UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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RIC 2014

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26th ANNUAL REGULATORY INFORMATION CONFERENCE

COMMISSIONER GEORGE APOSTOLAKIS PLENARY

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TUESDAY

MARCH 11, 2014

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The Regulatory Information Conference convened in the Grand Ballroom of the Marriott Bethesda North, 5701 Marinelli Road, Rockville, Maryland, at 11:15 a.m., Eric Leeds, NRR Director, moderator.

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

(11:15 a.m.)

MR. LEEDS: If you'd bear with us a moment, we're going to change out. I'm going to invite Dr. Brian Sheron and Commissioner Apostolakis, to the stage.

Thank you.

(Pause.)

DR. SHERON: Okay. Well, good morning. I'm Brian Sheron, Director of the Office of Nuclear Regulatory Research. And it is my privilege to introduce Commissioner Apostolakis.

The Honorable George Apostolakis was sworn-in as a Commissioner of the United States Nuclear Regulatory Commission on April 23, 2010, to a term ending on June 30, 2014. Dr. Apostolakis has a distinguished career as an engineer, a professor, and a risk analyst.

Before joining the NRC, he was a professor of nuclear science and engineering and a professor of engineering systems at the Massachusetts Institute of Technology. Excuse me. He was also a member and former chairman of the statutory Advisory Committee, excuse me, on Reactor Safeguards at the NRC.

In 2007, Dr. Apostolakis was elected -- I'm sorry, I'm having a little bit of trouble talking right now, George. Why don't you go ahead. I'm sorry.

(Applause.)

COMMISSIONER APOSTOLAKIS: Thank you, Brian.

If an interpretive dance --

(Laughter.)

-- can help this agency accept the recommendations of my favorite report, I am all for it. And I will follow it with a Greek dance.

(Laughter, followed by applause.)

Not now.

The title of this speech -- over the years, I have seen studies that take past incidents, past accidents of nuclear reactors, and through some statistical analysis they produce maybe the frequency of core damage or the frequency of releases. But it is really the core damage events that are usually of interest.

So I decided with some of my friends, the staff whom I will name later, to take a look and see what is the issue there, what do we learn from these analyses and what is the state of knowledge regarding the frequency of core damage.

Now, before I complete -- well, this is it, I suppose. I think I need to explain what I mean by "global statistical analysis." We struggled with trying to find a better terminology. By that I mean the estimation of core damage frequency or large early release frequency using accidents that happened at a high level, at the plant level, like core damage events.

PRA also uses statistics but at a much lower level, at the component level. So that is the big difference -- that in a PRA we use analysis to identify accident sequences, and so on, and then we use statistical information at the low level of components and human performance sometimes, whereas in the global analysis it is at a very high level, so many core damage events worldwide, divide by the number of years, and you get the estimate.

I think it is important to understand how decisions are made, and I believe the Chairman alluded to this earlier today talking about the kinds of knowledge that we have to have when we make decisions. Regulatory decisionmaking is based on what we know when we make the decision, on the current state of knowledge. It does not involve any prophecies as to what is going to happen in the future. It is what we know now.

And what is it that shapes this current state of knowledge? It's the design of the facilities. It's the operation and the regulations. And we are informing the state of knowledge by science, and the Chairman talked about the earth sciences earlier this morning; engineering, the design and operation of the facilities; and operating experience, especially including past incidents.

So it is important to bear in mind that probabilistic risk assessment does not predict anything. We are not trying to predict the future. We are evaluating possible evolutions of accidents based on what we know now. We don't claim we are trying to predict what is going to happen and enumerate future possibilities, so that the decisionmakers will have a better picture of what may happen and make better decisions.

So this is very important to bear in mind. Nobody is trying to predict what will happen in the future. And sometimes you hear, you know, did you predict Three Mile Island, and so on? Well, there are thousands, tens of thousands of sequences that are in a PRA. One of them may predict what happened. There will be thousands of others that didn't. So these are evaluations or assessments of possible evolutions of accidents.

Now, probability is not always an easy concept to use, and there is a nice story here. If you live to be a hundred, rejoice. Why? Because very few people die past that age.

(Laughter.)

Fundamental misunderstanding of the concept of conditional probability in the first statement, and unconditional probability in the second. Now, that's not my joke. It was told by a well-known American comedian, George Burns.

(Laughter.)

Now, let's talk a little bit about how these global estimates -- remember, at the plant level -- are produced. In order to be able to say something about the frequency of core damage of current reactors, and you want to use statistical analysis, you have to make sure that your statistical sample consists of reactors, plants, that are what is called in probability theory "exchange of events."

In other words, is a current reactor of the same design, of the same operation procedures, and under the same regulatory requirements, as a reactor back in the '70s? Back in the '80s? Is it the same as -- under the same -- operating under the same conditions as the Daiichi plants in Japan were operating?

This is a fundamental assumption that we cannot ignore when we sample -- when we create a statistical sample. So this exchangeability you will hear about throughout this speech.

So when people use this formula, dividing the number of incidents by the number of years, there is this assumption behind it that the incidents of reactors -- or that the incidence you are including in your sample happened at reactors that are -- that's called nominally identical with current reactors, at least in this country. And it turns out that this is not quite true, as we will see in a few minutes.

Now, the reason -- I think it's important to bear in mind this principle of exchangeability or assumption of exchangeability. And I think there is another example that really brings the message home.

Okay. Professor Wilson of Harvard published a book a number of years back where he listed the riskiest professions in the United States. And he stated that the riskiest profession is being President, that the probability of death of a President is .019 per year, followed by firefighters, a factor of 48 lower, and police officers, a factor of 59 lower.

Now, he didn't comment on it, but I thought that was strange. So I tried to find out how that number was derived. Well, as most people in this audience know, there have been four assassinations going back to 1865. So the number of years of the republic until the time that this calculation was done was 211. So if I use the formula I showed you a minute ago, divide for by 211, you get .019.

So the question is, then, is this really? Yah. Is .019 the risk of a modern President? I don't believe that. I don't believe that it is riskier than being a firefighter or a policeman. So if you think about it now, the answer is no, because what happened in 1865, 1881, and so on, the presidencies at that time are not exchangeable with the modern presidency.

The protections are higher. You might argue that the ways of attacking the President are also more sophisticated these days. But the point is that the whole structure of the presidency and the protections that various federal agencies provide are very different from those of 1865.

So this number is not valid. It was derived under the false assumption of exchangeability.

Now, even if we accept that Three Mile Island is not exchangeable with modern reactors, it would be nice to know how to do the analysis right. So if you take as statistical evidence one core damage event back in Three Mile Island, over 38 -- or approximately 3,800 reactor-years of experience, and you use what is known as Bayes Theorem, you get this uncertainty distribution which ranges from something like eight ten to the minus -- ten to the minus is important -- four, all the way down to ten to the minus six.

Now, this is the uncertainty that you would have derived if you had made the false assumption that Three Mile Island is exchangeable with modern reactors.

So you might ask, why do I say that? Well, look at the changes that have been implemented and continue to be implemented after Three Mile Island. There was a large number, according to some people a very large number, of regulatory changes after Three Mile Island. And right now, as it was pointed out by earlier speakers, there are major changes in our regulatory structure because of Fukushima.

The Institute of Nuclear Power Operations was established after Three Mile Island. That has had an impact on the way the facilities are operated. The NRC established the Individual Plant Examination Program and the Individual Plant Examination for External Events Program, where the licensees identified vulnerabilities and they took action to fix them.

And a major step forward is also the FLEX

Program that the industry is proposing and implementing right now after Fukushima. So these are a few of the changes that really invalidate the assumption of exchangeability.

Now, what are the numbers that reasonably recent PRAs are telling us about core damage? We have plotted here the point estimates that have been reported. These are not uncertainty estimates, unlike what I showed earlier. The curve earlier was the uncertainty distribution. This is just the point estimates of reactors as they have been reported, and they range from ten to the minus four again all the way down to ten to the minus seven, six.

The analysis is based on submissions by 61 units, and 90 percent of these submissions occurred after 2005. So they are fairly recent results.

If we move on to the large early release frequency, the statistical analysis is even more problematic, the reason being that there have been zero large releases in the United States. And, again, if you take zero with 3,800 reactor-years, if you divide of course you get zero, but if you go Bayes Theorem you get a distribution that you see here. And the numbers range from ten to the minus four to ten to the minus nine, a tremendous range of uncertainty. All this says is that this range is consistent with seeing zero events in 3,800 years.

Now, the distribution of the LERF estimates from PRAs, again, this is based on 55 units, 90 percent after 2005. It is a much -- it is a smaller range, ten to the minus five all the way down to ten to the minus six.

And, again, the statistical analysis not widely inconsistent with the PRA estimates, although, again, the statistical analysis is questionable.

So to reinforce -- well, first of all, I have already said that exchangeability doesn't apply, but the question then is, so all of these accidents in the past are useless? Of course not. Of course not. We are learning a lot from each accident or incident, and, again, this morning previous speakers talked about the changes that were implemented after Fukushima.

So this is a continuous learning process. In other words, the value of the experience with the accidents is the qualitative insights, what happened, trying to understand why it happened, what can we do so that it will not happen again. So here is a list of lessons learned and actions taken after Three Mile Island auxiliary -- a lot of auxiliary feedwater systems at the time before the accident were only manually actuated. After the accident, all of them converted to automatic actuation.

And there is a number of things here -- the emergency plant regulations were upgraded. There were requirements related to hydrogen control. Operator training was improved. Staffing requirements and the program on fitness for duty was established. If you look at Fukushima, we -- as it was mentioned earlier, the Commission has issued three orders that are being implemented right now.

So we require the mitigation strategies for beyond design basis accidents. We are studying very vigorously the issue of multi-unit accidents, although in the United States there is only a few sites that have three units. It was mentioned earlier also about the severe accident capable containment events for BWRs with Mark I and II containments and -- well, it's clear what we've done.

But it's important also to bear in mind that we are not learning only from experience, from our operating experience. Analysis is contributing a lot to our state of knowledge. Going back to the mid-'70s, the first probabilistic risk assessment, the reactor safety study, pointed out the importance of the small loss of coolant accident because at that time everybody was focusing on the large loss of coolant accident, the significance of human errors and support systems.

That study was followed by two industry-sponsored PRAs in the early '80s -- those for Zion and Indian Point -- which for the first time identified the significance of fires and earthquakes to nuclear power plant risk.

People were aware of the seismic risk and fires, and so on. There was a fire protection program before that. But, really, the focus was on the large break of a pipe, and it was for the very first time, interestingly enough, by a study sponsored by the industry that these two major contributors to risk were identified, and this finding has been confirmed time and time again in the last 30 years.

In the '80s, we received word from France that our colleagues there had done a PRA for lower power and shutdown modes, and they found that the risk from those modes was comparable to the risk from power operations. That was a surprise to people, at least in this country, because being shutdown was considered a safe mode. And that changed the way we looked at low power and shutdown. That did not come about because of operating experience. Somebody sat down and did a PRA and identified it.

And the last point I want to make here is that another finding over the numerous PRAs that have been done over the years for plants demonstrate that the risk is plant-specific. And a good example is, again, going back to the Indian Point studies of 30 years ago, where Indian Point 2 and 3 are called sister units, yet the dominant contributors are different.

At that time, the dominant contributor to latent health effects was fire in one of the units. In the other one, it was earthquakes.

So what is the message here? Global statistical analysis requires the assumption that, at least if you want to do it for the United States, that Three Mile Island 2 is exchangeable with current reactors. It is not. It is the qualitative insights from operational experience that are most useful, of course in regulatory decisionmaking but also for the industry.

It is not the frequency of core damage and release that is derived from that experience. And the PRA results represent a current design, operation, and regulation.

So regulatory decisionmaking, as I said earlier, must be based on the best current state of knowledge, and that state of knowledge includes -- refers to the design, operation, and regulation of the facilities. It is informed by science, engineering, and operating experience, including those past accidents. And, unfortunately, the need for the assumption of exchangeability between past, present -- past and present reactors or future reactors invalidates the global statistical estimates.

And another message that I would like you to leave with is that PRAs do not predict anything. They evaluate and assess potential accident scenarios, so that better decisions will be made.

So Mark Twain said something that is consistent with what I just told you: facts are stubborn things, but statistics are pliable.

And I want to finish by expressing my appreciation to Nathan Siu of the Office of Nuclear Regulatory Research for helping a lot with this study and the calculations, and Roger Davis, Nanette Gilles, and Belkys Sosa of my staff for providing comments that were occasionally helpful.

(Laughter.)

And with that --

(Applause.)

DR. SHERON: Okay. We have a number of questions. First one, it's on multi-unit PRAs. What is your and the NRC's opinion on multi-unit PRAs? Should they be done as a regulatory requirement?

COMMISSIONER APOSTOLAKIS: Perhaps.

(Laughter.)

DR. SHERON: Would you like to elaborate?

COMMISSIONER APOSTOLAKIS: No.

(Laughter.)

DR. SHERON: Moving on to the next question.

(Laughter.)

What is the most important lesson from the Fukushima accident?

COMMISSIONER APOSTOLAKIS: Hmm. Being prepared for a beyond design basis accident. You really have to be prepared for those. Two people agree with me.

(Laughter.)

Yes. Paying more attention to beyond design basis accident. I just used eight words in a sentence, but I really think I had to do it.

(Laughter.)

DR. SHERON: The next one is, Diablo Canyon is following the South Texas Project with risk-managed tech specs, risk-informed resolution for GSI-191, despite that it has -- being a low fiber plant, and soon graded QA or 10 CFR 50.69. These tools help us to focus on what is most important and operate safely and cost effectively. What do you think -- why do you think very few plants have taken full advantage of these tools, especially 50.69?

COMMISSIONER APOSTOLAKIS: Wow. I don't know.

(Laughter.)

I don't know.

DR. SHERON: Do you agree with the statements that some parts of the nuclear industry are raising with regards to the alleged failure of risk-informed regulatory activities? Has PRA failed us, or have we failed to implement PRA correctly?

COMMISSIONER APOSTOLAKIS: I don't know why you are asking a question about the PRA. Has the traditional deterministic system failed us as well? It's a matter of state of knowledge. It is not a matter of PRA predicting or failing or defense-in-depth failing. It is what we know at the time. Nobody predicted that we would be under station blackout for that long, not the defense-in-depth guys, not the PRA guys. So it's a matter of state of knowledge, and let's stop doing that. Did your PRA do this, or did your PRA do that? That's stupid.

It's a tool that contributes to the current state of knowledge. And, you know, if there are failures in the PRA, there are failures on the other side, too. You make me talk too much today.

(Laughter.)

DR. SHERON: Okay. The idea that forcing all power plants staying idle until all backfitting requirements are completely fulfilled, which is the case in Japan, seems not to be reasonable. What is your view regarding appropriate backfitting in the nuclear regulations?

COMMISSIONER APOSTOLAKIS: Here or in Japan? In Japan. Well, in Japan of course after such a major accident, there is a situation that is very different from what we have here or in other countries. And I don't want to comment about what is happening there, but here I don't think we are forcing anybody to stay shutdown while backfits are taking place.

DR. SHERON: How does reactor life extension and component aging factor into the chances of a core failure? Davis-Besse was an early warning.

COMMISSIONER APOSTOLAKIS: Well, yes, it's an important issue. Unfortunately, we cannot include it in the PRAs. It is outside. So we have all of these aging management programs that both we and the industry have implemented. And it is an important issue, especially as a plant ages -- plants age.

DR. SHERON: What are your feelings about a full term?

(Laughter.)

COMMISSIONER APOSTOLAKIS: I have no feelings.

DR. SHERON: I just read the questions.

COMMISSIONER APOSTOLAKIS: No feelings. It is not up to me to decide.

DR. SHERON: What is your expectation on the result of the rulemaking on containment venting and the prevention of long-term land contamination?

COMMISSIONER APOSTOLAKIS: What was the first word? What is my what?

DR. SHERON: What is your expectation on the result of the rulemaking on containment venting and the prevention of long-term land contamination?

COMMISSIONER APOSTOLAKIS: I would rather not comment on that.

DR. SHERON: Let's see. The question of exchangeability is applicable for PRA and component level data. How does this impact PRA uncertainties and the decisionmaking process using PRA?

COMMISSIONER APOSTOLAKIS: Well, as I said, at the lower level -- I mean, if you look at the pump or a valve -- it is easier to make that assumption and collect statistical evidence from a number of plants around the country. There are some differences, but the similarities are greater than the differences. So exchangeability applies at that level.

As you move higher up, then the issues of design, the issue of operating practices, and so on, become much more important, so exchangeability fails.

Now, how it affects decisionmaking I don't know. I mean, it affects the calculations that shape your state of knowledge. So that way I guess it affects decisionmaking as well.

Are there many more questions?

(Laughter.)

DR. SHERON: There's a lot of questions. What do you believe the largest challenge is to use risk insights in defense-in-depth from a culture standpoint? How do you think we can best overcome that challenge?

COMMISSIONER APOSTOLAKIS: Oh, that's a different culture.

DR. SHERON: It just says "culture."

COMMISSIONER APOSTOLAKIS: Overcome what?

DR. SHERON: What do you believe the largest challenge is to use risk insights --

COMMISSIONER APOSTOLAKIS: Oh. Oh, oh, oh.

DR. SHERON: -- in defense-in-depth from a culture standpoint?

COMMISSIONER APOSTOLAKIS: Well, there is -- I mean, the agency and the industry together have done very well using the deterministic -- so-called deterministic -- it's not deterministic, it's so-called deterministic regulatory framework. And PRAs were the new thing that came in the '70s and '80s, and as such was always considered as a new approach. And I think there is a number of reasons why people have been reluctant to embrace it.

One is by some -- in some circles it was viewed as a replacement of the traditional defense-in-depth approach, which is not true at all. I think fundamentally, though, engineers in this country are not trained in probability. That's a general but I think true statement. And there are in mechanical engineering -- in electrical engineering departments, you will find courses in probability and statistics.

But by and large, in mechanical engineering, in nuclear engineering, you don't. And thinking in probabilistic terms is not easy. And if you are used to doing certain things and say, "Gee, you know, I open a table and it tells me if, then, do this," then it's not my responsible; it's the table's responsibility.

Now, here come the PRA guys and say, "Well, you have to understand probability. There are uncertainties. You have to take an initiative and do this, do that." And people just don't like that, and you have to overcome that reluctance.

Many times you hear, "Well, I don't make those decisions. That's above my pay scale." Well, it's not anymore. You really have to think in terms of uncertainty and take action.

So if you are trained to think in terms of tables and manuals, it is very difficult to switch to that kind of thinking.

DR. SHERON: Based on your statement that exchangeability is of little value, what are your thoughts on the likelihood of plant operation beyond 60 years? What is the biggest obstacle to long-term operations?

COMMISSIONER APOSTOLAKIS: There is a paper in front of the Commission now on the issue of life beyond 60. I'll tell you, life beyond 60 is fine as far as I'm concerned.

(Laughter.)

But for power plants, maybe it is best not to comment. The Commission will make a decision in the near future, so --

DR. SHERON: Given the recent decommissioning announcements, do you anticipate as interest in nuclear engineering at the university level -- oh, I'm sorry, do you anticipate less interest in nuclear engineering at the university level? What can NRC do to address this?

COMMISSIONER APOSTOLAKIS: One thing that always surprised me in my previous life is that you have young people making decisions about their career which will be for 40, 45 years, based on what they heard last week. There doesn't seem to be a very long-term thinking there. In fact, we did see at MIT a difference in the applications for graduate school right after President Bush said that we need nuclear power. So that affected I guess young guys in their choice of profession.

Yes. If the news keeps being bad, I think it's going to affect the number of applications. People are influenced by that. I think, you know, am I entering an industry that will not exist 10 years from now? So, unfortunately, it does have an impact, as it should actually.

DR. SHERON: What is your assessment of the recent event at the WIPP, the Waste Isolation Pilot Project? Risk studies say it's one in 10,000 -- it is a one in 10,000-year event.

COMMISSIONER APOSTOLAKIS: I don't know. I don't know where you got that number, and I haven't really investigated that incident.

DR. SHERON: Okay.

COMMISSIONER APOSTOLAKIS: By the way, a lot of times you hear incredible numbers. And how many times have you heard that the Fukushima accident was unthinkable, of incredibly low probability? None of this is true. None.

The probabilities were not unthinkable. And if we had done it in this country on the basis of that probability, we would have shut it down. Ten to the minus four, I hear even higher numbers, apocryphal numbers. So it was not a highly improbable event.

So I don't know where the ten to the minus four came for the WIPP incident. A lot of this stuff reminds me of what the Chairman said about the guy with the Geiger on the west coast of the United States and saying, you know, "Look, I'm getting very high measurements."

DR. SHERON: If we have the same risk while operating as when we are shut down, why do tech specs require a shutdown when equipment fails?

(Laughter.)

COMMISSIONER APOSTOLAKIS: That is a remnant of the deterministic system.

(Laughter.)

DR. SHERON: Let's see. I like your explanation of exchangeability. But in a similar way we talked after Chernobyl, but Fukushima has happened. What have we missed? What are we missing now before the next major one?

COMMISSIONER APOSTOLAKIS: Well, that's a good question, but I'm not sure there is a good answer. In my view, when we have identified an issue, either -- for whatever reason, so science or engineering or experiments, PRAs, as a community we are pretty good at taking care of it. Pretty good at taking care of it, either through new regulations, through new requirements, or new equipment like FLEX, and so on.

It is when we have not identified the issue that bad things happen. And, in other words, this is an issue of incompleteness of our state of knowledge. And that incompleteness can be in the PRA; it can be in the traditional defense-in-depth approach. It is a matter of what we know.

So is there anything we don't know about lightwater reactors? I don't know. I think it's a mature technology, but there are always surprises, perhaps from external events. So that is really what should worry us more. What are the holes in our state of knowledge? Because once we have identified an issue, I have no problem. I think we are pretty good at taking care of that.

DR. SHERON: Load-following is a current reality. Has the risk profile for plants been evaluated for continued operation at reduced power?

COMMISSIONER APOSTOLAKIS: I don't think it has.

DR. SHERON: Let's see. I think this is, what statistics -- or it's not really clear. What statistics should be used for defense-in-depth analysis for non-reactor licensing activities?

COMMISSIONER APOSTOLAKIS: I don't know.

(Laughter.)

That's an easy way out.

DR. SHERON: Let's see. And I think the last one here is -- there you go.

(Laughter.)

Considering the bias of the PRA, why do regulators give so much importance to PRA as compared to deterministic safety analyses?

COMMISSIONER APOSTOLAKIS: Whoa. What is what? What?

DR. SHERON: Considering the bias of the PRA, why do regulators give so much importance to PRA as compared to deterministic safety analyses?

COMMISSIONER APOSTOLAKIS: This is one of the most wrong statements I have ever heard.

(Laughter.)

There is bias in PRA. There is bias in the deterministic world. The regulators give so much more importance to PRA? That's news to me, and I have been a regulator for years. We don't. I think the traditional system is well entrenched, and anybody who thinks that PRA takes precedence over that is mistaken.

And on that happy note, thank you very much.

(Applause.)

MR. LEEDS: Okay. I think this ends the morning session. So thank you very much.

(Whereupon, at 11:49 a.m., the proceedings in the foregoing matter were concluded.)