEVIC: You did tables when I was --

DR. XING: Yes, I have tables --

MEMBER DIMITRIJEVIC: Yes.

DR. XING: -- I can share. But without the detailed documentation, people say the paper only say a number. They always want to have more.

MEMBER DIMITRIJEVIC: Background, yes.

DR. XING: Yes, backup.

MEMBER DIMITRIJEVIC: I have one question. But you are applying this now to FLEX in two plants? The plant, you integrate that FLEX in PRA, and would that be acceptable? They're using different human action methods in the, you know, internally. Whereas the other PRAs were with FLEX.

DR. XING: Yes.

MEMBER DIMITRIJEVIC: That would be okay, I mean, to have ---

DR. XING: Yes. That's actually, in the testing team they can talk about that. Some people say, okay, I will use the ECA method. But I also want simultaneously try a different method, see how it works.

MEMBER DIMITRIJEVIC: Okay. But one is they integrate the FLEX into that PRA, they will have two methods in the PRA.

MR. PETERS: Yes. I mean, I don't want to speculate too much on what industry is doing. I know that they've had their own FLEX explicitation that they used. And I think that they just came up with human error probabilities that they want to plug into their PRA models. So I don't even think they're even going to say use a method. They're just going to put in placeholder values that for ---

CHAIR BLEY: I saw something sometime back from NEI, wasn't it?

MR. PETERS: Yes.

MEMBER DIMITRIJEVIC: Well, because you wanted ---

CHAIR BLEY: Pretty fuzzy.

MEMBER DIMITRIJEVIC: You think that, I

would like you to say something about where that can be used, right?

MR. PETERS: Yes.

MEMBER DIMITRIJEVIC: So that's a very important thing. Most of the current facilities have developed PRA, and not any reason to go to more expensive method, with adding FLEX. And the question is, is it okay to have two different methods?

So it's not applicable for the, it's not likely to be applicable for current rate. For the new coming plant, when you don't have a closing advertised, this is like shooting the, you know, as I say, chicken with a gun. I mean, you know, we don't have enough information. And maybe we should use simpler methods, simplest method to do HEPs for the new plants.

So now the question is where would we visualize this application? The one other thing it could be, there will be plants coming to be the completely new, you know, the not light water, new designs where we are not familiar. And maybe this is a good general method to be applicable for different stuff.

DR. XING: Yes.

MEMBER REMPE: Perhaps a plant might be so safe they say I don't need FLEX for many days ---

MR. PETERS: The level that I'm hearing right now is they're saying they don't even need operators. And so that's a whole nother ball game. There are no human actions to model. So this is, yes, I don't know the future. And that's the other part of my branch is trying to work through some of those issues.

But, yes, but where the general methodology would be utilizable, I think it could be utilized in new applications. We could use the at-power methodology for certain applications. So yes, or even ECA, we could probably utilize in those new applications also.

DR. XING: What our vision like is they want to use IDHEAS-ECA. Even back to 2017, there was a public meeting. Four plants indicated that they wanted to send an application for modifying their PRA model in which they gave an extra credit for using FLEX equipment. For some point in outage, you use the FLEX generator, diesel generator.

MEMBER DIMITRIJEVIC: I know, we understand. They want to credit FLEX.

DR. XING: Yes, they --

MEMBER DIMITRIJEVIC: Based on some of the recovery actions in the end of event tree. Now, the question is, should they have a mix and match of different methods, you know?

DR. XING: We cannot ---

MR. CHECK: Jing, I think I want to --

DR. XING: -- dictate what --

MR. CHECK: -- caution what we say here, right. So we cannot dictate what method the industry would use to calculate the HEPs or even to get the data, what kind of data they would use for the equivalent reliability.

We can have tools and methods available for our staff to use. And we can make those available for industry to use. But we're not supposed to be dictating the tools and models that industry would use.

DR. XING: Thank you.

MEMBER DIMITRIJEVIC: Yes. But you should visualize the application. I mean, why would NRC use this to review what?

MR. CHECK: Understood. So I think one very potential application, obviously, is in FLEX. Another one could be something like, you know, we had a NUREG on the alternate shutdown panels for Appendix R. And we can actually test that out with the NUREG we have that used expert elicitation.

And so there were other control room actions, we can also use it. We have a Level 3 model that we can always, in the office, pilot IDHEAS-ECA for those actions. And so we can have a lot of different applications where we can now document the potential users for them. Again, that would be what the staff could see them being used, but there's no way we could dictate if they're used that way.

MR. PETERS: And the other users that we would have is all of our significant determination process and ASP analyses that we do, even for in control room type action. So there's a very good use for IDHEAS-ECA.

CHAIR BLEY: Let me try something. We could do this under the auspices of a subcommittee for those who are interested from the member side. And one would be to have an hour, hour and a half of demo of the software tool.

Another would be to provide us with the three tables, the HEP table, the PIF weight table, and the PIF interaction table, with at least a key to what the columns mean. And you must have acronyms or something in there, you know, a key to what the acronyms mean without having the report to go behind it. And we can ask you some questions about it. So that'll give us a sense of the completeness and the kind of things that are --

DR. XING: Yes.

CHAIR BLEY: -- that are here.

DR. XING: I can provide that if you accept that it's in progress.

CHAIR BLEY: I would. I'm thinking of just, I assume those are computer files, three separate computer files.

DR. XING: Files, but there are, like, a lot of short names, for example, like a broken steam generator operator. Other people may take it for a different meaning.

(Laughter.)

CHAIR BLEY: Is there so much of that that it would be hard to give a cross list of the names that are in the table and what they really mean? Is that a big deal?

DR. XING: I don't know. I have to check.

CHAIR BLEY: Okay.

MR. CHANG: Because right now, while I work on both tables, sometimes I got lazy. Like, I will just write a D. I know that means detection.

CHAIR BLEY: Yes.

DR. XING: At another time, I wrote a word D, it may mean something different. I have to do some check. But I think you wouldn't mind to see part of the table. I'll make sure, if I only give you a small portion of each table, you can at least get a sense of how the table looks.

MR. PETERS: I even want to clarify. It probably just depends on when you're looking for the meeting. Jing could feasibly get it all together within a year, within a half year, something like that. But if you're looking for it in the next month or two, then that would be the more broken up tables.

CHAIR BLEY: Well, I guess the question is, are there actually three computer files that are the three tables?

DR. XING: I actually have a lot more computer files, like ---

CHAIR BLEY: So they're in pieces.

DR. XING: -- when the file gets to long, I got too lazy. I just break it down into small files. Otherwise, when I'm looking for something I have to ---

CHAIR BLEY: So it would be pretty hard to show them to us? And I guess that's ---

DR. XING: Yes. But look like this, you

have at least 15 sub-tables when I classify the information by each PIF. The 15 means I collapse all the PIF related to the environment in one computer file. So I can provide those tables.

CHAIR BLEY: Okay. Well, let's give it some thought and talk with Chris. And then I'll work with Chris on that.

DR. XING: And also I'd like to clarify what your comment early. In IDHEAS-G, we on purpose do not claim we have all this data here. We only, the Chapter 6 is all about we use IDHEAS-G as a method. So we establish this table. But putting the data in the table is an ongoing and lengthy process

CHAIR BLEY: Yes, I got that.

MEMBER REMPE: When you talk about a potential or potential IDHEAS for a future subcommittee, I think and update on IDHEAS-ECA progress would be also useful to discuss in such a subcommittee. What do you think, since you're over this thing, and not me?

CHAIR BLEY: I don't see them having much to discuss in that area until --

MR. PETERS: Summer time.

CHAIR BLEY: Yes.

MEMBER REMPE: They're doing the plant

visits, I think you said, this week and the next week.

CHAIR BLEY: But it's going to be several months before they work out all the scenarios they're doing. And then it's going to be several more months before they use the tool.

MR. PETERS: You know, they're looking at, I think, the preliminary results in the December to January timeframe. So, I mean, it's on a very tight schedule. Because --

CHAIR BLEY: Wow.

MR. PETERS: Yes. So using --

CHAIR BLEY: But to be able to come here and talk about them --

MR. PETERS: Yes. Getting into the proper state of documentation, that's a different piece.

MEMBER REMPE: I really see it's a problem to have nice view graphs and all that, but a 20-minute status report, like, in this project, we've had informal meetings where I thought we said you don't have to have slides even. Or it maybe came to Level 3 --

(Simultaneous speaking.)

MR. PETERS: We've given draft reports and really ---

CHAIR BLEY: You've had experience ---

(Simultaneous speaking.)

MR. PETERS: -- and we've had some pretty bad experiences.

(Laughter.)

MEMBER REMPE: But just some sort of status. I just am curious on how it's going. I mean, you brought up what kind of experts do you have at this, and what are you thinking. Off the wall, this is where we're at would be kind of nice. But again, it wouldn't be more than 15 or 20 minutes.

CHAIR BLEY: A slide show with ---

MR. PETERS: That wouldn't be hard at all. And we could give you preliminary results in the slide show, is what we're finding with the tool use and ---

CHAIR BLEY: I don't know when we have an opening to have a subcommittee meeting if we have it. And we'll talk some more.

MR. PETERS: Yes. I don't think that would be a challenge.

MR. MOORE: Mr. Chairman?

CHAIR BLEY: Sir?

MR. MOORE: With regard to the opening, I just point out that the NuScale schedule's going to get really busy during the spring, especially during the March, April, May timeframe. And that'll take up many full committee meetings and some subcommittee meetings. So it's just going to get busy during that time period. We'll have to look for an opening.

MR. PETERS: We might be able to do a February timeframe if you're just looking for a presentation on the status.

CHAIR BLEY: The status and seeing maybe a demo.

MR. PETERS: Oh yes, easy. A demo will be easy by then.

CHAIR BLEY: And maybe seeing some of the tables in a little more length to understand what's there. I think that would be good if we can do that.

But then, you were also thinking about when you'd have a cleaned up IDHEAS-G a little bit in the areas you talked about. And is that kind of in that same timeframe?

MR. PETERS: It seems like it.

CHAIR BLEY: Would that be before that?

MR. PETERS: Yes, it seems like that same timeframe.

DR. XING: Yes.

MR. PETERS: But I need to go back and really, we need to go back and really analyze it, but it does seem like the February timeframe would be good for a cleaned up IDHEAS-G.

DR. XING: It's doable.

MS. LUI: Okay, sorry.

CHAIR BLEY: No, just talk into it but from very close.

MS. LUI: Sorry. I just wanted to point out that this time the reason why we didn't do a live computer mode because the software apparently only exists on the research network server. So in order for the staff to do a light demo, we have to be able to connect with a research server and somehow get that projected into, I mean, out to a screen in this particular room. So in terms of ---

CHAIR BLEY: That's hard to do.

MS. LUI: So in terms, I mean, we'd probably be here until midnight for that to get worked out. So in order for that to actually work we need to make sure that the software would be portable so that we'll be able to set it up in each room. Otherwise, we have to look for another venue for that to become operational. I just wanted to point out that there was some logistic issues that we all need to work out in addition to a technical progress.

MR. PETERS: Okay, thanks, Chris.

MEMBER REMPE: One option might be if we could get back into White Flint Three. Don't they have an internet connection? And we've had subcommittee meetings there, perhaps.

CHAIR BLEY: I'm wondering, I didn't want to come back here at all in January, but somebody else is making me come back in January if we could have a subcommittee meeting then.

I'm not sure we even need the subcommittee. If we could put this in a steering committee meeting --

MR. PETERS: We could probably just give you guys access to the tool on the network, and you could play around with it if you like. And that's another ---

CHAIR BLEY: That could work for me.

MEMBER REMPE: I would like to find out more about what's happening with the ECA stuff.

MR. PETERS: Yes. I mean, as soon as we get it cleared through our IT department to load it into the NRC network.

CHAIR BLEY: I think a briefing on the ECA stuff could happen at our full committee meeting.

MEMBER REMPE: There's going to be a lot of members who aren't here. They're going to have to come up to speed with what happens in the full committee meeting. But it's up to you.

CHAIR BLEY: Yes.

MEMBER REMPE: Actually, January, adding a half day, is not a big deal. I don't think we need a full day but, I mean ---

CHAIR BLEY: Well, we'll talk some more about that. I don't know if we need a subcommittee meeting or not.

MR. PETERS: Okay.

CHAIR BLEY: But if we're aiming toward February, that would mean we'd need revisions to IDHEAS-G in January to support that.

MR. PETERS: And ruining Jing's Christmas. Yes.

CHAIR BLEY: Or we could slip it for a few months. Because it's true, Scott's right. We have hard schedules on ---

MR. PETERS: Totally understand.

CHAIR BLEY: -- on NuScale which just aren't going to yield any space. I don't know what it does to you guys if we delay until summer.

MR. PETERS: Well, I mean, I don't think it has much effect on us for delays. Because we are going to progress along the path we laid forward, completing IDHEAS-G, completing IDHEAS-ECA.

CHAIR BLEY: If that's the idea, we have full committee sometime after the bulk of the NuScale stuff slides by. You have more stuff done.

MR. PETERS: Yes.

CHAIR BLEY: And we'll be in a much better place to write a letter for you.

MR. PETERS: Jing wants to be done now.

DR. XING: I personally don't favor that plan, because I have several other projects coming up. If I wait that long, we talk that PIF early, if you wait too long to do something, there's a high chance of facing a new set of error in the report. So I would rather forget about the Christmas thing, as early as we can do it. I don't mind we do it on December 23rd.

MR. PETERS: So we tell Jing that we're doing it December 23rd, but we actually do it next summer. That's a good plan.

(Laughter.)

MR. PETERS: But we'll figure it out. We'll figure it out offline.

CHAIR BLEY: Talk some with Chris, and I'm okay whichever way we go.

MR. PETERS: Okay.

CHAIR BLEY: I think February is probably it. We can either do it in February or we so it in summer.

MR. PETERS: Okay.

DR. XING: Okay.

CHAIR BLEY: And if there's a slot in January to have either a subcommittee or some people participate in a small working session with you guys that might do it too. So see what works out.

You guys are all done?

MR. PETERS: I have one last slide real quick. We don't have to talk about it. I'm just telling you what's the future of our work once IDHEAS-G is done. And so obviously, we have a lot of documentation, technical basis work which we've already talked about, ECS implementation support.

So once you have a tool out there, a method out there, once people start utilizing it, there's a lot of support with plans to come forth with it.

And so dependency, recovery, minimum joint HEP, these are areas where we didn't do a lot of innovation in the IDHEAS-G methodology. And we get a lot of feedback from users that these are areas of concern to them. And this is something that we will be looking into in the near future.

And Jing mentioned that we have a side project looking into the challenges, just characterizing the challenges of dependency right now. And once we have that characterized, we'll go into trying to figure out better ways to model it. But we did get good feedback from the ACRS that maybe we solved a lot of the problem here with the IDHEAS-G methodology. But we were ---

CHAIR BLEY: We didn't talk much about dependency. But to me, if you do, I think you've called them base case scenarios, then you do variance with them, they'd create difficult conditions. I think that's really where dependency crops up in a big way. And that links together things because of the extreme context that can come up.

And I think that's a major piece of the dependency, you know, the little tricks for saying one person, two person kind of stuff is small potatoes. Something that changes a scenario so that we're looking at very difficult spots for the operator gets us into the kind of things that have gone wrong when it's real tough to recover.

And for me, that is where most of the dependency is hiding, in those severe context events which are variants on the others. Go ahead.

MR. PETERS: And the last thing, data, data, data.

CHAIR BLEY: Okay. We know we have the June data over some years. We know SACADA is going to chug along and keep creating data. What else are you thinking?

MR. PETERS: So we're starting a data program right now which, now that we have the base structure of IDHEAS-G laid out, it will show us where we're lacking. And we're going to be doing a cross comparison of what data we need in IDHEAS-G, versus what we have available, versus our current methods, and what we have, I'm sorry, versus our current databases. And then we'll be doing searches out there for data in external counterparts, you know, like military data, NASA data, things like that.

CHAIR BLEY: And this would, in principle come into the Jing ---

MR. PETERS: This will come into Jing's stack of thousands of reference documents that we would then be back incorporating into the IDHEAS-G.

CHAIR BLEY: You still have stuff going on with Halden?

MR. PETERS: We do. So Halden is one thing. I'm also looking to propose a new task on our international workgroups or the working group on the interorganizational factors and WGRISK. We're looking at putting a new CAPS out there that would get international partners in to contribute data. So we have interest from several other parties in that.

So the long term picture, I think, is that data piece is really filling in the missing gaps in HRA by finding what's out there and having a coordinated program for getting it.

And then I always like to leave the TBD, because I just don't know what's coming down the pike next. Fukushima changed a lot for us from an HRA perspective. So I don't know what the next big thing will be from the NRC or industry's perspective.

A lot of it may be modeling, people that just go out and push the easy button on these new and advanced reactors with no human actions otherwise. I mean, we just don't know.

CHAIR BLEY: Okay. Well, thank you.

MR. PETERS: Thanks.

CHAIR BLEY: I think we're going to go to public comments, and then we'll go around the table. But first we have comments from Mr. John Stetkar who's here as a member of the public today. John, I think you should stand for this.

MR. STETKAR: I'll come to the microphone and be clearly or whatever it says. First of all, my name is John Stetkar. And full disclosure, I'm a former member of the ACRS but speaking today as a member of the public.

I'll try to keep this as brief as I can. And I only have one page. So it'll be pretty quick. I read the NUREG. I like a lot of parts of it. I think it emphasizes the importance of the qualitative analysis. I think it emphasizes very well the importance of the scenario context. And it provides a method to link the contextual elements of the scenario to factors that, in principle, can be evaluated objectively and related to human error probabilities.

Four items that I'd like to highlight, first of all, the NUREG does not contain any methodology or guidance for performing a feasibility assessment. And I think that's an important omission. Performing a feasibility assessment is a fundamental part of any human reliability analysis methodology.

And furthermore, earlier drafts of the methodology I had, in my opinion, was pretty good guidance. And it's just gone. So I'd hope that you'd consider resurrecting that and adding it.

The second comment is the methodology does a fairly thorough job in identifying those detailed cognitive failure modes. I found that really, really useful. I'm thinking in terms of a potential practitioner. You say people can redefine them, you can go down to the details, you can stay at the middle level, you can stay way up at the macrocognitive functions. But I found the detail set was very good.

In a similar manner, you defined the 20 performance influencing factors, you develop a set of, I think, pretty well thought out attributes for each of those.

What I found lacking, and what the report actually discusses, is that in many cases analysts, if they use, for example, a three variant rating scale of a performance influencing factor, it's good, it's average, it's bad. Well, my average might be different than your average. Or your good might be my average.

It would seem helpful to me anyway if the report made an attempt to provide a scale for each of those performance influencing factors, in a sense arrange from zero, you know, as good as it can get to as bad as it can get, with some examples so that it would help practitioners to anchor.

You know, if you used a scale from zero to ten, let's say, it could look at descriptions of combinations of the attributes and say, oh okay, that's kind of what they were thinking about for a seven. So when I went in and said, well, this thing is kind of a seven, we would be able to speak on at least a similarity of scale. You might think it's a five, and I might think it's a seven. But we're not talking about the difference between, you know, a two and an eight.

And looking, I know nothing about the ECA. It's the first I've heard about it today. I think you may have already done some of that in the background of whatever is wired into the computer model for ECA. You almost have to have done that. If it's done at that fine structure level in the computer model, it would strike me that you ought to be able to pull it back out at the higher level in the general methodology so that there is that set of information in the general methodology.

Somebody wants to use ECA as an application, then fine. If somebody wants to use a different X, Y, Z application, they still have that more comprehensive set of scaling thoughts. I don't want to call them guidance, because that's a phrase that I don't want to use in the general methodology. So I just make that thought.

The third point is that I think that there should be what I'd call a healthy skepticism about the quantification model as it's presented in the general methodology.

As a professional cynic, I look at that quantification model and I say, yes, this is yet another algorithm to relate ratings and weights of performance influencing factors to human error probabilities. And at that level, it's no different than THERP, or HCR/ORE, or SLIM for anybody else's methodology that has been roundly criticized as not having a fundamental basis or an anchorage for data.

That anchorage might be there in your analyses of the data. There might be good justification for why those three performance influencing factors are the predominant means of determining the relationship with a human error probability and why some linear combination of the other 17 principle performance influencing factors are a secondary effect, if you will.

But I just can't get it. I certainly can't get it from what's in the general methodology, and I don't get a good sense of confidence in it. I'm concerned that, because it's presented in the NUREG and now apparently has been implemented in ECA, that it is now suddenly the recommended, NRC recommended model for quantifying human error probabilities.

Because again, I personally think that a healthy amount of skepticism is prudent until somehow you can provide a lot more confidence in that model, the linkages and the logical structure of that model.

The fourth comment that I wanted to make, and this is a focused comment, it's on Example 1 in Appendix M. It's the example on the, if I don't put it down in notes, I don't remember, the H.B. Robinson fire example. And in particular, I have some real problems with the way the important human actions and success criteria are defined in that example.

And in particular, the example says that an important human action is to trip the reactor coolant pumps. That must be done to prevent seal damage. And furthermore, that it alone is a necessary insufficient to prevent seal damage. I do not believe that's true.

So I know that the abnormal operating procedure at that particular plant instructs the operators to trip the pumps. I believe that's to prevent failure of a really expensive piece of equipment in the plant and not to prevent damage to the pump seals.

So I would urge you very, very strongly to look at that particular requirement and the way it's reflected in that example. Why is that important? Because there's only two examples in the whole NUREG. And people are going to look at those examples and examine them in exceeding detail as NRC recommendations for how to do HRA. So those examples had better be crisp, and clear, and well thought out.

And if people have fundamental questions about how you've defined the important human action, how you've defined the success criteria in the context of the only two examples you provide, you're going to be in trouble.

So again, my recommendation is look at that example pretty carefully, and in particular for that set of success criteria. And with that, I promised I'd be short.

CHAIR BLEY: But don't go away.

MR. STETKAR: Okay, I won't go away.

CHAIR BLEY: Out of all the things you had to say, the first one doesn't sit great with me, that they really need a feasibility study. Now, most of the feasibility studies I've seen were done to essentially see if there's enough time to get this done. And they're doing that. So what is it you want in a feasibility study that isn't getting picked up in the process as it's laid out?

MR. STETKAR: Okay. Time is only one element. If the former guidance was there, and in fact, in NUREG 2199, he had power.

CHAIR BLEY: That's the fire?

MR. STETKAR: No, 2199 is the at-power application --

CHAIR BLEY: Oh, okay.

MR. STETKAR: -- of the general methodology. Lays out in that NUREG, the things to think about for a feasibility study. Do you have enough people, not are the people stretched, do you just have enough people? Do you have the tools? Do you have, time is one element that's looked at.

So there are, I don't remember how many different ---

DR. XING: There are eight criteria.

MR. STETKAR: -- criteria, eight criteria. I was going to say about a half a dozen.

CHAIR BLEY: There's nothing among them though that doesn't need to be looked at when you carry out the processes that have defined it.

MR. STETKAR: That's true, but there are many people who have defined, this is part of defining human failure events in your model. There are many people who have defined human failure events without even thinking about the feasibility and then gone into a lot of effort to analyze them and later found out that they weren't feasible, that they wasted a hell of lot of time building a model for something that couldn't be done.

CHAIR BLEY: Good Lord.

MR. STETKAR: Because they hadn't --- it doesn't require a lot of work.

CHAIR BLEY: So then you leave this up to prevent overwhelming stupidity from causing problems.

MR. STETKAR: It's only my opinion.

CHAIR BLEY: It's true. Okay, thank you.

MR. STETKAR: And it was, as I said, it was in ---

CHAIR BLEY: Yes.

MR. STETKAR: -- an earlier version of --

CHAIR BLEY: Yes. I probably recommended to get rid of it, because they ought to look at that automatically.

(Laughter.)

CHAIR BLEY: But I don't know if I did or not.

MR. STETKAR: Okay. But that's ---

CHAIR BLEY: I headed elsewhere.

MR. STETKAR: Those are the four kind of bigger ones.

CHAIR BLEY: Thank you.

MR. STETKAR: You're welcome.

DR. XING: Thank you.

CHAIR BLEY: Anybody else have anything for John?

MR. PETERS: I just want to thank John for all his hard work and guidance as an ACRS member.

MR. STETKAR: I was paid, you know, very well as an ACRS member for all of that. I ain't paid now. I'm going back to sit down.

CHAIR BLEY: You have a different sense of being paid well than some of us.

(Laughter.)

MR. STETKAR: One final comment. I'm retired. My income is precisely zero. So relative to zero, you know.

(Simultaneous speaking.)

MR. PETERS: Yes. That's when those tables will be useful, to figure out what the averages are for people.

CHAIR BLEY: We're getting the phone lines open. Is there anybody else in the room who would like to make a comment? We'd love to hear from you.

Okay, is there anybody on the phone line who like to make a comment? If so, state your name and give us your comment, please.

Thank you very much. As we go around the table with the members, I'm interested in any general comments you have but also do we need a subcommittee meeting, and what's your feeling about that? And what should be in it if we have one? Are you leaning towards saying, yes, this is pretty good, and with a little cleanup it could satisfy the SRM and our own view of that. And I won't ask you if we need to write a letter, because we're going to have to write a letter on this one. Ron?

MEMBER BALLINGER: Well, I should say that I now know about 75 percent of the acronyms.

CHAIR BLEY: He thought.

MEMBER BALLINGER: All kidding aside, I do understand it now. But I'm kind of in favor of an update kind of thing, of something related to this ECA issue. Because I think that might just close ---

CHAIR BLEY: In a full committee or in a subcommittee?

MEMBER BALLINGER: Well, I don't know. You have to have discussions about how to do that.

CHAIR BLEY: they're going to work on that, but you aren't ---

MEMBER BALLINGER: To me, it would sort of close the loop on this a little bit.

CHAIR BLEY: Yes.

MEMBER BALLINGER: Anyway, and maybe I'll know 80 percent or 90 percent of the acronyms by then.

CHAIR BLEY: Just a minute before we go on. Harold?

MEMBER RAY: By the way, I calculated that this presentation would have been an hour longer if they had not used acronyms.

(Laughter.)

CHAIR BLEY: I thought you had something to do this afternoon, Mr. Ray.

MEMBER RAY: Well, I think this is essential to risk informed regulation generally. I expressed myself earlier thinking that where I see its great value is in what lies in the future as opposed to application to current plants. But I may be wrong about that. So I'll just leave it at that. But in any event, there's a lot of progress been made, and I think it's going to be valuable.

As far as how to get from here to the next step, I won't opine on that, Dennis. I don't feel confident to that.

CHAIR BLEY: Thank you, Harold. Matt, and that thank you for the extraordinary effort to get here today. I appreciate it.

MEMBER SUNSERI: So it's seems like it's good work to me. And, you know, I think it's well thought out, and designed, and put together.

I guess as far as what more involvement we have is, I'm unclear what our objective is. I mean, what is the purpose of our going forward with reviews if the reviews cite the aspects? Is it to produce the operating manual? Or, you know, I'm just somehow not clear on it. So I can't answer the question about should we have a subcommittee or not. If maybe you could clarify what our objective is.

CHAIR BLEY: Thank you. Joy?

MEMBER REMPE: So I think, in order to have confidence in endorsing this, I would like to have another subcommittee meeting to improve my confidence in it.

And that involves seeing how the NUREG has been cleaned up, it means understanding what's happening from the people involved in this ECA evaluations to say how is this really working, so I have a little more confidence.

The data, it's also, if you're using it as a quantification method, and you really are in it, I think the data are important.

And what was the, oh, I'm less into the software tool but, yes, I'd be curious to see it. But it's not as essential to my endorsing the method. Because I don't think we're endorsing the software tool. But it would be interesting to see.

CHAIR BLEY: Thank you.

MEMBER REMPE: Oh, I do want to thank you for your presentations today. Over the time I've participated in these meetings, I've seen growth and confidence. And I think that it helps with it. So you should be commended on that too.

CHAIR BLEY: Dr. Kirshner?

MEMBER KIRCHNER: Yes, thank you. I think the first thing I'd like to do is quantify the human failure of these damn microphones switches. But it's very high. I think it's about 3.967 with a 95/95 confidence. But it's very high for a simple switch to watch how often everyone struggles with, one, remembering to turn it on and, two, to actually function. It would be a nice, rich, dataset, actually.

So on a more serious note, thank you. I think I was at one or two of these IDHEAS presentations when I had first joined the committee. And I see a lot of progress. I think I made most of the points I would like to have made during the course of the presentation.

So on the question of subcommittee versus full committee, we almost have the full committee here. I would be, whether it's subcommittee or full committee, much interested in the ECA implementation out at the two sites and how that exercises both the methodology and your software. Because then it would be, for me, a little more tangible in terms of results and application.

So again, thank you for the presentations. Thank you, Dennis.

CHAIR BLEY: Thank you. Vesna?

MEMBER DIMITRIJEVIC: Okay. First, we always say thank you.

CHAIR BLEY: Microphone, please.

MEMBER DIMITRIJEVIC: Oh, my goodness.

(Laughter.)

CHAIR BLEY: I don't know, we got a lot of data on Vesna today.

MEMBER DIMITRIJEVIC: We always say thank you, but I want to say special thank you. You have been so responsive, and open, and brought everything with you, and it was a pleasure. So thank you very much. That was really a lovely presentation.

DR. XING: Thank you.

MEMBER DIMITRIJEVIC: I cannot really form my opinion. This letter goes against everything I believe in.

(Laughter.)

PARTICIPANT: Tell us how you really feel.

MEMBER DIMITRIJEVIC: No, I don't know. I have not have a chance to develop, I only have the chances to participate, develop on one risk informed methodology. And I thought during the develop to keep things simple, because less you know, more complicated we want to make things. But that's why we actually have to keep them simple, in my opinion.

So I strongly believe I succeed to keep fracture mechanics, macro models, all kind of things out of this methodology so it can be easily applicable. Because what was the main goal that was important?

So from my perspective, we're making

guesses. We don't really know what human probability error is. That's not scientific fact, but I cannot be calculated based on question, so we make guesses.

Now, are we better when we make guesses on ten staff instead of one? So like this is beginning of the PRA. You know, we broke four, three, so we can make, but we didn't make guesses. We had data. We brought them to the thing where we have data.

Here, we are breaking it. So what we do, maybe we make a better guess, but what we are introducing its high uncertainty, and we are missing interaction between those guesses.

So for me to think is that good or not, I have really to think this over, look at examples and things that, you know, to say okay. Because I'm also not sure what is the goal of our Letter. It's not going to say that he said that this matter is valid and right, documenting well, blah, blah, blah, but also where we suggest to be applied.

And I will maybe, when I'm convinced it's really doing good things, I will suggest it to apply to some important human actions related somewhere. That's why I would use it to track something. But I'm not sure.

So what I was thinking, I don't even think we need subcommittee meeting in my opinion. Because if we have informal meeting, we check the data and software so we get a little more familiar with that. I think for me that will be enough. However I think we need subcommittee meeting between ourselves, some short lunch meeting, so that we understand what will be goal of our letter.

CHAIR BLEY: Yes.

MEMBER DIMITRIJEVIC: What do we want to say in the letter, and what do we envision saying? Actually, I'm all new for this. I may even excuse myself depending how the letter goes with that. Because I am just coming on the end of the process. But anyway, thank you very much.

DR. XING: Thank you.

MR. PETERS: And if we wait long enough, there will not be any of the original commissioners nor any of the ACRS members, or no staff members left to answer from the original intent of the ---

(Laughter.)

CHAIR BLEY: We're getting close.

MEMBER BALLINGER: Don't mess with my fracture mechanics.

(Laughter.)

CHAIR BLEY: Well, I too want to thank you. Everybody who was here. And everyone did a great job. The report has really progressed from what it was to something that one can read from cover to cover and understand what's going on there.

My opening comments I stand by. I think it would be a big help to people to have some of that simple clarification up front about qualitative analysis and how that links through all these pieces that are coming. And I think it's a big thing.

I'm on a different side than Vesna on this, because I spent a lot of time looking at bad events, things that have gone really bad, nuclear plants and other places. And they don't go really bad because an operator, you know, forgot to turn a switch. They don't go really bad for all the simple things we see and people usually recover from pretty. They go when the context lines up to make it really hard to get out of the situation. It fools you.

You know, some of the events that were looked at in the empirical studies were designed to be events that masked what was going on. It looked like one thing, ended up being something else. The one Jing focused on near the end was not that way. It was pretty clear what was going on. But the speed at which it got them in trouble was a bit surprising. And, you know, there was another crew who did the test case, and they did it fine, no trouble. So then we had four cases that were in there.

If we're going to have a method that helps us do risk assessment, and helps us find the things that are risky, the kind of things that have turned up when we've had really bad events, then I don't know a way other than digging into the context to really help you find them. And figuring out how to identify the context is part of it. And you have a story in there on that.

I think pointing so heaving to the quantification method before the documentation exists to show its quality and pedigree is awkward and could leave us in a, you know, if we never get that report done for one reason or another, we're sitting there with numbers that we just don't have anchors to.

That goes back, as we heard, to many of the early methods that claimed they had a basis, but whenever you tried to dig into it, it kind of vaporizes. And they're just numbers.

These could be very good, and the story, the verbal story is good. But we don't have a way to ---

MR. PETERS: So what Dennis is saying is at least without the documentation we're at least as good as the existing methods for publication, ha, ha, ha. And we're working towards the documentation.

CHAIR BLEY: I think you've come a long way. You know, you guys could talk with Chris and work it out. I think, I'm thinking right now, without more thought, that a subcommittee-like working meeting, I don't think we need an official transcript of it, but to let us go through the three areas that people have talked about, I think it will be worthwhile if we can do it.

And if we can see that and see a February date for the letter, that's okay. If we can't, then it's going to move off to summer. And you'll get more details on that from Chris.

In any case, we will be waiting to hear when it would be convenient or possible for you and us to get back together again and hear those three things. But you've got to have real confidence that you'll have the tool in a fashion we could play with it, that you'll have something you can show us on the data, and that you'll have an update on the ECA project and what it looks like.

And, you know, informal, without formal presentations. Well, I think you'd need something formal on the ECA status, but without just a lecture but really a talk through, I think, would be adequate on that. So we'll see how that comes together. And once again, thanks a lot.

MR. PETERS: Okay, thank you.

CHAIR BLEY: We are adjourned.

(Whereupon, the above-entitled matter went off the record at 6:20 p.m.)

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

The General Methodology of an Integrated Human Event Analysis System (IDHEAS-G)

NRC Staff Presentation to the
Advisory Committee on Reactor Safeguards
Reliability and PRA Subcommittee
September 18, 2019

Acronyms

ACRS	Advisory Committee on Reactor Safeguards
ANS	American Nuclear Society
ASME	American Society of Mechanical Engineers
CFM	cognitive failure mode
CT	critical task
D	detection (macrocognitive function)
DM	decisionmaking (macrocognitive function)
E	action execution (macrocognitive function)
ECA	event and condition assessment
EOP	emergency operating procedure
FLEX	flexible and coping (strategies)
gpm	gallons per minute
IDHEAS	Integrated Human Event Analysis System
IDHEAS-ECA	Integrated Human Event Analysis System for Event and Condition Assessment
IDHEAS-G	General Methodology of an Integrated Human Event Analysis System
IHA	important human action
I&C	instrumentation and control
HAMMLAB	HAlden HuMan-Machine LABoratory
HEP	human error probability
HFE	human failure event
HRA	human reliability analysis
HSI	human-system interface
NPP	nuclear power plant
NRC	U.S. Nuclear Regulatory Commission
NRR	Office of Nuclear Reactor Regulation
PIF	performance-influencing factor
PORV	power-operated relief valve
PRA	probabilistic risk assessment
PZR	pressurizer
RCS	reactor coolant system
RO	reactor operator
SACADA	Scenario Authoring, Characterization, and Debriefing Application
SG	steam generator
SGTR	steam generator tube rupture
SM	shift manager
SRM	staff requirements memorandum
SS	shift supervisor
STA	shift technical advisor
std	standard deviation
T	teamwork (macrocognitive function)
U	understanding (macrocognitive function)

HRA RESEARCH PROGRAM OVERVIEW

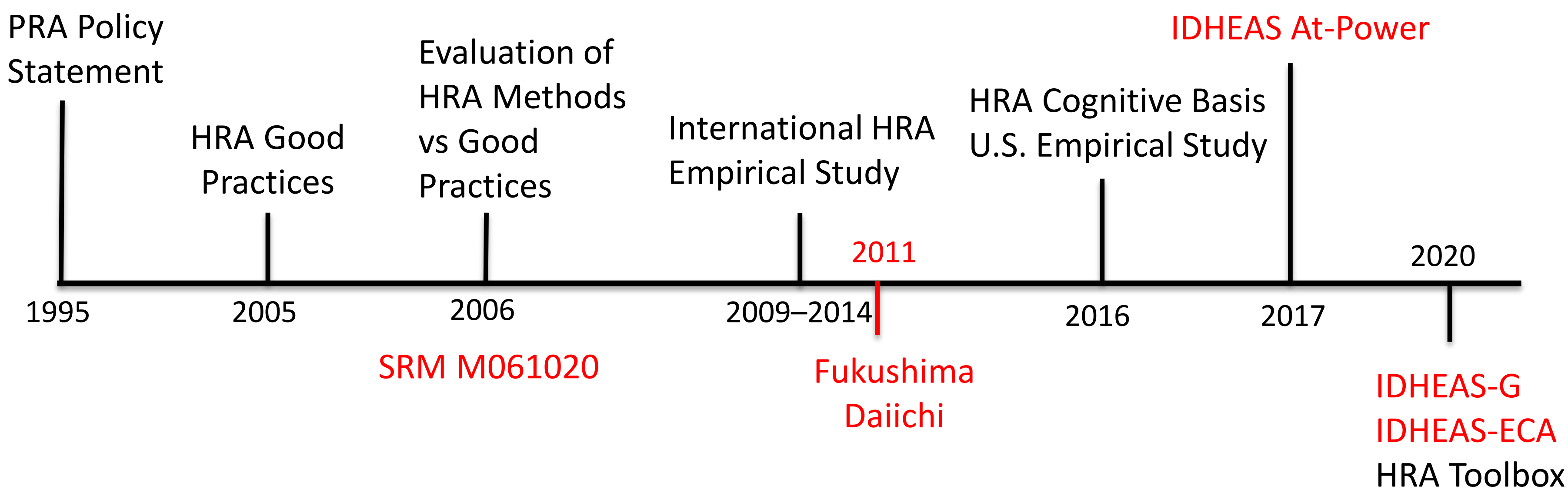
Sean E. Peters, Chief
Human Factors and Reliability Branch
Division of Risk Analysis
Office of Nuclear Regulatory Research

Why are we here?

SRM-M061020

The Committee should work with the staff and external stakeholders to evaluate the different Human Reliability models in an effort to **propose either a single model for the agency to use or guidance on which model(s) should to be used in specific circumstances**.

Timeline of HRA Development



Timeline References

- PRA Policy Statement " (60 FR 42622) – "The use of PRA technology should be increased in all regulatory matters to the extent supported by the state of the art in PRA methods and data, and in a manner that complements the NRC's deterministic approach and supports the NRC's traditional defense-in-depth philosophy."
- NUREG-1792 - Good Practices for Implementing [HRA] (ML051160213)
- NUREG-1842 - Evaluation of [HRA] Methods Against Good Practices (ML063200058)
- NUREG/IA-0216 - International HRA Empirical Study (ML093380283, ML11250A010, ML14358A254)
- NUREG-2127 - The International HRA Empirical Study: Lessons Learned from Comparing HRA Methods Predictions to HAMMLAB Simulator Data (ML14227A197)
- NUREG-2114 - Cognitive Basis for [HRA] (ML16014A045)
- NUREG-2156 - The U.S. HRA Empirical Study (ML16179A124)
- NUREG-2199, Vol. 1 - [IDHEAS] for [NPP] Internal Events At-Power Application (ML17073A041)

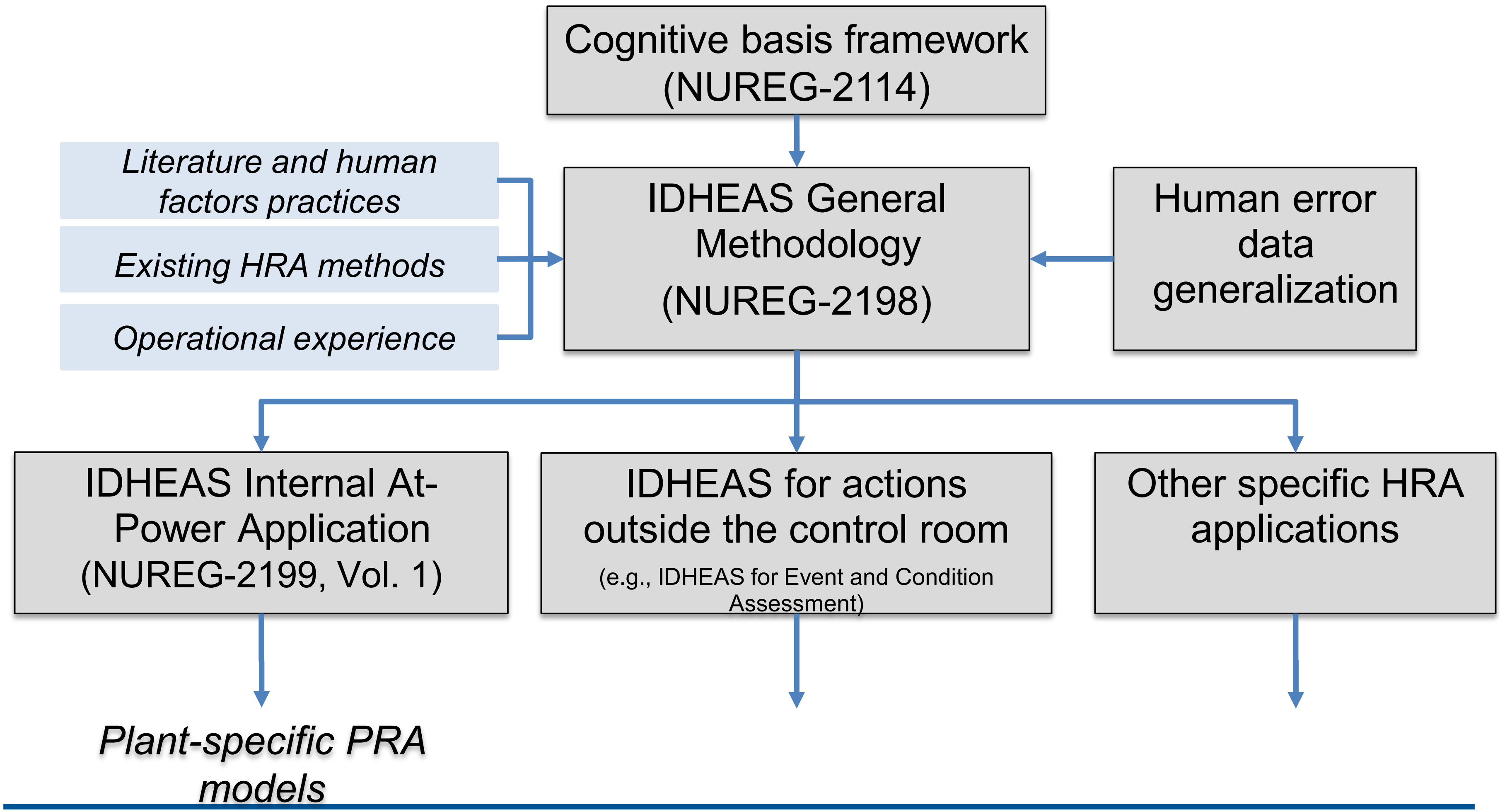
IDHEAS-G Development

- All evaluated HRA methods had strengths and weaknesses
- IDHEAS-G was developed to integrate strengths of existing HRA methods and enhance HRA in:
  1. Application scope
  2. Scientific basis
  3. Reduction of HRA variability
  4. Use data for HRA

Intended Uses of IDHEAS-G

- High-level guidance for developing application-specific HRA methods or tools
- Platform to generalize and integrate human error data from various sources for HEP estimation
- Perform HRA for all nuclear applications
- Systematically analyze human events, including identifying human failures and root causes

IDHEAS-G Framework



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Outline

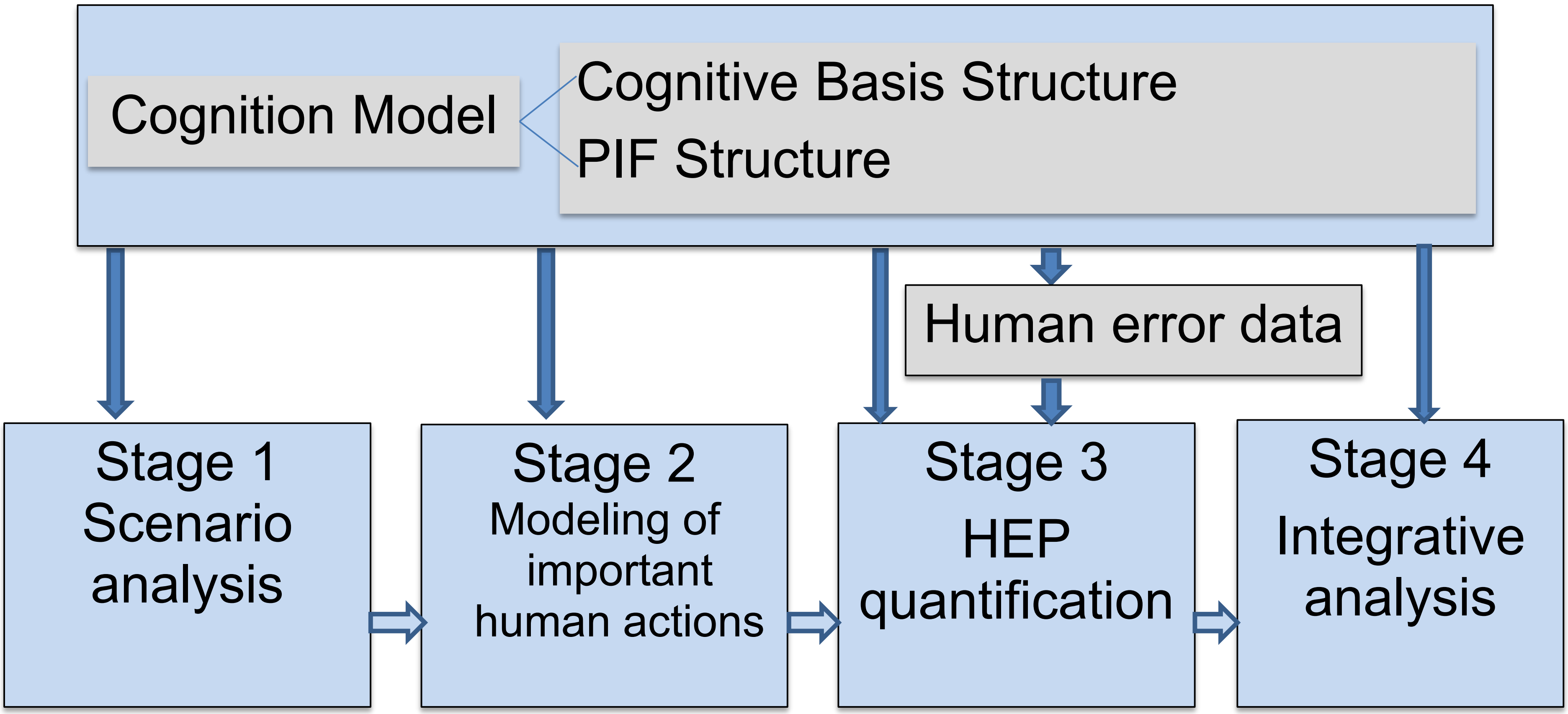
Part I. The General Methodology of an Integrated Human Event Analysis System (IDHEAS-G)

Part II. IDHEAS-G Applications

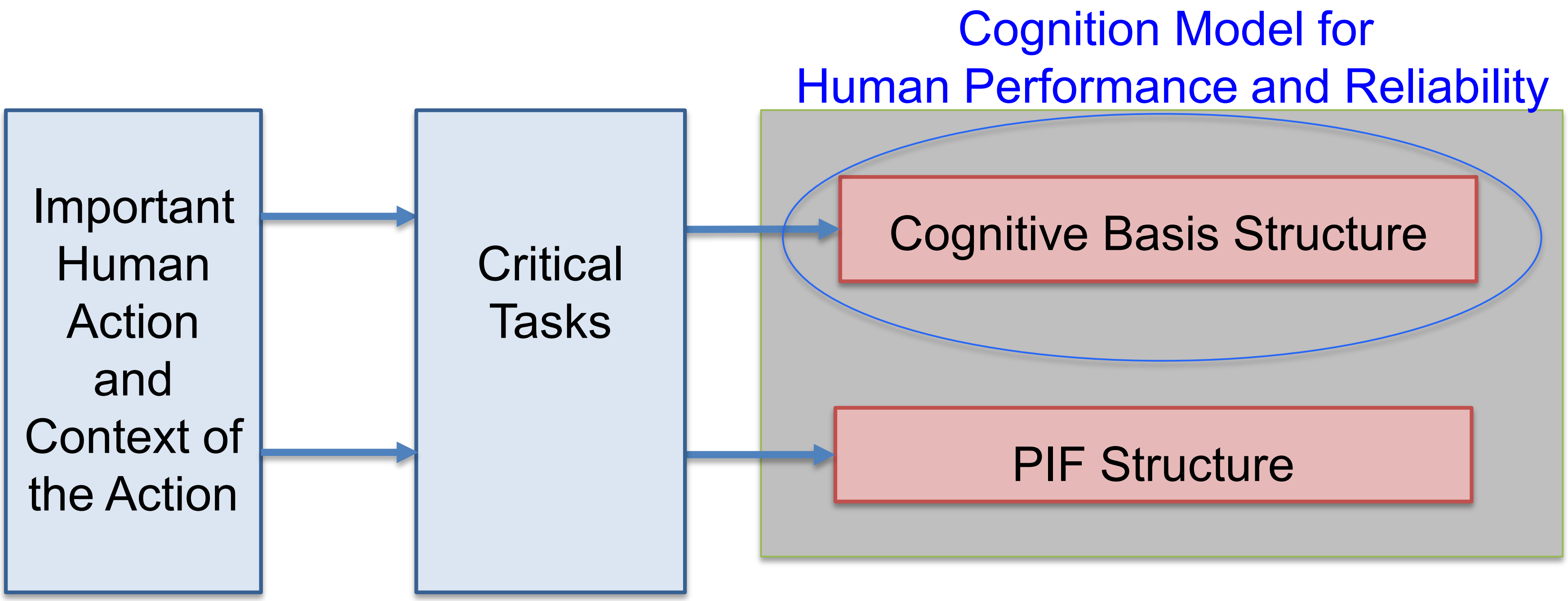
Part III. Demonstration of an IDHEAS-G Application—IDHEAS for Event and Condition Assessment (IDHEAS-ECA)

Jing Xing, Senior Human Performance Engineer
Human Factors and Reliability Branch
Division of Risk Analysis
Office of Nuclear Regulatory Research

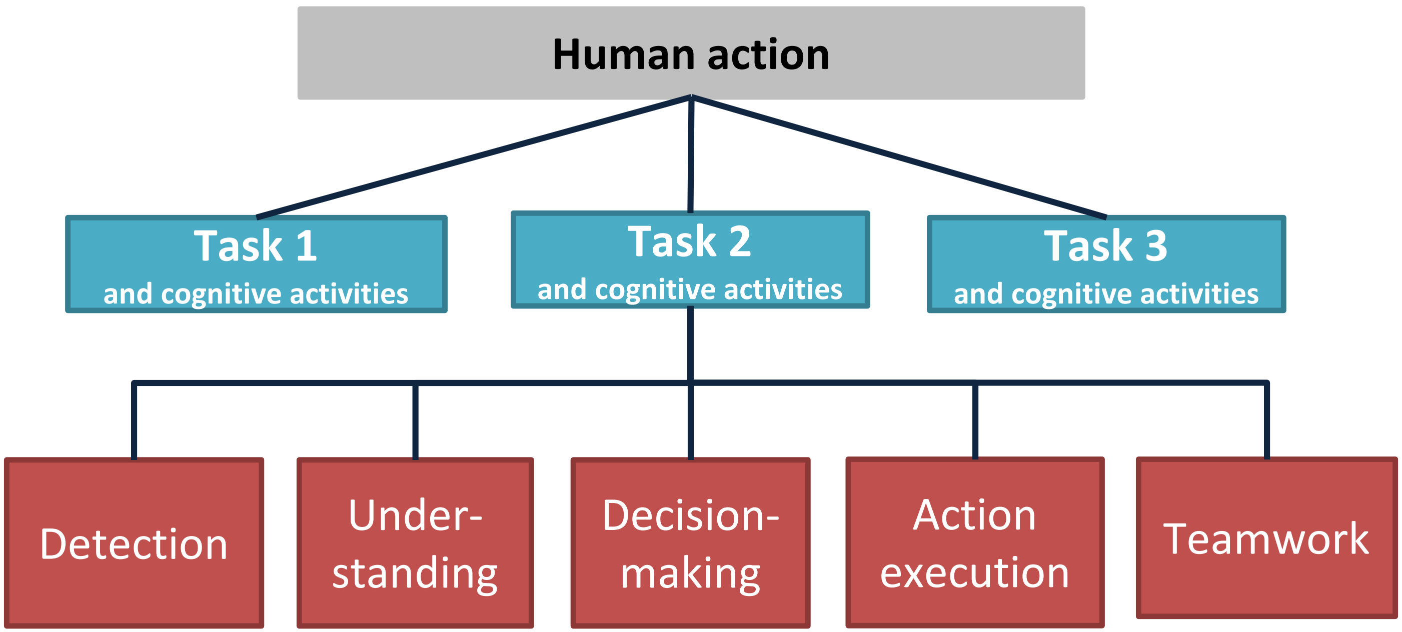
Overview of IDHEAS-G



Cognition Model—Overview



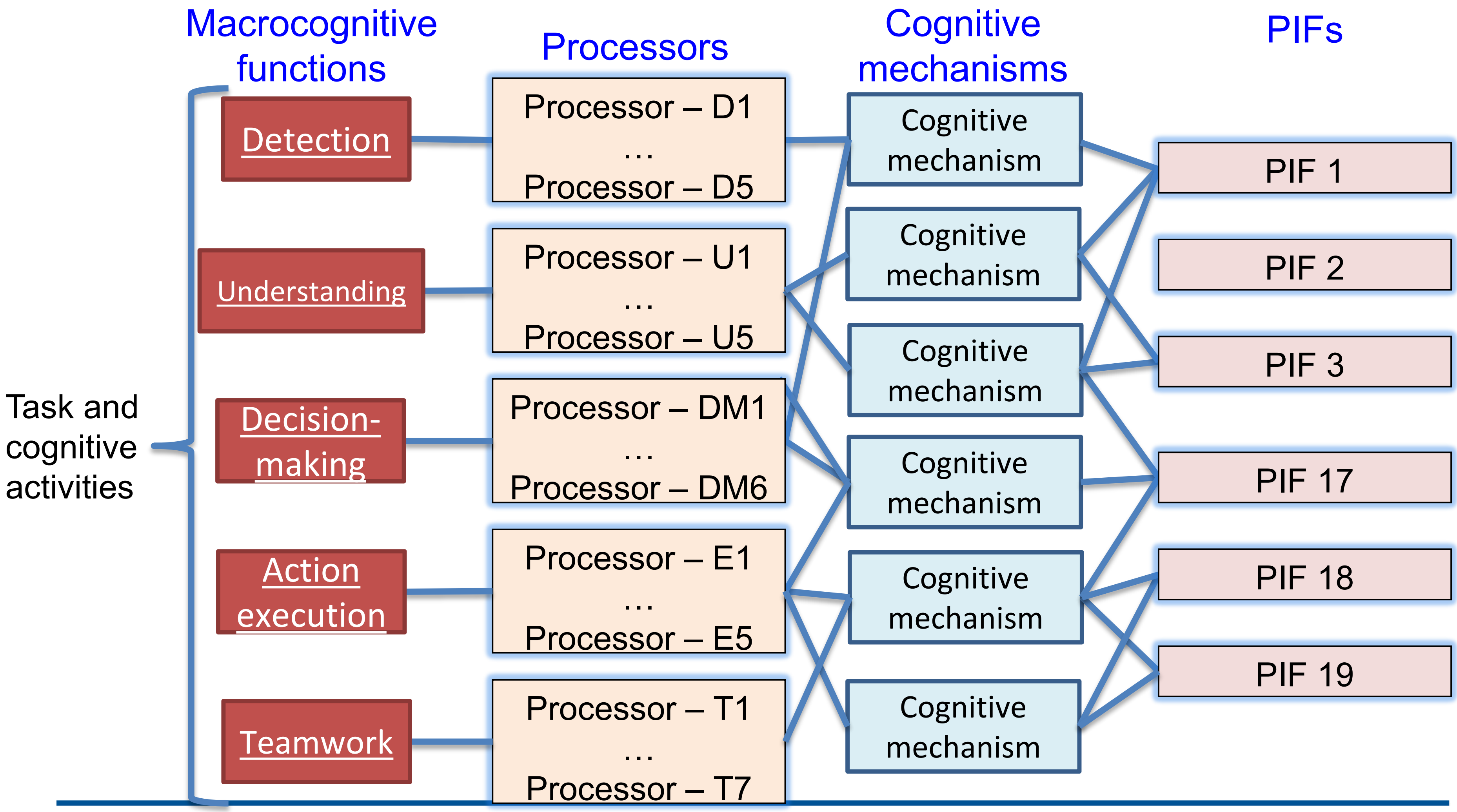
Cognitive Basis Structure



Macrocognitive Functions

- *Detection* is noticing cues or gathering information in the work environment.
- *Understanding* is the integration of pieces of information in the work environment with a person’s mental model to make sense of the scenario or situation.
- *Decisionmaking* is selecting strategies, planning, adapting plans, evaluating options, and making judgments on qualitative information or quantitative parameters.
- *Action execution* is implementation of the decision or plan to make a change in some physical component or system.
- *Teamwork* is various teams interacting and collaborating on tasks.

Cognitive Basis Structure (continued)



Detection

Detection cognitive activities

- Detect cues
- Acquire (gather) information

→

Detection processors

D1. Initiate detection – Establish the mental model for information to be detected

D2. Select, identify, and attend to sources of information

D3. Perceive, recognize, and classify information

D4. Verify and modify the outcomes of detection

D5. Retain, document/record, or communicate the outcomes

→

Detection cognitive mechanisms

D.a. Mental model of the cues

D.b. Perception of sensory information

D.c. Attention

D.d. Working memory

D.e. Vigilance

D.f. Information foliage

D.g. Pattern recognition

D.h. Shared cognition within a team

D.i. Infrastructure for exporting the information detected

Return to Cognitive Basis Structure

Go to detection CFMs

Understanding

Understanding cognitive activities

- Maintain situational awareness
- Assess status based on indirect information
- Diagnose problems and resolve conflicts in information
- Make predictions or form expectations for the upcoming situation development

Understanding processors

U1. Assess/select data

U2. Select/adapt/develop the mental model

U3. Integrate data with the mental model to generate the outcome of understanding (situational awareness, diagnosis, resolving conflicts)

U4. Verify and revise the outcome through iteration of U1, U2, and U3

U5. Export the outcome

Understanding cognitive mechanisms

U.a. Data

U.b. Selection of data

U.c. Mental model

U.d. Integration of data with mental model

U.e. Working memory

U.f. Shared cognition within a team

Return to Cognitive Basis Structure

Go to understanding CFMs

Decisionmaking

Decisionmaking cognitive activities

- Make a go/no-go decision for a pre-specified action
- Select among multiple options or strategies
- Change or add to a pre-existing plan or strategy
- Develop a new strategy or plan

Decisionmaking processors

DM1. Adapt the infrastructure of decisionmaking

DM2. Manage the goals and decision criteria

DM3. Acquire and select data for decisionmaking

DM4. Make decision (judgment, strategies, plans)

DM5. Simulate or evaluate the decision or plan

DM6. Communicate and authorize the decision

Decisionmaking cognitive mechanisms

DM.a. Decisionmaking model

DM.b. Data for decisionmaking

DM.c. Selection or judgment

DM.d. Cognitive biases

DM.e. Deliberation or evaluation of decision

Action Execution

Action Execution cognitive activities

- Execution of a cognitively simple action
- Execution of a cognitively complex action
- Long-lasting action
- Control action
- Fine motor action
- Physically strenuous action

Action Execution processors

E1. Assess action plan and criteria

E2. Develop or modify action scripts

E3. Prepare or adapt infrastructure for action implementation

E4. Implement action scripts

E5. Verify and adjust execution outcomes

Action Execution cognitive mechanisms

E.a. Physical movement and motor skills

E.b. Mental model of the actions and the systems to be acted on

E.c. Working memory

E.d. Attention

E.e. Vigilance

E.f. Sensory feedback of motor movement

E.g. Automaticity

E.h. Action programming

E.i. Executive control

E.j. Error monitoring and correction

E.k. Initiation of action execution

E.l. Spatial precision or accuracy of action execution

E.m. Timing precision of action execution

E.n. Coordinate motor movement of action execution personnel

Teamwork

Teamwork activities

- Communication
- Cooperation
- Coordination

Teamwork processors

T1. Establish or adapt teamwork infrastructure

T2. Manage information

T3. Maintain shared situational awareness

T4. Manage resources

T5. Plan interteam collaborative activities

T6. Implement decisions and commands

T7. Verify, modify, and control the implementation

Teamwork cognitive mechanisms

T.a. Teamwork infrastructure

T.b. Command

T.c. Control

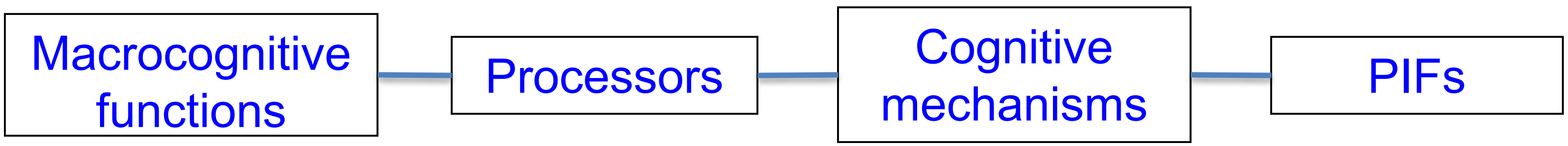
T.d. Line of communication

T.e. Data processing and information management

T.f. Shared mental model

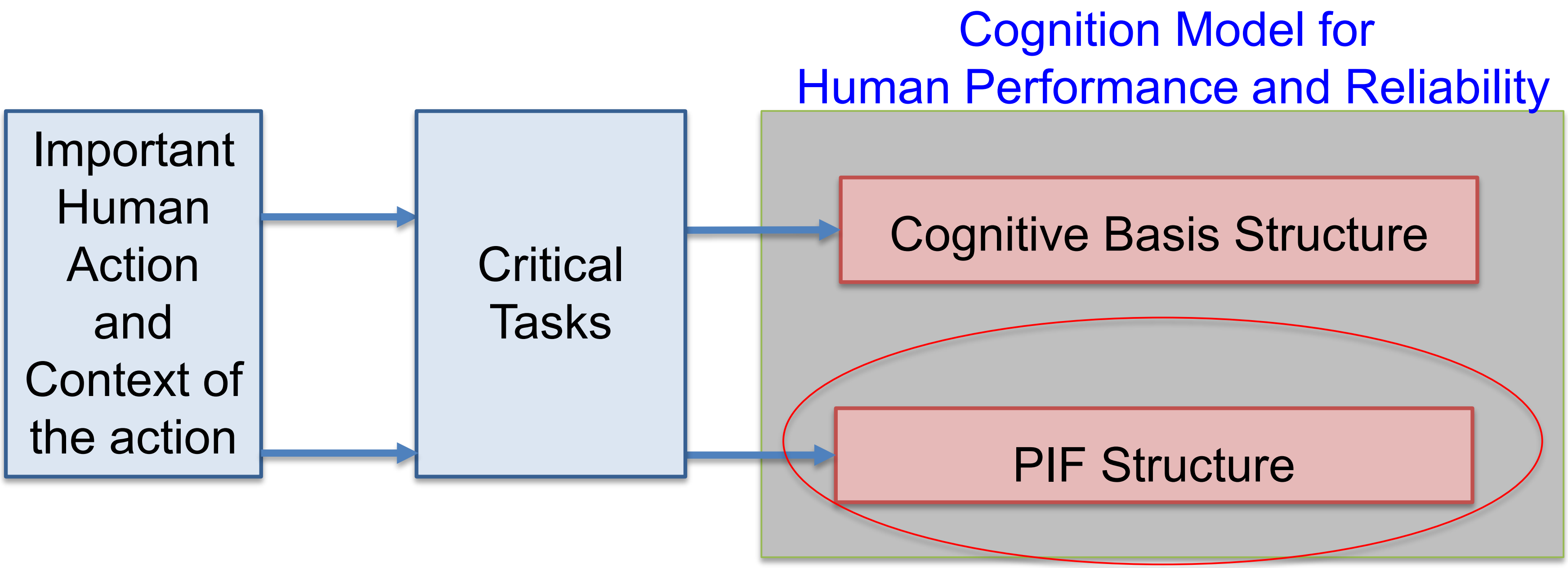
[Return to Cognitive Basis Structure](#) [Go to teamwork CFMs](#)

Cognitive Basis Structure—Failure of Human Actions



- Failure of any macrocognitive function leads to the failure of the task and the human action.
- Failure of a macrocognitive function results from errors of one or more processors.
- Errors of a processor may occur if one or more associated cognitive mechanisms do not work properly or reliably.
- PIFs affect the capacity limits of the cognitive mechanisms.

PIF Structure—Introduction



- Context are the conditions that affect human performance of an action.
- PIFs are used to model the context.

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PIF Structure—Introduction (continued)

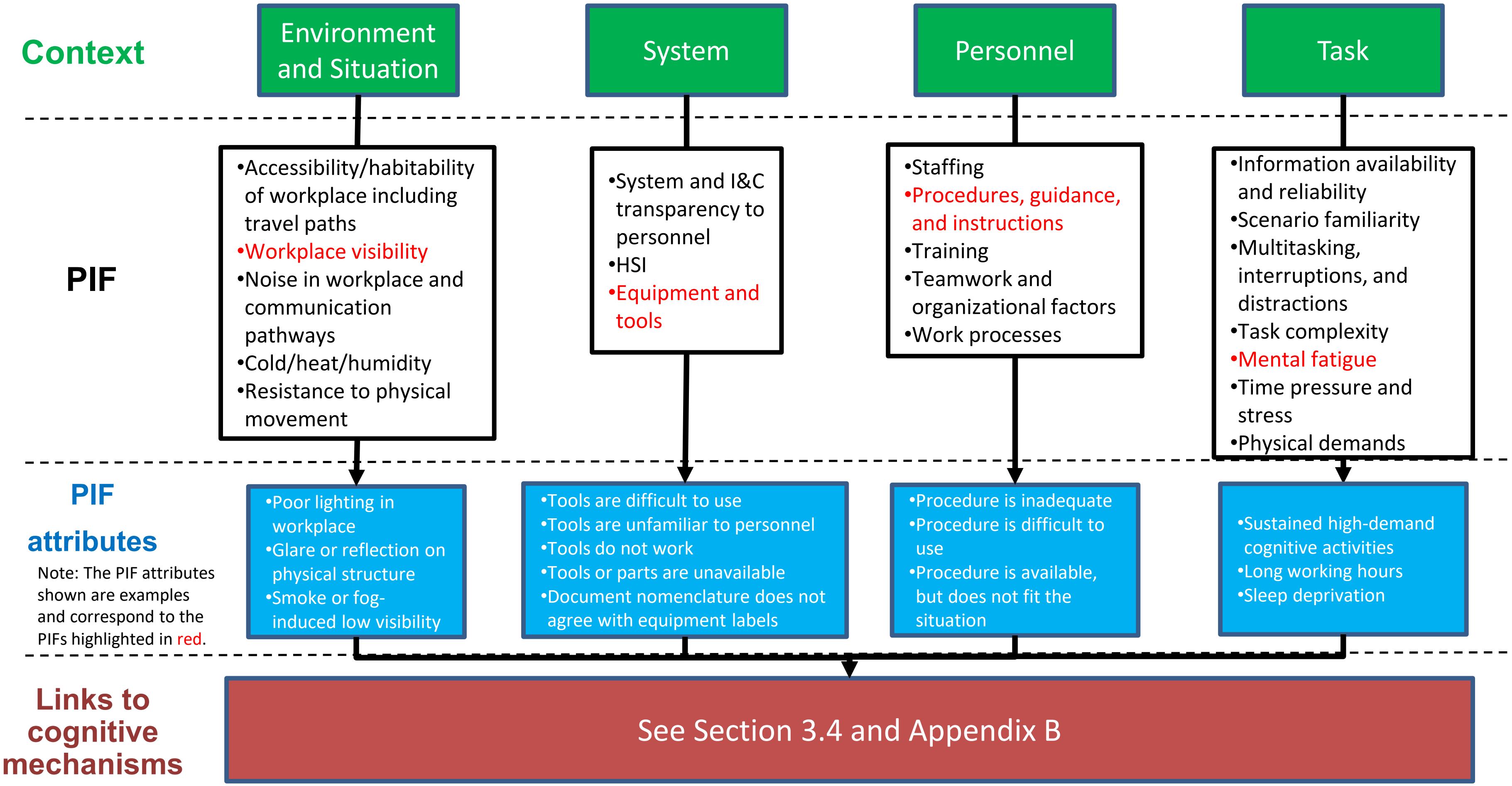
- The NRC staff established the following criteria to develop the PIF structure:
  - Pertinence and comprehensiveness
  - Independence
  - Specificity
  - Explainable
  - Assessable
  - Quantifiable

PIF Structure—Introduction (continued)

- Starting point for PIF structure development:
  - All PIFs in existing HRA methods
  - Also, considered the ASME/ANS PRA standard

- Developed new PIFs to address criteria discussed in previous slide

PIF Structure



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PIF Structure
Environment and Situation Context

- Consists of the conditions in personnel's work environment and the situation in which actions are performed.
- PIFs
  - Accessibility/habitability of workplace including travel paths
  - Workplace visibility
  - Noise in workplace and communication pathways
  - Cold/heat/humidity
  - Resistance to physical movement

PIF Structure
Systems Context

- Systems are the objects of the actions, through which the work missions are achieved.
- PIFs
  - System and I&C transparency to personnel
  - Human-system interface
  - Equipment and tools

PIF Structure
Personnel Context

- Personnel are the people who perform the action and include individuals, teams, and organizations.
- PIFs
  - Staffing
  - Procedures, guidance, and instructions
  - Training
  - Teamwork and organizational factors
  - Work processes

PIF Structure
Task Context

- An action may consist of one or more discrete tasks.
- PIFs
  - Information availability and reliability
  - Scenario familiarity
  - Multitasking, interruptions, and distractions
  - Task complexity
  - Mental fatigue
  - Time pressure and stress
  - Physical demands

Example PIF - Human-System Interface

- Definition: HSI refers to indications (e.g., displays, indicators, labels) and controls used by personnel to execute actions on systems.

- Attributes: HSI attributes depend on the specific interfaces used in an application. New HSI technologies may introduce additional attributes.
  - The source of indication (e.g., indicators, labels) is similar to other sources nearby.
  - The indications have low salience.
  - Indications are confusing or nonintuitive.
  - Controls are difficult to maneuver.
  - Labels on the controls do not agree with document nomenclature.
  - Controls are not reliable, and personnel are unaware of the problem.

Return to System PIFs

PIF Attributes

- PIF attributes are assessable traits of the PIFs
  - They describe ways that the PIF challenges the cognitive mechanisms and increase the likelihood of human error.
- They were identified from cognitive and behavioral studies, as well as human error data from various sources.
  - Attributes have the capability to link to existing human error data for HEP quantification.
  - Using attributes to specify a PIF allows HRA analysts to examine, if not completely eliminate, the interdependency between PIFs.
- The list of PIF attributes is considered a living document
  - New technologies and changes in conduct of operations can introduce new PIF attributes (e.g., use of computerized procedures)

PIF Effects on HEPs

- The quantitative relationship between PIFs and HEPs has been ambiguous.
- IDHEAS-G needs data to explain the following:
  - Assessment of PIF attributes
  - Quantification of the change in HEP when the PIF attribute changes
  - Combination of multiple PIFs on the HEP
- Metadata analysis* was performed to gain insights into these three aspects.

* A metadata analysis combines data from multiple studies to arrive at a conclusion or obtain insights into the answer of an inquiry.

PIF Effects on HEPs (continued)

- Assessment of PIF attributes
  - Some HRA methods use discrete levels (e.g., low, medium, high) to model the state of a PIF
    - Assessing, for example, *task complexity* as low, medium, or high does not link its impact on HEPs
  - Cognitive studies assess specific PIF attributes
  - Quantification of HEP should be based on PIF attributes and how they change from a baseline where there is no impact on the HEP

PIF Effects on HEPs (continued)

- Quantification of the change in HEP when the PIF attribute changes
  - Cognitive studies measure human error rates while systematically varying the attributes of one or more PIFs
    - Measurements: no impact or low impact versus high impact on the error rate
  - PIF weight factor:

$$w_i = \frac{ER_{PIF} - ER_{PIF_{Base}}}{ER_{PIF_{Base}}}$$

  - $ER_{PIF} \equiv$ error rate at a given PIF attribute
  - $ER_{PIF_{Base}} \equiv$ error rate when the PIF attribute has no or low impact

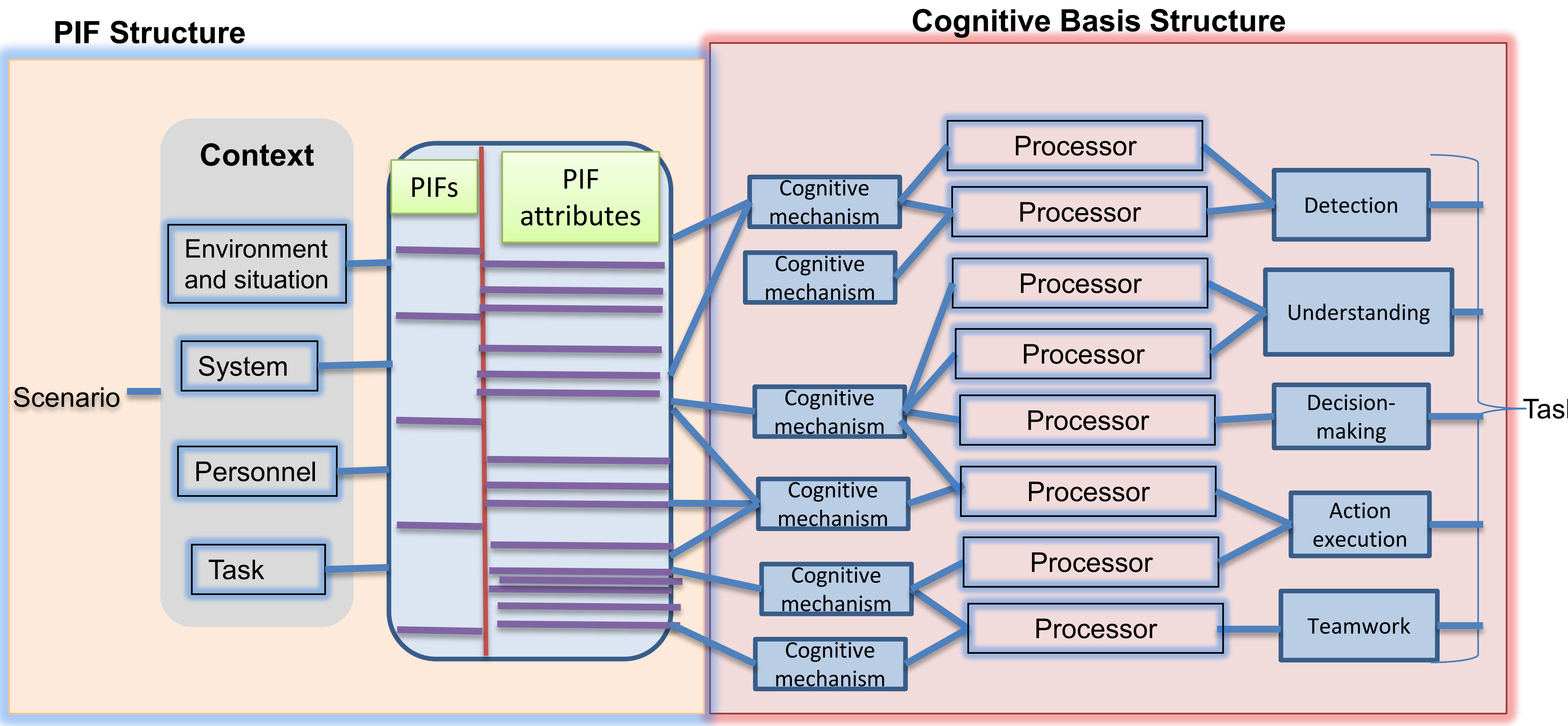
PIF Effects on HEPs (continued)

- Combination of multiple PIFs on the HEP
  - Holistic
  - Combination of individual effects
  - Using the PIF weight factor, the NRC staff observed that the effect of the combination of multiple PIFs can be roughly estimated by adding the effect of individual PIF weights.
  - Future research, including extensive metadata analysis, should be performed to establish the cognitive basis for combining the effects of multiple PIFs.

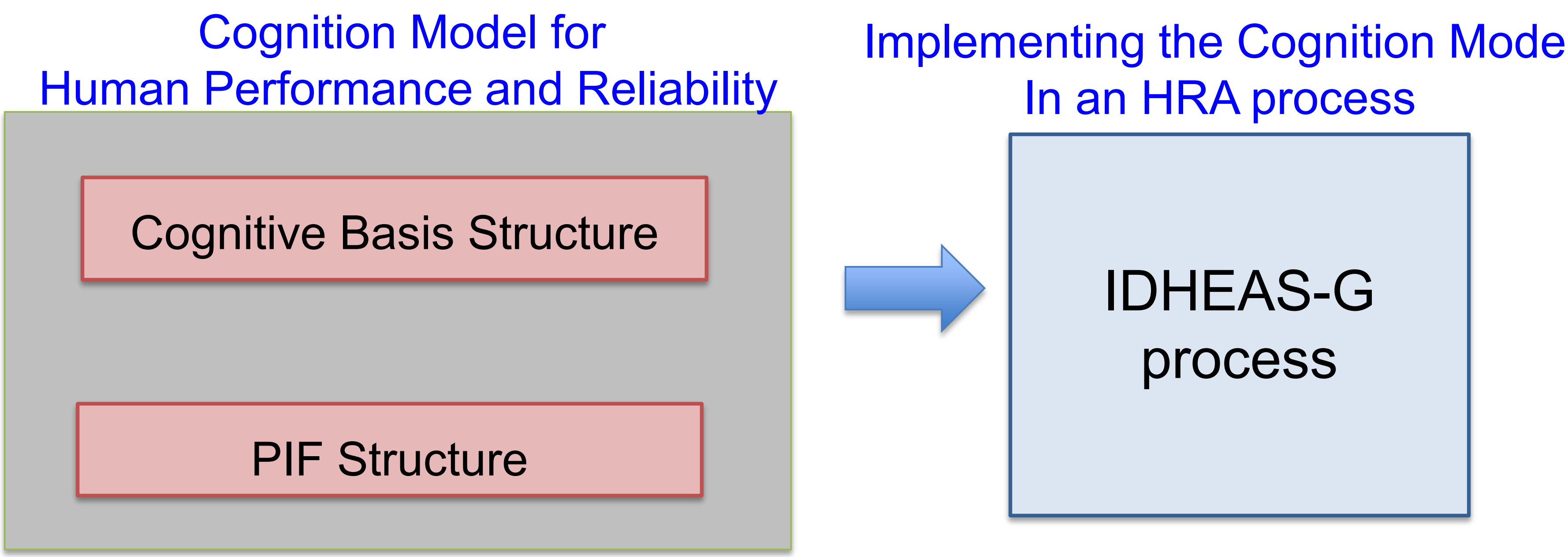
PIF Structure—Conclusion

- Covers all PIFs in the reviewed HRA methods and factors reported in the literature and nuclear-specific human event databases
  - Pertinence and comprehensiveness
- PIF context
  - Independence
- PIF attributes
  - Specificity, explainable, assessable, and quantifiable
- Sharing the PIF structure should increase the consistency of different HRA methods and allow comparison of the HRA quantification results from different methods.

Cognitive Basis Structure and PIF Structure



From the Cognition Model to HRA



AN INTEGRATED PROCESS FOR HRA WITH IDHEAS-G

Jonathan DeJesus, Reliability and Risk Analyst
Human Factors and Reliability Branch
Division of Risk Analysis
Office of Nuclear Regulatory Research

Note—The time uncertainty analysis is covered in this section as part of the IDHEAS-G HRA process.

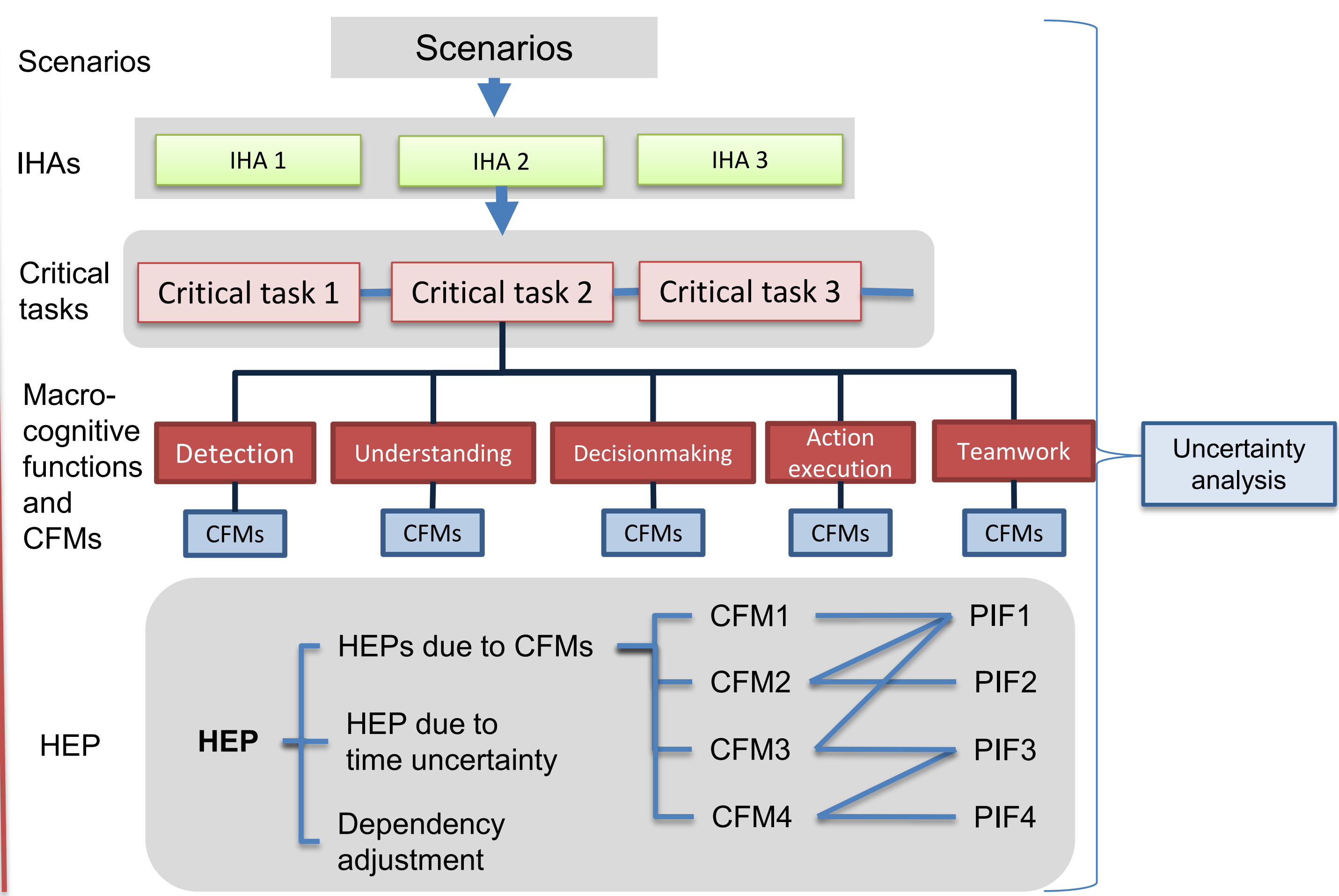
IDHEAS-G HRA Process

Stage 1: Scenario analysis
- Develop operational narrative
- Identify scenario context
- Identify important human actions

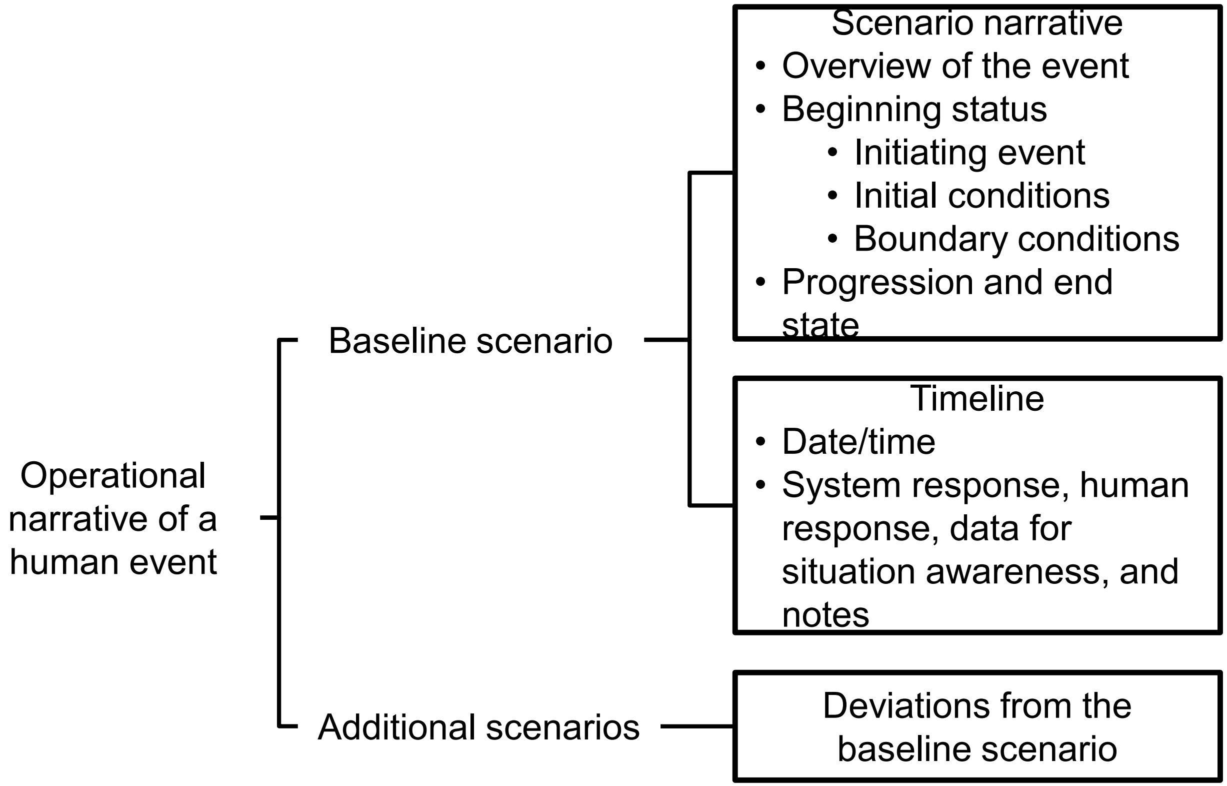
Stage 2: Modeling of important human actions
- Identify and analyze critical tasks
- Identify applicable CFMs
- Assess PIFs

Stage 3 – HEP quantification
- Estimation of P_t
- Estimation of P_c

Stage 4 – Integrative analysis
- Document uncertainties
- Assess dependencies



Stage 1
Develop Operational Narrative



Stage 1
Identify Scenario Context

- Search for the conditions that challenge or facilitate human performance in the scenario
- Context provides a basis for estimating HEPs and is represented by the PIF attributes
- Search process should focus on conditions that affect the macrocognitive functions
  - Environment and Situation
  - Systems
  - Personnel
  - Task

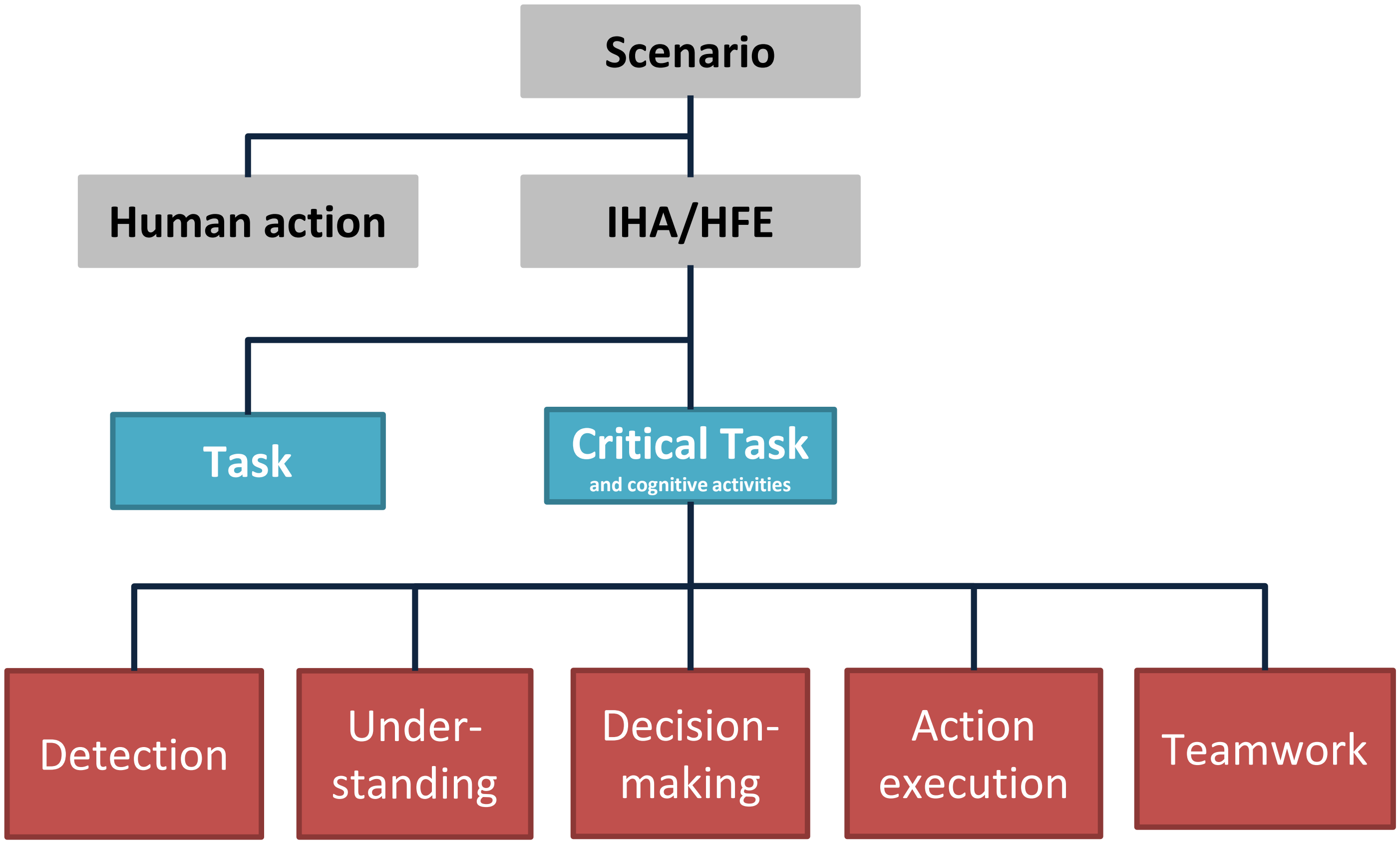
Stage 1
Identify Important Human Actions

- IHA (or HFE) is the unit of analysis of an HRA
- Identification
  - Actions required in the scenario progression to achieve the goal of the event (e.g., achieve safe and stable state)
  - Search in baseline and deviation scenarios
- Definition
  - Success criteria of the action
  - Consequence of the HFE
  - Cues and indications (including their timing)
  - Relevant procedure guidance
  - Time available

Stage 2
Identify and Analyze Critical Tasks

- Objective
  - Identify critical tasks
  - Characterize critical tasks
- Critical tasks
  - Essential to the success criteria of the IHA
  - Basic units of HEP quantification
- Failure of any critical task = Failure of the IHA

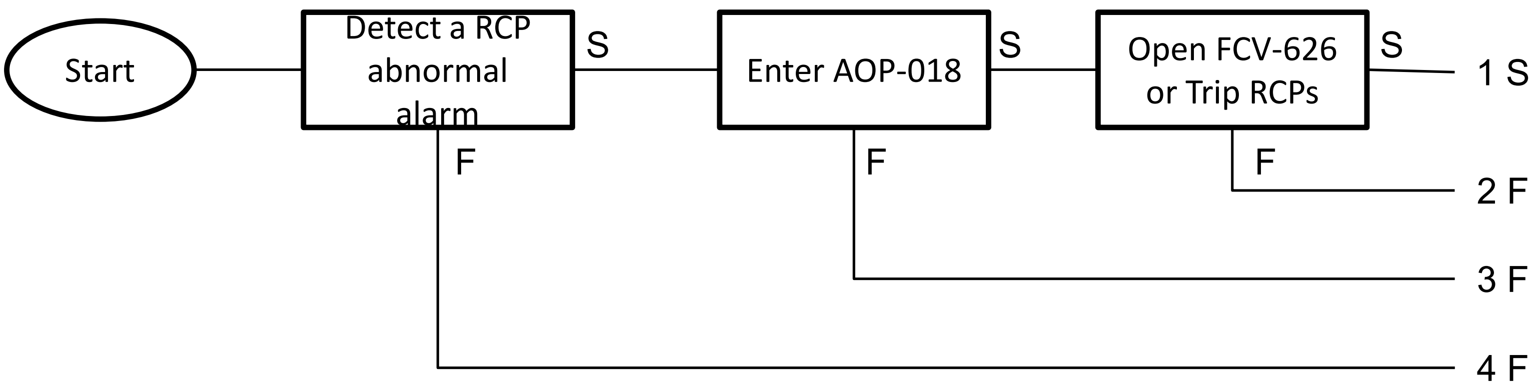
Stage 2
Identify and Analyze Critical Tasks (continued)



Stage 2

Identify and Analyze Critical Tasks (continued)

- Identification → Use task analysis
  - Task Diagrams
    - Help identify critical tasks and their relations, cues, and timing information
    - Show success path and the order of tasks



AOP = abnormal operating procedure
F = failure
FCV = flow control valve
RCP = reactor coolant pump
S = success

Stage 2
Identify and Analyze Critical Tasks (continued)

- Breaking down IHA (or HFE) into critical tasks
  - Use as few critical tasks as possible to represent the IHA
  - Further break down the IHA only when the PIF attributes vary for different portions of the IHA
  - An IHA should be broken down into critical tasks at a level that retains the context of the IHA and can be represented with macrocognitive functions
  - Stop breaking down at a level where there are performance indications or empirical data available to inform the HEP

Stage 2
Identify and Analyze Critical Tasks (continued)

- Characterization
  - Define scenario context and PIFs
  - Identify the cognitive activities involved in the critical task; use taxonomy of cognitive activities
  - Cognitive activities determine the macrocognitive functions and processors required for the critical task
  - Basis for identifying the CFMs applicable to the task

Stage 2
Identify and Analyze Critical Tasks (continued)

Task characteristics	Description
Task goal	The expected outcome of the task with respect to the success criteria of the action.
Specific requirements	Specifications on the task goal such as timing requirements, criteria of task outcomes, and how the task goal should be achieved (e.g., monitoring parameters at a certain time interval, using secondary cues when the primary cues are not available, cooling down the RCS within a certain rate).
Cues and supporting information	The cues to initiate the task and key information needed to perform the task. A cue could be an alarm, an indication, a procedure instruction, or others (e.g., an onsite report). The supporting information is in addition to the cue required to perform the task.
Procedures	Available procedures, guidance, or instructions designed for the task.
Personnel	Types of workers needed for the task, minimum staffing required, special skillset required.
Task support	Job aids, tools, and equipment needed.
Location	Places where the task is performed, special environmental factors about the locations.
Cognitive activities	Cognitive activities that are involved in the task and that place demands on their corresponding macrocognitive functions.
Concurrent tasks	Concurrent tasks (critical or noncritical) that compete for personnel's cognition and resources.
Teamwork considerations	Interteam collaborative activities required for the task and requirements for communication facilities (e.g., equipment, tools, devices).

Stage 2
Identify Applicable CFMs

- Criteria for CFMs in HRA
  - Completeness
  - Non-overlapping
  - Specificity and sensitivity
  - Observability
- Since IDHEAS-G is a general methodology, the CFMs in IDHEAS-G should be independent of HRA application.

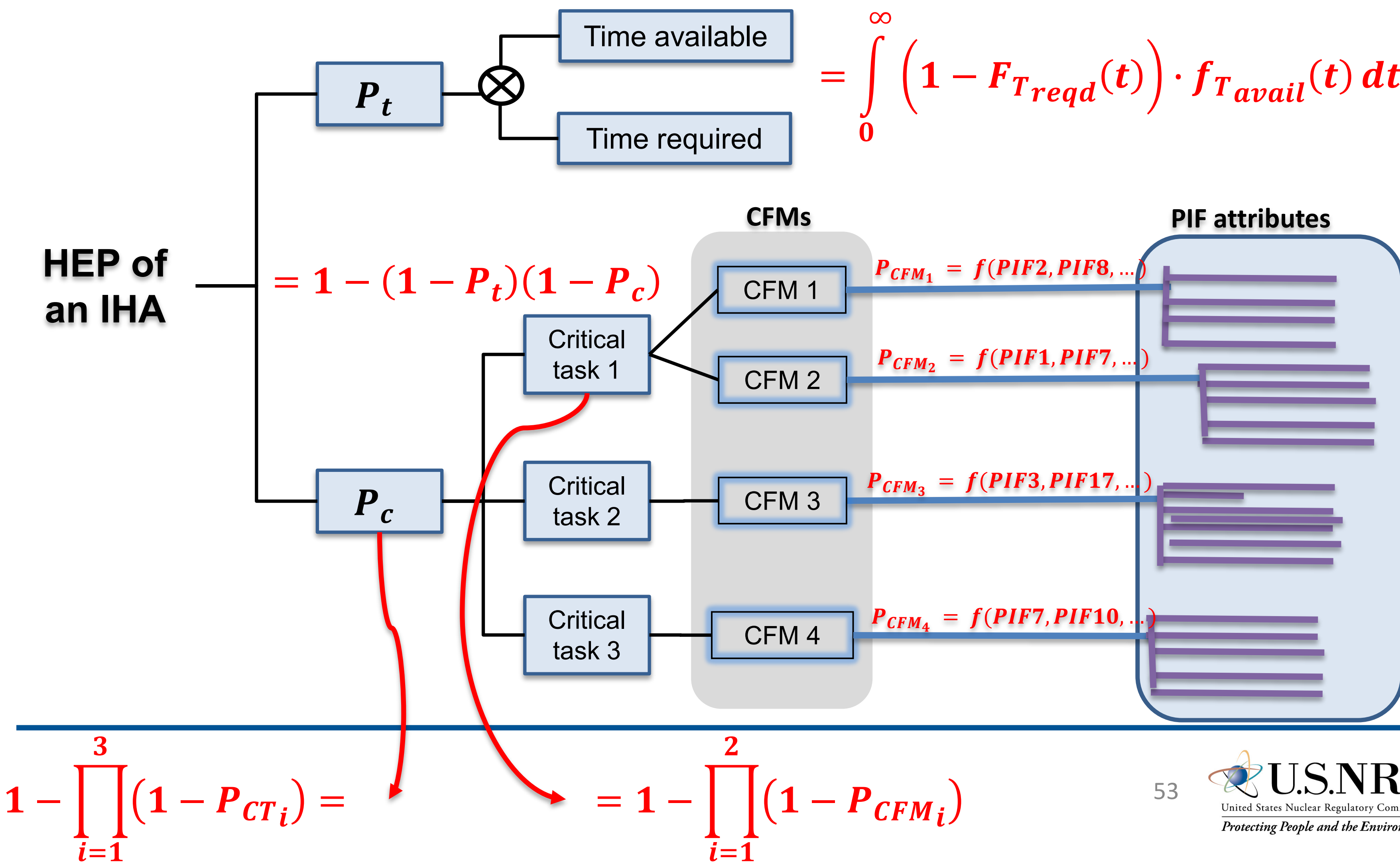
Stage 2
Identify Applicable CFMs (continued)

- Basic set of CFMs in IDHEAS-G
  - High-level CFMs → Failure of the macrocognitive functions
  - Middle-level CFMs → Failure of the processors of the macrocognitive functions
  - Detailed CFMs → Behaviorally observable failures of the processors
- NRC staff developed a reference set of detailed CFMs
  - Specific HRA applications may develop its own set of detailed CFMs from the middle-level CFMs or adapt the reference set

Stage 2
Assess PIFs

- PIFs have a baseline where there is no impact on error rates
- Determine the applicable PIF attribute based on the context identified in scenario analysis and task characterization.
- When the context
  - challenges task performance, it maps to applicable PIF attributes
  - facilitates task performance, it moves PIF to baseline

Stage 3
HEP Quantification—Overview

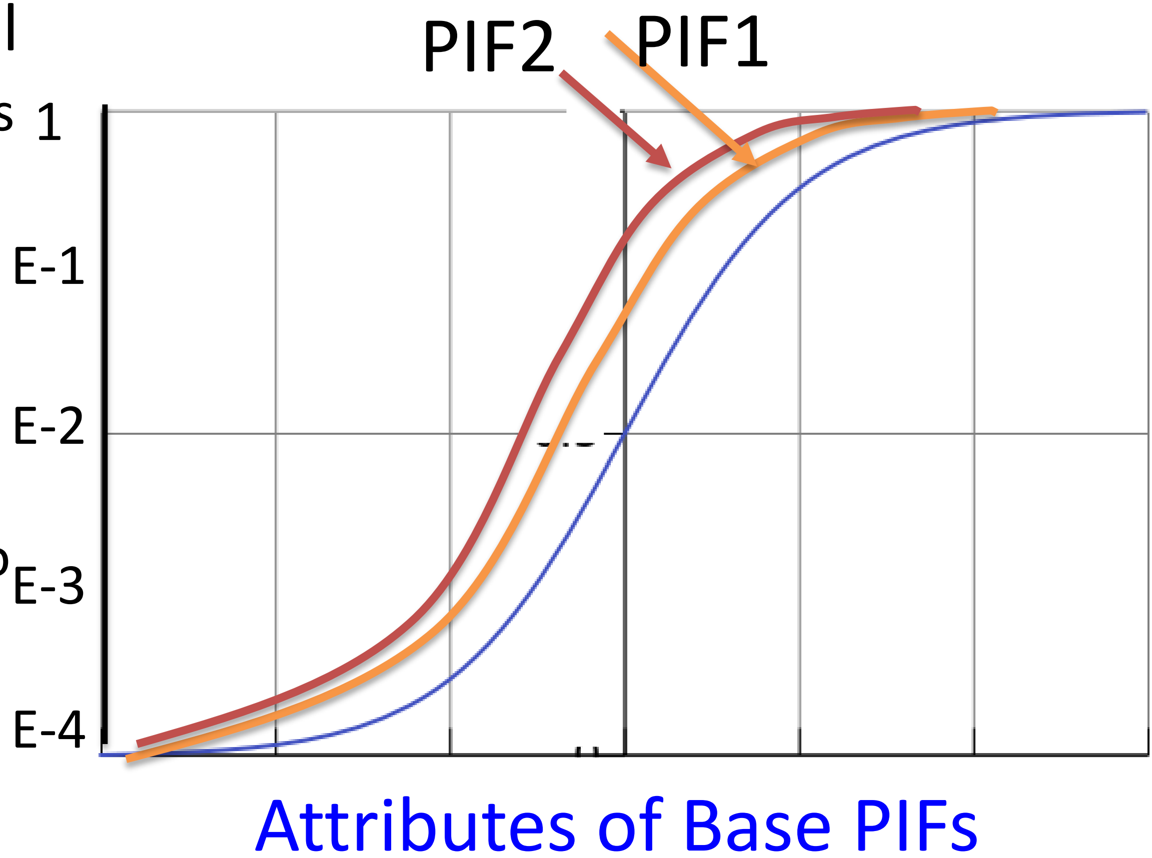


Stage 3
HEP Quantification—P_c

- Probability of CFM, P_{CFM}, can be estimated in one, or a combination, of the following three ways:
  - Data-based estimation
  - Expert judgment
  - HEP quantification model

Stage 3
HEP Quantification—P_c (continued)

- HEP quantification model
  1. Base PIFs and Base HEPs
- Base PIFs can change HEP from a minimum value to 1 (blue curve)
  - Information availability and reliability, task complexity, and scenario familiarity
- Modification PIFs
  - Remaining 17 PIFs (orange and red curves)



Stage 3
HEP Quantification—P_c (continued)

- HEP quantification model (continued)
  2. Linear combination of PIF effects

$$P_{CFM} = \underbrace{P_{CFM_{Base}}}_{\text{HEP from Base PIFs}} \cdot \underbrace{\left(1 + \sum_{i=1}^{n} w_i\right)}_{\text{PIF weight factors from Modification PIFs}} \cdot C \cdot \frac{1}{Re}$$

C: PIF interaction factor; set to 1 with linear combination

Re: Recovery factor; set to 1 unless data suggest otherwise

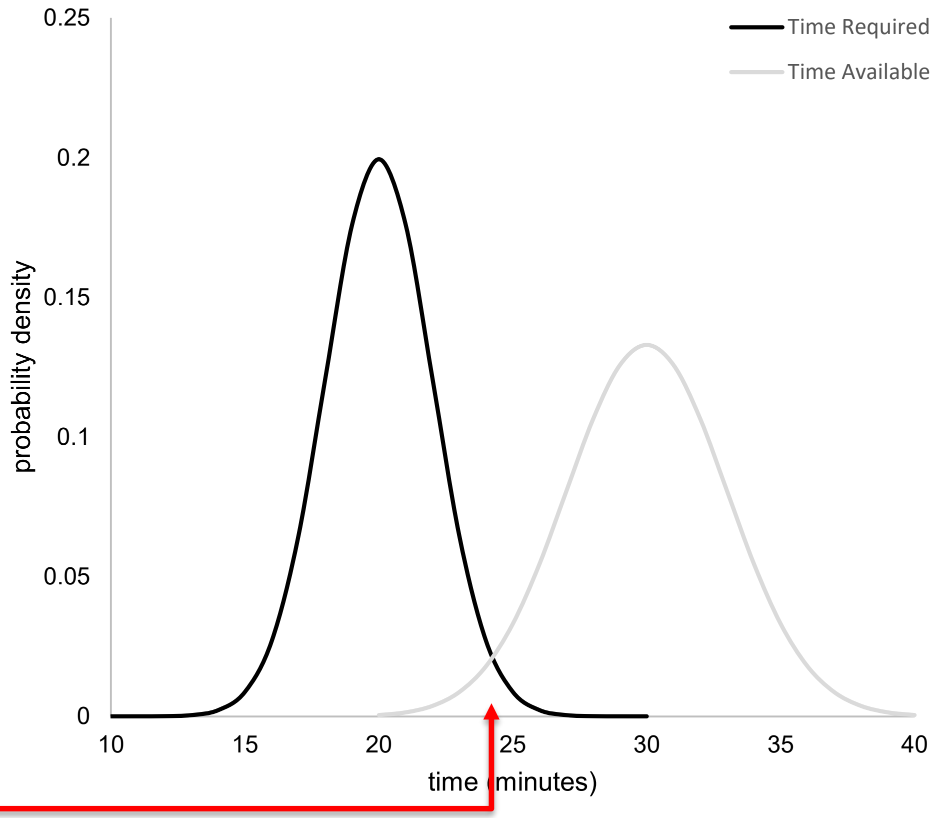
Recall $w_i = \frac{ER_{PIF} - ER_{PIF_{Base}}}{ER_{PIF_{Base}}}$

$ER_{PIF} \equiv$ error rate at a given PIF attribute

$ER_{PIF_{Base}} \equiv$ error rate when the PIF attribute has no or low impact

Stage 3
HEP Quantification—P_t

- In response to ACRS comments, time uncertainty model was developed
- Convolution of time available and time required distributions
- $P_t = P(T_{reqd} > T_{avail})$
- P_t is proportional to this area



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Stage 3
HEP Quantification—P_t (continued)

- Time available (T_{avail})
  - No credit for situations with excessive T_{avail}
    - Experimental studies (e.g., [1], [2]) show that it does not have an impact on human error rates in task performance
    - However, extra T_{avail} makes recovery possible, but does not guarantee it.
  - Factors affecting distribution of T_{avail}
    - Thermal-hydraulic calculations
      - System time window and time delay for the cue
    - Crew-to-crew variability in performing actions
      - May affect T_{avail} of subsequent actions in the scenario

[1] H. Topi, et al. "The effects of task complexity and time availability limitations on human performance in database query tasks," Int. J. Hum. Comput. Stud., Vol. 62, No. 3, pp. 349–379, March 2005.
[2] M. A. DeDonno, "Time Pressure and Decision Making," Ph.D. Dissertation, Case Western Reserve University, 2009.

Stage 3
HEP Quantification—P_t (continued)

- Time required (or needed) (T_{reqd})
  - Assumes action is performed at a normal work pace
  - Time pressure is accounted for in P_c
  - Factors affecting distribution of T_{reqd}
    - PIFs
    - Crew-to-crew variability

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Jing Xing, Senior Human Performance Engineer
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IDHEAS-G Applications

1. A general HRA method for human event analysis in all nuclear HRA applications

2. A platform for generalizing and integrating human error data to support HEP estimation

3. A methodology for developing application-specific HRA methods

1. IDHEAS-G as an HRA method for human event analysis in all nuclear HRA applications

Human event → IDHEAS-G process →

- Event context – conditions that challenge or facilitate human performance
- Important human actions and critical tasks – potential failures and consequences
- Relevant CFMs and PIFs – How an human action may fail and what contributes to failure

Piloting studies using IDHEAS-G for human event analysis:

- Fukushima Daiichi accident
- A set of seismic events
- Digital I&C events
- Halden simulator experiments

2. IDHEAS-G as a platform to generalize and integrate human error data

$$HEP(failure\ mode\ under\ specific\ context) = \frac{\#\ of\ errors\ (failure\ mode)}{\#\ of\ occurrences\ (under\ the\ same\ context)}$$

- Ideal world:

- The same task for a failure mode is repeated thousands of times with the same people under the same context;
- Do this for all possible contexts

Failure modes	# Occurrence	Context	Variety
✓ Well-defined failure modes	✓ Known, sufficient number of task occurrences	✓ Context clearly defined and repeated	✓ Sufficient data for all failure modes and contexts

Human error data: The real world

$$HEP(failure\ mode\ under\ specific\ context) = \frac{\#\ of\ errors\ (failure\ mode)}{\#\ of\ occurrences\ (under\ the\ same\ context)}$$

- Reality:

Good news – There is human error data in human error analysis, operational databases, cognitive and human factors experiments.

Not so good news

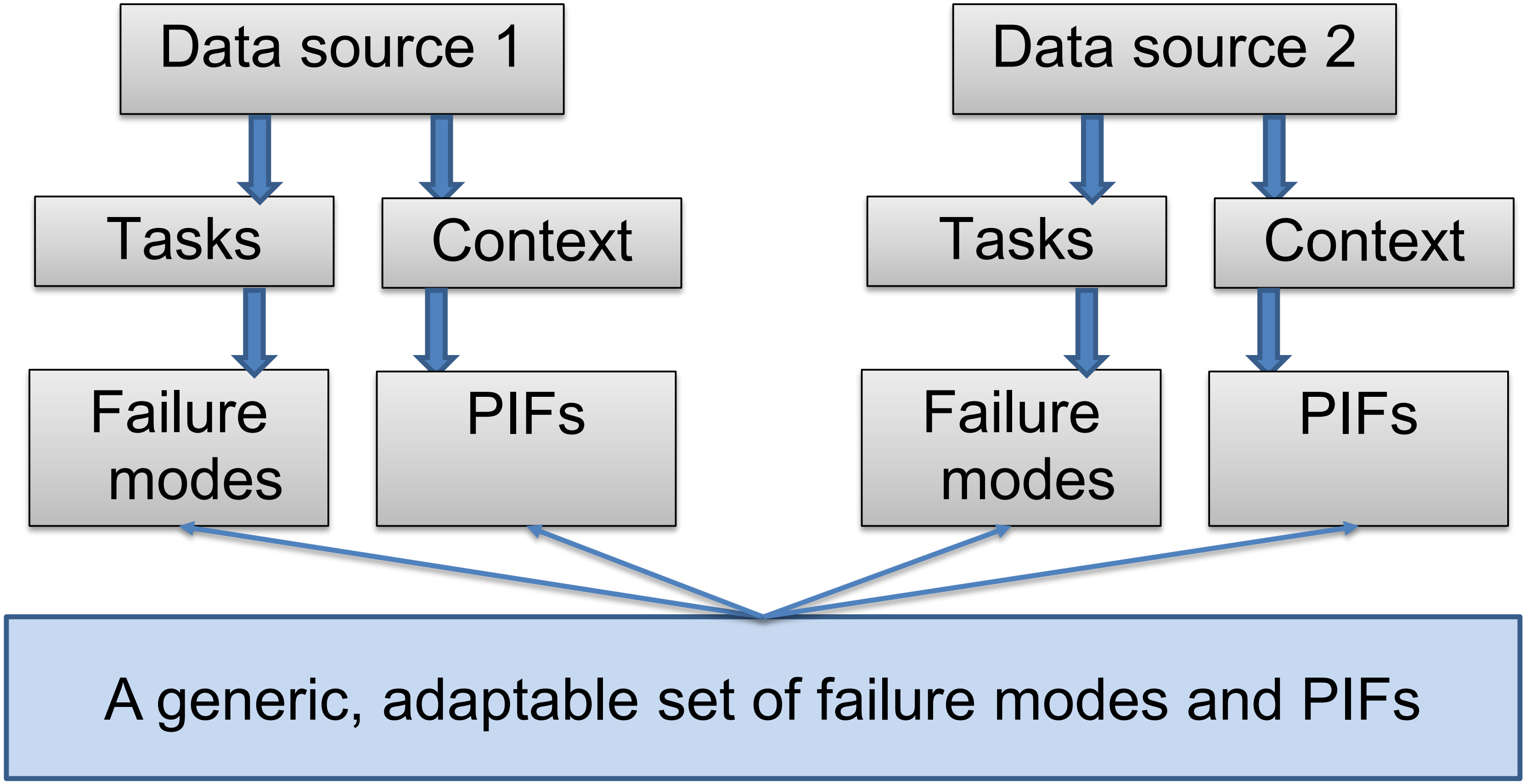
X Failure modes not analyzed nor in great variety

X Context undocumented and/or unrepeated

X Limited coverage – limited failure modes / context tested

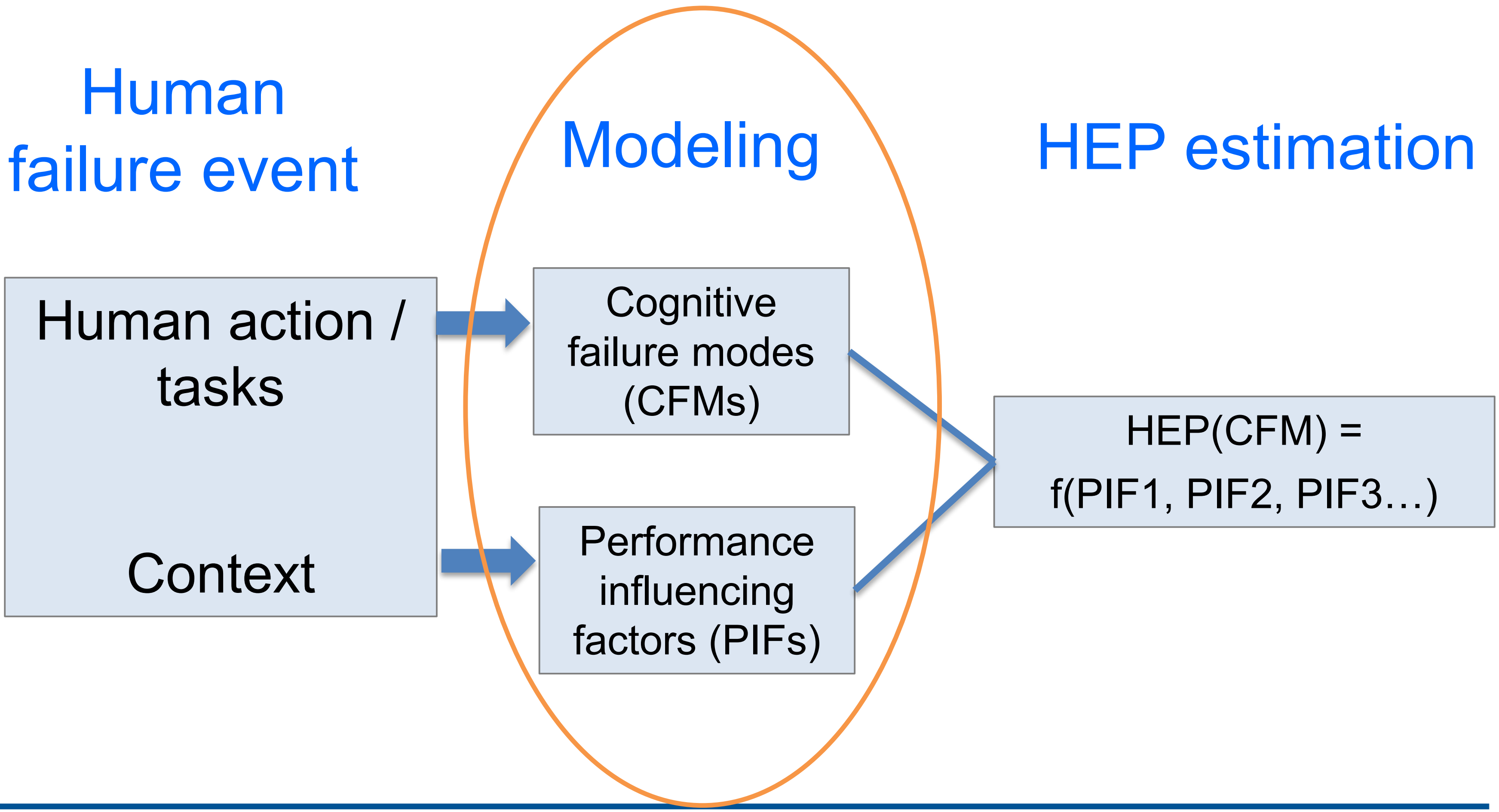
X Not talking to each other

Generalizing human error data to inform HEP estimation



IDHEAS-G

Modeling human errors and estimating HEPs



Generalizing Human Error Data with IDHEAS-G CFMs and PIFs

1. Evaluate data source

2. Interpret and represent data

3. Consolidate data into IDHEAS-G Human Error Data Tables

Human action / tasks

Context

Cognitive failure modes (CFMs)

Performance influencing factors (PIFs)

HEP Table – *Error rates*

PIF Weight Table - w_i

PIF Interaction Table - *C*

IDHEAS-G HEP Tables

- The HEP Table consolidates data of human error rates and HEPs for every cognitive failure modes.
- Cognitive activities involved in the tasks of a data source are mapped to corresponding IDHEAS-G CFMs of different levels.
- Human error rates or HEPs for the CFMs are documented along with their associated PIF.

The HEP Table documents the following dimensions of information for every data point:

- CFMs
- Human error rate or HEP
- PIF attributes applicable to the data point
- Time information, (with or without time-constraint, adequate/inadequate time).
- Brief narrative of the task or types of human failure in the data source
- Uncertainties in the data source and interpretation

Example 1: Human error rates in a flight simulator study

The effect of incomplete information on decision-making in simulated pilot de-icing

Task: Make decision on de-icing in flight simulation under icing weather

Context: Pilots were provided with incomplete or inaccurate information for handling icing encounters; They performed time-critical decisionmaking.

Failure mode: Failure of decisionmaking.

PIFs: Incomplete or unreliable information (30%), time pressure

% error	Accurate and complete information	Accurate and incomplete information	Inaccurate and complete information
% Stall	18.1	30	89
% recovery	26.7	63.8	75

- **ER_{DM}** (adequate information + inadequate time) = 0.18
- **ER_{DM}** (inadequate information + inadequate time) = 0.3
- **ER_{DM}** (inadequate info + unreliable info + inadeq. Time) = 0.89

IDHEAS-G PIF Impact Table

- The PIF Impact Table has many sub-tables, one for each PIF.
- The PIF Impact Table documents the data points of which the human error rates or HEPs of a task are measured for two or more PIF states, typically a base or low-impact state and a poor PIF state with one or more attributes.
- The weight of a PIF between a poor and base state can be calculated.

A PIF sub-table contains the following dimensions of information:

- The context or PIF description in the original data
- Relevant PIF attributes
- Error rates or HEPs
- PIF weight, calculated as the error rate for an attribute divided by the error rate at the base or low-impact PIF state.
- CFMs associated with the data point
- Uncertainties in the data and mapping to PIF attributes

Example 2: The effect of long working hours (mental fatigue)

Reference: Effects of sleep loss on team situation assessment (J. V. Baranski, et al. 2007)

Task: Team makes judgment of threat on a military surveillance task (situation assessment)

CFMs: Failure of *Understanding* - Incorrect situation assessment

PIF attributes: Long working-hour; no feedback information, no supervision / peer-checking

Results: Sleep loss affects assessment accuracy and time needed.

Data: Assessment error rate (%)

	No sleep loss	Sleep loss
Full feedback	4.2	5.5
No feedback	4.5	6
Solo	6	8
Team	4.5	5.5

Generalized PIF weights:

- **W** (mental fatigue) = (5.5-4.2)/4.2=0.31
- **W** (no supervision / peer-checking) = (6-4.5)/4.5= 0.33
- **W** (no feedback) = (4.5-4.2)/4.2= 0.07

IDHEAS-G PIF Interaction Table

- The PIF Interaction Table documents data points in which there are human error rates measured as two or more PIFs vary independently and jointly.
- A data point in the table consists of human error rates in a 2x2 or larger matrix for individual or combined PIFs.
- The combined effect of multiple PIFs can be inferred from the data point.

PIF 1 / PIF2	Low impact	High impact	PIF weight
Low impact	R11	R12	W1 =R12/R11
High impact	R21	R22	
PIF weight	W2 =R21/R11		W3 =R22/R11

No interaction (linear sum): W3=W1 + W2
Multiplicative interaction: W3=W1 x W2

Example: PIF Impact Table on Multitasking/Interruption/Distraction

IDHEAS-G PIF attribute	Tasks and macro-functions	Context in the original data	Error Rate (% of incorrect)	PIF weight
Multitasking – intermingled	D – missing cue	Single vs. dual task	2.8% vs 21%	**7.5**
	D - missing changes	Single vs. dual task	5% vs 20%	**4**
	U – Wrong diagnosis	Single vs. dual task	1% vs 37%	**37**
Excessively frequent or long interruption	E- sequence task	0, 3s, 30s	2%, 4%, 16%	**2, 8**
	E – nonsequence task	0, 3s, 30s	2%, 2%, 2%	**1**
Interruption by same task modality		No interruption vs interruption	4% vs. 8%	**2**
Interruption by different task modality	D	No interruption vs weak interruption	4% vs. 4%	**1**
Distraction – irrelevant to the task	D – Monitoring target	Without vs with distraction	2.5% vs. 7%	**2.8**

SACADA (Scenario Authoring, Characterization, and Debriefing Application)

The NRC's tool to collect operator performance data in simulator training to estimate the HEPs

- A software
  - Standalone (not connected to the simulator or other systems)
  - With an user interface and database
    - Simulator data are entered before and after simulator training
    - All data/information are entered by plant staff
- A tool for operator training, e.g.,
  - Expedite communication of crew performance in training
  - Reports: identify training focuses, trending crew or individual performance
- A database for HRA
  - Plants: plant-specific data
  - NRC: generic data (integration of plant-specific data)

SACADA Software Main Functions

- SACADA-1
  - Design simulation scenarios (Authoring)
  - Characterize performance challenges (Characterization)
  - Debrief performance results (Debriefing)
  - Output data (Reporting)
- SACADA-2
  - SACADA-1
  - Job Performance Measures (JPM)
  - Written exams
  - Crew notebook features
  - Simulator Guide Preparation

An Example of SACADA Data on PIFs (total 7042 Data Points)

PIF	Status 1	Status 2	Status 3	Status 4	Data Points
Cognitive Type	Response Planning (R.P.)				1990
R.P. Basis	Skill	Procedure	Knowledge		1282
R.P. Familiarity	Standard	Adaptation Required	Anomaly		959
R.P. Uncertainty	Clear	Uncertain	Competing Priority	Conflicting Guidance	861
Workload	Normal	Concurrent demand	Multiple concurrent demand		523
Time Criticality	Expensive	Normal	Barely adequate		408
Communication Required	Normal	Extensive Within MCR	Extensive Onsite		226
Miscellaneous	Non-Standard	Noisy Background	Coordination	Communicator Unavailable	201
	Memory Demand				

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	Memory Demand				

Mapping SACADA Taxonomy to IDHEAS-G

- IDHEAS-G and SACADA taxonomies share the same cognitive framework so their elements can be mapped to each other (not necessarily a one-to-one mapping).

  – The error mode statistics of SACADA is generalized to IDHEAS-G HEP Tables; data gathering SACADA context factors is generalized into the PIF Impact Table and PIF Interaction Table.

- The scopes of the functions in SACADA-1 are specifically for NPP control room actions performed by licensed crews, so SACADA error modes and context factors are mapped to only a subset of IDHEAS-G CFMs and PIF attributes. SACADA-2 will provide data in the broader scope.

Summary of IDHEAS-G for Generalizing Human Error Data

- Human error data of various sources are generalized into three IDHEAS-G Human Error Data Tables: HEP Table, PIF Impact Table, and PIF Interaction Table

- SACADA data can be generalized into IDHEAS-G Human Error Data Tables.

- The generalized human error data can be integrated to inform HEP estimation.

- Data generalization is an on-going, continuous effort; Data integration should be periodically updated.

IDHEAS-G Applications

1. A general HRA method for human event analysis in all nuclear HRA applications

2. A platform for generalizing and integrating human error data to support HEP estimation

3. A methodology for developing application-specific HRA methods

IDHEAS-G as a Methodology for Developing Application-Specific HRA Methods

- IDHEAS-G has comprehensive sets of CFMs and PIFs, using all of those for HRA is time-consuming
- Human error data is limited for getting all the base HEPs and weights of PIF attributes in IDHEAS-G
- Different HEP models may be adapted for specific HRA applications

IDHEAS-G vs. application-specific method

IDHEAS-G	Application-specific method
Applicable to all nuclear applications	Specific for the application
Comprehensive but low usability	Concise and easy to use
Referencing the Human Error Data Tables	Calculating HEPs of human actions

Approach to Develop Application-Specific IDHEAS Methods

- Define the scope of application, requirements, and available sources for the intended use
- Keep the qualitative analysis the same as that in IDHEAS-G
- Develop application-specific sets of CFMs and PIFs and HEP models

IDHEAS-G	Application-specific method
Scenario analysis	• Same guidance as in IDHEAS-G • Specifications on guiding questions
Human action and Task analysis	• Same guidance as in IDHEAS-G • Specifications on developing task diagrams
Failure analysis • A basic set of CFMs • The comprehensive PIF / attribute list • Guidance on estimating HEPs • Time uncertainty analysis	Failure analysis • A subset of CFMs • A subset or an adapted set of PIFs / attributes • Base HEPs and PIF weights for calculating HEPs • Time uncertainty analysis – same

IDHEAS-ECA

Define IDHEAS-ECA by NRR users:

- Scope: Perform ECA for all nuclear HRA applications; specifically, be applicable for FLEX HRA
- Requirements: Easy to use, not over-burden HRA analysts
- Resources: IDHEAS-G HEP Tables, NRC 2018 FLEX-HRA Expert Elicitation

DELTA between IDHEAS-G and IDHEAS-ECA – modeling failures and calculating HEPs

IDHEAS-G	IDHEAS-ECA
A basic set of CFMs in three levels of details	Five high-level CFMs (failure of D, U, DM, E, and T)
20 PIFs and their attributes	• All 20 PIFs preserved • A compressed set of PIF attributes based on human error data available (combining attributes with similar effects)
IDHEAS-G Human Error Data Tables	Base HEPs and PIF weights integrated from IDHEAS-G Human Error Data Tables, allowing HEP calculation for given failure modes and PIF attributes

HEP Quantification in IDHEAS-ECA—P_c

- HEP quantification model

$$P_{CFM} = \underbrace{P_{CFM_{Base}}}_{\text{Base HEPs}} \cdot \underbrace{\left(1 + \sum_{i=1}^{n} w_i\right)}_{\text{PIF weight factors from Modification PIFs}} \cdot C \cdot \frac{1}{Re}$$

Base HEPs

PIF weight factors from Modification PIFs

Recovery factor; set to 1 unless data suggest otherwise

PIF interaction factor; set to 1 with linear combination

Recall $w_i = \frac{ER_{PIF} - ER_{PIF_{Base}}}{ER_{PIF_{Base}}}$

$ER_{PIF} \equiv$ error rate at a given PIF attribute

$ER_{PIF_{Base}} \equiv$ error rate when the PIF attribute has no or low impact

Integrated Base HEP Values and PIF Weights for IDHEAS-ECA

Example: Base HEPs for *Information availability and reliability*

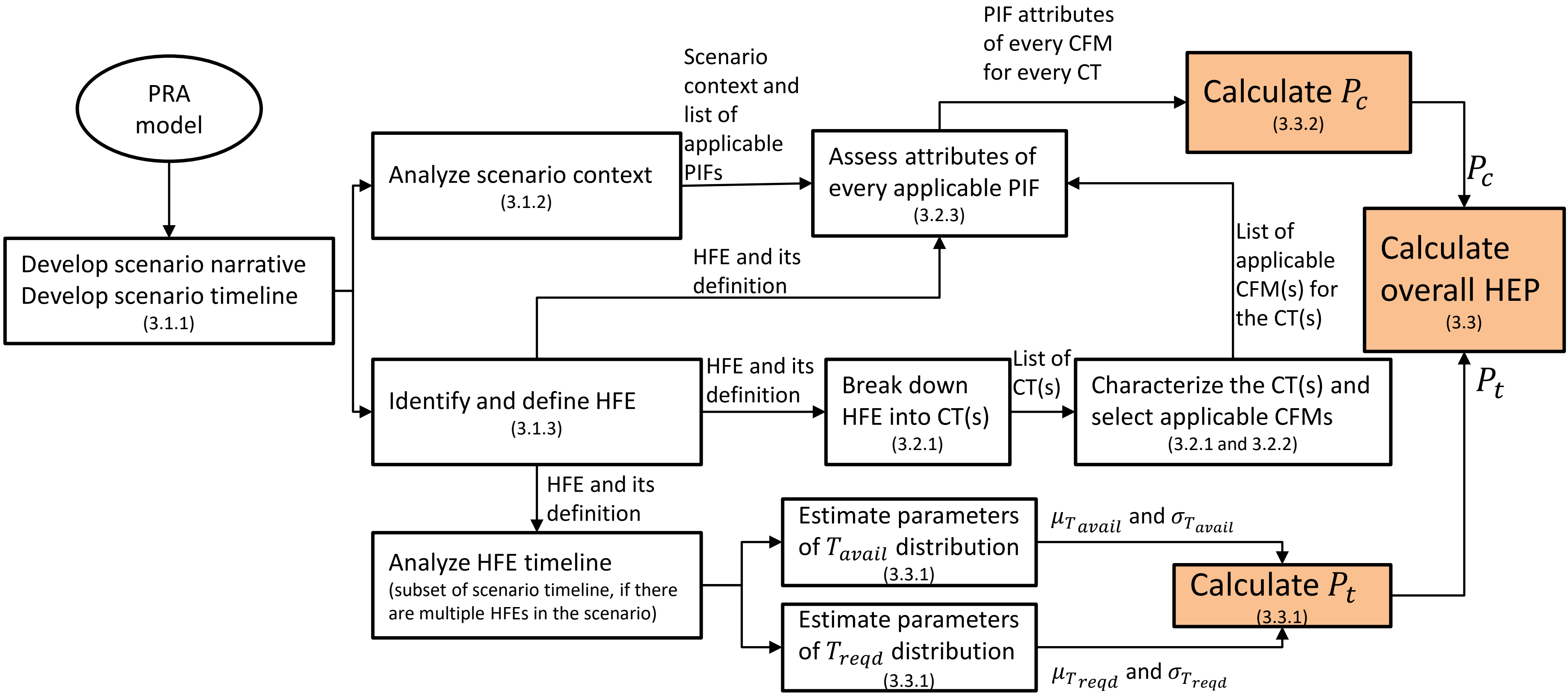
PIF Attribute		D	U	DM	E	T
Inf1	Information is temporarily incomplete or not readily available	NA	5E-3	5E-3	NA	NA
	Information is moderately incomplete – a small portion of key information is missing	NA	5E-2	5E-2	NA	NA
	Information is largely incomplete - Key information is masked or indications are missing	NA	2E-1	2E-1	NA	NA
Inf2	Unreliable or uncertain - Personnel is aware that source of information could be temporally unreliable - pieces of Information change over time thus they become uncertain by the time personnel use them	NA	E-2	E-2	NA	NA
	Moderately unreliable or uncertain - Personnel recognize information unreliable - Conflicts in key information	NA	5E-2	5E-2	NA	NA
	Key information is highly uncertain	NA	E-1	E-1	NA	NA
	Extremely unreliable - Key information is misleading	NA	E-3	E-3	NA	NA

Integrated Base HEP Values and PIF Weights for IDHEAS-ECA

Example: Generalized PIF Weights for Multitasking/Interruption/Distraction

PIF Attribute		D	U	DM	E	T
MT0	No impact	1	1	1	1	1
MT1	Distraction by other on-going activities that demand attention	1.2 – 2.8	1.1	1.1	1.2 – 2.8	1.2 – 2.8
MT2	interruption taking away from the main task	1.1 - 4	1.1 – 1.7	1.1 – 1.7	1.1 - 4	1.1 - 4
MT3	Concurrent visual detection and other tasks	2 - 10	NA	NA	NA	NA
MT4	Concurrent auditory detection and other tasks	10 -20	NA	NA	NA	NA
MT5	Concurrent diagnosis and other tasks	NA	3-30	NA	NA	NA
MT6	Concurrent Go/No-go decision-making	NA	NA	2	NA	NA
MT7	Concurrently making Intermingled, complex decisions / plans	NA	NA	5	NA	NA
MT8	Concurrently executing action sequence and performing another attention/working memory task	NA	NA	NA	2.3	NA
MT9	Concurrently executing intermingled or inter-dependent action plans	NA	NA	NA	5	NA
MT10	Concurrently communicating or coordinating multiple distributed individuals or teams	NA	NA	NA	NA	5

IDHEAS-ECA Process—same as IDHEAS-G



$\mu_{T_{avail}}$ and $\sigma_{T_{avail}}$ = mean and standard deviation of T_{avail} $\mu_{T_{reqd}}$ and $\sigma_{T_{reqd}}$ = mean and standard deviation of T_{reqd}

CFM = cognitive failure mode
CT = critical task
HEP = human error probability
HFE = human failure event

PIF = performance-influencing factor
PRA = probabilistic risk assessment
P_c = error probability due to CFMs
P_t = error probability due variability in T_{avail} and T_{reqd}

T_{reqd} = time required
T_{avail} = time available

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IDHEAS-ECA Products

- IDHEAS-ECA report – including guidance, worksheets, base HEPs and PIF weights, and three full examples
  - The worksheets document the analysis results and basis
    - Worksheet A: Scenario analysis
    - Worksheet B: Modeling of important human actions – Definitions of the actions and critical tasks
    - Worksheet C: Modeling of human failures – Task characterization, applicable CFMs and PIF attributes
    - Worksheet D: Summary of HEP calculation
    - Worksheet E: Time uncertainty analysis

- NRC HRA Tool Box – A software implementing IDHEAS-ECA and other HRA methods for HEP calculation
  - Recommended use:
    - Analyze the event and document the results in IDHEAS-ECA worksheets
    - Enter the information from the Worksheet in the NRC HRA Tool Box to calculate the HEP.

Summary of IDHEAS-G Applications

1. An HRA method for human event analysis in all nuclear HRA applications
   – Analyzed and documented 10+ real and simulated human events
2. A platform for generalizing and integrating human error data to support HEP estimation
   – Developed IDHEAS-G Human Error Data Tables and continued generalizing available data to the Tables
3. A methodology for developing application-specific HRA methods
   – Developed IDHEAS At-Power Application (2017) and IDHEAS-ECA

Outline

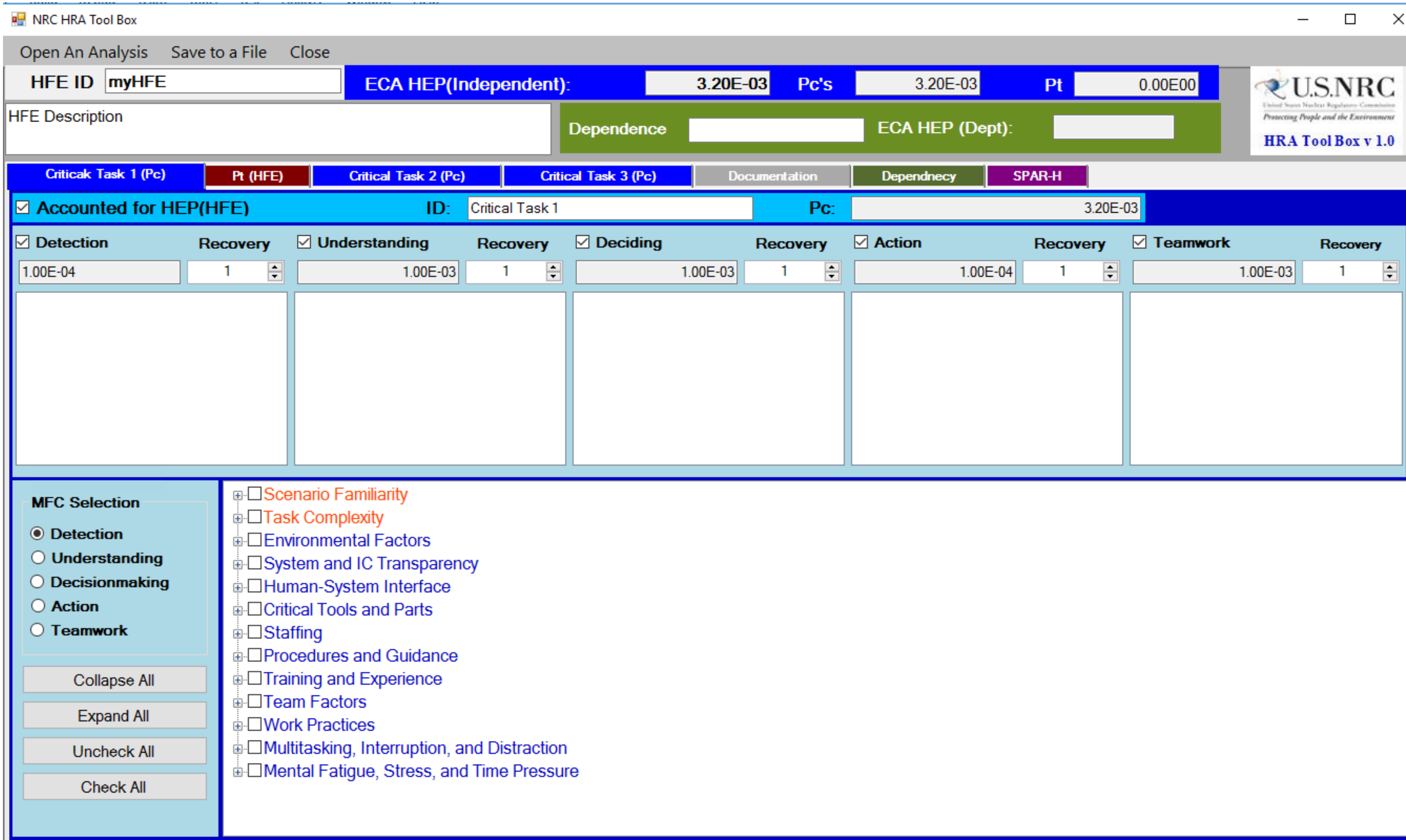
Part I. The General Methodology of an Integrated Human Event Analysis System (IDHEAS-G)

Part II. IDHEAS-G Applications

Part III. Demonstration of an IDHEAS-G Application—IDHEAS for Event and Condition Assessment (IDHEAS-ECA)

James Chang, Human Reliability Engineer
Human Factors and Reliability Branch
Division of Risk Analysis
Office of Nuclear Regulatory Research

IDHEAS-ECA
Implemented in the NRC HRA Tool Box

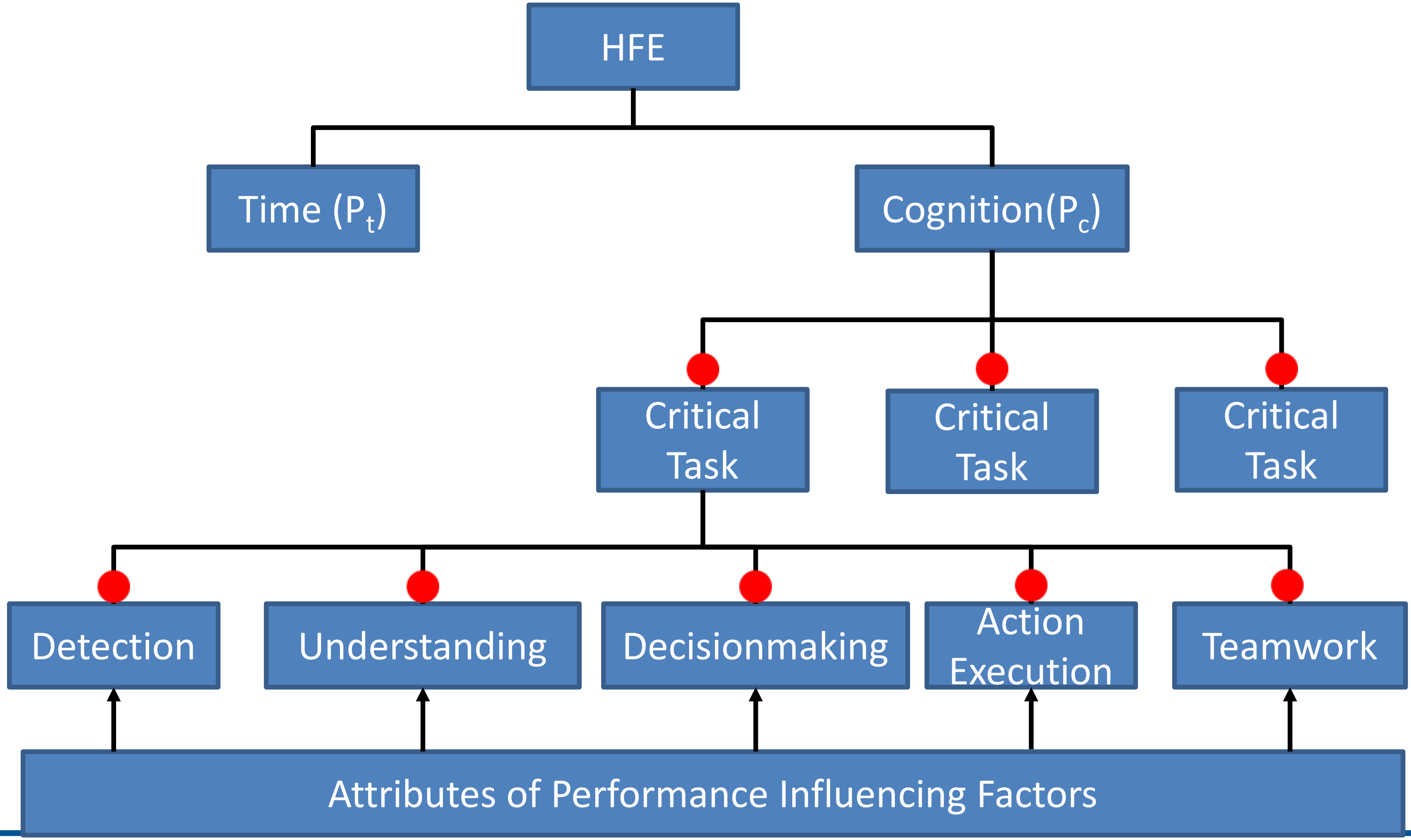


IDHEAS-ECA—Software

- Objective: To reduce the analysts' effort of using the IDHEAS-ECA method

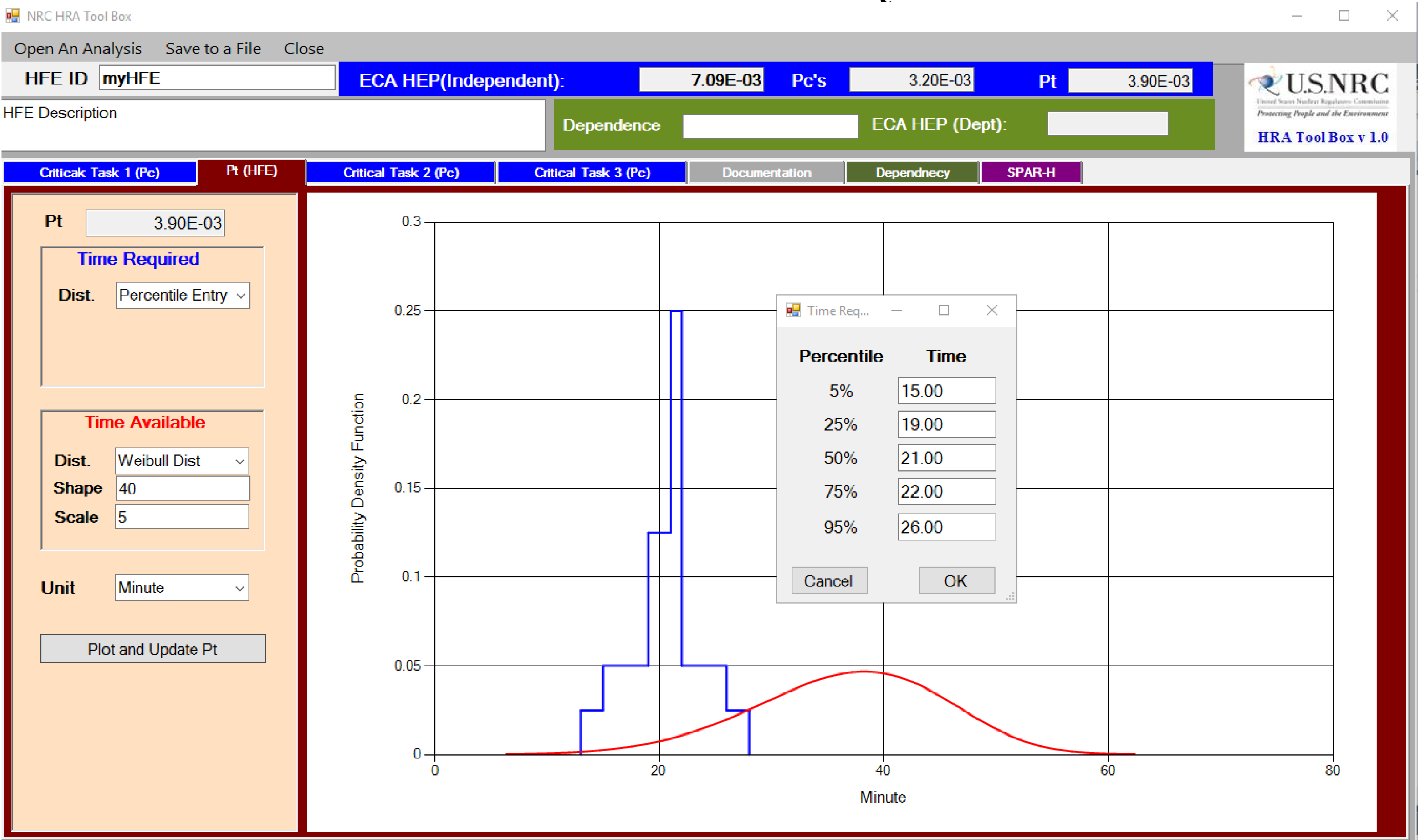
- Scope:
  - To calculate the HEP of an HFE in an analysis
  - Include dependency analysis (based on NUREG-1921)

IDHEAS-ECA—Software
HEP Calculation Structure



● A switch that the users can open and close

IDHEAS-ECA—Software Calculate P_t



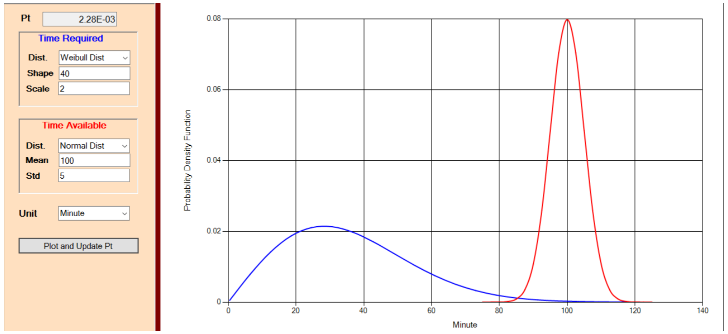
IDHEAS-ECA—Software
Calculate P_t (continued)

- P_t is the probability of being unable to complete the task within the specified time
  - Assume the operator responses are as expected
  - Calculated by two parameters
    - The time required for the operator to complete the tasks (Time Required)
    - The system time window within which the tasks have to be completed (Time Available)
- Time Required and Time Available are distributions
  - Monte Carlo sampling is used to calculate P_t (sample size: 1,000,000)

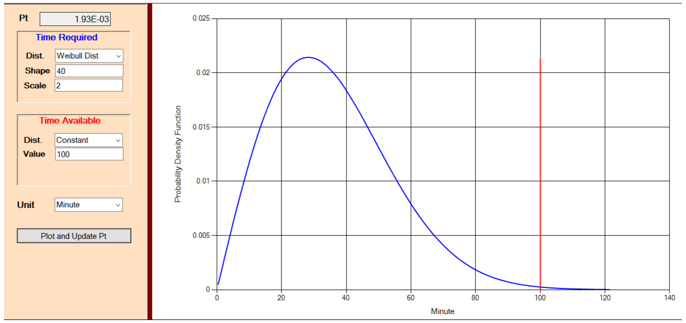
IDHEAS-ECA—Software

Calculate P_t—Applied Distributions

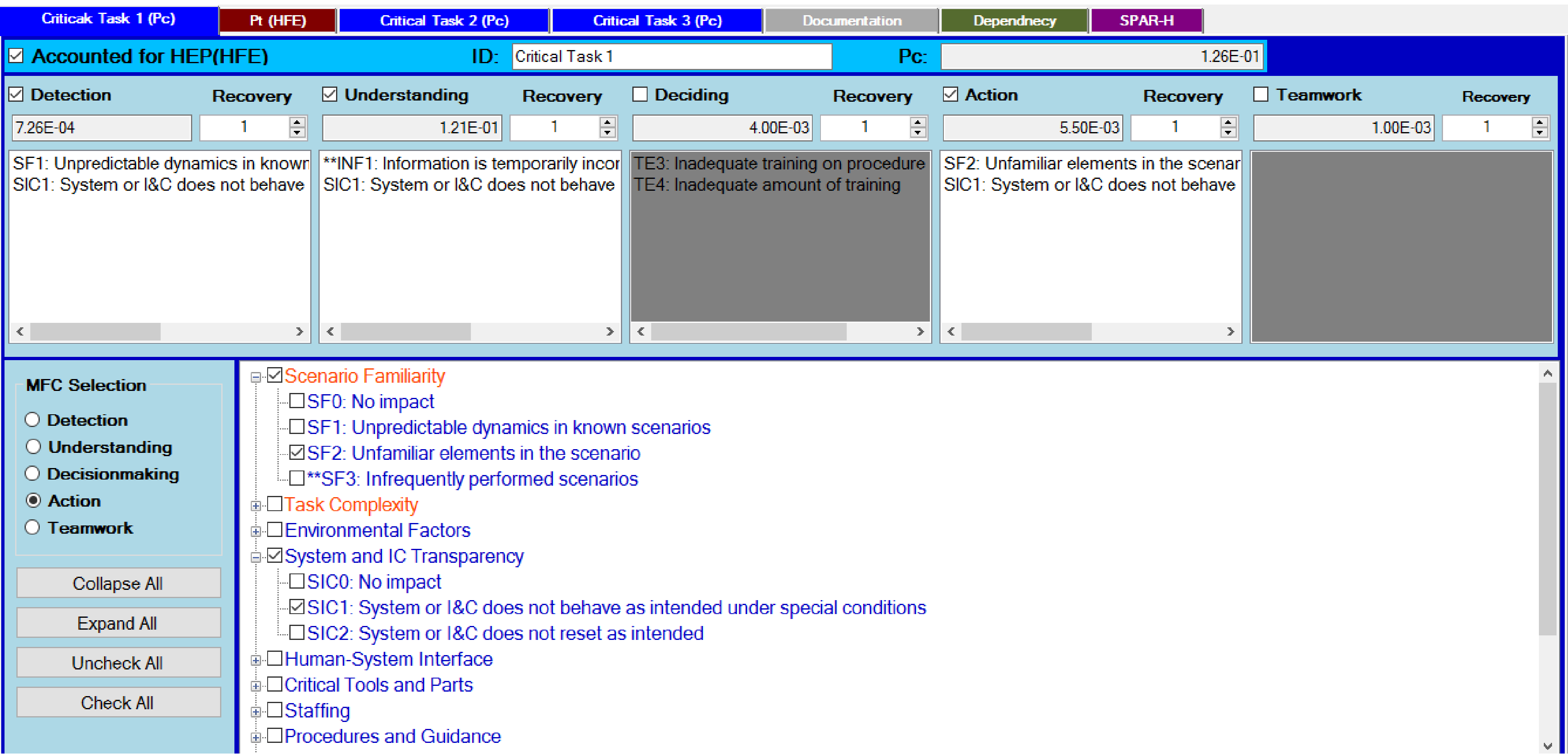
- Time Required
  - Normal distribution
  - Gamma distribution
  - Weibull distribution
  - Percentile (5, 25, 50, 75 and 95 percentile)



- Time Available
  - Normal distribution
  - Gamma distribution
  - Weibull distribution
  - Percentile (5, 25, 50, 75 and 95 percentile)
  - Constant



IDHEAS-ECA—Software Calculate P_c



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IDHEAS-ECA—Software Calculate P_c (continued)

- IDHEAS-ECA implements 20 PIFs (the master set)
  - Each PIF consists of a set of PIF attributes
  - PIF attributes are the basic element to calculate P_c
- An HFE may contain one or more critical tasks
  - $HEP(HFE) = 1 – (1 – HEP(CT_1)) * (1 – HEP(CT_2))…$
  - A critical task may contain one or more macrocognitive functions
  - $HEP(CT) = 1 – (1\text{-}HEP(CFM_1)) * (1\text{-}HEP(CFM_2))…$
  - A CFM is only affected by a subset of PIFs and a subset of the PIFs' attributes

PIFs Affecting Each CFM

As Implemented in the Software

Detection PIFs

- Scenario Familiarity
- Task Complexity
- Environmental Factors
- System and IC Transparency
- Human-System Interface
- Critical Tools and Parts
- Staffing
- Procedures and Guidance
- Training and Experience
- Team Factors
- Work Practices
- Multitasking, Interruption, and Distraction
- Mental Fatigue, Stress, and Time Pressure

Understanding PIFs

- Scenario Familiarity
- Information Completeness and Reliability
- Task Complexity
- Environmental Factors
- System and IC Transparency
- Human-System Interface
- Staffing
- Procedures and Guidance
- Training and Experience
- Team Factors
- Work Practices
- Multitasking, Interruption, and Distraction
- Mental Fatigue, Stress, and Time Pressure

Decisionmaking PIFs

- Scenario Familiarity
- Information Completeness and Reliability
- Task Complexity
- Environmental Factors
- System and IC Transparency
- Staffing
- Procedures and Guidance
- Training and Experience
- Team Factors
- Work Practices
- Multitasking, Interruption, and Distraction
- Mental Fatigue, Stress, and Time Pressure

Action Execution PIFs

- Scenario Familiarity
- Task Complexity
- Environmental Factors
- System and IC Transparency
- Human-System Interface
- Critical Tools and Parts
- Staffing
- Procedures and Guidance
- Training and Experience
- Team Factors
- Work Practices
- Multitasking, Interruption, and Distraction
- Mental Fatigue, Stress, and Time Pressure
- Physical Demands

Teamwork PIFs

- Task Complexity
- Environmental Factors
- Staffing
- Procedures and Guidance
- Training and Experience
- Team Factors
- Work Practices
- Multitasking, Interruption, and Distraction
- Mental Fatigue, Stress, and Time Pressure

Task Complexity's Attributes for Different Macrocognitive Functions

Detection

- Task Complexity
  - C0: No impact
  - **C1 : Detection overload with multiple competing signals
  - C2: Detection is moderately complex
  - C3: Detection demands for high attention
  - C4: Detection criteria are highly complex
  - C5: Cues for detection is not obvious
  - C6: No cue or mental model for detection

Understanding

- Task Complexity
  - C0: No impact
  - **C11: Working memory overload
  - **C12: Relational complexity (Number of unckunkable topics or relations in one understanding task)
  - C13: Understanding complexity
  - C14: Not a simple yes or no
  - C15: Ambiguity associated with assessing the situation
  - C16: Conflicting information, cues, or symptoms

Decisionmaking

- Task Complexity
  - C0: No impact
  - C21: Transfer step in procedure –integrating a few cues
  - C22: Transfer procedure (Multiple alternative strategies to choose)
  - C32: Decision criteria are intermingled, ambiguous, or difficult to assess
  - C24: Multiple goals difficult to prioritize
  - C25: Competing or conflicting goals
  - C26: Decision-making involves developing strategies or action plans
  - C27: Decisionmaking requires diverse expertise distributed among multiple individuals or parties
  - C28: Integrating a large variety of types of cues with complex logics

Action

- Task Complexity
  - C30: No impact
  - C31: Straightforward Procedure execution with many steps
  - C32: Non-straightforward Procedure execution
  - C33: Simple continuous control that requires monitoring parameters
  - C34: Continuous control that requires manipulating dynamically
  - C35: Long-lasting action, repeated discontinuous manual control
  - C36: No immediacy to initiate execution
  - C37: Complicated or ambiguous execution criteria
  - C38: Action execution requires close coordination of multiple personnel at different locations
  - C39: Unlearn or break away from automaticity of trained action scripts

Teamwork

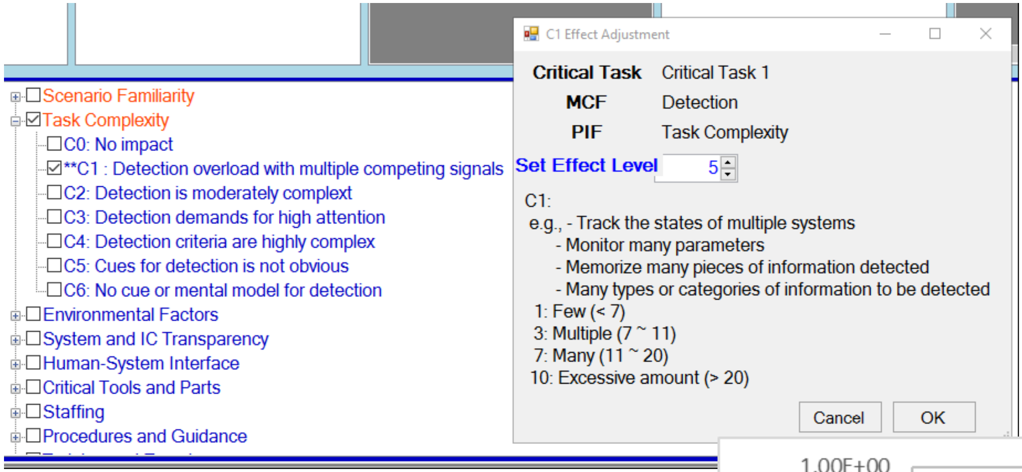
- Task Complexity
  - C40: No impact
  - **C41: Complexity of information communicated
  - C42: Complex or ambiguous command-and-control
  - C43: Complex or ambiguous authorization chain
  - C44: Coordinate activities of multiple diverse teams or organizations

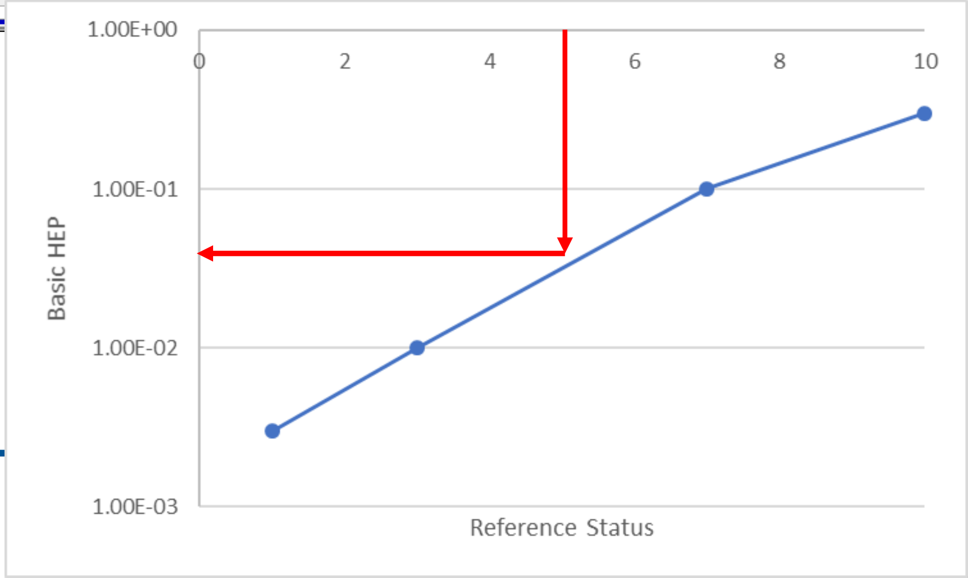
IDHEAS-ECA—Software

Assessment of PIF Attributes applicable to a CFM

- Types: Basic HEP or HEP Modifier
- Effect specification: A single value or a range
- Apply the effect of the PIF attribute with a range effect
  - The software provides anchor points (from 1 to 10 with descriptions)
  - The analyst picks a value between 1 and 10.
  - The software calculates the corresponding effects on P_c.

Specify the Effect of Task Complexity Attribute C1 on Failure of Detection





IDHEAS-ECA—Software, Documentation

Criticak Task 1 (Pc) | Pt (HFE) | Critical Task 2 (Pc) | Critical Task 3 (Pc) | Documentation | Dependnecy | SPAR-H

Save File   Document

9/13/2019 3:47:43 PM ECA Analysis

HFE: myHFE
HFE Description: HFE Description
HEP(ECA, Independent) = 3.74E-03
HEP (Pc's) = 3.74E-03
HEP (Pt) = 1.35E-03

Critical Task 1:Critical Task 1

HEP(Pc):2.40E-03

HEP(Detection):2.40E-03
Recovery Factor(Detection):1

- HEP(Detection):Task Complexity: C2: Detection is moderately complext
  C2(Basic HEP): 0.001
- HEP(Detection):Task Complexity: C3: Detection demands for high attention
  C3(Basic HEP): 0.001
- HEP(Detection):System and IC Transparency: SIC1: System or I&C does not behave as intended under special conditions
  SIC1 PIF Weight Factor(Wi): 0.1
- HEP(Detection):System and IC Transparency: SIC2: System or I&C does not reset as intended
  SIC2 PIF Weight Factor(Wi): 0.1

HEP(Pt):1.35E-03

Time Available Parameters
Type: Percentile Entry
5% = 6
25% = 7
50% = 8
75% = 9
95% = 10
Time Required Parameters
Type: Normal Dist
Mean = 15

IDHEAS-ECA—Example 1

SGTR Event (Based on Empirical HRA Study, NUREG-2156)

- Isolate the broken SG in a SGTR event
- Initial condition
  - At 100% power operation
  - A five-operator crew (SS, RO(2), STA, and SM) in the main control room
- Initiating event:
  - A SGTR event of 500 gpm occurred in one SG
- Boundary condition
  - All components and equipment function as designed
  - Simulator training on SGTR event variation is routinely conducted for all crews
  - Reactor trips automatically four minutes after the SGTR if not manually tripped

IDHEAS-ECA Example

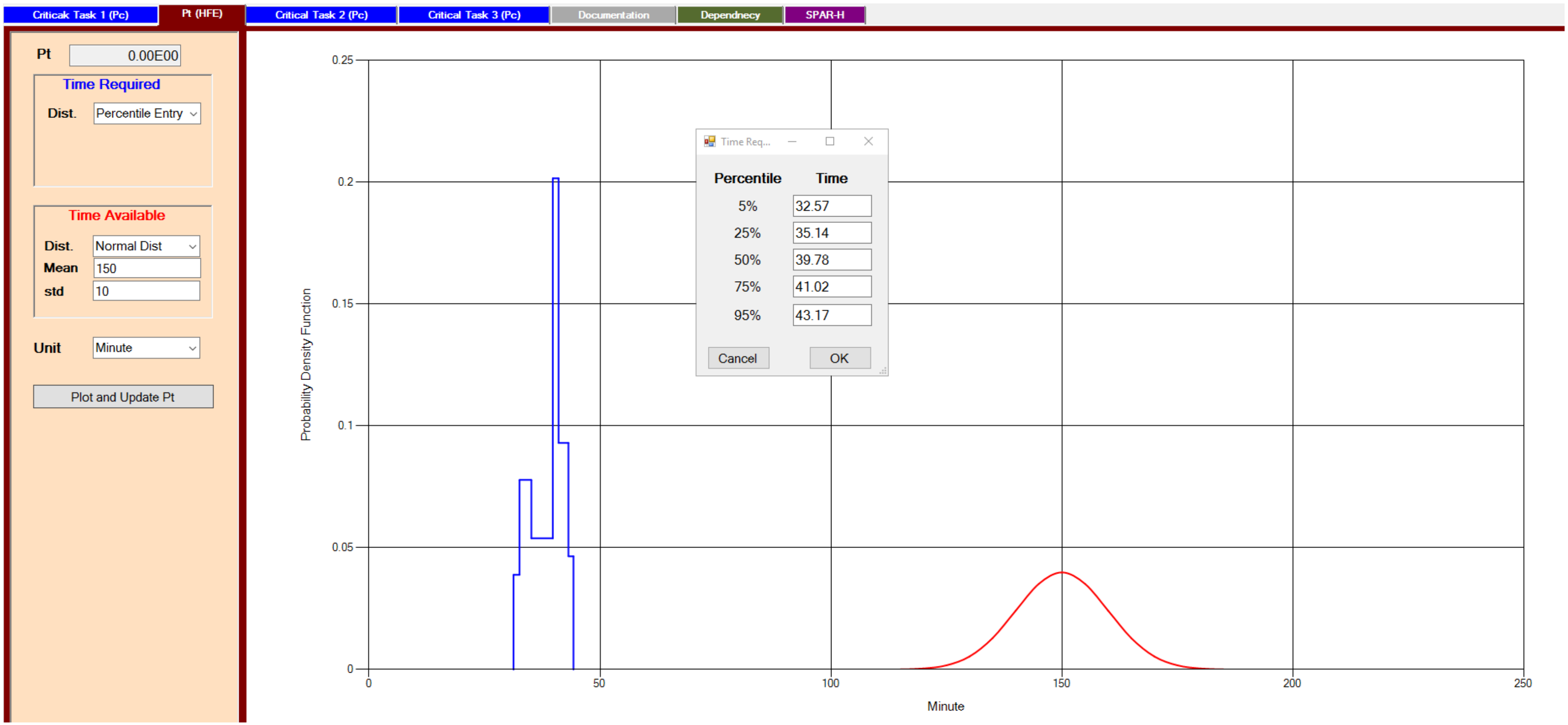
SGTR Event

- HFE: Fail to isolate the broken SG and control RCS pressure to prevent SG PORV from opening
- Scenario context
  - Environmental and situational context
  - System context
  - Personnel context
  - Task context
    - Alarm pattern recognition in addition to EOP instruction

Time

- Three data points on the time the operator completed RCS depressurization based on simulator exercises
  - Data: 36:00, 40:10, 43:10 (in mm:ss)
  - Represented by 32.6(5%), 35.1(25%), 39.8(50%), 41.0 (75%), and 43.17(95%)
- It is estimated the RCS depressurization needs to be complete within two to three hours after the tube rupture to prevent PZR PORV from opening
  - Represented by Normal distribution: Mean: 150; std: 10

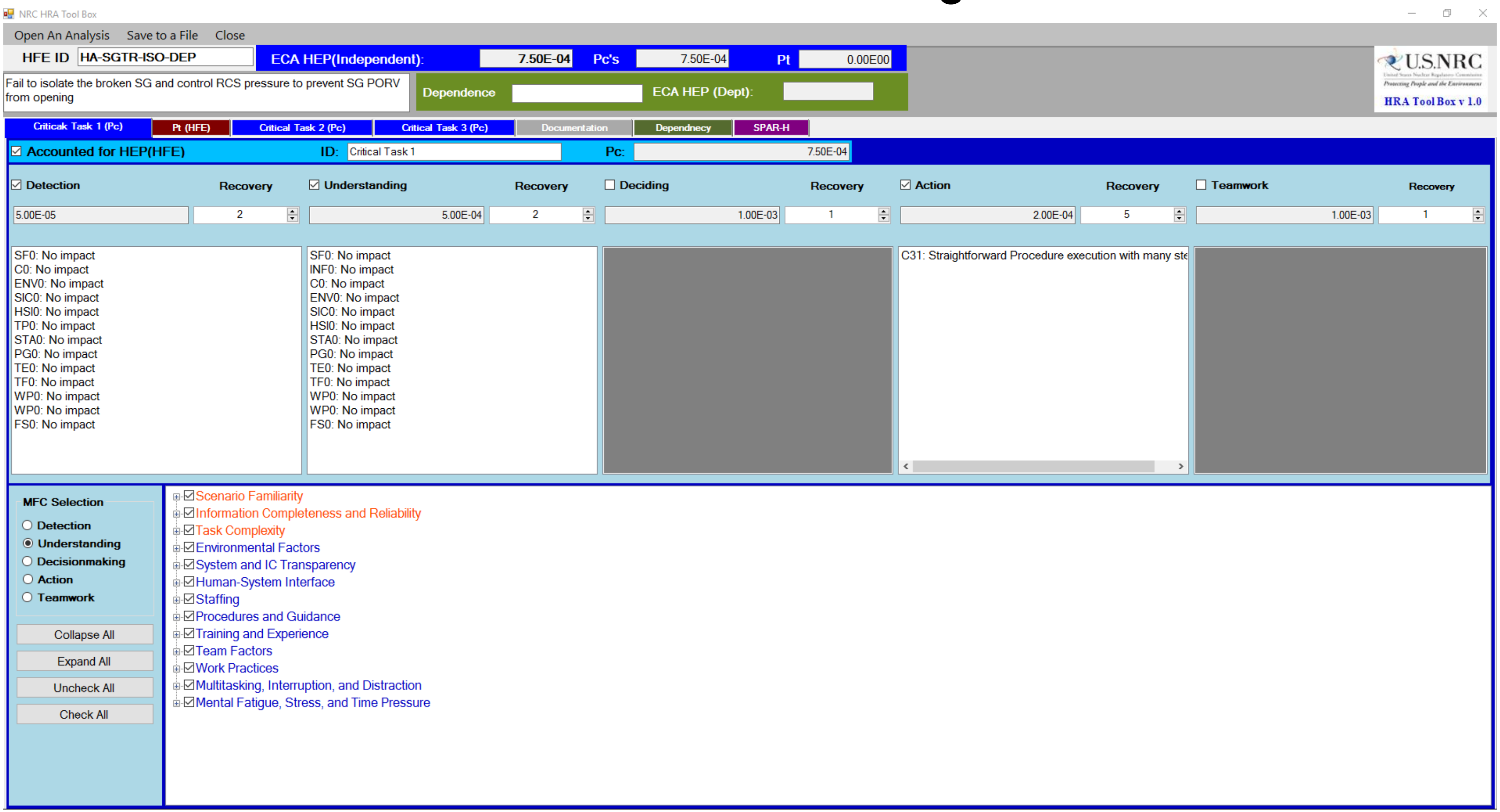
Calculate P_t



CFMs Description

- Detection CFM: Fail to detect the key system information for the diagnosis to enter E-0 and E-3
- Understanding CFM: Correctly detected all key information but failed to understand this is a SGTR event or identify the broken SG
- Decisionmaking CFM: Not applicable because the procedure directs the action after having a correct understanding of the problem.
- Action execution CFM: failed to successfully execute the decided actions(isolate the broken SG and depressurize RCS)
- Teamwork CFM: Not applicable because not in a multiple team environment.

Calculate P_c



Documentation

Open An Analysis Save to a File Close

HFE ID HA-SGTR-ISO-DEP | ECA HEP(Independent): 7.50E-04 | Pc's 7.50E-04 | Pt 0.00E00

Fail to isolate the broken SG and control RCS pressure to prevent SG PORV from opening

Dependence | ECA HEP (Dept):

Criticak Task 1 (Pc) | Pt (HFE) | Critical Task 2 (Pc) | Critical Task 3 (Pc) | Documentation | Dependnecy | SPAR-H

Save File Document

9/16/2019 2:54:27 PM ECA Analysis

HFE: HA-SGTR-ISO-DEP
HFE Description: Fail to isolate the broken SG and control RCS pressure to prevent SG PORV from opening
HEP(ECA, Independent) = 7.50E-04
HEP (Pc's) = 7.50E-04
HEP (Pt) = 0.00E00

Critical Task 1:Critical Task 1

HEP(Pc):7.50E-04

HEP(Detection, with recovery):5.00E-05
Recovery Factor(Detection):2

- HEP(Detection):Scenario Familiarity: SF0: No impact
  SF0(Basic HEP): 0
- HEP(Detection):Task Complexity: C0: No impact
  C0(Basic HEP): 0
- HEP(Detection):Environmental Factors: ENV0: No impact
  ENV0 PIF Weight Factor(Wi): 0
- HEP(Detection):System and IC Transparency: SIC0: No impact
  SIC0 PIF Weight Factor(Wi): 0
- HEP(Detection):Human-System Interface: HSI0: No impact
  HSI0 PIF Weight Factor(Wi): 0
- HEP(Detection):Critical Tools and Parts: TP0: No impact
  TP0 PIF Weight Factor(Wi): 0
- HEP(Detection):Staffing: STA0: No impact
  STA0 PIF Weight Factor(Wi): 0
- HEP(Detection):Procedures and Guidance: PG0: No impact
  PG0 PIF Weight Factor(Wi): 0
- HEP(Detection):Training and Experience: TE0: No impact
  TE0 PIF Weight Factor(Wi): 0
- HEP(Detection):Team Factors: TF0: No impact
  TF0 PIF Weight Factor(Wi): 0

IDHEAS-ECA TESTING AND HRA FUTURE WORK

Sean E. Peters, Chief
Human Factors and Reliability Branch
Division of Risk Analysis
Office of Nuclear Regulatory Research

IDHEAS-ECA—Testing

- NRC – Industry joint team
- Purpose – Model FLEX scenarios using ECA to support regulatory decisionmaking
  - Better understanding of human challenges in FLEX implementation
  - Feedback for ECA method improvement
- 2 teams – Scenario developers, HRA practitioners
- 2 sites – Peach Bottom, Surry
- Site visits Sep/Oct 2019
- Scenario modeling – Nov/Dec 2019
- Testing documentation/final ECA tool – Summer 2020

HRA Improvement with IDHEAS-G

- A general methodology
  - Models cognitive process underlying human actions
  - Application-independent
- Enhanced scientific basis
  - Based on state-of-the-art cognitive science
  - Models cognitive activities in a teamwork and organizational environment
  - Cognitive mechanisms are built-in and explain why humans may fail an action
- Enhanced guidance to reduce HRA variability
  - Structured HRA process with detailed guidance for consistently analyzing an event and transparently documenting the results
- A built-in interface with HRA data
  - Models cognitive elements of human behavior
  - Data from different events or domains can be mapped to the cognitive elements

IDHEAS-G Specific Improvements Over Existing HRA Methods

1. Qualitative analysis (2015 ACRS recommendation)
   - Guidance for operational narrative: description of scenario progression and context
   - Guidance for searching and documenting context and how to model context with PIFs

2. Modeling of human failures
   - Cognitive basis structure provides a structured and systematic understanding of success and failure of human actions.
   - PIF structure is the most comprehensive model of conditions leading to human failure.
   - Basic set of CFMs improves the completeness, independence, specificity, and sensitivity of modeling human failures.

IDHEAS-G Specific Improvements Over Existing HRA Methods (continued)

3. Time uncertainty analysis (2015 ACRS recommendation)
   – Includes the contribution of the probability that an action cannot be completed in the available time window to the overall HRA results
   – Models the effect of time on the HEP

4. HEP quantification model
   – Based on data and findings in the cognitive literature
   – Allows use of human error data, which is generalized with IDHEAS-G, to compute HEPs
   – Moves HRA from expert judgment to data-based HEP quantification
   – Allows continuous improvement as more data sources (e.g., SACADA) become available

IDHEAS-G Specific Improvements Over Existing HRA Methods (continued)

5. Guidance for HRA Practices
   – Guidance on how to perform different HRA elements (e.g., HFE identification and task analysis) is provided
   – The guidance improves HRA practices, as demonstrated in the piloting of human event analysis using IDHEAS-G.

Closure of SRM-M061020

- Complete IDHEAS-G
- Complete IDHEAS-ECA
- ACRS letter
- Regulatory Guide?

HRA Future Work

- Documentation and technical basis work
- IDHEAS-ECA implementation support and updates
- Dependency
- Recovery
- Minimum joint human error probabilities
- Errors of commission
- Data, data, data, data.....
- TBD

BACKUP SLIDES

Detection

Detection cognitive activities

- Detect cues
- Acquire (gather) information

Detection processors

D1. Initiate detection – Establish the mental model for information to be detected

D2. Select, identify, and attend to sources of information

D3. Perceive, recognize, and classify information

D4. Verify and modify the outcomes of detection

D5. Retain, document/record, or communicate the outcomes

Detection cognitive mechanisms

D.a. Mental model of the cues

D.b. Perception of sensory information

D.c. Attention

D.d. Working memory

D.e. Vigilance

D.f. Information foliage

D.g. Pattern recognition

D.h. Shared cognition within a team

D.i. Infrastructure for exporting the information detected

Return to Cognitive Basis Structure

Go to detection CFMs

Understanding

Understanding cognitive activities

- Maintain situational awareness
- Assess status based on indirect information
- Diagnose problems and resolve conflicts in information
- Make predictions or form expectations for the upcoming situation development

→

Understanding processors

U1. Assess/select data

U2. Select/adapt/develop the mental model

U3. Integrate data with the mental model to generate the outcome of understanding (situational awareness, diagnosis, resolving conflicts)

U4. Verify and revise the outcome through iteration of U1, U2, and U3

U5. Export the outcome

→

Understanding cognitive mechanisms

U.a. Data

U.b. Selection of data

U.c. Mental model

U.d. Integration of data with mental model

U.e. Working memory

U.f. Shared cognition within a team

Decisionmaking

Decisionmaking cognitive activities

- Make a go/no-go decision for a pre-specified action
- Select among multiple options or strategies
- Change or add to a pre-existing plan or strategy
- Develop a new strategy or plan

Decisionmaking processors

DM1. Adapt the infrastructure of decisionmaking

DM2. Manage the goals and decision criteria

DM3. Acquire and select data for decisionmaking

DM4. Make decision (judgment, strategies, plans)

DM5. Simulate or evaluate the decision or plan

DM6. Communicate and authorize the decision

Decisionmaking cognitive mechanisms

DM.a. Decisionmaking model

DM.b. Data for decisionmaking

DM.c. Selection or judgment

DM.d. Cognitive biases

DM.e. Deliberation or evaluation of decision

Action Execution

Action Execution cognitive activities

- Execution of a cognitively simple action
- Execution of a cognitively complex action
- Long-lasting action
- Control action
- Fine motor action
- Physically strenuous action

→

Action Execution processors

E1. Assess action plan and criteria

E2. Develop or modify action scripts

E3. Prepare or adapt infrastructure for action implementation

E4. Implement action scripts

E5. Verify and adjust execution outcomes

→

Action Execution cognitive mechanisms

E.a. Physical movement and motor skills

E.b. Mental model of the actions and the systems to be acted on

E.c. Working memory

E.d. Attention

E.e. Vigilance

E.f. Sensory feedback of motor movement

E.g. Automaticity

E.h. Action programming

E.i. Executive control

E.j. Error monitoring and correction

E.k. Initiation of action execution

E.l. Spatial precision or accuracy of action execution

E.m. Timing precision of action execution

E.n. Coordinate motor movement of action execution personnel

[Return to Cognitive Basis Structure](#)   [Go to action execution CFMs](#)

Teamwork

Teamwork activities

- Communication
- Cooperation
- Coordination

→

Teamwork processors

T1. Establish or adapt teamwork infrastructure

T2. Manage information

T3. Maintain shared situational awareness

T4. Manage resources

T5. Plan interteam collaborative activities

T6. Implement decisions and commands

T7. Verify, modify, and control the implementation

→

Teamwork cognitive mechanisms

T.a. Teamwork infrastructure

T.b. Command

T.c. Control

T.d. Line of communication

T.e. Data processing and information management

T.f. Shared mental model

Workplace Accessibility and Habitability

- Definition: Workplace has hardware facilities, physical structures, and travel paths to support personnel in task performance. Those should not impede personnel in performing required tasks.
- Attributes:
  - Accessibility (travel paths, security barriers, and sustained habituation of worksite) is limited because of adverse environmental conditions, such as steam, high water, fire, smoke, toxic gas, radiation, electricity shock risk, and blocked roads.
  - There is limited accessibility because of security system operation. Doors or components that are normally locked require keys to unlock. A fire or flood may cause electric security systems to fail locked.
  - Habitability is reduced. Personnel cannot stay long at the worksite because of factors like radiation or earthquake aftershocks.
  - The surface of systems, structures, or objects cannot be reached or touched (e.g., because they are hot).
  - The worksite is flooded or underwater.

Return to Environment and Situation PIFs

Environment- and Situation-Related PIFs Other than Workplace Accessibility and Habitability

PIF	Attributes
Workplace visibility	- poor lighting in workplace - glare or reflection on physical structure - smoke- or fog-induced low visibility
Noise	- loud noise in workplace impeding face-to-face communication - noise in communication devices
Cold, heat, humidity	- extreme cold - extreme heat - high humidity
Resistance to personal or vehicle physical movement	- wearing heavy protective clothes and/or gloves - slippery surface (e.g., icing) - traffic impeding vehicle movement

Return to Environment and Situation PIFs

System and I&C Transparency to Personnel

- Definition: Systems and I&C should be designed for personnel to understand their behaviors and responses in various operating conditions.
- Attributes:
  - System or I&C does not behave as intended under special conditions.
  - System or I&C does not reset as intended.
  - System or I&C is complex, making it hard for personnel to predict its behavior in unusual scenarios.
  - System or I&C failure modes are not transparent to personnel.

Return to System PIFs

Human-System Interface

- Definition: HSI refers to indications (e.g., displays, indicators, labels) and controls used by personnel to execute actions on systems.

- Attributes: HSI attributes depend on the specific interfaces used in an application. New HSI technologies may introduce additional attributes.
  - The source of indication (e.g., indicators, labels) is similar to other sources nearby.
  - The source of indication is obscured or masked in many potentially relevant indications.
  - The indications have low salience.
  - Related information is spatially distributed or unsynchronized.
  - Indications are confusing or nonintuitive.
  - Secondary indications are not promptly available, or personnel are not aware of them.
  - Controls are difficult to maneuver.
  - Personnel do not anticipate the failure modes of controls and their impacts.
  - Indications of states of controls are inadequate.
  - There is confusion in action maneuver states.
  - Controls provide inadequate feedback (i.e., lack of adequate confirmation of the action executed (incorrect, no information provided, measurement inaccuracies, delays)).
  - Labels on the controls do not agree with document nomenclature.
  - Controls are not reliable, and personnel are unaware of the problem.

Return to System PIFs

Tools and Parts Availability and Usability

- Definition: The tools, equipment, and parts assessed in an event include all the things needed to support personnel actions. They should be available and readily usable.
- Attributes:
  - Tools are difficult to access or to use (e.g., lack of administrative control of tools).
  - Tools are unfamiliar to personnel.
  - Failure modes or operational conditions of the tools are not clearly presented (e.g., ranges, limitations, and requirements).
  - Critical tool does not work properly because of aging, lack of power, incompatibility, improper calibration, lack of proper administrative control, or other reason.
  - Tools or parts needed are missing or not available.
  - Document nomenclature does not agree with equipment labels.

Return to System PIFs

Staffing

- Definition: Staffing refers to having adequate, qualified personnel to perform the required tasks. Staffing includes the number of personnel, their skill sets, job qualifications, staffing structure (individual and team roles and responsibilities). Adequate and qualified staff is normally expected.
- Attributes:
  - shortage of staff (e.g., key personnel are missing, unavailable, or delayed in arrival; staff pulled away to perform other duties)
  - lack of backup or lack of peer-check or cross-checking (e.g., an overseer or independent reviewer is not available)
  - ambiguous or incorrect specification of staff roles and responsibilities
  - inappropriate staff assignment (e.g., lack of skills needed)
  - key decisionmaker's knowledge and ability are inadequate to make the decision (e.g., lack of required qualifications or experience)
  - lack of administrative control of fitness for duty

Return to Personnel PIFs

Procedures, Guidance, and Instructions

- Definition: This PIF refers to availability and usefulness of operating procedures, guidance, instructions, and protocols. Procedures should be validated for their applicability and usefulness. Following procedures should lead to the success of important human actions.
- Attributes:
  - The procedure is inadequate.
  - The procedure design is difficult to use.
  - The procedure lacks details.
  - The procedure is confusing.
  - The procedure is available but does not fit the situation (e.g., it requires deviation or adaptation).
  - The procedure is not available for skill-based tasks.
  - The procedure is not available; thus, personnel have to find ways to perform the task based on their knowledge.
  - The procedure is misleading.

Return to Personnel PIFs

Training

- Definition: This PIF refers to training that personnel receive to perform their tasks. Included in this consideration are personnel's work-related experience and whether they have been trained on the type of the event, the amount of time passed since training, and training on the specific systems involved in the event. It is expected that adequate training is required for professional staff.
- Attributes:
  - Training frequency is low (greater than 6 months between sessions).
  - Training duration or the amount of training is not adequate.
  - Training on procedure adaptation is inadequate. The training focuses on following procedures without adequately training personnel to evaluate all available information, seek alternative interpretations, or evaluate the pros and cons of procedural action plans.
  - Training is inadequate on collaborative work process as a crew (e.g., inadequate supervision in monitoring actions and questioning current mission; inadequate leadership in initiating assessment of action scripts, facilitating discussion, and avoiding tunnel vision).
  - Training or experience with sources of information (such as scope and limitations of data and information on the failure modes of the information sources) is inadequate.
  - Experience in diagnosis (e.g., not being aware of and coping with biases, not seeking additional information, and not avoiding tunnel-vision) is inadequate.
  - There are gaps in team knowledge and expertise needed to understand the scenario.
  - There is inadequate specificity on the urgency and criticality of key information such as key alarms, system failure modes, and system design to the level of detail needed for responding to the situation.
  - The training is inadequate or practice is lacking in the step-by-step completion of action execution.
  - The training lacks practicality.
  - Hands-on training on action execution is lacking (e.g., training consists of virtual training, classroom training, or demos only without hands-on practices).
  - Experience or training is lacking on procedures, guidelines, or instructions for the type of event (e.g., use nonoperators to perform some actions outside the control room).
  - The action context is infrequently part of training or personnel rarely perform the actions under specific context (greater than 6 months between performance).
  - Personnel are not trained on the procedures or for the type of actions.

Return to Personnel PIFs

Teamwork and Organizational Factors

- Definition: Teamwork refers to everything affecting team communication, coordination, and cooperation.
- Attributes:
  - Inadequate team information management
  - Inadequate teamwork resources
  - Distributed or dynamic operational teams
  - Inadequate team decisionmaking infrastructure
  - Team coordination difficulty
  - Authorization difficulty
  - Inadequate communication capabilities between teams
  - Inadequate teamwork practices or drills together

Return to Personnel PIFs

Work Processes

- Definition: Work processes refer to aspects of doing work, supervision, management support, policies, and safety-conscious work environment at the organizational level.
- Attributes:
  - poor work prioritization or scheduling
  - lack of or ineffective instrumentation (e.g., prejob briefing) to inform personnel of potential pitfalls in performing the tasks
  - lack of or ineffective instrumentation (e.g., supervision) for safety issue monitoring and identification
  - lack of or ineffective instrumentation for safety reporting
  - lack of or ineffective instrumentation for corrective actions

Return to Personnel PIFs

Information Availability and Reliability

- Definition: Personnel need information to perform tasks. Information is expected to be complete, reliable, and presented to personnel in a timely and user-friendly way.
- Attributes:
  - Updates of information are inadequate (e.g., information perceived by one party who fails to inform another party).
  - Information from different sources is not well organized.
  - Conflicts in information
  - Information updates are inadequate
  - Different sources of information are not properly organized
  - Personnel are unfamiliar with the sources or meaning of the information.
  - Pieces of information change over time at different paces; thus, they may not all be current by the time personnel use them together.
  - Feedback information is not available in time to correct a wrong decision or adjust the strategy implementation.
  - Information is unreliable or uncertain.
  - Primary sources of information are not available, while secondary sources of information are not reliable or readily perceived.
  - Information is misleading or wrong.

Return to Task PIFs

Scenario Familiarity

- Definition: The scenario is familiar to personnel, with predictable event progression and system dynamics, and does not bias personnel in their understanding of what is happening.
- Attributes:
  - Scenario is unfamiliar.
  - A bias or preference for wrong strategies exists.
  - Personnel are unfamiliar with system failure modes.
  - Personnel are unfamiliar with worksites for manual actions.
  - Plans, policies, and procedures to address the situation are lacking.
  - Unpredictable dynamics
  - Dynamic decisionmaking is required
  - Shifting objectives

Return to Task PIFs

Multitasking, Interruptions, and Distractions

- Definition: Multitasking refers to performing concurrent and intermingled tasks. Distraction and disruption refer to things that interfere with personnel's performance of their critical tasks.
- Attributes:
  - excessively frequent or long interruption during the continuous performance of critical tasks
  - distraction by other ongoing activities that are relevant to the critical task being performed
  - concurrently detecting (monitoring or searching) multiple sets of parameters when the parameters in different sets may be related
  - concurrently diagnosing more than one complex event that requires continuous seeking of additional data to understand the events
  - concurrently making decisions or plans that may be intermingled
  - concurrently executing intermingled or interdependent action plans
  - command and control multitasking

Return to Task PIFs

Task Complexity

- Definition: Task complexity, also referred as cognitive complexity, measures task demand for cognitive resources (e.g., working memory, attention, executive control). Nominal complexity refers to the level of complexity that does not overwhelm personnel.
- Attributes:
  - Detection criteria are complex.
  - Detection overloading.
  - Detection requires sustained attention.
  - Cues for detection are not obvious.
  - Multiple causes for situation assessment
  - Relations of systems involved in an action are too complicated to understand
  - Key information is cognitively masked
  - The potential outcome of the situation assessment consists of multiple states and context (not a simple yes or no).
  - Decisionmaking involves developing strategies or action plans.
  - Decision criteria are ambiguous and subject to different interpretations.
  - Multiple, intermingled goals or criteria need to be prioritized.
  - Goals conflict.
  - Decisionmaking requires integration of a variety of types of information with complex logic.
  - Decisionmaking requires diverse expertise distributed among multiple individuals or parties who may not share the same information or have the same understanding of the situation.
  - Competing strategies
  - Personnel may need to unlearn or break away from automaticity of trained action scripts.
  - Controlled actions may require monitoring of action outcomes and adjusting action accordingly.
  - Action criteria are difficult to use
  - Action requires out-of-sequence steps.
  - Long-lasting, noncontinuous action sequences, or long-time gap between the cues for execution to initiation of the execution are necessary
  - Action sequences are parallel and intermingled.
  - Action execution requires close coordination of multiple personnel at different locations.
  - Action execution requires long sustained attention

Return to Task PIFs

Mental Fatigue

- Definition: In the normal status of mental fatigue, personnel do not experience decrement of vigilance and abilities to perform complex cognitive tasks.
- Attributes:
  - sustained, high-demanding cognitive activities
  - long working hours with cognitively demanding tasks
  - sleep deprivation, exposure to noise, disturbed dark and light rhythms, and air pollution

Return to Task PIFs

Time Pressure and Stress

- Definition: Time pressure refers to the sense of time urgency to complete a task, as perceived by personnel. This sense of time urgency creates psychological pressure affecting personnel performance.
- Attributes:
  - reluctance to execute an action plan because of potential negative impacts (e.g., adverse economic impact or personal injury)
  - high time pressure because of perceived lack of adequate time to complete the task
  - emotional stress (e.g., anxiety, frustration)
  - physical stress (e.g., noise, disturbed dark and light rhythms, air pollution)

Return to Task PIFs

Physical Demands

- Definition: Physical demands indicate that a task requires extraordinary physical effort, such as twisting, reaching, dexterity, or strong force.
- Attributes:
  - Action execution requires highly accurate fine motor skills, fine motor coordination, or skills of craft.
  - Fine or difficult motor actions, such as installing or connecting delicate parts, must be performed.
  - The task is physically strenuous (e.g., lifting heavy objects, opening or closing rusted or stuck valves, moving heavy things in water or high wind).
  - There is resistance to motor movement (e.g., wearing heavy clothing; lifting heavy materials; opening or closing rusted or stuck valves; executing actions in water or high wind, in extreme cold or heat, or on unstable ground).

Return to Task PIFs

Taxonomy of Cognitive Activities

Macrocognitive function	Types of cognitive activities
Detection	• Detect cues (through carefully monitoring, searching, inspecting, or comparing, etc.). • Acquire information (checking, reading, communicating or chatting, computing, etc.).
Understanding	• Maintain situational awareness. • Assess status based on indirect information. • Diagnose problems and resolve conflicts in information • Make predictions or form expectations for the upcoming situation development.
Decisionmaking	• Make a GO/NO-GO decision for a prespecified action. • Select among multiple options or strategies. • Make changes or additions to a preexisting plan or strategy (e.g., changes of personnel, criteria, subgoals). • Develop a new strategy or plan.
Action Execution	• Execute complex actions. • Execute simple actions. • Execute fine motor actions. • Execute strenuous dexterous actions.
Teamwork (within-team and between-team interaction)	• Communicate. • Coordinate (including command and control). • Cooperate.

Return to Task Characterization

High-Level CFMs

Macrocognitive function	Cognitive Failure Mode
Detection	Failure of detecting cues/information
Understanding	Failure of understanding/assessing situation
Decisionmaking	Failure of making decisions/planning actions
Action execution	Failure of executing planned actions
Teamwork	Failure of interteam teamwork

Return to Basic set of CFMs

Detection CFMs

High-Level CFM: Failure of Detection	
Middle-Level CFMs	**Detailed CFMs for Detection**
Fail to initiate detection	D1-1 Detection is not initiated (e.g., skip steps of procedures for detection, forget to check information, fail to realize the need to check information, no mental model for detection) D1-2 Wrong mental model for detection (e.g., incorrect planning on when, how, or what to detect) D1-3 Failure to prioritize information to be detected
Fail to select, identify, or attend to sources of information	D2-1 Fail to access the source of information D2-2 Attend to wrong source of information
Fail to perceive, recognize, or classify information	D3-1 Unable to perceive information D3-2 Key alarm not perceived D3-3 Key alarm incorrectly perceived D3-4 Fail to recognize that primary cue is not available or misleading D3-5 Cues not perceived D3-6 Cues misperceived (e.g., information incorrectly perceived; failure to perceive weak signals; reading errors; incorrectly interpret, organize, or classify information) D3-7 Fail to monitor status (e.g., information or parameters not monitored at proper frequency or for adequate period of time, failure to monitor all of the key parameters, and incorrectly perceiving the trend of a parameter)
Fail to verify the perceived information	D4-1 Fail to self-verify the perceived information against the detection criteria D4-2 Fail to peer-check the perceived information
Fail to communicate the acquired information	D5-1 The detected information not retained or incorrectly retained (e.g., wrong items marked, wrong recording, and wrong data entry) D5-2 The detected information not communicated or miscommunicated

Go to components of detection

Return to Basic set of CFMs

Understanding CFMs

High-Level CFM: Failure of Understanding	
Middle-Level CFMs	**Detailed CFMs for Understanding**
Fail to assess or select data	U1-1 Incomplete data selected (e.g., critical data dismissed, critical data omitted) U1-2 Incorrect or inappropriate data selected (e.g., failure to recognize the applicable data range or recognize that information is outdated)
Incorrect mental model	U2-1 No mental model exists for understanding the situation U2-2 Incorrect mental model selected U2-3 Failure to adapt the mental model (e.g., failure to recognize and adapt mismatched procedures)
Incorrect integration of data and mental model	U3-1 Incorrectly assess situation (e.g., situational awareness not maintained, and incorrect prediction of the system evolution or upcoming events) U3-2 Incorrectly diagnose problems (e.g., conflicts in data not resolved, underdiagnosis, failure to use guidance outside main procedure steps for diagnosis)
Fail to iterate the understanding	U4-1 Premature termination of data collection (e.g., not seeking additional data to reconcile gaps, discrepancies, or conflicts, or failing to revise the outcomes based on new data, mental models, or viewpoints U4-2 Failure to generate coherent team understanding (e.g., assessment or diagnosis not verified or confirmed by the team, and lack of confirmation and verification of the results)
Fail to communicate the outcome	U5-1 Outcomes of understanding miscommunicated or inadequately communicated

Go to components of understanding

Return to Basic set of CFMs

Decisionmaking CFMs

High-Level CFM: Failure of Decisionmaking	
Middle-Level CFMs	**Detailed CFMs for Decisionmaking**
Inappropriate decision model	DM1-1 Incorrect decision model or decisionmaking process (e.g., incorrect about who, how, or when to make decision, the decision model or process does not support the decision goal DM1-2 Incorrect decision criteria
Incorrect goals or priorities	DM2-1 Incorrect goal selected DM2-2 Unable to prioritize multiple conflicting goals
Data are under-represented	DM3-1 Critical information not selected or only partially selected (e.g., bias, undersampling of information) DM3-2 Selected information not appropriate or not applicable to the situation DM3-3 Misinterpretation or misuse of selected information
Incorrect judgment or planning	DM4-1 Misinterpret procedure DM4-2 Choose inappropriate strategy or options DM4-3 Incorrect or inadequate planning or developing solutions (e.g., plan wrong or infeasible responses, plan the right response actions at wrong times, fail to plan configuration changes when needed, plan wrong or infeasible configuration changes) DM4-4 Decide to interfere or override automatic or passive safety-critical systems that would lead to undesirable consequences
Failure to simulate or evaluate the decision/ strategy/plan	DM5-1 Unable to simulate or evaluate the decision's effects (e.g., fail to assess negative impacts or unable to evaluate the pros and cons) DM5-2 Incorrectly simulate or evaluate the decision (e.g., fail to evaluate the side effects or components, or fail to consider all key factors) DM5-3 Incorrect dynamic decisionmaking
Failure to communicate or authorize the decision	DM6-1 Decision incorrectly communicated DM6-2 Decision not authorized DM6-3 Decision delayed in authorization

Go to components of decisionmaking

Return to Basic set of CFMs

Action Execution CFMs

High-Level CFM: Failure of Action Execution	
Middle-Level CFMs	**Detailed CFMs for Action Execution**
Fail to assess action plan and criteria	E1-1 Action is not initiated E1-2 Incorrect interpretation of the action plan (e.g., wrong equipment/tool preparation or coordination) E1-3 Wrong action criteria E1-4 Delayed implementation of planned action E1-5 Incorrect addition of actions or action steps to manipulate safety systems outside action plans (e.g., error of commission)
Fail to develop or modify action scripts	E2-1 Fail to modify, adapt, or develop action scripts for a high-level action plan E2-2 Incorrectly modify or develop action scripts for the action plan
Fail to coordinate action implementation	E3-1 Fail to coordinate the action implementation (e.g., fail to coordinate team members, errors in personnel allocation) E3-2 Fail to initiate action E3-3 Fail to perform status checking required for initiating actions
Fail to perform the planned action	E4-1 Fail to follow procedures (e.g., skip steps in procedures) E4-2 Fail to execute simple action E4-3 Fail to execute complex action (e.g., execute a complex action with incorrect timing or sequence, execute actions that do not meet the entry conditions) E4-3A Fail to execute control actions E4-3B Fail to execute long-lasting actions E4-4 Fail to execute physically demanding actions E4-5 Fail to execute fine-motor actions
Fail to verify or adjust action	E5-1 Fail to adjust action by monitoring, measuring, and assessing outcomes E5-2 Fail to complete entire action scripts or procedures (e.g., omit steps after the action criteria are met) E5-3 Fail to record, report or communicate action status or outcomes

Go to components of action execution

Return to Basic set of CFMs

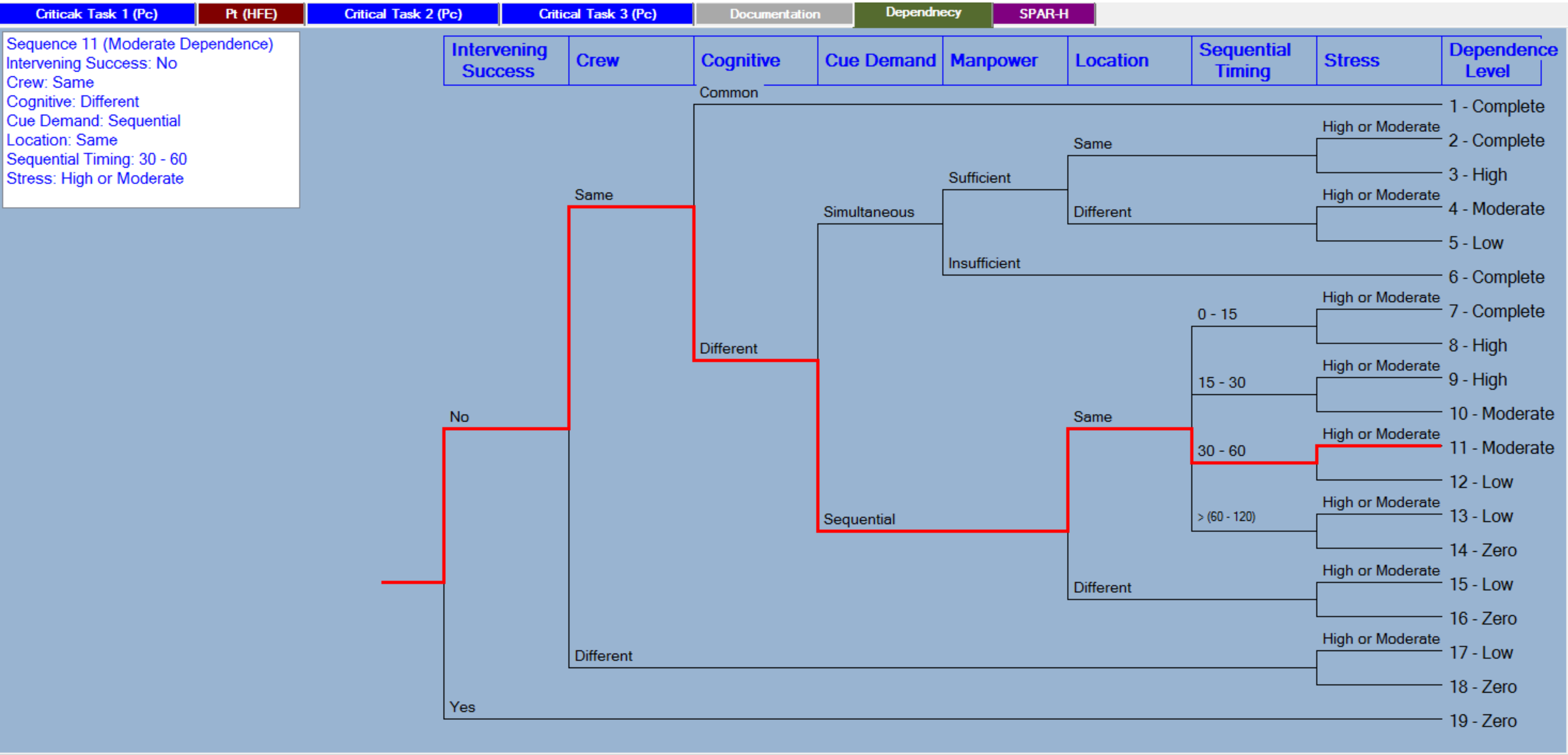
Teamwork CFMs

High-Level CFM: Failure of *Teamwork*	
Middle-Level CFMs	T1 Fail to establish or adapt the teamwork infrastructure
	T2 Fail to manage information
	T3 Fail to maintain shared situational awareness
	T4 Inappropriately manage resources
	T5 Fail to plan or make interteam decisions or generate commands
	T6 Fail to implement decisions or commands
	T7 Fail to control the implementation

Go to components of teamwork

Return to Basic set of CFMs

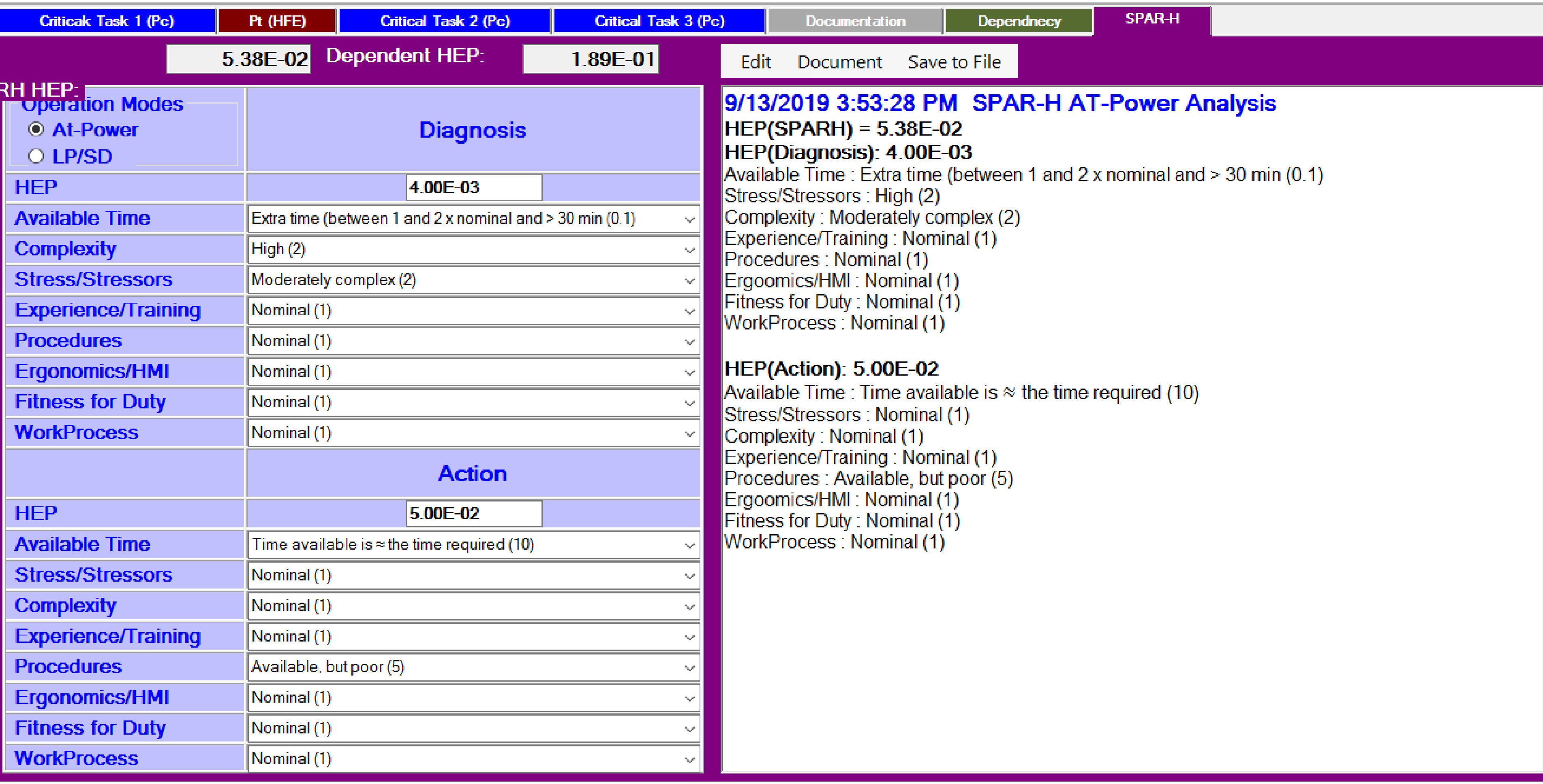
IDHEAS-ECA—Software Dependency (based on NUREG-1921)



Return to IDHEAS-ECA software objective and scope

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

NRC HRA Tool Box Implementation of SPAR-H



Return to IDHEAS-ECA software objective and scope

U.S.NRC
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