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UNITED STATES NUCLEAR REGULATORY COMMISSION'S

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

February 5, 2008

The contents of this transcript of the proceeding of the United States Nuclear Regulatory Commission Advisory Committee on Reactor Safeguards, taken on February 5, 2008, as reported herein, is a record of the discussions recorded at the meeting held on the above date.

This transcript has not been reviewed, corrected and edited and it may contain inaccuracies.

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARD

(ACRS)

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SAFETY RESEARCH PROGRAM SUBCOMMITTEE

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TUESDAY,

FEBRUARY 5, 2008

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ROCKVILLE, MARYLAND

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

COMMITTEE MEMBERS PRESENT:

DANA A. POWERS, Chairman

MARIO V. BONACA, Member

J. SAM ARMIJO, Member

SAID ABDEL-KHALIK, Member

DENNIS C. BLEY, Member

NRC STAFF PRESENT:

HOSSEIN NOURBAKSH

ASHOK THADANI

ISABELLE SCHOENFELD

ALSO PRESENT:

CHRISTER VIKTORSSEN

MICHEL SCHWARZ

JACQUES REPUSSARD

CARLO VITANZA

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

9:38 a.m.

CHAIR POWERS: Let's come into session here. This is a meeting of the ACRS Subcommittee on Safety Research Program. I'm Dana Powers. I'll be chairing the meeting. The ACRS Members that are in attendance include Said Abdel-Khalik, Sam Armijo, Dennis Bley, Mario Bonaca. We also have Ashok Thadani, who will be leading us through much of the meeting today.

The purpose of the meeting is to discuss the scope of long-term research that the Agency needs to consider. As I have indicated to some of you, we are at the cusp of a flowering of use of nuclear energy in this country and perhaps in the world. And we need to think seriously about the issues of how do we direct our reactor safety research. And we're looking for guidance from our distinguished visitors in that area.

The Subcommittee will gather information, analyze relevant issues and facts and formulate proposed positions and actions, as appropriate, for deliberation by the Full Committee. Dr. Hossein Nourbaksh is the designated federal official for the meeting.

A transcript of the meeting is being kept and will be made available, as stated in the Federal Register notice. It is requested the speakers first identify themselves, use one of the microphones and speak with sufficient clarity and volume, so that they can be readily heard.

We have received no written comments or requests for time to make oral statements from the public regarding today's meeting.

What I propose we do is now turn to Ashok Thadani, who will lay out some of the background on this meeting and provide some guidance as we go through the discussions. Before I do that, I should ask are there any opening statements that Members would care to make? Seeing none, Ashok, could you start us off on this?

MR. THADANI: Thank you very much, Dana. Good morning. First, let me thank all of you for agreeing to participate in this discussion. It's, obviously, a very important subject matter. The Commission has asked the Advisory Committee for their recommendations in terms of areas where this Agency should conduct some long-term research.

As one part of seeking views from others, there was a meeting held on December 18th where there were various members of the industry represented by the Nuclear Energy Institute, Department of Energy, NRC staff who provided their views on what they thought was important in terms of long-term research.

We also had Dr. John Ahearne participating in that panel. You may know that John Ahearne was the previous chairman of the Nuclear Regulatory Commission and has been very active in terms of long-term thinking, all aspects of nuclear power. And he provided some very interesting insights. One that I thought was important he pointed out was he said remember the Agency's credibility is very, very critical and you must keep in mind public -- and public includes some skeptics and you have to make sure that you have good sound basis for your decision making.

Sometimes we get so caught up in our discussions, we tend to forget that part.

CHAIR POWERS: I'm delighted that you -- because that certainly was the point --

MR. THADANI: Yes.

CHAIR POWERS: -- that drove home to me was his emphasis that as we move to more complicated advanced reactors using a great deal of technical sophistication, we still have to demonstrate to the public that we have adequate technical sophistication to protect their interests. And not only protect their interests, but persuade them that we're protecting their interests.

MR. THADANI: Yes. And that's how you develop trust, also.

CHAIR POWERS: That's right.

MR. THADANI: So this was -- besides he identified several areas of research, but I think this was probably the key statement that we should keep in mind. And today, obviously, we are particularly appreciative of your participating in this discussion, as everything is pretty much global now. Nuclear safety is and should be a global consideration. And I think we can really benefit from your thinking in terms of areas you think that are important for long-term consideration.

We had also invited India. As you all know, India has a very strong research program. They are not able to attend today, but they sent us a brief overview of their long-term research program. And I am assuming that everyone has copies of what we received from India.

Hossein, do all the people have copies? Make sure.

And if you have any comments on what they are suggesting, feel free and this afternoon we will have an opportunity for that. Thank you. So what we are going to do is I will go through, as Dennis said, a brief background in terms of objectives and assumptions that the Committee is considering for this study. And after my brief overview, we will then go through your presentations and I would certainly recommend presentations on the on the order of half an hour to 45 minutes to be consistent with the schedule.

And then in the afternoon, we will have more of an opportunity for discussion on what I would propose is to pick a specific topic and to have sort of comment discussion and see where we end up.

With that, let's see, can I have the first chart, please?

MR. NOURBAKSH: Oh, do you want your presentation?

MR. THADANI: Yes, the objectives.

MR. NOURBAKSH: I can do that.

MR. THADANI: That would be helpful.

MR. NOURBAKSH: Okay.

MR. THADANI: Do I need to sit there?

MR. NOURBAKSH: I can go ahead and --

MR. THADANI: Anyway, I'm happy to do it.

Well, let me just go ahead and read to you the objectives and the reasons.

Should a portion of NRC research activities be devoted to the development of the technical infrastructure that may be needed in 10 to 20 year time frame and to the development of user friendly tools? That basically is because the computing technology has advanced so much that you can do wonders nowadays with the -- at your desk.

So the two parts in this particular objective are, first is, infrastructure, which is technical expertise, having good analysis tools and having access to some facilities to keep up with the advances, if you will. And the second part is more in terms of efficiency and effectiveness of conducting business, regulatory business, if you will.

In order to be timely, some of the decisions may have to be made in let's say 10 years from now, but if it takes a decade or so to develop infrastructure, one has to start now. So the thinking has to be done in a manner that the results are available in a timely way for decision making process.

And of course, taking advantage of the best science and technology in terms of having the right tools. And Dana touched on this earlier, in making maximum use of realistic assessment, realistic because if one can understand what realism is, then one can perhaps have a better definition of what margins, in fact, are there and how to maintain those margins. So understanding what realism is, often times requires more information and not less.

The second objective is what is it? If you agree with the first part, this is sort of a subset, if you will, then what should be the focus of the Agency research or in terms of what we're talking about today, global considerations of long-term research? And some issues are should that research be focused on light water reactors?

A decade from now, we would expect quite a number of plants operating with passive safety systems. We have very limited database for passive safety systems. So what is it that one should be considering, if anything, to be able to address potential long-term needs with plants which employ passive systems?

One shouldn't be surprised to see, once these plants start to operate, some things happening, which would require a good understanding of why. Then the next part is to do with non-light water reactors, such as gas-cooled reactors or metal-cooled reactors.

Is there a need to develop technical infrastructure for these designs? And if so, are there some areas that deserve earlier attention than perhaps other?

Another aspect is, and I sort of briefly mentioned it, there are lots and lots of advances in technology. The ability to predict failures is much better than it used to be, both for, for example, pipes and cables and things of that sort. Technology has really, really advanced quite a bit to be able to predict the performance of hardware systems.

Now, to what extent these advanced technologies may be applied to existing plants and future plants is not necessarily clear, but nevertheless, you employ these technologies. You are also likely to see some potential new failure modes and that would be the area that the safety authority would have to understand. Are there some areas here that the regulatory authority should be considering? Those are the key objectives.

And I'm going to what are some of the assumptions that have been made, that have not been made, that are on the table, because we will come back and seek your views on them.

Certainly, in the U.S. and I expect worldwide, the nuclear power is going to grow and could be considerably more plants operating, one would expect in the next decade or so. Again, it's also clear, based at least on what we are seeing here in the U.S., that light water reactor technology will be dominant over the next decade, several decades.

On the other hand, there is considerable interest to try and move forward on non-light water reactor technologies. And the Agency may have to be-- may have to make certain decisions over the next decade or two in non-light water reactor technologies in terms of safety requirements and so on and so forth. So there may be some need in this are to consider some focused initiatives.

The next assumption is that it's pretty certain that the industry is going to continue to look for greater economies in operation and they will continue to look at all the existing margins and try and increase productivity with the, you know, minimum costs, so to speak. So one would expect many submittals from the industry that would likely utilize even more sophisticated analytical capability to perhaps reduce some of the existing margins.

This would then post challenges for the regulatory authorities as well to be able to pass judgement on the appropriateness of those reductions and margins.

And Assumption No. 3 is why we are all here today. It's absolutely a global issue. Nuclear safety is a global matter. Plants operating are of pretty much similar designs. And collective focus on important safety matters, obviously, is important. This is even critical, more critical, because as the demand work load increases, it's not clear, certainly at the NRC, that the growth in staff will be commensurate with the growth in nuclear power and the challenges of the staff we will be facing. So that's yet another reason to go for efficiency effectiveness as well as global cooperation.

Assumption No. 4, we lost.

CHAIR POWERS: While we are discovering Assumption No. 4, I think we need to maybe just elaborate a little bit on this international aspect of reactor safety and the issue of productivity, because I think that's the one it's going to pinch as we see support in vendor functions become international, can we, in fact, inspect them the way we have in the past? And at what point do we come along and say well, they get inspected in India.

MR. THADANI: Um-hum.

CHAIR POWERS: By an Indian authority, at what point do you say well, they probably did a good enough job?

MR. THADANI: Yeah.

CHAIR POWERS: I mean, that's the issue that we have to come to grips with, because it's not clear that you can do the same as we have done in the past.

MR. THADANI: Yeah. This is -- actually, that's a very critical issue and this is one of the elements of the Multinational Design Evaluation Program, also. And there has always been this question if research is conducted in French, and even assume that certain U.S. was not involved and that information is available, why should U.S. then repeat, conduct similar type of research?

So increased cooperation globally, more confidence in work done other places and willingness to accept the results is -- certainly in my own view, is this is going to become more and more almost a normal way of doing business down the road. And that's one of the objectives at the Multinational Design Evaluation Program also, Phase 1, certainly France is participating in that, as is Finland and the U.S.

And under Phase 2, there are 10 countries involved right now. And but we will see where it ends up, but that's certainly the intention of the program.

Going to the fourth assumption, this is driven largely by what we see here at the NRC. And it may well be applicable to some other countries, and I suspect it is not applicable to some countries. For example, I'm not sure this is applicable to countries like India and France and so on.

But here, when we look at the demographics, it's clear that the experience-base is significantly reduced and reducing at some rate as we go forward. As Dana talked about, the nuclear renaissance taking place, there's also demand for whatever knowledge is out there all across, not just the regulatory side, but the industry.

So it appears, certainly, that the available capability may be reduced down the road, which I guess in a way sort of adds to what Dana said earlier. The importance of having tools available to staff are more effective and efficient regulatory reviews. These are the basic assumptions. But the objectives, these are the basic assumptions for this study.

We are certainly very interested in your views and suggestions for areas you think are appropriate, not just for NRC, but in a more global sense to be undertaken and then maybe perhaps in some sort of cooperative fashion.

With that, I will stop. Obviously, these are the questions that we are interested in hearing from you about. Unless you have questions for me, I would recommend we get started and Jacques Repussard from IRSN. Jacques, if you will begin?

MR. REPUSSARD: Okay. My name is Jacques Repussard. I'm the Director General of IRSN, the French Institute for Radiation Protection and Nuclear Safety. Before going on -- going to the presentation as such, maybe not everybody here in this room is not familiar with the French Nuclear Safety Organization, so just a few words.

The IRSN is a public body, which -- the mission of which is to provide independent research and expertise in support to public policies in nuclear safety, security and radiation protection. This affects the whole theme of user ionizing radiation, whether for electronuclear power, whether for military purposes, means the nuclear ships and the weapons, and also the medical, another various industrial use.

So any time you use radioactive or ionizing radiation sources, you would find a mission of the IRSN to support public policies and the safety authority. So the IRSN has no regulatory power. We are a scientific body in an advisory role and, obviously, research.

The way our legal system is organized is that the operators are responsible for the safety of their installation and nuclear reactors, for example. Obviously, they need a license to operate. And this is given by the government or delegated organizations, as likely the ASN, which is the Nuclear Safety Authority, which is a similar body in its role to NRC as a regulating authority reporting to the parliament.

There is also, since 2006, a formal role to be played by stakeholders which are organized around each nuclear site. We have a committee for information and these people in there, which represent the stakeholders, local and national stakeholders, have the right to ask questions, have the right to access all documentation from the authority from the operators.

And as IRSN, we are providing services to these various people. Basically, when an operator provides a safety file to create a new reactor or to make some amendments or modifications, they submit that safety file to the authority and the authority asks us for a critical review. This critical review is then -- goes to a body equivalent to the ACRS, but it is also questioned by the -- at the local level, if it's a local decision. And finally, the decision is made.

The IRSN is 1,700 people strong with about 1,000 scientists, engineers, about 400 million Euro dollar budget and, of course, we are very much involved in international affairs, because, as Ashok said, nuclear safety is a global issue now.

So to go on with the presentation, this is the summary of what I would like to tell you. Also, on behalf of Michel Schwarz, who helped me prepare this presentation with many -- a lot of inputs from the various departments in our organization.

First, to go back to the key factors and the main assumptions. As seen from our French window, second time -- second element, what do we see as -- for ourselves long-term reactor safety research objectives and priorities covering these various four key items?

This is important for us, not only because you are asking us these questions, but the government, as you know, in France we have started to merge in the next phase of nuclear industry. And the government has reaffirmed the strategic importance. I recall the words of the minister of safety research. This was in a committee meeting. The government was minister presence in last November and they emphasized the research minister and the minister for environment emphasized the strategic importance of safety, nuclear safety research, and asked us to elaborate a long-term research plan to be proposed to our board by next summer.

So this is timely, because you asked these questions. These are issues which I have yet to see that these issues are also on the agenda here in Washington. And finally, of course, some reflects about the economy of the system, because you can't do research without resources, human and infrastructures, and without money.

So key factors and assumptions, four points. National electronuclear policy and technology, societal and environmental evolutions, progress of science, which affects what can be done or not done in terms of nuclear research, and, of course, also, the economical aspects. So these are the key assumptions for France covering between 10 and 20 years, depending on the items.

First, like here, we anticipate that

within the next 20 years we will still have pressure water reactors mainly, utilities. We will, obviously, maintain the close -- fully closed fuel cycle. There are no intentions to modify the economy of the fuel-- of the closed cycle.

We don't anticipate that there will be any new nuclear sites. But existing sites can absorb new -- more reactors. And it is a possibility that there will be more than one utility operating the nuclear reactors. We also anticipate that the industry will ask for operation beyond 40 years. As you know, the French system is different to the U.S. system and we have, by law, a safety review every 10 years. At the end of the 10 year period, the operator has to submit a safety file, which looks after all the modifications and justifications for the continued operation for the next 10 years, if they so want.

And obviously, the cost of maintaining old reactors will become one day not economical, but it's not a nuclear safety authority choice. It's the operator who asks or not. And, of course, it's demand made not -- if you don't spend enough money on refurbishment and on elevation of -- so one day it would become not economical, but we expect that it's possible that before -- behind 40 -- beyond 40 years is a possibility.

We also anticipate that we will be facing multinational designs, that means with existing or new reactors, elements coming from modifications. UINC coming from other parts of the world, so the reactors become more compositive, which would make things harder for us. Increased sophistication of methods and tools to support licensing requests. We already see the beginning of this for fuel safety, for example.

The industry wants to use margins and to demonstrate the feasibility. They propose very sophisticated mathematical methods and modeling systems which then we have to assess. We also think that there will be around the year 2020 to 2025 a fast sodium reactor, as a demonstration plant, industry sized, but the demonstration plant. And by then, Generation IV processes, we will probably be considering licensing process of a fleet of such reactors.

But the only decision taken by the French government is to actually ask for the sodium class reactor demonstrator. But there is also going on gas-cooled class reactors. Obviously, an ITER reactor is in France, so we will be involved in the assessment of the nuclear safety files, which pose specific problems.

With respect to the environmental and societal issues, well, these are general aspects, climate change, we already see things happening, so we have to -- when you think a reactor will be operating 50, 60, 70 years, you can't miss these issues. Security is a growing issue. We also believe that the grid in Europe may resemble in the future that of the U.S., which is not as good as the one we have, we enjoy in France, and this may have impact on the nuclear safety.

From the public, we note already a growing pressure on low dose exposure health issues. This is a growing issue you may be aware of. An inquiry study which has been published in Germany late last year about the emergence or at least the epidemiological study which points to an increased levels of leukemia, child leukemia near nuclear sites.

We do not believe that this study actually demonstrates the link, but such studies are being published and this raises concern and we are facing these sorts in France, so we -- and today, the point is that we don't understand it.

At really low dose, we have a radiation

protection doctrine with the non -- with the linear risk dose-effect relationship, but we don't know for sure that this is the right scientific -- that this is appropriate. So the public suspects this, so there is some -- from the other side, the industry pressure to increase the domain of operation within the existing fleet of reactors. That means reducing margins and all that to increase the burner introduction of new fuel designs, which can also use the existing design margins.

A power rating which can be increased, so they say, without changing anything else. And finally, an element which is affecting us, because we are emerged in the world, the development of nuclear energy in emerging countries, which do not have the scientific background, the equivalence of NRC or IRSN or authorities and these people have a right to nuclear energy, but there is an onus to sell them not only the technology, but also the safety. And this has to be taken into account somehow, because it's the same people doing the work.

Scientific progress, while these are things you know, obviously, I will be quick. Computer science, I shall mention that there is a tremendous progress in computer resource and also the computer science and mathematics. So that opens new vistas of things which could be done in modeling from a practical and a technological point of view.

We see in the near future a generalization of digital I&C including in existing plants, as they will be modernized for useful safety functions. And this poses a specific assessment issue.

Advanced materials, we see this in fuel elements, for piping, a better understanding of interactions between radiation and living material. Again, I go back to low dose pressure from another point of view. Existing resources in biology may help us to understand what we couldn't understand so far. So it opens new potential for research.

And finally, social sciences are also progressing and we believe that we should make the most of that in order to be able to improve our methods and tools to assess human-related aspects of safety, which by the way has been pinpointed as one of the main causes of past severe accidents, so it is certainly an issue which will not disappear.

Reactor safety research economy, while we see a trend already, which would certainly not stop off the industry to use on everybody, in fact, in society using the approach of cost/benefit. You know, one that is scarce everywhere and so it was doing something.

Secondly, something which is not so politic are our trade is the fact that when there is a vast -- when there are no accidents, nobody wants to pay the insurance. Okay. So that's life. That's humankind. Short-term humans tend to be short-term people. So we have to live with that and take that into account at least.

I go back to the human resource part in safety organizations. You mentioned people retiring. We don't have such a problem, because the ever dredge of fear is only 36, so we don't have the problem. But what we see is that companies like Areva, ADF and maybe other companies in U.S., because they want to launch new generation of equipment and change and replace existing reactors, etcetera, there is a huge demand on all also export technology. Export company like Areva recruits worldwide, about 4,000 people per year, and the continue -- they intend to continue to do so.

And, of course, they need trained people. So where do they find trained people? In places like IRSN. So this is a big challenge for us. And therefore, we need to attract people. We can't compete with them in terms of salary, because if they want to up the salary, well, we can't follow, obviously, as much as we would like to. So we believe that R&D is leeway to keep the good people.

And the last point is, obviously, the globalization of nuclear industry will induce/increase multinational cooperation on regulatory issues, as well as in research. We believe this trend will continue, including because it's a way to save money on some resources if we share work, well, it's cheaper for the taxpayer.

So now, to go to the research long-term objective imperatives. We see four key objectives for safety research. The first one, well, it echoes what Ashok said, we believe that if we don't have research, it will be difficult to maintain over time an independent capability of assessment. Independent assessment capability needs reference expertise. You need good excellent people and you need state of the art techniques and data. And if you don't keep up with progress, you lose the experts, because they go and work where things go at that time and you don't have the tools and, therefore, you are becoming a bureaucracy and not a science organization.

You can always do assessment on the basis of a bureaucratic questionnaire of things, but it's just not there, what makes people trust what happens. And we have the example of the genetically modified organisms in France. In France we, in this area, don't have independent research. That means all the research is actually mainly funded by the industry and there has been growing doubts in the French public about the absence of risks linked to the use of modified genetic organisms and the result has been the passing of a legislation which actually puts -- interrupts the sale and the use of genetically modified organisms in France.

When you look at what happened, it's the lack of independent research which has closed in the absence of trustable answer to the risk issue. And the government had no choice but to say okay, well, we're stuck, which is probably not a good solution, but this is a result of absence of funding of independent research. So it's a key issue.

The second point while we need, also nuclear accidents cannot be excluded with outside consequences under nuclear safety conventions and the legislation, such that the government is responsible for the protection of citizens and also the -- some of the economy consequences that would happen. So we have a duty to maintain at all times state of the art knowledge and operation expertise to deal with potential consequences.

And there also, technology moves ahead and we have new potentials which we did not have 20 years ago and it's a duty to actually take benefit from progress of science. You know that will improve our tools and methods, you know, that will deal with potential accidents. If we didn't do that and if there was an accident, we would be, I think, in big trouble as an institution.

The third point, we need also to make sure that industry itself takes the best of science for the progress of safety and not only the progress of productivity. And to do that, we have hidden concrete examples in our institute. The fact that we lift the corner of some research and publish results, we would force the industry to say well, we can't ignore that. We have to go along with it. And this is, therefore, an incentive, if you like, and public safety research can be a strong incentive and push industry to make the options, you know, either to improve safety, environmental protection and health.

And finally, research is also a way to allow the regulatory policy to not think short-term, which it tends to naturally, because of that's life, but by -- research programs may point to the future of the policy. You were mentioning Generation IV reactors, we believe in the IRSN that it is not too late -- too early, sorry, to start thinking of what should be safety included in Generation IV reactors.

If we can't do it now, we would be faced with already fairly solid designs and options would have been maybe bypassed and it's too late. And because the industry itself really can't redo it, we slide by. So it's today.

I remind you that when the EPR was starting to be designed in the 19 -- end of the 1980s, beginning of the '90s, in parallel, the French and German governments asked the industry to design a new generation of power water reactors, but they asked the IRSN under its German counterpart, TRS, to draw for the government, both governments, what could be the scope of safety improvements. This was done in parallel, not in succession.

And we are missing that today in Generation IV. I see no movement by the international safety community to say wait a minute, this industry will design things, but what do we want of safety authorities? What do we want a safety objective to be obtained? And if there is no message, the industry will be okay with that. They will not ignore safety, but it will not be pushed to its limits.

Now, more practically, what all this means, so first, there are some cross-cutting issues, which can be affecting pressurized water reactors, but which can also be applied to other type of reactors. Computational methods, we need to be up to date. The industry will use these things, new models, new uncertainties, methods, so we need to be in the practical knowledge of this. Which means we don't take part in the development of such tools. We can't really -- we are just users. We have to actually be involved in the development in certain fields, you know, to master these techniques fully.

The second point, we believe that probabilistic risk assessment is a very useful tool, as long as it's high quality. So therefore, we intend to continue leadership work in the IRSN in order to drive industry to have good PRA tools. Because if there is no drive from the public for such, we know from experience that the industry would not push PRA tools to its limits.

The European Commissioners just asked us to coordinate a five year program for European PRA with the industry and other safety authorities or regulatory bodies. This program has started this year and maybe that would be some exchange of information with the NRC about this.

In particular, we need to take into account aging, because there are many components which are not included today where we don't know their behavior and this -- obviously, if you do a PRA, you've got to do it fully and not only on the things you know. That's the point. So we have things with earthquakes which maybe we need to improve, the fire, flooding, etcetera, etcetera.

I mentioned earlier research on human factor. We believe that we can and we should over the next few years develop or increase our effort in research in this area. For example, we have as an experimental capability, at the moment, we have designed a system which exploits operating experience, but instead of looking at the technological point of view that means something failed and what happened, we have a review on how did the people in the control room, how did they react to an incident? And we do this systematically.

That means how long did they take? Did they hesitate? Did they make mistakes in the clearing of the situation which -- did they understand correctly the messages coming from the control room panels? Did they take the right decision? How long did they take? Did they discuss whether unanimous and this is actually very interesting. And we -- okay. So we can see that we can see trends. We don't know how to interpret them at the moment, but this has led me, in particular, to want to actually have research organized around this.

The next point is similar. We have the not so good experience. We hired a very good specialist in this area, but after three years they left, because they become even more specialized in the industry. These people are there, so they just went. Not necessarily to the nuclear industry, by the way, but so the only way to keep people is to have a lab doing research, then you can keep people. So that's what we want to do over the next few years.

And of course, fuel issues are central to nuclear safety and, therefore, we will in the long-term continue to work in these, which these are heavy and an expensive research program, but the government at this meeting, which I mentioned the end of November, has confirmed that we -- the reactor should be operating for the next 20 to 30 years for safety research. So that was a very good signal and we also have the decision by main utility, EDF, to actually invest in this reactor showing that they believe that fuel safety research by IRSN was central to nuclear operation in France, a strategic aspect.

Off-site consequences. I mentioned that of the responsibility of IRSN and the safety authorities. So we have started, two years, to develop a new generation of decision making tools, which would be -- which would take into account the latest available technologies, links with the weather, meteorological data live, you know, to have real time tools, short distance, medium distance, long distance, it will be whole set of tools also linking with the radiological consequences with the agriculture and the uptake of radionuclides, so it would be a set of tools.

Not integrated tools like the German did in the 1980s, but a set of coordinated tools. So that is not just a black box. We can use if an item is exposed, we can use various parts of it depending on what the question is at the particular time during the crisis. So we have made a market of that and the utility EDF has also taken an interest and will probably want to buy some of our tools, which means they must be up to date, because it's a lot of money for them and they made the review, international review and they have decided to do this. So maybe we could show you what the NRC will one -- one day what we are doing and we have already made the beginning of markets working.

Research on low dose effects on environmental. We have -- we believe that in between there are three ways to do this. One is epidemiology, which has limitations when you look -- when you go through very low doses. The other one is fundamental radiobiology, where you can study the direction between cell and the radiation. You can derive knowledge about personal sensitivity to radiation and that. But the link between the two is the missing element.

And we have with our own program, we believe that we have -- but it's very expensive. We need to understand functional effects of a particular internal contamination, chronic contamination. I remind you that some of the waste is released by reactors, carbon 14 and others.

In waste policies there is also some potential releases and we need to understand these things and we need animal testing, which we have started, but it's extremely expensive. And we are trying to push this in Brussels for our European approach that could actually take care of this middle element, which nobody has ever done, which, in our view, explains why we don't progress.

Passive safety features. Okay. This is for us a long time, because so far we don't have any plans to have an AP1000 in France, but you never know. And also, IRSN being an independent body, we also work for other authorities. For example, Bulgarian government has asked us to review the safety of the new BVR1000 reactor, so we need to be aware of, I believe, in a body like IRSN, which pretends to be a reference study, on an international level, and it is possible that we may need to be involved. Maybe not as a main actor, but at least to participate to the investigation of the realism of passive safety features in large power reactors. So not for immediate time, but maybe later.

Criticality cannot be abandoned. We in France together with CA are very significant databases for data for criticality. We see new materials coming and we need to maintain the research, so that we are-- again, we can be good in assessment, because there are changes and sometimes you just can't make the assumption that it is -- you are changing material, but you make the assumption that nothing has changed in terms of criticality. It's not always true.

And if you don't have good experts, again, the bureaucratic approach will prevail and we may miss things. And finally, knowledge management. Okay. It's not research, but can be some on the side of research. We believe that by developing international centers of excellence is a good way also to facilitate knowledge management and transfer by maintaining people and also by transferring people, that knowledge from the older generation to the newer.

Now, specific issues for pressurized water reactors. Obviously, we have aging. The industry has a lot of data on a lot of compliments, but not all. And we are concerned about some internal structures, concrete, electronics, cables and we believe that if we don't initiate some research, the industry will make some assumptions, which we will not be able to verify very easily until something happens and we don't want that to happen.

And similarly, default initiations in piping and in steel structures. I think we may also participate in the improvement of tools which are available to predict such events. I think there is also a scope using the potentiality of new technologies, in particular, computers, computer science. You know to facilitate rate time inspections, access to databases, I mean, we could use a lot of existing features, if you like, in the economic world and apply them to nuclear safety. That's very applied research, but it is research. It's creation of tools of today, therefore, it's research.

Obviously, severe accident. We will -- we had the big -- a very large debate in France about severe accidents, which has been concluded. The result is that the PHEBUS reactor will be closed, but we will -- the government is asking us to maintain research on severe accidents and we will probably look to use for our further research a new reactor, which the CA is building right now, which will be available in 2014. I will come back to that in a moment.

Now, with sodium and gas-cooled fast reactors, first, there have been a lot of experience in the world and in France, in particular, on the sodium fast reactors, which have been deployed in france. We had benefits for a short time.

And the problem is that most of the people who knew these things are now retiring. So we need to reappropriate past efforts of our R&D. There is no point in redoing what has already been done. There are codes which exist that very few people know how to use them properly these days. So we need to spend time in refurbishing all this knowledge, review the accident codes and fire propagation codes with sodium.

We had a lot of experience, a lot of knowledge and we're still using that today to help the Chinese, for example, but it's very few people and it's fragile.

Another idea is to actually from this type of reappropriation to -- rather then having specific codes to try and have as close as possible wide ranging codes, which would apply to several types of reactors. We are trying to do that, in particular with GRS. We're trying to see if we could have an overall code strategy. That means a long-term code strategy, rather than have teams developing codes here and there and see can we interface them or not and just to have a put down code strategy.

We are not sure we can do this, but we are investigating at the moment the feasibility of having the strategic approach code development. It is linked to the progress of computers and, therefore, the reduction, the probable reduction of the amount of physical testing that there will be.

Okay. This is a trend, but to know that this trend is successful, you need to have a big -- a very good overview of what you can do or not do in terms of codes. Codes are not just the -- in the future, they will not just be the consequence of testing. They will be -- the key point in testing will be the concept, rather the annex to the codes.

And for this to work, we need to have a clear strategy and understand whether it's going to work or not, because you're talking about slots of 10 years time. The developer may -- the code is 10 years. And if it trails at the end, well, then it is lost.

Complimentary research for code development. Okay. It's similar. Skip that one. Research on material and fuel under high neutron flux and high temperature. This, of course, is technological issues linked to the potential future reactors. And this kind of research would help us design the safety requirements, because, otherwise, it's only theoretical. Obviously, sodium reactors, they -- one of the issues with the super annex was the difficulty of having -- of inspecting structures, etcetera. And this was one of the gray areas. And we need to overcome this difficulty, if we want to propose new reactors of sodium code in the future.

Now, the last item with respect to ITER, there will be accidental -- accident scenarios in the large scale fusion reactor. So what about codes? Can we derive codes from existing codes? We need to look into these issues. Independent, obviously, the ITER team will look at that, but we need to also have our look into that.

And in particular, we have identified some phenomena, which you see here on this list, which could be the base of accident, which could be significant accident, maybe not with outside consequences, although, there would be maybe dust in the radioactive testers, etcetera. So you're not talking about a large scale, but you could have significant accident, in particular, for the staff.

So we need to understand these things. And the issue here is access to some information which is linked to military research. So it's not so obvious and this is a point we're trying to investigate and where probably we will need the international collaborations.

So the last part of this presentation about the resources which are needed. So as I said before, we believe that human resources are a key issue and to attract highest level people, we need to develop multinational networks operating around large data, that means research facilities, in other words.

If you don't -- a facility like PHEBUS has been the core to play the sound network which actually is the 95 percent or 99 percent of the capacity in Europe and even beyond to -- on severe accidents. But it was PHEBUS which -- if we had PHEBUS, this wouldn't have happened. So we need to keep that in mind.

The second point is that we have found by observing our -- or I have found as a director by observing various things in the institute that those who did well or better than the others, they will do well for us. But those who did better than others, was those were -- there was a close mix between R&D and operational safety assistance.

We have the two types of organizations. We have teams doing safety assessment for the authority, teams doing research and some of them are mixed. And those do very well. The others sort of diverge a little bit. That means the research is doing research and asking them in terms of what they will do next, that's not a good solution. So close mix. And mobility, young people, they don't want to spend 40 years in the same place. So if we don't provide for mobility, they will do it themselves. Maybe not in the optimal way as our own scientists, so we need to think about these things.

Capitalization of knowledge, obviously, is a key point, because these reactors lasting 60, 70 years, it's three generation of people, so we need to organize ourselves in such a way to be efficient. And, of course, the second point after human factors altogether with human factors is infrastructures.

First, we -- this is a strong point for us, we believe, and this we have made it clear to the government without any reactions that reactor safety research infrastructures are key to the long-term pertinence of regulatory action and to the continued high level competency of experts. This has been very strongly reaffirmed. And the other consequence, obviously, the IRSN is, okay, medium developed size, safety research body, but we can't do everything with what we have, so we -- this is the bottom line.

We look for international cooperation, because there are many fields of research and we don't want to be or we can't be heading everything. We need to be involved in most significant aspects, but we can't lead everything. But there are a few areas where we can have a leadership role, because we have facilities. We have experience and we have past results of high level.

Fuel behavior in reactivity accidents, this is linked to the CABRI reactor, which is being refurbished and from 2011, hopefully, we will be able to conduct for the next 20 or 30 years research programs and testing.

MR. SCHWARZ: 2010.

MR. REPUSSARD: 2010, okay. Whole core severe accidents, I mentioned before. The new Jules Horowitz reactor of COR, which will be a mixed use reactor producing pharmaceuticals, material testing reactor. But it will have the potential to also do safety research. And we are considering at the moment putting some of the financial resources, which we use to fund the PHEBUS Program, into this reactor. And the point is we will not do that alone.

So we would like to have the international community considering severe accident, let's say, nuclear safety research, consider what this new reactor -- you know, there was a PHEBUS International Group which said okay, we need fees to start PHEBUS, because there is -- there are needs for research, but not yet, in the future. And we don't know exactly what research. But, please, don't close it.

Now, we can't maintain it, because it's far too expensive and it's an old reactor or a relatively old reactor. But this new reactor will have some performance which could be useful and they should be investigated and we should consider whether safety programs could be invested in this reactor from an international point of view.

Fire propagation, we have a large scale test platform, which the NRC is now going to be a partner in that, and we believe that there is a long-term future in fires. It would always be -- remain a risk, a key risk for nuclear installations, not only reactors, and criticality cases, not on the same -- but we also intend to maintain experimental capacity and criticality for maintaining of knowledge and also evaluation of new materials that will be proposed from now and then by the industry.

All this needs to be put against background of international cooperation.

And finally, funding. While first, my pledge to the French government is that they should maybe maintain enough public resources in order to ensure that reactor safety remains industry independent. This is, of course, a key point. We --

such at the moment that we want to maintain it this way.

Secondly, we want to think multinational in a systematic, even more systematic than before. And for us the way The Halden Project is managed is a good approach. And we would like to take that experience into account in addition of future research programs.

The third point is a key point. We also are convinced that multinational research and development is in the long run the best, the fastest track to a good regulatory harmonization. And you talked about MDEP. Phase 2 will run into difficulties because of different codes, different knowledge, different science having been produced. And the science is not different by definition. It's different because it has been done separately.

This will cause obstacles which will be extremely difficult to overcome through a harmonization process. And if we did research together, then it would be harmonized from the start.

Okay. So we are talking about 20 years, but this is the -- your issue. You are asking the question what should be done with a 20 year perspective, well, one of the answers is multinational

R&D would eliminate by and large the absence of capacity to have multinational design.

And as such, the industry should facilitate that by investing. Industry has a natural tendency not to spend money on long-term research, but they are wrong in this particular case, because it's in their own interest. If we have a global nuclear industry, we should have a global safety research. And the global safety regime as the IAEA. But you can't do that without research or it could be fragile.

And how to do it? Well, NEA is a platform which has proven it's worth for establishing a good R&D program with the CSNI Committee. This should be continued and even enlarged probably. And one of the points is that all nuclear countries, even new nuclear countries, should in some way be able to function good. And I'll tell you they are in kind by sending researchers, training their people through such programs or funding, local funding at least.

And the point is not all countries have a vocation to be member of ICD, but through the IAEA, there could be arrangements that these countries have Atoms for Peace Program. They should have access to the information, because that's the logic of worldwide safety. So how to do that? Well, we have the actors here. Maybe we can discuss it. And the key countries like the U.S. or France or China, for example, this should be addressed quite clearly.

Okay. Maybe I've been a little bit long, but thank you for your patience.

CHAIR POWERS: Absolutely, most useful and keen insight. Several points that I want explore further, but I think we have opportunity for discussion afterwards.

MR. THADANI: Yes, we do. We do. In fact, I think --

CHAIR POWERS: One point.

MR. THADANI: If you want to pick up on one or two topics, I recommend --

CHAIR POWERS: There was just one I wanted to add to. The point here is on international cooperative research, one of the items that we see that bring is peer review.

MR. THADANI: Is?

CHAIR POWERS: Peer review.

MR. THADANI: Peer review.

CHAIR POWERS: We have such a small cadre of say severe accident researchers in this country, they don't get adequate peer review. But by going to NEA, IAEA, but especially at the PHEBUS Programs and now in the SARNET Program, they get peer review. And in some respects, I think, you were hitting on that when you made the point about harmonization there. So it's just a different set of words.

But I see that as perhaps a bigger value than even the experiments done in PHEBUS itself have been just the peer review. Because otherwise, they don't get it.

MR. THADANI: Yeah.

CHAIR POWERS: The cadre of severe accident researchers is so small that people can look and they can say well, this is plausible, but there are no real adequate peer reviewers, unless we work cooperatively in international numbers.

MR. THADANI: Yes. In fact, CSNI, and I completely agree with you, has several working groups and subgroups with expertise in selected areas and they provide a good platform as a starting point.

CHAIR POWERS: It's just absolutely crucial that we do that.

MR. THADANI: Yeah.

CHAIR POWERS: And quite frankly, one of the challenges we're going to have is as the Asian countries become more and more involved in the nuclear enterprise, it's the peer review there and the interaction there is going to have to be strengthened. I think you pointed out that some countries don't belong to all these agencies. Somehow, we're going to have to get them involved. And so I appreciated your points.

And there are several others that I would like to go through. I mean, I think you have given us a good starting point for our discussions.

MR. THADANI: Yeah.

MEMBER BONACA: Well, the issue of globalization or, you know, international experience, I would like to explore in part. I mean, I think the challenge we have in the U.S. right now is that we are trying everything. I mean, we do license renewal and so we have the process ahead almost to some of the research. We have a meeting in two weeks to determine, in fact, what research we should have to support beyond 60 years.

CHAIR POWERS: Yeah.

MEMBER BONACA: And so the step is very long already. And we have passive system designs. We have two in front of us already right now. We do have -- so the challenge, I think, in the U.S. is that our experience right now or our areas of involvement are so many that, you know, how can we capitalize? For example, you do have a narrower problem, because of the -- there is a design that you are focusing on, but you have expressed interest, for example, in aging.

Okay. So how do we bring it together in a way that we have shared interest in all these areas?

MR. THADANI: You are actively involved in, what is it called, SOARCA, is that correct, looking at perhaps more realistic consequences. But as far as I know, NRC is not fully engaged in terms of health effects from the low doses. And it's a slowly moving science, I'm sure, but nevertheless, it's not clear to me how you make those decisions in absence of real information.

I mean, information going back to convincing the public that this makes sense. You can do parametric studies, but I don't know what you do with the results in the end.

Okay. Well, thank you very much. Michel, did you want to add anything?

MEMBER ARMIJO: Does IRSN do research in water chemistry, both primary and secondary water chemistry, as it relates to material degradation or is it materials are tested under certain kind of chemistry regimes?

MR. SCHWARZ: We are making a few

assertions, corrosion areas, yes, as a primary and secondary surface. But I think that's part of the aging, in fact.

MEMBER ARMIJO: The aging?

MR. SCHWARZ: Yes. Not only the integrity of structures or mechanical point of view or the force used by neutrons. We see all sorts of corrosions.

MR. REPUSSARD: But going back to your remark, I think it's quite clear that nobody, no organization, no safety organization can cover the whole scope of research, you know, everything. And I think there is a strategic issue to have, to actually share together with those who want to do that. Kind of mapping of what we should be doing as a collectivity and then share and say, okay, you know, some countries have had more experience in these areas.

Okay. You are the leading of that and you will lead this and they kind of have shared strategy over the next 20 years. And then, of course, there will be things that happen. There will be incidents, etcetera. But nevertheless, if we had this map, it would be much easier in places like CSNI to do things not totally better, but also to mix them with also a strategic approach.

MEMBER BONACA: Yes.

MR. REPUSSARD: We say okay, we come to the U.S., you know, you will lead that, but, of course, we share the knowledge. We will lead this and the Chinese will do this and etcetera. This may be a dream, but --

MEMBER BONACA: But that's why organization, because I think the opportunity is there. The interest that they have shown here are similar with if you do not have license to rule, you rule out the issue of aging in several areas from materials to wiring to etcetera, digital I&C is a challenge we face right now in licensing. So, you know, how do we -- however, you seem to have an idea already on matrixing and finding areas of common interest.

But that may be a challenge and we have to work at it. And maybe we can talk about that later in the day.

MR. THADANI: Yes, Carlo?

CHAIR POWERS: We have one question.

MS. SCHOENFELD: Thanks, Dana. Thank you for your presentation. I'm Isabelle Schoenfeld.

CHAIR POWERS: Do you want to step up to the microphone?

MS. SCHOENFELD: I'm Isabelle Schoenfeld and I work in the Office of Enforcement at NRC. I'm also Chair of the Safety Culture Working Group. And we are interested to learn from other countries and international organizations and what they are doing in this area of safety culture. And I refer to your Slide 6, where you mentioned that social sciences offer improved methods to assist human-related aspects of safety.

And I wondered if you could provide some examples and if there is anything specifically being done relative to safety culture?

MR. REPUSSARD: I'll give you an example of what we are trying at the moment is to identify the way that we -- safety culture should co-exist with security culture. We have an increase of security issues and sometimes they are seen as conflicting. They mustn't, because if they -- it's everybody's loss. So how to get these two things together? How to get the, you know, cooperation, because in security you shouldn't spread information.

Safety culture you spread the knowledge, so how do you do it? And there are how do you manage that? And we have to talk about that with the people. It is not a research program, as such, but these are, at the moment, one area where we would like to continue to progress by proposing some documents to be discussed with the community of people in France and abroad.

This is just one example. I mentioned this program we have with the operating experience. And the --

MS. SCHOENFELD: Yes.

MR. REPUSSARD: This is also mainly to observation of what is safety culture, you know, in reality, in a control room reality. We also could mention about enforcement. How is the behavior of the inspectors, for example, within relationship with the utility people? Is there confidence there? Do people give information or not or is that information retained? There are many fields where we could or should investigate further.

So at the moment, we have a very small team and we have made some small studies. And we see that there is a scope to have actually go further into science. Another aspect is interaction with stakeholders.

MS. SCHOENFELD: Yes.

MR. REPUSSARD: What is -- you know, we have a new law on transparency. Okay. So the utilities have to provide all information they have. This could have a negative impact, that means information retention. They don't formalize information, therefore, they don't have to release it. Will this happen or not? So you see, there are-- these are sort of pieces where we should take on, items which should be now openly investigated.

MS. SCHOENFELD: Yes. Well, thank you. We're also looking into the safety-security --

MR. REPUSSARD: Yes.

MS. SCHOENFELD: -- relationship. Thank you.

MR. REPUSSARD: Christer?

MR. VIKTORRSEN: Yes. Can I -- I will comment on your point on safety culture later on.

MS. SCHOENFELD: Yes.

MR. VIKTORRSEN: But just to come back to this question about cooperation internationally on research. And as you said, Jacques, we -- no one organization can do everything. So we need to, I think, agree on where do we have the strong points, etcetera, and encourage research there and then share the results. And for example, in China, we are -- we were approached recently by the Chinese.

As you know, they have a unique program of expansion. They have today 11 reactors in operation. And by 2020, they told us that they would have 60, 6-0, reactors in operation, which is unbelievable, but it's a huge challenge anyway.

And in parallel to this, they are setting up research centers. They would like to have the Agency, the IAEA, co-sponsorship in the centers. And this would, I think, take very well with your idea if we can. And we are also cooperating with the so-called technical safety organizations, with Jacques' organizations and others. And maybe we can find in the future a way to integrate also the Chinese and get them to also share our knowledge and we get knowledge from their side. I think this is an idea we should try to retain.

MEMBER ABDEL-KHALIK: I have a related question. You indicated that the Bulgarian government has asked you to review their BVR1000 design. Is this a one of a kind project or is this viewed as a service that you intend to provide to countries in the future?

MR. REPUSSARD: Well, it's growing, but there are -- have been many precedents. The first -- some of the Chinese existing reactors were assessed by us. We help the Chinese set up their assessment capability. For example, the accident management procedures in China are the French one, which have been we trained them, we transport, we help them establish their own procedures on the basis of our existing French procedures.

We have a permanent contract with South African Safety Authority, whereby when they have changes which are not common, let's say when they want to -- recently they wanted to change some valves in the existing reactors and they said they didn't know how to work out the potential safety implications of the new systems, because they weren't exactly the same as the ones before, so they asked us. So we have a permanent contract where they come ask us questions and we will make assessment.

We don't want to be involved in inspections and, you know, normal routine work of nuclear safety, but when there are issues which require reference knowledge, then we do offer such service.

So the Bulgarians, we have since -- with our German colleagues after the Chernobyl catastrophe, you know, and the breakdown of the Soviet Union, there was this program, Safety Against Money, that means the West European Commission and European Construction Banks said to the Russians and the Ukrainians, etcetera, okay, we will fund a grading of safety in your reactors, but safety assessment will be done by Western organizations.

So we set up a joint operation, which is a giant operation, it's also German, and this provides services in most Eastern European countries, Russia, Ukraine and we -- so we do such services, at the moment, funded by the European Commission, European Banks. And now, we offer through this quite a good bit of knowledge of the reactors. And the Bulgarian reactor has -- will have a -- this is typical. This is Russian design, but it will have Areva/Siemens digital I&C.

There is noting there, you see, so we see the design is sort of changing and becoming sort of global mixes really. And it's important that there are safety organizations. We don't want to be alone in this and it would be better if there was a community of bodies working together, if you like, with the same shared science at the bottom. And there is a scope for, let's say, reference science in nuclear safety, because there are very tricky issues.

And then there is the run-of-the-mill safety, which should be mastered in every country. Every nuclear country should have a nuclear safety authority with inspectors, with people knowledgeable, well-trained, but it's not necessary that everybody has the top-most qualification, scientific qualifications. There would be a concentration in the industry. In 15 years, there would be approximately four main technology providers and there would be three, four, five centers of excellence in nuclear safety worldwide. And the French approach is to be one of those. Okay. So if I may make a suggestion?

MR. THADANI: If I may add to what you just said, Said, you may know that there is an umbrella agreement between the NRC and the Chinese Safety Authority, whereby they need assistance in many areas focusing on safety. So Westinghouse, for example, on AP1000 may have all kinds of agreements with China. The NRC agreement with China provides support and training in certain selected areas of safety. And it's a pretty broad range of areas.

So I think you would almost expect this from now on with the international community to have some kind of arrangement to be able to support in safety areas, I would expect.

Okay. All right. Christer?

MR. VIKTORRSEN: I have my presentation here.

MR. THADANI: Oh.

MR. VIKTORRSEN: Thank you very much for inviting also the IAEA to this event. First, a few words about myself. I am Christer Viktorrsen, Swedish has worked with the Agency for two years, were previously the elected DG of SKI, the Swedish regulatory body, and as such, I have been involved in international research, mainly through the -- to the CSNI and the NEA, but also through a number of bilateral agreements that we have, including the NRC and the Japanese and other countries.

So the Agency is not really a research organization, but we do come in contact with research. I'm just starting to say that the Agency was established in '57 and, as you know, it is part of the Atoms for Peace Program by President Eisenhower. And we have presently handled in 48 or 49 member states, so there are a number of small states which are not members, but all the major nations are members of the IAEA.

We are based in Vienna, have 2,200 staff, the majority works with safeguards, safeguards inspection where we have the nonproliferation treaty as the regulation. The Agency works according to three pillars: Nuclear technology transfer from develop to non-developed countries, we work in the area of safety and security, security has been emphasized, particularly, during the last 10 years, and then on safeguards.

And we have mentioned, I think, all these three key words have already been mentioned, the globalization that we clearly see, the nuclear renaissance, we will say a few words about this, and the importance that we introduce safety at the same time as we introduce the technology, particularly, in the new country.

That is the message that we convey and the Agency has recently published a small booklet. This came as a result from the many questions by El Baradai when he traveled around the world. And many countries asked him what should we -- how should we start the development of the nuclear program? So he wanted to pages to give them. And finally, then we inducted three pages, I believe. But we tried to summarize what is essential and then we had the security threats.

So in blue you see the countries today which operate nuclear power. And in red you have China and India, where nuclear developments really haven't gone on and it is, as I said before, expanding tremendously. And there should be a color, but it doesn't show on the screen, unfortunately, a lighter color where all the -- where I have marked all the countries that have expressed an official interest to the Agency through a letter or through a visit to Vienna where they have requested assistance.

And we have highlighted a few in the -- on the right hand side. So you see it's a new type of country. I mean, traditionally, nuclear power is in countries with a developed industry or technical infrastructure. But now, it seems that nuclear power will also go into countries with much less developed technical infrastructure.

So what we said before that we need to assist is obvious, because there will be a need for us in this new global world to help, because, as was said, everyone, every country has a right to develop peaceful nuclear power.

We have 29 countries today with operating nuclear power and the 30th country would probably be Iran, because they are very close to fuel loading and we are still allowed by the UN Security Council to assist in safety. So we have expert missions almost all the time in Iran helping the regulatory authority and helping the Busher Nuclear Power Plant, which is now built or finalized by the Russians.

And the Russians have trained the staff of this plant, but the regulatory body has not been trained. So they are not -- they are now looking for assistance how they can get experience to simulators and experiences from countries or regulators that regulate BVR reactors. So we are trying to organize that type of assistance.

I also wanted to highlight this in view of the globalization. We had the Chernobyl accident in '86 and many things have happened since then. And this map, which doesn't come out extremely well, is the work that we -- has been done in the European Union to map, in a more extensive way, the fall out of cesium-137 in Europe.

And at that time, I worked in the Swedish Radiation Protection Institute in '86 and we got more than 1 percent of the core content of cesium-137 on Swedish soil. And this is still a problem and there are still contaminated mushrooms, lake fish, elks, reindeer and other animals that live from organism where the cesium doesn't disappear very quickly.

And, of course, this gave rise to a lot of research on off-site consequences of nuclear accidents. And it was -- although it was tragic, it was a good boom for the off-site radiologic science to expand. But we can see again in Europe that it is starting to go down, because this is not believed to happen again. And we tried to say that we will never be sure. We need to keep the main thing, our knowledge, to estimate how radioactivity spread in the environment. Where are the sensitive parts? Which soil? Which type of fruits take radioactivity?

And many new concepts emerged after this accident: safety culture and safety management and regulatory independence. It was clear that this was not the case in the Soviet Union and safety culture was also missing at that time. The question of stakeholder involvement has come to also -- in focus. And there were new instruments created internationally.

In addition to the conventions, there has been four international conventions, one on early notification, which is intended really to avoid that we are not alerted, because we don't want to be surprised once more. Because we sat in this emergency center in Stockholm and we got suddenly measurements from one of the power plants of cesium-137 or iodine, sorry, of iodine-131, and nobody knew from where it came.

So one of the reactor stations that submitted these results were almost closed by us. But then more results came from other places, from other power plants and then it was finally thought, but no one admitted it, but the cloud came from the east, somewhere from the east and it took a couple of days before there was confirmation that there was a small accident in Chernobyl.

The INSAG was created and also the industry group, WANO. This is also very bad looking. I'm sorry, I will read. So I wanted just to highlight also in the security area, there has been a big evolution.

On the top, I'm talking about the main actors. Before, I mean, in the Cold War area, we had nations that were the threats, that were the main actors. It was roughly bi-polar and we had superpowers. Today we have non-states as actors, small groups. We have small states that can be actors. We have global networks. A completely different strategy we have to use to deal with the security issue.

About the threats, we have high density, big bumps, high intensity. There was a lower probability and there was certainly overkill. Today we have a lower density in these devices, but we have a higher probability of them being used. And we have more socio-psychological terror.

And the motivation is completely different. It was more from -- we have gone from a geopolitical one or rather predictable and calculable motivations to malicious acts, unpredictable behavior or terrorists.

So it's a completely new strategy we need and, in this area also, new conventions have been created. But what is the summary of this is that we are all in the same boat and this boat is very small, but I think there is place for everyone. But we need to cooperate in order not to run into a cliff. And that is really the message of this picture.

So going into the Agency. So we have in the safety area, we will only talk about safety and security area. Our main role is to provide international community with high quality standards. And they are grouped in three levels: Fundamentals, requirements and guides. But not -- and this is said in the statute of the Agency from '57, but this is the main role.

The second is to provide for the application of the standards and make sure that they are continuously updated. So we do radio services, training courses and sharing experience, creating networks. And we are also there to support the implementation of conventions. So these are the standards. There is one fundamental now containing 10 basic safety principles.

And this was a major effort in order to try to integrate the various professional communities, particularly radiation protection and traditional nuclear safety community to agree on threat 10 important principles. And one is the role of the operator, which is the prime responsible for safety. A second principle is that there is a big role for governments to oversee and regulate nuclear power.

And as a third principle it's management for safety, which is quite unique that such a principle is now considered among one of the 10 major safety principles. It just shows that leadership, the leader is still -- has extremely big responsibility to promote a good safety character in his organization. That is the key message of this principle, etcetera.

Then we have safety requirements. They are today 16 in these areas. I don't need to go through them, you know them, but they are on the Internet if you want to look at them. And every guide, they are about 100 today becoming downloaded from the Internet.

For the application of the service -- of the standards, we do peer reviews. On the regulatory framework and activities, which we call IRRS, and there will be such one in NRC during one of the coming years. We are this week in Spain doing a fully integrated regulatory review service with a team of about 20 experts from all over the world.

The more traditional services are in operations and OSART is one we do similar also fuel cycle facilities now, because there are standards there. And in safety culture, the last one was done in the Spanish plant where we assessed by interviews, observations and documents the safety culture in this plant, which is a very interesting exercise.

Research reactors are also done and we have done one in Halden, because of the license renewed on the Halden reactor and also in design and engineering.

So I approached this topic, this was sort of an introduction, using the following methodology. We are every three years asked by the contracting parties to the convention for nuclear safety to give a report on what we see from the Agency as issues and trends in the world going on. And then I have added to that corresponding research needs.

And this report we based on all the safety review services we do on the events that are reported in the IRRS system and analyzed and other types of information that is available through all our meetings, etcetera. So there are maybe 10 such issues and trends, which we raise in this year's report, which will go to the review meeting in April in Vienna.

So the first one is the ambitious nuclear development plans that we see in the world. It is not only new builds, but there is also life extensions and the globalization. And it is evident that light water reactor technology is dominant today and will be so for decades ahead. And I say that or we say that because the present fleet is only slightly less, the average age is slightly less than 30 years. And most countries go for extending life beyond 40, which seems so. So one can say that the present fleet of reactors can serve the rest of their life.

And also, what we see that the reactors, the few reactors ordered today including in China are sort of evolutionary. Similar types of reactors that we operate today. And in relation to this, one must conclude that the major safety issues are aging and the importance to keep research going that is to try to force the aging effects. And we will always have surprises, but we should try to keep research going on on aging.

And the question of the human resource has been mentioned already. And in relation to life extension, there are, of course, modernization of the facilities and in many countries, there are significant modernization projects of the control room, for example, but also adding additional safety features, even additional trends, safety trends and modernizing the I&C, for example.

And so we have the new technology, which coming not -- under new technology is an issue in itself. We also put it in old facilities. And there is an important safety assessment aspect in that.

In the event that we analyze, we can see that safety culture is often blamed to be the reason for an event. We have had such one in my country, in Sweden, the Forsmark event. It was considered a safety cultural, the main reason. So when we say that, we must also be prepared to work with the safety culture. And it is a difficult concept. It was around essentially after the Chernobyl accident and it took until 2006 until safety culture was introduced in the international safety standards of the Agency.

Now, there is a characterization of safety culture and there are also to each of the five characteristics attributes developed, which can serve as assessment tools. And those are the ones we are using when we go to South Africa, for example, or Spain or whatever country to assess the safety culture. And we see that the management part is extremely important in such assessment results.

And the safety assessment of life extension, modernization is also an issue that comes back into events, so we need to, I think, model the plans even better. And the work management, we have a large number of contractors entering the nuclear power plants during a short period and it's extremely difficult to introduce safety culture into this huge number of contractors, often having different languages, speaking different languages and the first time in a power plant.

Education and training, as I mentioned, the Chinese are building now a huge system for education and training, which we need to support. And of course, the research facilities aging and closing. And the work done by the Agency -- by the NEA is extremely important in this respect.

We also see, of course, that new reactor concepts are emerging and we do take part in the generation for risk and safety group and also in the MDEP. But concerning new reactors, I think, we need a significant research activities in many areas and I think we have already this. And I'm not going to repeat it. But we will also need support -- I mean, various types of fuel cycle facilities supporting these new type of reactors.

And we must not forget this. We might need new type of fuel. We see in South Africa they have been building the pebble bed reactor and I think the fuel part is extremely complicated and you gain that question from them, how can we manage this? And how to take care of this fuel then.

And the globalization again, increasing the cross-border responsibilities and we have few reactor vendors, etcetera. I mean, not all of this has necessity of the research component, but it is important to keep in mind.

The really second part is the need of nuclear safety infrastructure and international cooperation. And because of the decline in nuclear power new build in many countries, not in all parts of the world, but in many parts, have degraded the nuclear infrastructure. I mean, this is very well-known, education and training, for example, but also research.

And infrastructure is also weak in the countries considering nuclear power plants. So we need to be prepared for -- from countries like the U.S. to support in these activities and to take our responsibilities to make sure that we promote safety.

And this could be done through bilateral-- I think the international organizations have an important role as well as the Technical Safety Organization. And we try to work with them and jointly with NEA to try to see what can be done in order to facilitate the sharing and distribute of tasks.

The global nuclear safety regime was mentioned. It is a concept that has been introduced from the Agency and INSAG is supporting this concept. It means, essentially, the whole system of international instruments, such as the conventions, such as the safety standards, such as the, of course, national systems are at the base and the international part support this. And we have all the expert and research networks, which would contribute.

And again, I would like to say that it needs support from the major nuclear countries in order to keep the worldwide safety strong. We see also a clear trend since maybe 10 years or so that there is more and more reliance on the safety standard produced by the Agency. And this gives a huge responsibility on our side, because we need to make sure that they are of high quality, that they are updated continuously to reflect best and good practices from the world.

Because I have mentioned China a couple of times and I will do it a third time, they are one of the examples of countries that use the IAEA Safety Standard directly. They are -- plug them into the national regulatory system. So what we manage to put into the safety standards will have some implication in China and in many other countries. This means that we must keep them on a high level.

There is more and more demand for independent safety reviews and I mentioned we are doing them now on regulatory bodies on operators, but also on design organizations. But we are about and we are discussing with the TSO whether we could also have a peer review on research organizations and technical research, TSOs. And I hope this will materialize.

I think we must recognize the importance of regulatory effectiveness for a successful TSO organization on nuclear power. The question of independence and independent safety assessment capability, for example, is very, very important. Becoming more and more important as the public demands more and more responsibility from the regulatory.

So the competence building of regulators is important and I think we need to maintain some form of safety assessment capabilities independent from the industry, but to do that we need strong support from research organizations.

The licensing is one of these challenges for many regulators, particularly, concerning new reactors, but also in renewals considering aging effect. The pressure from the industry to reduce safety or to optimize, but one can say reduce in safety margins perhaps. The public participation in licensing through international interest is not more a national interest only. The licensing process it is an international interest. And we have the new technology.

We have mentioned already the passive system and the lack of experience and data and I think there is a need to have some research facility for this purpose. And at the same time, there is a strong demand from the industry on harmonization of regulatory stability. And that has to in some way be met. And our approach is that concerning the standards, we are trying to maintain the requirements, the standard from the requirements level, rather stable for a number of years, maybe after 10 years before updating, where the guides should be more giving good practices.

The operational safety performance, we are in this report to the contracting parties on the safety conventions stressing that the -- we see safe performance from the operating reactors, 440 reactors operating, but we also see recurring events. We suggest that maybe the root cause analysis is not always done in a way that it should be done.

So I believe there is more or there is a need for continued support in this area from the research area. And we also see when we look at operational experience that electrical system behavior, maybe it's an area which has been neglected, because we should also have a defense in that sort of see-in approach in that way in those areas. And I think the Forsmark event showed that it was not really thought true.

Reactivity control systems are continuing to better operators. We have had many events, particularly, in BVR reactors, but also in some western pressurized water reactors. We have, of course, the brand new issue of seismic events and the event that happened in Japan, which clearly showed that the seismic hazard was not very well-analyzed.

There is now a big work going on supported by the Japanese who tried to create with the help of the Agency and knowledge center for -- to spread, to collect and spread best practices in this area in the world. We are just in the start, but this is supported by other countries as well. The Japanese are in particular interested. And then the new technology I have -- we have already mentioned.

Let me come to the -- one of the fundamental safety principles. And we stress this also in the report. That nuclear organizations are unique. They are not as any organization, because they contain this particular feature of radiation risk and the waste issue and etcetera. So we need strong leadership recognizing the importance to manage safety strongly and to develop and promote safety culture.

And I think there is still more work to do in order to understand better the concept of safety culture, particularly, in the various national cultures. We may find an agreement in the west, for example, what is strong safety culture. But when we come to countries like Japan, they have other -- for example, one of their strong principles is ownership. You can do everything for -- to make sure that your plant survives. It's very strong ownership.

And this sometimes conflicts with the -- what we say concerning safety culture, that you need to be open. You need to share, etcetera, within the-- within an organization. So we have a good discussion with them also on this issue with their operating -- with their organization, which is now developing also this area of safety culture.

And what is the relation between the formal management system and strong safety culture? There is certainly a relation, but what is it really? There is need -- more research needed. We mentioned already the safety and security culture and I don't need to go into that, because there are conflicting issues, which need to be handled by operator, for example, in the same culture. We can never have two different cultures.

And how to start the development of safety culture in new or weak infrastructures. That is still an area which we do not know exactly how to do. The approach we are having we say that in document like this, in parallel when you introduce nuclear technology, you have to introduce safety culture in the country. But how should this be done really, that is still not evident.

Openness and transparency is a part that has been mentioned also. Public confidence, the openness within organizations to ensure feedback of how things work. And the security issues again. And the technical development and safety which has led to enhancement in safety, but I think plant modifications need continuous attention to this.

When we assess new technology, when we operate power, when we consider long-term operation, etcetera, and we need to better understand safety margins, how to model in human organization factors and to develop management strategies to cope with severe accidents.

I think we agree with Jacques' comment that there is a need to continue some severe accident research. But still there needs to be coping measures, how to deal with uncertainties from the operators. I think we -- one should try to once more draw the lessons, what we have learned, and give good advice to operators.

Long-term operation and aging management, maybe I don't need to go into this. Sharing our experience and lessons learned have improved, but it needs continuous enhancement and the INSAG group is preparing now or finalizing a report on how to enhance international operating experience, because, of course, they also recognize with recurring events that there is not full effectiveness in risk elimination.

It is easy to learn from your own mistakes, but mistakes done in a country far away is very difficult to feel ownership with. I think this is human and this is something that we need to also be aware of.

And the human and knowledge resource is the key to successful renaissance for sure. You get completely what was said and we need to create stronger safety networks. We cannot -- everyone has, in the past, or almost all nations, tried to be independent. Today it's not possible. And there is a strong need for international cooperation in research.

So we are seeing now regional training centers growing. We are establishing one in Argentina to support the Latin American region. We have just signed an agreement with KINS in Korea to support the Asian region with training and nuclear radiation safety. We are discussing with Lithuania after they are closing down Ignalina Power Plant. They have good training centers which would be empty. And we are trying to establish also a regional center there to train future operators and also regulators.

We have also something what is called coordinated research projects in the Agency. If you have ever heard, I just wanted to mention it's not really a systematic research, but we promote common research between industrial countries and non-industrial countries. So there is every two or three years documents sent to every -- all the 148 member states which contains ideas from the secretariat and its working groups on proposals for research projects and some are in reactor safety. And I have this document with me, if somebody is interested in it.

So summary for existing reactors, I think there is a need to keep the basic technical safety research alive. This is purely of importance for safety, but also for knowledge management. But we need to put specific emphasis on some weaknesses from operational experience and, of course, topics related to new design and power uprates and life extension.

And some external phenomena in reactor safety, such as seismic, extreme weather conditions. We have had flooding events. We have had the tsunami and this type of extreme weather conditions. And the security issue and the interface safety-security. And also in the interface safety-security, INSAG is now producing a document on how these two areas should synergetically cooperate in order to support each other.

And on the barriers, I mean, the fuel is certainly in need of continued research. Reactor pressure vessel and primary systems for the aging, failure mechanisms. Containment, we saw, at least in my country, several -- we had several examples of leakages in the containment. And we do not really have good known destructive testing methods for concrete, particularly, when we have liners and concrete. And to understand better the aging mechanism, but also to have more automatic surveillance of these issues.

And I mentioned some reactor systems, including the great consideration that was mentioned. And then for new reactors, I think, there is this extensive research needed and probably it is difficult to maintain the research in all the sort of concepts that, for example, Generation IV is suggesting. I think a country has to decide at some point we are going in this direction and then the research should follow.

And I had mentioned, I think, the other one, fire safety also and safety culture and the maintenance of large scale test facilities, of course, and I think the NEA is doing an excellent work in this area. We will probably hear from Carlo Vitanza more that that -- on this. And I want to stress again, safety culture, safety management needs to get its part of research, including regulatory effectiveness.

So this was our contribution. It is based on our experience from the practical work with the countries all over the world. Thank you.

MR. THADANI: Thank you, Christer. Questions?

CHAIR POWERS: Yes, I think we will kind of hold the questions until our discussion period, but I think this is pretty good for validating and expanding on our assumptions.

MR. THADANI: Yeah.

CHAIR POWERS: And I am facing a rebellion of my Members if I don't take a break here. And then we'll come back and, Carlo, you can close out the formal presentations and then we will break for lunch and then come back for discussions.

MR. VITANZA: Okay.

MR. THADANI: Take what, 15 minutes?

CHAIR POWERS: At five after we will come back.

MR. THADANI: Five after. Okay.

(Whereupon, at 11:50 a.m. a recess until 12:06 p.m.)

CHAIR POWERS: Let's come back into session and I'll turn it back to you, Ashok.

MR. THADANI: Well, Carlo?

MR. VITANZA: Okay. Thank you very much, Mr. Chairman. I would like then to outline the OECD-NEA approach for long-term nuclear safety research. And in doing that, I will give you a brief overview of the OECD-NEA and also the outcome of recent NEA workshop in the role of research in the regulatory context, which, in fact, apprised also the long-term research. And also, I will mention the OECD-NEA International Research Project, which we call it sometime "joint project," which has been referred upon earlier by previous speakers. And also, I will try to summarize with a couple of slides regarding the possible NEA options for long-term safety research.

When I say NEA role or NEA option, the NEA is actually not doing the things by themselves and they are promoting activity. And through the working groups, through the CSNI, they try to put together the expertise that is necessary to conduct this work. And I will mention that in the presentation.

The OECD is 30 member countries and they correspond to 20 percent of the world population, about 60 percent of the world's experts and generate 80 percent of nuclear power in the world. So 346 reactors are in the OECD countries.

The OECD Nuclear Energy Agency has a mission to assist these member countries maintaining and developing through international cooperation, scientific, technological and also the legal bases for the safe and economical use of nuclear energy. So this goes together with the work that was discussed before in terms of international cooperation for today and future research.

It has a small size budget. There is only 80 staff members. The budget is 13 million Euros, but actually the one that is involved with the things that we are discussing today may be one-fourth of that. So it's not a big organization. It's very small.

And in addition, there are some voluntary contribution and projects. I will mention now that this international project we will be referring to, they correspond to about $50 million per year, that's the overall budget of this project. Of course, some of them are larger than others, but this is what we are talking about. And, of course, this has to be -- this money has to be found somewhere and I will try to mention later on how we try to do that.

So the NEA also aims to put together the world's best expertise among member countries. And is organized by specialized committees. The committees that are dealing with the safety and regulation are the Committee on Nuclear Regulatory Activities, CNRA, and the Committee on the Safety of Nuclear Installations, CSNI, and the CSNI is the one that deals with the safety research, primarily.

This CSNI works through working group. They are listed there. And the recent things are risk assessment, analysis and management of accidents that these primarily thermal hydraulic and CDR accident work is done there, integrity of components and structures, aging is addressed there, but not only aging, inspections and, for example, seismic is included in that working group.

And there is also a group on human and

organizational factors. We have heard a lot of that this morning. And then fuel safety and fuel cycle safety. And in addition, as I said, its sponsored joint research project.

Within the frame of the CSNI and the CNRA, there was very recently that there is, yes, exactly two months ago, a workshop on the rule of research in the regulatory context. And the objective to review the progress made there since the previous forum was held in 2001. And also set forth the high priority safety issues currently and in the near-term for current plants and those for new build.

Identified the challenges for safety evaluation of advanced reactor designs and those are for organizing the long-term research and infrastructure that would be needed. And through the above, provide input to the CSNI regarding strategies for how these things can be addressed in the future within the CSNI.

The program is outlined there. Jacques Repussard was co-chair together with Mr. Soda of the Nuclear Safety Commission in Japan and they had the opening. Then there was a session dedicated to the need and the facility utilization. Facility means, we are talking about test facilities, research/test facilities for operating reactors.

There we had, from the U.S., Rosa Yang from EPRI. And then we have two French and one Japanese presentation. Then there was a session dedicated to the new reactors. Again, the countries that are mostly involved with new reactor and new builds were represented and U.S. NRC was present there.

Finally, there was the session on the R&D procedures and infrastructure for advanced reactors, that is the longer term. There we had the presentation from Michael Johnson, actually the presentation was intended to be Brian Sheron. Brian couldn't come and Michael had the presentation. In addition, we had presentation from CEA and two presentations from Japan. Then we had summary and recommendation and we tried to come back to what this main summary and recommendations were.

The main conclusions were that the regulator research institutes and industry should promote stronger research cooperation. These things are the industry participation, research, not only for today, but also for the longer term is important. The CSNI put attention to that thing and how to conduct cooperative research programs with the industry and with the regulated cooperating together in the data gathering phase, at least.

Especially for expensive data gathering, this is -- this can be done. And can be done by maintaining also transparency, as long as we don't involve into that interpretation and drawing the conclusions, we leave them to the individual parties, but at least in the data gathering phase, it's important that there is this thing. And there is a full set of reasons for that and I will not enter into it.

And then there are different new and advanced reactor designs. And for water reactor, I think we have today some sort of base infrastructure, which if we are able to keep it, it would be useful also for the future. But for new build, new designs, that is non-water reactor designs, we have to do something about it. And we don't know if the current infrastructure can be adapted to that or an extent to which it can be adapted or not.

Certainly, some of the test reactors, for example, use the -- for fuel testing can be, to some extent, modified. But we have to address what is needed for the future.

It was also said at the meeting, and I'm glad it was also mentioned during the previous presentations, that the OECD-NEA projects are a good means for insuring facility infrastructure and for maintaining a competence network in a practical manner. The OECD-NEA joint project approach should also be used for the long-term research.

There was again some other reasons for this multinational cooperation, but it was -- the OECD-NEA was encouraged to play a role and promote this long-term research through efficient project arrangement. This is principles, but then how to do it in practice.

Okay. The first step is that's the way the CSNI operates. They set up a task force probably working for one year time or something like that and try to set the priorities for that and then we take it from there. Again, it's the country that decides. It's not the secretariat. It's not us. It's the people that know the matter and know their priorities and bring these priorities on the table.

And this task group was proposed by the U.S. NRC by Brian Sheron. And the intention was to set up the long-term strategy and approach to joint efforts for this infrastructure build-up and, in particular, define key safety and risk issues as related to specific design concept issues that will require experimental data and also the infrastructure that would be needed for developing the required data, including key infrastructure element, timing and roles for -- and the role of regulator, the support organization and the industry.

And so we will start with this thing now and we presume that we be finished in about a year's time. At the same time, we are not -- we have already this project interest, research project interest. Actually, that has been there from before and I will mention it. This was to cooperate. It consist of project in different disciplines and technical area.

I mentioned this thing with the project, because I presume that if the NEA will make some contribution, it would be through this type of project arrangement. And I will tell you in a second what this project arrangement is.

The motivation and goals of this project is to address safety issues relevant to the nuclear community by means of research shared by many countries. If you will talk to us seven years ago, you will see the first sentence would have been maintain facilities. Maintain facilities doesn't stand on its own. You have to maintain facilities that are able to do meaningful work. And if they are not able to produce meaningful work, that means they are not good enough.

MR. THADANI: Amen.

MR. VITANZA: And so this is what we had to find out.

MR. THADANI: Does that apply to maintaining competence also?

CHAIR POWERS: Let's not go there, Ashok.

MR. THADANI: All right.

MR. VITANZA: That is good you mentioned. Let me go back through something. 35 years when I was young, before this today, this -- the younger generation and how to attract them and have research, I think, it was Jacques that mentioned that how it is important to have challenging program. I came at the age of 27 years. And the reason for which I stayed there was because there was this dynamic research environment, but also because it was an international environment.

It was an exciting human experience at the same time. So this, we have put it together. Of course, you cannot live with that only, but this is a part that we should consider.

And then there is enhance technical

exchange, cooperation and consensus-building internationally. That was also mentioned before. Support the data counts as a third point. Support the continued operation of unique test facility, which are a value for the community. And then help to retain the expertise. We just mentioned that.

Finally, facilitate these through cost-sharing arrangements where many countries contribute to the program funding. But there is no money sent today up front, that's also another important, I will say, quality. There is no money there that needs to be distributed. The money has to be found on a case-by-case basis. And this is a positive thing, because if the project is not attractive enough, people will not put the money on the table.

So the way to operate maybe we shouldn't go into this. I just mentioned that there is no funding available up front. And that's it. So next.

CHAIR POWERS: Well, let's point out that there is also a priority issue over us. The project may be very worthwhile today, but if you try to call your funds doing other worthwhile things --

MR. VITANZA: Yes.

CHAIR POWERS: -- maybe it has to be -- I mean, don't immediately throw it away before --

MR. VITANZA: Yes.

CHAIR POWERS: -- we may have to wait.

MR. VITANZA: Yes. Well, concerning this thing, if I may mention, I don't know if I should mention and make another digression, but I will mention that later on when we come to the projects themselves. So this is a typical cost arrangement. It's not the same in all cases, but that's the basis. That's the host country comes in with the technical proposal and puts on the table 50 percent of the cost of the program. And then the other countries, there can be many, 10, 12, 15 or something, they come with the remaining.

And the way is cost-shared. They have some general rules for that and we don't need to go into details, but, of course, the largest country contributes normally more than the small country.

These are the projects that we have today. And I just wanted to mention that, for example, France is running some of them as a host country, like the SERENA fire safety, there is the steam explosion together with Korea. If you look again in the middle, there is a SETH Program, which is a containment program where they run -- France running together with Switzerland. The CABRI Program. which is No. 2, is again a French program. There is a Japanese in kind contribution from NSRR, which is becoming important in this phase, in which the CABRI reactor is being refurbished.

All these projects are run after the model of the Halden Project. And the model is on -- the way it is administered is very, I would say, straight administrative rules for that, but at the same time, allowing for some flexibility when needed, especially in adopting the program.

They address different areas. One thing that I wanted to mention and I'll come back later on is that there is also a U.S. program on severe accident, MCCI. This is run at Argonne National Laboratory. If you want to have another way of how the -- these projects start to look like, it's like that. This is divided. It's more or less in technical discipline.

Now, I just make a small digression on, for example, the thermal hydraulics facility. The PKL facility is in Germany, PWR. ROSA is their facility in Japan. It's also a PWR facility. These two facilities exist today. They are there today because of this international program, otherwise, they would both be shut down. And I think they are doing good work.

And when we are looking for the future of the passive system, for example, and so on and so forth, we have to try to bridge today's reality, in which these programs are not there yet, to the time when these programs will be important and try to do something meaningful today with these facilities, otherwise, we are not there today.

Nobody today would say that the Halden reactor is useless. But in the '80s, I can tell you, after TMI, we had very tough problem in convincing many organizations that we should continue with fuel program, at that time. Do you believe it?

MEMBER ARMIJO: I heard it.

MR. VITANZA: And now how we cross the desert is another story and we can tell you -- we can talk about that in another occasion, but we did it. And today we have the facility that everybody recognized that is -- should be there. So maybe sometime we have to be a little bit forward looking and be maybe a little bit tolerant if programs are not always giving you 100 percent or giving the best today. They should give something at least. But also here maybe some degree of flexibility should be allowed in determining this and conceivably in the longer term.

So now, let me come to the conclusion and try to put together some of the possible NEA options for the long-term safety R&D. This is not on the subjects that we looked at. Again the subject would be determined by those who -- by the stakeholders. It's not us that do that, but how we can approach it will be -- well, probably through the OECD Project. This is a good way to perform experimental research and especially when the cost is high. And this can also be used for the longer term research.

How we are to work on a step-by-step basis. The joint project also provides the ground for an efficient regulatory industry TSO cooperation. It is there today in many cases for producing data. At the same time maintain data interpretation independent.

Incidentally, we talked to the U.S. NRC partners and they participate in virtually all OECD safety projects today. Given the size of the U.S. program, the U.S. NRC may consider initiative for hosting projects based in this country in the future and we are in contact with U.S. NRC in that project.

An NRC proposal was made at the last -- it was mentioned before. And the NEA will set up a task group addressing the long-term strategy as it was recommended. For this, the NRC contribution will be very important. Of course, the contribution of France would be very important and contribution of many other countries is important.

Challenges and questions for advanced reactors, while that can be 300 questions, but one can be that the reactor design is not always clearly identified. So we cannot arrange over full spectrum of designs. We have probably to narrow it down to some specific things. For example, water reactor or one or two type of gas reactor or one or two types of sodium reactor, for example. But again, it would not be absolutely certain.

The risk that we also have to consider is the long-term research may be too abstract, just because it's so long-term. I was reassured yesterday when I was talking to our police at the NRC that things are actually coming very soon. Some of these gas reactor designs might need to start the licensing process already in a few years. So probably will not be that abstract. It would be probably more concrete than one may imagine.

How should the program be organized? And then also where to find the money, because one important contributor for this thing is -- for this project is that we have to find enough people that are interested and are prepared to put the money. And if you are looking at the long-term, we don't know. I think again it will be important to have public funding, but also industry funding in that.

I mean, the industry funding will have -- will keep this program less exposed to the changing wind of politics and budgeting. You know what I mean? So we have to try to find a way, but again, we have to discuss and try to find an optimal solution.

MEMBER ARMIJO: Carlo, just in these various programs, does the Department of Energy participate in any of these OECD research projects or is it just the NRC?

MR. VITANZA: The NRC is primarily -- there was only minor participate of the DOE in the PSB-VVR Project, which you will find here on the left side.

MEMBER ARMIJO: Um-hum.

MR. VITANZA: But that is more -- mostly for historical reason. We have been -- but in Halden, of course, then we have a collaboration of EPRi.

MEMBER ARMIJO: Right. Yes, that's industry. That's industry and NRC, but not the

Department of Energy.

MR. VITANZA: Not DOE, no, no.

MEMBER ARMIJO: Yeah.

MR. VITANZA: We don't have DOE in it.

CHAIR POWERS: Most of these things are -- most of these programs are devoted to existing water reactors.

MR. VITANZA: Correct.

MR. THADANI: Sam, we tried very hard to get DOE to participate. We were not successful. Particularly, if you recall, Carlo, in some of these accident issues.

MR. VITANZA: Yes, correct. Ah, I forget. Our national laboratory started with the contribution of DOE.

MR. THADANI: Yes.

MR. VITANZA: And then apparently now it's they withdrew that contribution. I had an example, but I don't know how pertinent that is on maybe some of the things that we need to be addressed in this working group that will come up in the future.

We have already addressed the facilities available for light water reactors in a group called SPEAR, SESAR SPEAR in the CSNI. It was support facilities for existing advanced reactor. In reality, it limited -- it was a catalog of existing facilities for light water reactor. Now, we have ability to go beyond that and do these exercises. And maybe one other thing that we had talked about is how do the existing facilities -- can the existing facility be adapted also for non-water reactor purposes?

Which are the ones that are good for that? Which are the ones that would be available presumably for that purpose? Here, I take, for example, the test reactor. There is a spectrum of test reactors. Some of them would be available. Some of them -- they are all old, older, that's another consideration that we have to keep in mind.

There are also very new ones like, where is it in France, there is a -- in France there is the Jules Horowitz reactor here that will come in the future. It is not there. It's just a baby at the moment. We will see what we are able to do in five or six years time in this reactor. But this is the infrastructure and the question that we had to pose to ourselves how are we going to use these things?

There are also some things that are a little bit more -- they are there, but they are not put on international scene so much. And for example, the Japanese high temperature test reactor is a facility that has been operating for 10 years, but we don't hear very much about it. Maybe we should talk to the Japanese about that.

There is the Joyo reactor or the Monju reactor there, they are the only operating, in the OECD, sodium reactors. One is a test facility, the one there, the Joyo. The Monju is more a prototype. Phoenix is also there, sorry.

So maybe we have to put on the table this infrastructure and try to give some questions on, for example, how big are the patience needed? Will new reactors be needed, if you are talking about test reactor? Who will pay for this thing, for this reactor? And also how to get started. Maybe the best is to start gradually with sub-programs within existing waste projects.

For example, in Halden, there is -- there are projects on digital I&C that can be maybe projected into the advanced or maybe fuel testing that can be done in one program just as an add-on to existing program for current reactor or maybe it will be necessary to start from scratch with new project. There will be some researchers here with that, because when you're doing -- projecting things in the longer terms, it's a bit more risky.

Maybe it would be necessary to pool different test reactors in one comprehensive project. Okay. These are the things that maybe we have to discuss in this group and come up with options for maybe the first set of steps, second steps and following steps. Thank you very much.

MR. THADANI: Carlo, I know I have a quick question. What you talked about was how OECD member countries, you have other research facilities. China has small PBMR, I think, 10 megawatts. India has a passive high full pressure scale facility for passive systems and so on. In this one year effort that you are talking about, are you going to limit the resources out there to just OECD countries or beyond?

MR. VITANZA: Again, it's not a thing that the NEA has to decide. We are to discuss together with our partners. But I think we would be wise, as we have done in the past, when it comes to facilities to see what is on the table worldwide. It would make no sense if there is a good facility in a country that is not an OECD country and that if our partners want to use it, not to do it.

MR. THADANI: Yes.

MR. VITANZA: And we should put bureaucracy to come after practicality.

MR. THADANI: Good.

MR. VITANZA: And we have done that in other cases. So pragmatically, I think we should go that way, but it has to be our partners that make the decision.

MR. THADANI: Okay. Thanks.

MEMBER ARMIJO: In this list of reactors, test reactors, are any of these at risk of being shut down? I know JMTR, the Japanese government decided to refurbish that and upgrade it.

MR. VITANZA: JMTR has decided to be upgraded. You know, it depends on the way you look at it. They seem to be -- all have a reasonable healthy economy today. So partly -- part of them like the HFR in the Netherlands, they lead with radiochemical and medical applications mostly. They were very good, if you remember in the past, but they went more in that direction for political or maybe for convenience.

But I think that they should be available for some period of time. They are all aging, as I said. But the fact that they are aging, doesn't mean that they are in risk of being shut down.

MEMBER ARMIJO: Um-hum.

MR. VITANZA: ATR, for example, in -- we know of this facility, but it tends to be very much national. And maybe it does open up for some international testing with the Japanese in that part, but we are to have a dialogue with this --

MEMBER ARMIJO: Well, that's DOE. DOE-controlled.

MR. VITANZA: Yes, exactly. But maybe also DOE can make -- maybe DOE may see the convenience of opening up for the international work. But for them to decide. It's not for us to decide.

CHAIR POWERS: You just can't dynamite time on the ATR. I mean, it's just extremely limited timing on it and it has nothing to do with DOE.

MR. VITANZA: Right.

CHAIR POWERS: Okay.

MR. THADANI: This chart is very striking, Sam. I mean, if you had this 15, 20 years ago, North America would have had a huge list, a pretty significant list of facilities. It's really remarkable, I think.

CHAIR POWERS: Well, you know, there are all -- for instance, the Texas A&M reactor is not listed on there.

MR. VITANZA: Yes.

CHAIR POWERS: There is a couple of zero-power facilities are not listed there.

MR. VITANZA: Yes, yes.

CHAIR POWERS: And I don't fault you for not listing them. I think we have to do our own homework.

MR. VITANZA: Yes.

MR. THADANI: But, I think, if you look in terms of safety research, you know, both of the Sandia facilities are basically gone and there has been a --

MR. VITANZA: I should say, Mr. Chairman, that when you look at this here, the one that we are really doing fuel work are OSIRIS, Br-2 is very small amount or a relatively small amount. OSIRIS, Halden and then the rear area of CABRI. So it depends on -- they are there, but they are not all doing, for example, fuel work.

MR. THADANI: I was broadening funds just to test reactors to --

MR. VITANZA: Right.

MR. THADANI: -- safety research facilities.

MR. VITANZA: Right, yes.

MR. THADANI: Yeah.

CHAIR POWERS: Okay. Well, I think you have given us a lot to discuss. And there is issues connected, not with just reactors, but thermal-hydraulic facilities that I think we need to go through because we are making specific recommendations in that area. And a lot of discussion points probably better done over full stomachs than empty ones.

So I will take a recess for an hour for lunch and --

MEMBER ARMIJO: At our great cafeteria.

CHAIR POWERS: Well, to utilize the facilities we have, you go to lunch with the facilities we have, not the facilities you want.

(Whereupon, the meeting was recessed at 12:40 p.m. to reconvene at 1:48 p.m. this same day.)

CHAIR POWERS: Let's come back into session. What I wanted to do this afternoon, Ashok, is have you lead us through this. We've just had three, what I think, are just tremendous presentations that sharpen focus on the questions that we have. And now I'd like to help us come to some conclusions that we can represent before the full committee. And I look to you to help us go through that.

One of the things I've noticed in all three of the presentations spoke to the issue of international collaboration in research. There was an interesting suggestion of mapping the capabilities of various organizations. As you're aware, we have been advocating the virtues of cooperative international research, pointing to our own severe accident research program as a point example and indicating areas within the NRC research program where greater international collaboration could be most useful and highlighting, in fact, issues of fire protection safety and thermohydraulic safety.

And we've also noted the area from of thermohydraulics is undergoing a fair revolution from the days of yore when the current generation of plants were developed. And we see the emergence computational fluid dynamics more. And I believe it was Mr. Repussard who crystalized that when he says, gee, the era now is the codes are driving the experiments, not the experiments driving the codes. And as you are aware, this is an issue we saw also in the relatively geriatric experimental facilities that we have avail for thermohydraulics. That seems to be an issue that we can focus in on as an example of where we could focus the discussion a little bit, draw some conclusions out of that.

So with that, I turn it to you, Ashok, to lead us through.

MR. THADANI: Yes. And if I may just add to what you were saying. My understanding is that long-term thinking by the Department of Energy here is mostly focused on doing analysis suite of codes and so on and as I understand very little or very limited experimental --

CHAIR POWERS: I think Carlo kind of raised this point, in fact, in his presentation, the dilemma we face in regulatory research for advanced reactors. There is no design. The designers tell us this reactor's very safe; we'll be able to prove to you it's very safe. There's nothing you can look at. Dollar resources are short for manpower and dollars, and so you go to your prioritization scheme, and you say let me invest some money in long range and look at this advanced reactor for which there is no design, and they kind of laugh you out of the room and say we've got to send our resources to more pressing issues. And then the design gets submitted for certification and the people doing the certification say, we're not going to hold up our certification waiting for your research to get done. So you can't -- you don't have a long-term research, then you can't it started. You can't get it started until there's a design. Once there's a design, it's too late --

MR. THADANI: It's bad luck.

CHAIR POWERS: -- in a dilemma here. And, you know, we've encountered this dilemma in the past, and that was the origin of a lot of these international collaborative efforts. We said we can't afford it individually, but maybe we can afford it in sum. This may be another area where we have to think in a collaborative fashion because some of these design issues -- for instance, the issue of fuel for the gas reactors seems to challenge analytic capabilities even at the CHASE FIRST DATA kinds of levels. And the experimental database that we have available is wholly inadequate to address what will be even the operational environment of fuels, let alone upset conditions.

And yet doing these experiments, my goodness, they are extraordinarily expensive experiments because with the gas reactor fuel, you have to do them in pile. There is no good -- I mean you can't set up a Verdon facility or the Oak Ridge facility and do out of pile experiments and get anything useful out of it.

MR. THADANI: Yes. Actually, I was thinking that Carlo might have talked a bit more about sphere report. It ties in with the point I think you're making, Dana, it seems to me. You can talk about two-phase CFD codes a an example if you want.

But there are a number o f likely needs in the thermohydraulics area for example. If you can lay those out and then you say okay, what are the limitations and where are these capabilities, if you will; do they exist.

And I think you did -- I think CSNI did a pretty good job of identifying some challenges and gaps in where either the facilities don't exist or the facilities that might be needed are in some danger of being shut down. It would be useful, I think, at some point -- obviously, we don't have it today -- but useful to lay out the specific potential needs, tying it to perhaps in a worldwide sense where the capability is or is not. And if there isn't, then going to Carlo' point which is there may be some -- if some handful of countries can agree on that, then see if there are sponsors in those selected areas.

I would think -- and again, I think probably the best organization to be able to Domestic Industry that is, I think, the NEA. The CSNI is probably the best organization. So the support you talked about that you would produce in a year may be something to look to as -- you know, it could spawn. It could actually bring countries together and see -- and I'm hoping that, at some point, the U.S. will have some integral facility. I look to future passive systems and plants, designs for passive systems, even just focusing on light water. I personally think we should expect some surprises.

I think if you don't learn from history, where else can you learn from? I mean we've seen with light water reactors, we learned a bunch of stuff.

MEMBER ABDEL-KHALIK: Ashok, if I may? We listened to -- we got a lot of information. And from my perspective, I'm trying to organize all this information. The difficulty is sort of a mix of detail and concept. And for me, in order to organize this process, I need a structure. And so the first question in my mind was what is the timeframe that we're looking at and based on everything that we've heard today and in the past, we're looking at essentially a 20-year rolling horizon.

MR. THADANI: Okay.

MEMBER ABDEL-KHALIK: And once we have identified that timeframe, the next question that would come in defining this structure is what are the issues that I'm going to look at in the next 20 years. And you don't sort of pull these issues random obviously. So to me, what one should do is start out by dividing the issues into technology-independent issues and technology-dependent issues. And there are a lot of technology-independent issues that need to be looked at -- human performance, advanced PRA tools, digital I&C, etcetera. And, therefore, to come up with that list issues under technology-independent issues that likely will become important over the 20-year rolling horizon. That, you know, you can get a group of people to come up with that list of issues.

And then the second category would be the technology-dependent issues. Now here, we have to start bifurcating a little bit. We have to look at LWR-related issues and non-LWR-related issues. LWR-related issues including GENERATION III. So you look at advanced methods whether they are thermohydraulics or neurotics, and all this stuff comes into whether you're talking about CFD or talking about uncertainty analyses or aging issues or even passive system. All of this falls under LWR.

And then you have non-LWR. And here, we run into the issue that Dr. Powers was talking about. You have so many concepts on the table right now in different stages, and as far as deciding where you're going to put your money, you don't know really how to prioritize this. But one just needs to go back and ask the question what is the motivation for putting forth these non-LWR concepts. They are -- the motivations come from enhanced -- potentially, enhanced economics, enhanced safety and fuel utilization. And when you look at these three motivations, I'm not sure that enhanced economics amongst all the concepts that I've look at really will pan out. Enhanced safety, with the new advanced reactors? Well, I'm not really sure that that's going to pan out either.

But enhanced fuel utilization is certainly going to be a driver and, therefore, as far as, you know, non-LWR options, maybe the focus ought to be on breeders. Fusion, I'm afraid we'll have to treat it on a case-by-case basis, on a facility-by-facility basis, because our horizon is only 20 years. And that, to me, provides a structure as to how one can organize the entire enterprise. Without that, I think we're jumping all over the place between issues for some of these long-term/short-term. It's --

MEMBER BONACA: The only thing that concerns me about -- I agree that you have very good points there. The point I was bringing this morning, for us, 10 to 20 years is too late. We are being pressed to review these concepts now or, you know, in the immediate future. So we're not talking about long-term research now. I mean if you look at, you know, we have in front of us these passive systems, the ESBWR, AP1000. We're looking at them. We have no integral facilities with which they've ran experiments of some type. We've heard the results and the vendors are in a position where they can say, yes, we will do them almost as a false verification because they don't want to invest the money now. So what do we do? Are we going to sponsor research in the short term, in a year or two. We don't even have test facilities yet out there that we can say they're adequate to do --

MEMBER ARMIJO: The burden's on the designers or promoters of the technology to bring the data that's adequate --

MEMBER BONACA: I agree.

MEMBER ARMIJO: -- to the Committee and if they don't, they just don't get -- they don't get their certification, and particularly if it's just a -- for example, the gas reactor in the United States, the promoter is -- or developer-funder is Department of Energy plus some commercial organizations. Well, they have to bring us the data to anser the questions --

MEMBER BONACA: Well, look at the AP1000. As they certified, okay, and yet so much is left to the ITAACs that will come at a later time when they have a contract and finally they can build a facility and then they will test it as a first time. So I'm not discouraging at all the fact that we need to have, in fact, an international effort in the long term. I'm just feeling challenged by the timetable we've set in front of us, 10 to 20 years. But that, for us, is too late for some of the decisions we have to make now.

MR. REPUSSARD: May I come in the conversation? You're looking at your structured approach. There is another division you could make is between talking about new designs. Those new designs where the safety community believes that existing tools can be adapted. Okay? Yes, but obviously things which could be used. There are models which could be probably altered in which case, okay, it's not the same scale. And there are other designs -- Chairman Dana Powers mentioned one of them -- where we, on the contrary, believe that the existing knowledge is not adequate.

And that poses a great difficulty and I think it should be made -- it's a matter for national decision, because to go into design for which we know nothing, where we have not only to build the technology but also to invent the safety signs that go with it. It's a huge effort also for the -- on the taxpayer, etcetera, and that could be discriminating against designs for which everything has to be invented and for -- and which do not -- maybe do not -- well, that's not for us to decide -- but which do not have an edge, an advantage which is so obvious that this effort should be made.

So it's not just a question of technology. Development is also a question of safety tool development, and in those areas where models, test platforms, all our knowledge cannot be applied, we believe that there are good reasons to think that they cannot be translated to these new designs. That should be an alarm signal to the government that says, this is an unmapped area. Okay, we can go to it but then there should be a massive investment by the public in the same way as it was done in the 70's when PWRs were invented. There was many amount of public money to create those bodies as the NRC, the NUREGs. I mean that was not funded by the applicants. That was funded by the public, by the taxpayer basically.

And now, of course, this investment has some time limitations, it can be adapted. The results -- you know, what we know can be adapted too some certain level. And if there could be a report, maybe international report on what are the main -- the key limits of this knowledge we have. Then anything outside, okay, it's not forbidden place but it should be earmarked as needing a totally different type of economic framework to deal with it. That could be guidance to believe in your country to say, okay, watch out, because there not only do you have to develop the technology, but you also have to develop a total new frame for safety, and that's not cheap.

MR. THADANI: To go back to Sam's point, I think you sort have to ask yourself a very fundamental question, and then that has to be tied in, I think, with what Said was saying: What's the role and responsibility of safety authority? Fundamentally, what do you really expect from them? And as John Ahearne told us in fairly certain terms about responsibilities, one of them is to have confidence in the regulator's ability to make sound safety decisions. What does it take?

If you can first -- and if it takes having independent analytical tools or data from wherever it's coming -- nevertheless, in a transparent manner, something that people have truly agreed to. If you can first say, yes, this is really what I think safety authority has to be able to do; if you can define that, then you can break it into three areas like you did. I think it's a very, very logical way to go forward.

But it's critical to have some understanding what does it really take for the safety authority to make those kinds of decisions. You know, this is -- you know, we keep coming back to this do we have the expertise; do we have the people who really understand the technology; do we have the tools they can use to study and whether it's design bases or beyond design base conditions and things of that sort. I would think that that would be the driver.

We talked a lot about sever accidents. I didn't want to inject them but I will now. You know, there are bypass scenarios. We didn't talk about steam generator tubes and what sort of technology advances there might be in that area. Interfaces between high pressure and low pressure systems -- maybe these designs should not have such low pressure design pressure for residual heat removal system. I'm into some bit of a detail, but the high level is are there some areas which have potential for large consequences? Probability is fairly low. Do we understand? Are there things of that sort? I would think that those would be kinds of things that the safety authority has to think about, because it may be the designer doesn't pay as much attention to those things.

If you can come to some understanding of expectations from safety authority and that context three categories, if you will, what stands out within those categories? I think it would be helpful if you sort of put it in that structure that you talked about.

MEMBER BLEY: You just hit on a piece of the structure that meshes up with what Jacques was saying that I think is really important. In the GEN IV International Effort, in the first step, tried to do that, and that's identify where there are technical knowledge gaps to couple them with what you said, Ashok, and how important could these be to safety, to vulnerability to terrorists, whatever the issue is, but put them in context. You know, there are places where we don't know a lot but it won't hurt us, and there are other places where it's really important. Jacques said something this morning that kind of --

MR. THADANI: Jacques said that, yes.

MEMBER BLEY: -- that really struck me was having this level of technical expertise is important in the confidence your communities and your larger communities. And if you don't push forward, you find bureaucratic solutions to all these. And that's a place we get caught in sometimes. It looks like kind of it's okay, but it really won't stand up because of the knowledge gaps with --

MR. THADANI: Dana's point, I think, is absolutely a critical point because I happen to also believe what he said, that practically what happens is if you keep saying that, you know, we're probably not going to have this challenge in the next several years, you keep putting it off and then suddenly the challenge shows up and you have to make a decision, and let's be honest, every agency will make a decision because that's generally the way the system works. And so we're almost -- sometimes we almost are setting ourselves up to maybe not make as good decisions as perhaps we should. This is, you know, which having been part of some of the challenges over the last decade, I can tell you that that was a real issue all through.

MR. VIKTORRSEN: I think, to compare the situation when the reactors were developed, the present ones, and the situation where we are today, I think there is some fundamental differences, and it's, to me, the safety community is almost always lagging sort of behind the industrial development. This is maybe an understatement but this is the case. And in previous time, this was less serious because nuclear energy development was part of a national strategy. It was supported strongly by the governments and we built universities. We built research institutes who worked together with industry, and we had very responsible vendors.

Today this is a business, much more a business than it was previously. So I believe that at some point, we need to, as was suggested, we need to write down where the limitations of knowledge exist and also say, in connection with what we say is the knowledge we have and these are the limitations, and if you want to go further outside this sphere of knowledge, we'd advance the signs, you have also to demonstrate that they are safe. I mean you have to demonstrate not only with advanced models but also with test facilities, and until you have done that, the sort of present type of reactors can't be licensed.

I mean at some point, I think the governments or international community or whatever needs to make this point, because we are seeing now the GENERATION IV going forward and there is a small risk and safety group, but I don't think they have too much to say -- just for the sake of being there. So it's technology-driven completely. This worries me also and us a lot.

MR. VITANZA: Can I go back to what Said said before and the structure, the separation between or the difference between light water reactor and non-water reactor systems. For water reactor systems, I have the feeling that we still have -- and I'm look at that in the perspective of facilities now -- I think that we have a reasonable set of facility available both for severe accidents and thermohydraulics.

But I'm surprised when I hear the urgency that Mario was mentioning before about, for example, addressing these passive systems and for different route and at the same time, the sort of modest input that we receive sometimes for the utilization of these facilities. Why are -- if there is such an urgent thing, and these facilities can address many of these passive safety issues and they can maybe, in cases, modify -- I think there is, at some point, also, a disconnect between the existence and the availability of the facility and the input that they are receiving or the lack of input that they are receiving, because when I hear that the Japanese are shutting down or there has been a risk of shutting down their ROSA facility which is the unique in the world, at full pressure, the only one left on the PWR side.

And at the same time, for these things. Then I think we have to fill up this as a matter of urgency. There is a gap there that we have to fill up and maybe this Committee can help filling up these gaps. Then there is the issue on the longer term for advanced reactors, and of course, that has to be addressed in a different way because there are things that we don't know.

But for the things at least that we know that are a challenge and for which there are facilities, I think we should come with some input. We have a very hard time trying to convince people to participate in severe accident programs. And I keep hearing that this is still an issue that needs attention. So at some point in time, we have to fill up that gap.

MR. THADANI: You are being too practical.

MR. REPUSSARD: hy has the NRC certified the AP1000 if you are not sure that the passive systems are totally safe?

MR. THADANI: No, no. Let me make sure --

I'm happy to respond to that because I made the statement that I made, and I see, technically, as confident in terms of the operation of -- adequacy of the design of AP1000. And that conclusion was arrived at because of two factors. One, the experimental and analytical studies by Westinghouse. Two, experimental and analytical studies by the NRC. NRC did independent analyses, did some independent experiments, did experiments in cooperation with Westinghouse and others, so there is a whole range of, I think, a really pretty good technical base.

Nevertheless, all these studies are based on a set of assumptions and you have reasonable assurance that these plants will behave nicely. Having reasonable assurance and being prepared for some unanticipated things is, in my mind, to me, that's good regulatory approach, that you should now say it's a very good design but when we go into operation, things may come out of operational experience, and they did for light water reactors in operation today. And the question is -- and I will use the TMI accident, BMW designs -- we had a difficult time saying we really understood small breaks in those designs, and we didn't have any way to do any experiments, so we had to go and rush and develop some capability to be able to understand small breaks in those designs. And I --

MEMBER BONACA: So that's the issue -- is how far do you have to go.

MR. THADANI: Yes.

MEMBER BONACA: And the desire is the one that you would want to address all the issues. Now I think there is a number of commitments in the ITAAC program. The ITAAC is the final inspection tests, etcetera, that should close a number of open issues there or questions that we have. I don't disagree with that. Are we satisfied that that's that's the whole spectrum and are we satisfied that for the ESBWR we have all the information that we need? I don't know yet. We're reviewing it now. Okay, what if we suddenly stumble on an issue for which you need some testing, do they have a test facility that can be used to do that? I don't know. This is where it would be a real shame if ROSA Facility is shut down, because that provides that capability for passive.

MR. VITANZA: Or the PKL's, you know, it depends whether the experiment needs to be done at full pressure or not. But anyway, the new program on the PKL facility in Germany and in the ROSA, they are addressing passive cooling issues. And I hope that they will receive the right support and the right team from the participants on the detail to help to run these experiments.

MEMBER ARMIJO: Is GEH in the ROSA project?

MR. VITANZA: Is whom?

MEMBER ARMIJO: The General Electric-Hitachi consortium that's building the ESBWR, are they going to run some ESBWR tests at --

MR. VITANZA: In the ROSA project, from the Japanese side, there is Mitsubishi for the moment. Whether TECO will join in the future is a possibility and TECO maybe we'll bring in also this -- but it is a PWR facility, so.

CHAIR POWERS: I mean, let me raise an issue somewhat aligned to this question of experimental facilities but really kind of -- I keep coming back to this -- the codes are driving the experiments, not the other way around now, because I think it's true. One of the issues that one of our who couldn't be here raised is his thesis was computational fluid dynamics was going to become more involved in the regulatory process, the justification of reducing margins.

And he said he insisted that commercial

CFD codes were not validated to the levels that we ordinarily expect reactor safety codes to be validated at. And he had a half a dozen examples of things they've done to encourage convergence in those commercial codes without naming them. And he said that's not the way to go for the regulatory agency. So the designers will use those commercial codes when they design things. The regulatory agency needs to use something independent and different from that, and it needs to be something build to the regulatory standards.

And unfortunately, developing a CFD code is not something you undertake for $1.95 and three guys or one guy or a part-time guy. And he said, now we, as an international community, ought to develop a CFD code for doing reactor accident analysis, ought to be an international undertaking. And coupled with that, we ought to have experimental facilities for validating CFD kinds of code.

What we have -- some experimental facilities that purport to having been designed for validating CFD codes. I point to THAI on your list and I think there are a couple of others there. But now this issue of should we engage in an international development of a reactor safety CFD code comes up, and

I tie to that the idea of a center of excellence where that might be done in a modern electronic network sense. I mean that, in fact, si how the commercial CFD codes are developed. There are lots of little home operator that are all connected together and whatnot, but with a requirement that it be validated to this standards that's common in reactor safety.

I mean is that -- I bring it up because it seems like a very tangible point issue that everybody faces that might be an area of focus and I toss that out.

MR. VITANZA: It's interesting that you mention that there has been in one of the -- in the working group that I was mentioning before and the CSNI and the one dealing with accident management was this use of CFD for nuclear safety. And it has addressed basically three different items. One is guidelines for the user because there are a lot of user effect involved in it. The second was on a validation matrix for single-phase, and the third one was two-phase problems. And the test scale now to a point where there is a web-based sort of system where CFD operators can be addressing that.

But of course, this is a modest effort and they can -- should be perhaps scaled up. And again, it depends on the international community for formulating a perspective of whether that can be done at a higher level.

MR. THADANI: Yes, Dana, I think what Carlo is saying is that there actually was a conference also on this particular topic. But if I remember correctly, and I may not, there were a set of recommendations about what things one needs to do to move to having a validated, I think, two-phase CFD capability. It might well be really a good case addressing the issues of having independent validated code and also at the same time having, you know, a center of excellence. But if I remember correctly, the problem you had was the same. To go forward, you got to have countries willing to participate and provide resources. And to the best of my knowledge, it is still kind of --

MR. VITANZA: The CFD has enough support and -- but of course, those who have these fluent or whatever code are not so many, and those who are able to use it, so there's a limited participation for the moment.

MR. THADANI: That's what I thought.

MR. VITANZA: But it is a trend to go more and more in that direction, especially for containment issues or for some primary thermohydraulic issues. Where it's not used, for example, is on fuel for gas reactors. There could be, for example, very fascinating potentials. Still, that is an area where people maybe should be looking.

MR. SCHWARTZ: There are some actions that you will be unable to -- and solve some development of CFD codes by the new regime actions which is supported by the Commission. But you find the industry or some safety organization and just say go forth.

MR. VITANZA: I think from the U.S., in this exercise that I was mentioning, there was Mojave was --

MR. THADANI: Mojave, yes, I think was --

MR. VITANZA: -- co-sponsored by the NRC?

MR. THADANI: Yes, but I think if I remember, NRC didn't participate in the second part.

MR. VITANZA: Not directly. That's correct.

MR. SCHWARTZ: But the question is what kind of experiments do you need to validate these codes, because I think you have to have analytical tests as well as integral tests, because you need to have a multi-scale approach and very, very far measurements.

CHAIR POWERS: Yes. I mean the very high precision measurements goes without saying almost, because if you're doing a high precision calculation -- and that's why one thinks in terms of a center of excellence, because a major tour is just developing the experimental capability to do it. I mean that is an undertaking in itself, you're staying aware of what developments occur there.

The flip side of centers of excellence is ossification, that is they tend to get established and they never go away. And they become increasingly irrelevant and demand resources without yielding a product. I mean there's a certain advantage to the competitive approach to research in that new ideas or relevant ideas come forward in a competition framework, but it does limit you on this kind of high precision sort of stuff that takes a huge amount of investment of time. Instrumentation tends not to be so terribly expensive as far as the hardware, but it's horribly expensive as far as the manpower.

MR. VITANZA: And in Switzerland, for example, there is a PANDA facility that was, in the past, used for thermohydraulic studies on BWR, on HBWR. Now it has been converted into more containment type of studies and it has been developed with good instrumentation.

In France, there is a facility also for doing -- operated by CEA, also for doing specialized studies just for CFD containment studies. And they are recommended in this SFEAR report that Ashok was just mentioning before. So there is some effort being done. In the primary systems, there is some work in the context of ROSA where they have instrumented with very different instrumentation in some areas in order to be able, for the CFD, to reproduce those areas of interest. So there is some effort.

But again, we have to bring the input together so that this effort is correctly focused and correctly addressed. Again, I see sometimes a mismatch between the interest that is seen, the opportunity of having it there and there is something in between the two missing.

CHAIR POWERS: Well, let me ask you this question: suppose one set up a facility in the institution says, here, we can do CFD calculate -- we can do experiments that will be use -- everybody agrees that these experiments will be useful for validating the CFD code and after five years, what happens to that facility?

MR. VITANZA: Well, we are to take one

step at a time and we are to -- I think if a facility is good to produce good data, people will not abandon it. And I think it's important also to mix together the industry and the public organization. The reason for that is that, in my experience at least, the industry tends to be more stable in terms of their drive and their funding and their interest. Of course, the are oscillation also there. Public money can be exposed to winds that are changing and then all of a sudden, something that was priority one becomes priority five. That is less likely to happen with the industry. That's why it's good to have this merging of industry and regulator in terms of the data generation.

But what will happen with any facility in five years is difficult to -- nobody can guarantee anything except that this facility has to be lively enough to generate continuous interest. That's the prerequisite.

MEMBER ABDEL-KHALIK: But, you know, validating large-scale codes, you know, like CFD codes, does not necessarily require large-scale experiments. Okay? And therefore, to think from the very beginning that we need these very, very expensive experiments that have to have a life of their own after five years or whatever is not necessarily the right focus, because if you design small-scale, clever experiments, you can get 95% of the work done with these very small, disposable, dispensable experiments --

MR. VITANZA: But that would make --

MEMBER ABDEL-KHALIK: -- and then the rest of it.

MR. VITANZA: But that will make the ROSA facility redundant and there's a natural selection if that happens. Nobody wants to keep an expensive facility if you can do an experiment with less money.

CHAIR POWERS: Well, just to pursue that a little bit -- I concede your thesis that you can get 95%. Ninety-five percent -- is that good enough? Or do we have to get 5%, and do we have a situation that we often do that the last 5% takes 50% of the effort?

MEMBER ABDEL-KHALIK: That may very well be the case but, you know, to think from the very beginning that all you need is large-scale experiments that have to sustain themselves for a long period of time is maybe fallacious. Oftentimes, you can get the majority of the work done if you just think hard enough and are clever enough to design appropriate small-scale experiments that answer specific questions that you can toss out afterwards. You don't have to worry about long-term use or reuse of these small-scale experiments.

CHAIR POWERS: Said, we've got a member who says, gee, the thermohydraulic facility at Oregon State is no good because it's not full height. The facility in Europe is not good because it's not full height. We've got a draft recommendation that says the commercial CFD codes are no good because they're not validated. I mean are you contesting that?

MEMBER ABDEL-KHALIK: Well, I don't know. I always have subscribed to the philosophy that the scale of an experiment is directly proportional to the level of ignorance, and therefore, if you don't understand the problem, you'll just build a full scale experiment and test and get an identical set of data. But if you think long and hard, you may be able to come up with, you know, small-scale experiments that answer some of the critical questions. That does not preclude the need for large-scale experiments. I think --

MR. THADANI: Yes, because, you know, if there are scale issues that cannot be resolved, by gosh you will need large-scale experiments.

MEMBER ABDEL-KHALIK: I think -- I don't

think anyone -- certainly, I don't think -- most people would not argue with that logic, but you got to go through that thinking up front. And if you're convinced up front that you do need some large experimental facility -- I can tell you for AP600, NRC staff and the ACRS, I doubt, would have supported certification of that design without ROSA.

CHAIR POWERS: You had to have the ROSA.

MR. THADANI: I think you had to have it and so it's -- intellectually, I agree with what you're saying of course, but I'm saying you should also up front in your thinking not exclude -- and you said it, you said it.

MEMBER ABDEL-KHALIK: I agree.

MR. THADANI: And for ESBWR, for example, the staff apparently is going forward without large-scale --

CHAIR POWERS: Well, it's hard to anticipate what they'll do. Let me turn to another object, and I'm simply using these as examples. One of the areas we've not spoken of is the safety of the reprocessing system, fuel reprocessing. And another one is the safety strains or threats posed by climatic change. I'm not a big supporter of global warming, but I am a great believer in trends in the climate that threaten our reactors. Are these areas that have not gotten the attention that they deserve in the past and do deserve attention in as we move into the 20-year timeframe?

Certainly, I'm familiar with reprocessing of fuel within the weapons complex where we've had our moments. We've blown up a couple of facilities pretty good, and we are -- there are issues. The most famous one is called "red oil" where we have no understanding of the phenomena whatsoever. They may actually understand it in France. There's some very good research going on in France in the area. But we've proceeded ahead with operating facilities despite not having an understanding. That's probably doable in a security framework. Can we do that in a commercial framework or do we need to move into reprocessing safety?

MR. VITANZA: That would be a yes. It was mentioned before if you are going more and more in the direction of better fuel utilization and especially liquid metal-type of structures; of course, that will be an essential step that one has to look more and more into these facilities.

CHAIR POWERS: Is it inevitable that we go to reprocessing? I think it is.

MEMBER ARMIJO: I think it is. I think so.

MR. THADANI: I would even -- I don't know if you remember -- John Ahearne said that yes, NRC should get ahead of reprocessing, regeneration, recycle. I mean certainly that was his recommendation, but the NRC will have to face those issues.

MR. VITANZA: It is more difficult maybe to imagine how we research -- activity can be put together there, but it is certainly something that people should look into.

CHAIR POWERS: And I know for certain the history of "red oil" research has been almost classic that one trains a researcher so that he kind of understands the problem, and just about the time that he begins to actually make progress, they cut it off because they come up with a new administrative safety limit.

MR. VITANZA: Right.

CHAIR POWERS: It's almost impossible to sustain your research in those areas. It is very difficult.

MR. VITANZA: But concerning that point, maybe there is also a related thing on the enrichment and the 5% limitation. I don't know if this is the right time to bring it up, but there are some people that are thinking, some countries, at least one, that is thinking that maybe the 5% limit doesn't need to stay there forever and ideas to get around it with some burnable poison mixing of more than 5%s, traces of burnable poison. I don't know if that can also be a subject of interest for the longer term.

MR. THADANI: The U.S. industry, I know, has a strategic plan. In that strategic plan, they talk about their long-term intention is to go to 85 gigawatt-days per metric ton by way of burn up and enrichment in excess of 55, so --

MEMBER ARMIJO: There's a big infrastructure cost.

MR. THADANI: Yes.

MEMBER ARMIJO: Huge --

MR. THADANI: So that's --

MEMBER ARMIJO: -- historic burden. I mean it's everything from transportation to conversion to everything --

MR. THADANI: High cost.

MEMBER ARMIJO: It's very costly.

MEMBER BONACA: It's the need for your cost. Cost goes up

MEMBER ARMIJO: Yes.

MR. VITANZA: Even if you add burnable poison into the uranium? Of course, that will be after the conversion. But if you do after the conversion --

MEMBER ARMIJO: There may be simpler, other ways to get there, you know, without going above 5%, other kinds of fuels, higher density fuels, carbides, nitrates.

MR. VITANZA: Yes, nitrates.

MEMBER ARMIJO: But I haven't seen anybody really working on that. That's the sort of think that the industry or DOE or somebody would have to really be promoting and have an economic justification before NRC would start fooling around with it, I would think.

CHAIR POWERS: Well, we've already been panting getting cross sections to -- for enrichments beyond 5% up to 10%. And certainly --

MEMBER ARMIJO: I don't see anything wrong with getting that kind of basic information, but until somebody makes some fuel and starts getting it into test reactors and things like that, it's going to --

MR. VITANZA: I put it on the table because --

MEMBER ARMIJO: Sure.

MR. VITANZA: -- there is some interest, at least at governmental level in Japan for doing work in that direction. They're talking about 7% with some traces of burnable poison which I don't remember exactly what it is.

MEMBER ARMIJO: But their refuel factory would have to go through an awful lot of work if -- to work with it, unless you built a special purpose facility just to make that level of enrichment, rods of that type and then put them in bundles.

MR. THADANI: And may I follow-up on this thought -- still, centers of excellence. If you look ahead 10 to 20 years and say we would need this expertise and it's crucial -- I mean they have to be really crucial safety areas -- do we have to build it or are we at risk of maybe losing it? Or do you have some thoughts on what those crucial areas might be, a handful presumably where one better do some solid thinking now and see if some centers of excellence exist or should be developed. And again, I think all of us have been scientists. It very likely would have to be in some international collaboration -- collaborative way.

Do you see some critical safety areas where one should be paying attention now so that 10 to

20 years form now, you can say, yes, you have that access with that type of capability? And refuel keeps coming up, clearly.

MR. REPUSSARD: Fuel is safety criteria because the industry would want to innovate.

MR. THADANI: Yes.

MR. REPUSSARD: And the current system where each country -- in fact, if you look at the past 20 years, the criteria have been diverging. Initially -- the NRC has had the initial historically, and they're able to us those because everybody else will see them out, and so we use them. But little-by-little, as knowledge was acquired, as different interpretations, different regulations, and today, it's -- when you look at the -- I was shown a map on one slide of the different criteria which exist in the world today -- it's not communicatable to the public. But it is safe here. It's not safe there.

And we are trying to get together with the TCRs and NRC as a beginning to try and converge again, which would also induce the joint research. If we have a joint goal, it's easier to have a joint research, because I think on these critical areas, there should be more than just NEA projects which may happen or may not happen for some time and stop. I think facing a global nuclear industry, there should be, on these critical areas, almost a treaty between the safety agencies -- okay, we are going to work together a long time.

And it is quite good what you said about proportionality between ignorance and the scale of the experiments. This was applied to nuclear weapons. And the point I was making, in fact, earlier -- you could decline it the other way around. That means GENERATION IV designs for which we have no knowledge; therefore, we have ignorance, we'll call start at the beginning; that is to have large-scale experiments which will be very extremely expensive.

And that should be stated. That's part of the learning curve that you start with very expensive stuff because you have the need to understand. If you have a thousand equations with we don't know anything about it, then the only thing is to make a scale one model. That is true. And that will be applicable to maybe some exotic designs which then should be -- that should be added to the bill and say, okay, when you do the economic viability of such projects, that should be included what the safety agencies together would need to investigate.

And the other way around, when we have

learned and gradually we need less -- this was what happened to PHEBUS for example. We say okay, we need less because we can do a lot of -- we can do source term which is an analytical test. And people said, well, okay, from time-to-time, you need to have a concluding global test to see. That's an intermittent stage and I think we should be careful when we -- for example, with the ROSA LOOP, before you kill the last one, I think, you know, you can reduce down scale here. You have five, four, three. Then when you have one last one to say okay, we know enough forever and -- secure -- that's a risk.

CHAIR POWERS: The other trend -- we may have a major philosophical evolution here that we start with big tests; we go to small tests; then once you implement, you start cutting margins finer and finer so you have to go back to big tests, so you need all the competing effects. So you may have a major innovation in experimental philosophy.

MR. SCHWARTZ: Regarding GENERATION IV, it may distinguish between high-temperature gas-cooled reactors and certain liquid metal-cooled reactors, because most liquid metal-cooled first reactors, we are not starting from scratch. We have already wrote the codes and we have just forgotten them. We have to use them again. But this is maybe not the case for, I'm sure, high temperature and gas-cooled reactors. We have just new materials.

MR. VITANZA: Certain materials, yes.

UNIDENTIFIED SPEAKER: New graphite.

MR. SCHWARTZ: And the other point is that --

MR. REPUSSARD: And with thermohydraulics, I mean it always amazes me is that the finite capacity of gas is not great in general.

MR. SCHWARTZ: And the other point is we cannot wait for the industry to give us the data that we need because we have to build the competence to that level, independent review of what we are going to propose. This is a difficult --

MEMBER ABDEL-KHALIK: If I may go back to the issue of centers of excellence, are you sort of thinking in terms of sort of area-specific, like a thermohydraulic center of excellence or a neutronic center of excellence or a materials center of excellence? Is that what is being proposed? Or is this sort of a -- you know, oftentimes, the big problems are the interface between different disciplines and, therefore, to sort of think in terms of a narrowly defined center of excellence may not really advance the state of knowledge very much in terms of resolving critical issues that would be of importance.

MR. SCHWARTZ: We have the experience of the network of excellence, which is not a center of excellence but a network of excellence, around severe accident research. And in fact, we are organizing in such a way that we -- how can I say -- we optimize our resources and so as a network, we are sharing those different tasks and capitalizing on the knowledge in one-twos. This is, I think, a very federated way of working.

MR. REPUSSARD: But it's not one discipline?

MR. SCHWARTZ: Yes.

MR. REPUSSARD: It's what?

MR. SCHWARTZ: It's multidisciplinary around -- yes.

MR. REPUSSARD: I think that the networks should be around safety issues, not about disciplines.

MR. VIKTORRSEN: So one area that probably may need more research is site-related issues. I think the Japanese are particularly learning that lesson given the Kashiwasaki. And I think we have to do this better in order to avoid surprises like this, like they have had and with a risk of shutting down permanently seven reactors on one site. And then to take into consideration also extreme weather conditions which are more extreme than in some of the design-basis accident considerations that we start to see.

I think this is an area -- I don't know -- many of you or us are considering new sites but we might need to reassess existing sites. And in many new countries, we have to establish new sites. And we saw clearly that the IAEA safety guides on siting were not enough, so we are now going to revise them and issue new, much more strict safety guides -- may have implications for all of us.

CHAIR POWERS: We have been reassessing now four of our sites, because they're seeking to install new reactors. One of the problems that we ran into, we said, okay, what are the extremes of weather that you can have at this site. And people came back and said, well, we looked back 100 years and sure enough, this is the coldest weather we've ever had and this is the warmest weather we've ever had in this time. The question came back, well, if that's -- that's all very true. It's factual evidence and whatnot.

But is there a reason to think what happened in the last 100 years is what's going to happen in the next 100 years. And that's about the time period you have to think about for these, because you approve the site for 20 years, and then you put a reactor on it that lasts for 60. Well, that's 80 years right there, so it's almost 100 years. And what we found is that all of these were done on the -- nearly all of them were on the eastern coast of the United States where we have weather records of reasonable reliability going back to the 1700's. And in that record, you could indeed see that there were cycles in the extremes of weather.

But it became almost an imponderable to address within the reactor safety community because we don't have models that are predictive in that sense. So we didn't -- I mean we ended up throwing up our hands and saying, okay, we're going to take the 100-year historical record and we're going to pay attention to it. Now we know very well we won't pay attention to it, because we're not going to see it. I mean it's going to be all a very gradual sort of thing.

But you can see those kinds of problems come up in the -- I mean this -- and all of that was done within a context of not worrying about global warming, anything like that. That was simply looking at the factual evidence that indeed, there are cycles and there are a couple of them and when they're in phase, things get very bad and we happen to be entering in, on the east coast of the United States, into a phase where the two cycles are in phase. And so we expect horrible hurricanes and things like that. In the area of tsunamis, we've just finished a study because the Cape Verde Islands periodically collapse off and create tsunamis. They're not the kind in Indonesia. They're a different kind of tsunami. And then we discovered, sure enough, the Caribbean does the same sort of thing. I mean these are all very difficult things whereas on these sites --

MR. VIKTORRSEN: That's common to waste siting or waste a reactor for whatever facility, so I think we need to keep this in the research area. That is my connection.

CHAIR POWERS: Yes. Our -- we are enjoying a reasonable challenge people have frequently mentioned in the presentations on the area of seismic research. And I think we'll learn a lot from the Japanese experience in this recent reactor. Most of the people that talked to me about it are very optimistic that what we'll see is a change in what happens, not a, in fact, the outcome is actually better than what we had thought. It's just different. So they're very optimistic.

And we're going through a change in our regulatory approach toward seismic effects, because we -- our seismic hazard has gone up by roughly -- estimated seismic hazard on the east coast of the United States has gone up by roughly a factor of five or six based on earthquake frequencies, so we're going through that challenge. But having a PRA that encompasses that seismic effect at the level of risk it imposes is a challenge that we haven't really overcome yet, because there are a lot of little very technically detailed things -- what do high frequency parts of the spectrum do to you and things that that.

But the general concept of a network of expertise seems very attractive to me as opposed to a center, an actual physical center, though I don't see how you get out of center concept when you talk about experiments. I'm thinking not just in thermohydraulics but for instance, non-destructive examinations. And for instance, mention was made of non-destructive examination of containment leakages, one I've not thought of but you're right. We don't have any capabilities there. And yet it's --I mean for the ESBWR, that's a major issue right now is that we get enough leakage that you threaten the control room, and we don't have any capability there.

MR. VIKTORRSEN: There is research going on in some of the European countries, at least on this. But I think more needs to be done, because this might be a trap to a whole fleet if they start to degrade.

CHAIR POWERS: We actually know they are. Well, I mean we have --

MEMBER ARMIJO: Some of them almost dissolved.

MR. PECKENPAUGH: I mean we are -- in our main steam isolation valves, we've not required anybody to test them for 10 years, and it's kind of find to test when you know that they won't pass the test. But we also know that the man-rems involved in fixing them is -- it's a burden. It's a major burden and so now what do you do with that piece of information.

MR. VIKTORRSEN: And the PWR too, we had holes like this in the liners, corroded. And this took -- I mean it was a major effort to repair them. And this may also exist in other places without testing.

MR. REPUSSARD: There are many areas where there's not so much a need for research but there is a need to maintain high level expertise. And unfortunately, you don't -- you can't do it unless you do a little bit of research. Otherwise, the experts just get away. And if you -- we'll use your ecology for example. Okay, we are -- in Europe now, there are very few countries, France one of them, but when you look at the capability in Europe -- in fact, why do I, because in the States, it's the same. It's becoming less than critical.

And if anything comes up, there is a risk that we can't deal with the issue, because we just don't have anyone who knows about these things. And that is also a responsibility for the -- a collective responsibility to try and maintain some level of expertise, because there's always some issues on a daily basis. And there could be problems which we would need -- you can't exclude an accident or a waste spillage or whatever. And if you don't have people who understand, then you're in big trouble.

And so I think there could be -- you know, there are areas where regulatory safety needs its own research to be able top criticize the industry to address, okay, we -- these are key -- what you call the key issues where you probably need to concentrate because it's so expensive that you -- okay, this is a sharing. But there are other areas where you need people who understand seismology. You need then in Japan. We need them in other countries. But you don't really -- I wouldn't call that research, because it's not separate research from those needed by chemical industries or to build schools or hospitals, it's basically the same.

So what you need is -- in the IRSN, for example, we have a laboratory with quite a few good people, but we've been pressurized to close it and says why do you need this in the IRSN. I mean you can ask anybody to do it. And I said, yes, but this is a key issue and I keep a small lab, but they spend half of their time working for other projects for us. You know, when there is a seismic activity, the French -- I don't know, in the Caribbean, okay, we have problems there because not all the public buildings have been built without taking care of -- so we have a grant, so we contribute to that. So that keeps my expertise going because they work on other things, but I know they're there if I need the, people who still know about nuclear facilities and seismicity.

And I think these networks, not concentrated, but it's a way maintain such knowledge by having exchange. But I wouldn't call it research really. It's not really. It's a totally different configuration but is still something we need that has a productivity.

MR. VIKTORRSEN: But radio-oncology is research. For example, when the Chernobyl happened and we had to answer in the morning, we had 5 kilobecquerel of iodine or 10 kilobecquerel of iodine on the vascular meter. Can we allow the cows to go out? Fortunately, we had people from the -- who had done research because of the fallout from the Russian bomb tests, so they could answer. But they were, I think, less than five in Sweden. And they were all more than 60 and today there are not anymore there. But fortunately, Chernobyl helped us to build a new generation, but they are also phasing out.

But it is on paper now and ICRP has published this, and so we have quite dose conversion factors. But you need also expertise to be able to elaborate them and to understand them.

CHAIR POWERS: We turn now to the question of digital electronic systems, because it's one that we've been specifically asked to address. And what is it that we need to know about these systems from a regulatory point of view, and do we need a network or a center of expertise on digital electronic systems?

MR. SCHWARTZ: Maybe not only for nuclear or community but you can open that to lots of industry.

MR. REPUSSARD: I think there is one question that I would love very much to announce, because there's no doubt that digital I&C will, for safety functions, will give it up. That's -- and there's no reason to be against it in principle. And one of the questions I'm asking my people but I can't answer is, is it reasonable to allow the nuclear industry to use commercial -- that means standard digital, which have many functions which only a subset will be used in a particular -- or do we spend more? Because if you do that, of course, it's more expensive but it's a lot more reassuring. But do we have arguments to criticize the use of very cheap, off-the-shelf software which can do anything you want including safety. But then they have so many other functions built in for commercial purposes that it's totally impossible to even begin using those tests.

And that is a tough question and at the moment, I have no strong arguments to say to our

French authorities that you must not allow commercial and that there would be an uproar in one place and the other, but there maybe a good case for that. Maybe this is -- it's a simple question, not an easy answer. And as Michel says, it's not specific to -- it's aeronautics. I mean we have an Arian rocket fall out of the sky because of that, because the software went to pick up the wrong information which normally had no role at all, but the fact is it was there and somehow it happened, and it deviated the rocket. One chance in one million.

CHAIR POWERS: Well, one chance in a million is the kind of levels of probability we're working in.

MEMBER BLEY: But I suspect we don't know that it was once chance in one million. You know, we -- that's the problem with these. We don't know what the -- we don't have good models, especially if they're complicated.

MR. REPUSSARD: After it happened, they knew -- they found out eventually through a very complex inquiry that the chance was -- I mean the probability of that particular logical circuit being active at that particular moment.

MEMBER BLEY: Good point, yes, but the

problem with that is is that a member of a class or is that a specific thing?

MR. REPUSSARD: It's not a member.

MEMBER BONACA: You know, the probability of one bridge hand is extremely low but the probability of a bridge hand with a certain number of points is pretty high, and you need a model that can deal with that. We don't have good models just yet. We don't even have good explanations of all the different kinds of failure modes and how they might get actuated. It seems like this is an area that might be a nice one --

MR. THADANI: Dennis, we tried to model -- we tried to estimate likelihood of TMI after TMI happened.

MEMBER BLEY: Yes, sure.

MR. THADANI: Okay, we traced the whole sequence of events including all the failures for you know that exact one because we knew. It came up like one in a billion or something like that.

MEMBER BLEY: The chance that the plant is out there working today is exactly in the state it's in is extremely low.

MR. THADANI: Right. Well, if you ask me something simple like small break and failure of a high pressure injection system, I come up with a different estimate.

MEMBER BLEY: Much higher, of course.

MR. THADANI: Yes, and so more credible that you can have an accident like that. So I think it's very -- you know, you can make these estimates, but if you go to a very detailed level, more often than not, you'll estimate fairly low likelihood of things happening.

MEMBER BLEY: And that's not very helpful to you.

MR. THADANI: No, that's --

MEMBER BONACA: In fact, it gives you false comfort.

MR. THADANI: For decision making, that's false, yes.

CHAIR POWERS: The general question -- you said it exactly correct -- is we know it's inevitable we will have digital safety systems in nuclear power plants. Are those digital safety systems going to be COF systems, commercial off-the-shelf systems or not? Right now we say not, because you have to follow an IPEEE standard which it can't do. But is that unfair, overly conservative? Probably. What's the alternative? We don't know. And we have before us a proposal coming from a relatively high level that says let's set up a center of excellence on this. And I'm sitting here saying, you know, is this one that we support, or should we support a network of excellence in this area, or should we go it alone? I mean that's the question I'm wrestling with right now.

MR. THADANI: You have a very practical issue of where, for example, not digitalizing the context of the hardware but the software aspects -- is there international agreement on what is adequate software system for safety criticals functions such as protection system or certain actuation systems? As you probably know, an earlier design certified by the NRC, there was a requirement that you have to have a hard-wired limited backup capability.

UNIDENTIFIED SPEAKER: Yes.

MR. THADANI: Is that going to continue on for the next 20 years the same philosophy, or is there some international agreement? As you said, systems may be built in different countries and applied elsewhere.

MEMBER BONACA: Well, typically, you have a hard backup system or you do have circumstances that give credit for operator action or operator intervention.

MR. THADANI: Right.

MEMBER BONACA: And that's a concern to me for new designs where, in some cases, you're asking the operator to step back from the console to do nothing. So, you know, the solution we have had in the past, which was essentially giving credit for operator intervention on feedback systems, now is going to disappear. I mean because simply you step back and you cannot intervene and maybe the plant is not going in the right direction. So that's a concern. I mean, you know? But the backup system, I believe, still now is a solution, right, when the NRC has?

MR. THADANI: It's currently being debated still.

MEMBER BONACA: Being debated?

MR. THADANI: But I guess my point in this, bringing it up, was on Dana's issue -- are you really looking in the long-term for some consistency in safety requirements? And let's take digital systems, both hardware and software. Well, what are those requirements? If you're going to allow off-the-shelf, NRC's not going to allow, and you're going to have the same question -- why is it okay in one country and not okay in another country. So you're back to is this -- are we -- are there issues like digital I&C where you really do want to achieve some semblance of international agreement? Agreement may be too strong a term to use.

MEMBER BONACA: I do believe that's a great candidate for a center of excellence at the international level, because, I mean, particularly, I think there is a lot to learn from people who have worried about common cause more than we have done in the U.S. Like, you know, the Germans used to design plants assuming single failure but also common cause failure in a systematic way. I don't know how effective but they did. And I'm sure that that was -- a central issue was the, you know, I&C. So there is probably information out there that can be leveraged. And I think it's an area of common interest. I mean every regulatory body that I know is concerned about this. This is happening and is being pushed by the licensees and we're not ready.

MR. VITANZA: I would just like to mention that in this context, of course, it would be very appropriate to build up a center of excellence. There is already a center of excellence, to some extent at least if you want to go in this way, at Halden in that Halden has devoted a lot of work in the history. But of course, then here are some specific items and doing research. Then if you want to bring it together, all this research and maybe do additional complementary work, that, of course, can be done in whatever alternative context. But there is already at least some important work that has been done in one international sphere.

MR. REPUSSARD: But for me, it's clearly an area where we need to -- as I said, we have difficulty to maintain expertise, experts. You don't have expertise without experts. And the only viable solution for me would be a network of expertise. Of course, that will include some research programs, but we have to be careful not to institute, in our eyes, research too much in any of our areas.

But we need committed people who understand and top people, and the only way to give them something to feed is to offer them an international network and also some research issues who could, on that scenario, where we could say, okay, what are the five questions we ask for in research. And also, will you please work together because we want only one answer to each of the questions. And it's not so expensive, it's just manpower plus some experimentation.

MR. VITANZA: One thing is to perform research. Another thing is also to bring the results together and make sense out of it and possibility a consensus out of that. We see that in many areas. For example, in the RIA, there are good data that have been produced for the fuel, and I think we are in the position where at least we can come together with some consensus, at least on a provisional basis. So one thing is to perform the research. Another thing is to bring things together. That can be a very good thing to be done in these sort of networks.

MR. VIKTORRSEN: Yes, I also believe that this item is more a question for a network than as a real center of excellence, because this knowledge is spread in so many areas --

MR. VITANZA: And it's not only nuclear.

MR. VIKTORRSEN: -- and it's not -- no, it's not only nuclear, exactly. So we have just to draw the question about specific application in the nuclear area. And I think many elements of the necessary knowledge exists, and I agree with Carlo. We have to try to put it together. And in that sense, a network is probably the best thing.

MEMBER BONACA: The thing that troubles me about these issues is that we've been presented by the industry with examples, the sophisticated hardware-software out there -- I remember we went to Germany a few years ago, and we went to Siemens -- they presented us a system that was very elaborate -- so from one end, we get very supportive statements and presentation by the industry, and then we have the examples being brought by the NRC. I remember they gave us examples of failures. That's a horror story over a 10-year period -- I mean of events that were caused by failures in programming or really the combination of hardware-software interaction that took place. So it's a difficult issue because although there are many applications, etcetera, you know, I always hear two stories and they diverge. You know, the proponents are coming in and telling me I don't have to worry about it. And then the events are telling me I should worry about it.

MR. VIKTORRSEN: The licensing is particularly difficult for a computerized system. How -- I mean a mechanical system, you can go through in a sort of a normal engineering way, but in a computer, you have to go deep into the programming. It needs to be done, really, in the development stage rather than when a product is there.

MR. VITANZA: And we've heard recently --

I mean I was reading about horror stories, some elaborate control systems of expensive cars, top of the line cars. And the reason is that top of the line cars, they're building such little quantities that you don't have a lot of repetitiveness of the same faults, so suddenly you have fault and, you know, the car is simply stopping on the highway.

MEMBER BLEY: That's a different order of problem, though, and I think that's -- some of our problem in this area, you know, a tremendous use in the process industries where, on a normal basis, they run very well. You get 95, 99%, you're doing very well. You're producing more product, because they're controlling things better. But these funny cases where you go out of the range that's been tested and some bit of data gets dropped in a register where it isn't normally, and that's used somewhere else, and funny things happen.

And we don't -- you know, we're looking at those funny things, the rare events that can cause us big troubles. And that's not where the focus, at least that I've seen, that's not where the focus has been in the industry. So we're trying to -- you know, so I'm not sure that broad experience, how helpful that is to us.

MR. VITANZA: Anyway, when you're thinking about long-term research, there is a risk, in some areas, of going in the wrong direction. But if you focus on digital I&C for example, there is very little chance that you're making a wrong choice.

MEMBER BLEY: That's true.

MR. VITANZA: The world is going in that direction and so it's certainly a very sound avenue to take. Another one would be on an new related area like, for example, wireless communication. One would imagine that with cable agin they would be making new penetration and so on, maybe the industry should consider that. Also, the possibility of reducing the human error with adequate support system, computerized support system, or maybe even support for inspections like that -- all these sort of, say, support elements that help that the human in performing his work. I think it has to go in that direction, and they are transversal. They are not related to one particular system or another, and the risk of making a mistake there is lower than in other area. By mistake, I mean of going in the wrong direction.

CHAIR POWERS: I wonder if we're making mistakes since we're pretty much not looking at wireless communication now.

MR. REPUSSARD: I suppose the point of having networks of expertise in our areas is that I believe very strongly that the nuclear safety community, regulatory-oriented, we look at questions a different way from the industry. If we don't have the different questions, then we shouldn't do it. We should just let the industry do it and we look at it.

But if we have a different approach to the question because we have a different task to them, then it's worth us investigating with our own approach. It doesn't mean that we don't work with them but it's a safety driven network, not an industry -- not a technology development driven network, because we can send -- we have some of our people -- they participate in industry doing that work because that's the way to learn things. That's fine.

But there are areas where we believe that our motion causes us to know things and to have our own doctrine, and the point of this meeting today, I think, is how can we -- because we -- there are, I'm sure, many areas where we share this, although it has never been explicit. And as we don't have infinite resources, how can we pool together?

But the question is how to map --, I mean you have yet on your mind in which the theory of mapping what are the areas where we need to do reactor system research for regulatory purposes. Where are the areas where we need high-level expertise to be able to assess and define the policy and rules and then apply them? If we could map these things, which has never been done really in CSNI because CSNI has been about to map things where researchers are. Maybe if we put this together, it would be cheaper. That's not at all the same process. The top down -- say, okay, these are all the problems which are important, which one are long-term, which one is really research, which one is just a matter of having no independent knowledge and where do we get that from?

If we -- three or four countries -- I mean, France would certainly be willing. I know that the U.S., Japan and maybe a country like India also, because all these people have been there. I was in Bombay not long ago and they're asking the same questions, because they want to develop a fleet of reactors and say, okay, we have to get -- how can we solve all these issues.

MEMBER BLEY: Logic.

MR. REPUSSARD: So we would be willing to go together with the NRC in a mapping exercise with no, you know, no commitments, just to map things, seriously, do it properly.

CHAIR POWERS: Said has been a thorn in my side saying this is exactly what we need to do is -- maybe articulate a little bit what you're --

MEMBER ABDEL-KHALIK: Well, just thinking about the structure in a logical way. You don't need to get lost in the details from the very beginning. I think you need a framework to start out with and then the issues will be almost self-identifying when you get to that stage.

MEMBER BLEY: That's a nice structure. I mean you've got technical issues; you've got applications, reactor designs, whatever, parts of the fuel cycle; you've got the knowledge gaps that fit within those; and you've got the relevance of those things. And that almost gives you a natural way to structure where you ought to be focused first, second.

MR. THADANI: And how is -- I'm a little unclear about this. I completely agree with you and I think sometimes it's better if you have a handful of countries trying to do that. But did I misunderstand you Carlo? I thought that's what you were saying -- yes, and I was going to try to do over the next year? Isn't that -- I mean that's -- I think that's what I heard.

MR. VITANZA: Looking, however, more in the frame of facilities and strategy for the utilization. I think the exercise that is being done here seems to me a little bit more general content.

MR. THADANI: Okay. So you do want to limit to facilities?

MR. VITANZA: If you want to do an exercise in one year, probably we have to cut some parts and presumably, we focus --

CHAIR POWERS: It seems to me if you could do an example, that that is extremely useful to, say, okay, here's what you need to do in the grand scheme of things, but here's an example. I mean that would be very helpful.

UNIDENTIFIED SPEAKER: Okay. I think so, yes.

CHAIR POWERS: Can train it so you can get it done in a year and we can look and see what it looks like.

UNIDENTIFIED SPEAKER: Yes, okay.

CHAIR POWERS: One of the issues that we have, especially with the advanced reactor concepts, is people from the political realms say why should the regulatory body do any research at all; all you have to do is review what the licensee provides, and if he doesn't provide enough, tell him to go back and provide some more.

And what we have learned is that the applicant can make a cost-benefit tradeoff and his cost-benefit tradeoff is whether to provide the other data or go complain to the political body that the regulatory authority is being too tough on him and that they should chastise him for being so tough. And oftentimes, that turns out to be the cheaper route, to complain about the regulatory authority. And so I was then intrigued by the comment that pretty much universally across the spectrum says that we need to have an independent regulatory examination of these things that's demonstrably independent.

And I -- you know, I'm willing to believe. It's not clear to me how I persuade my political cousins that this is essential and yet it's -- I mean every single one of -- I bet you I could find the word independent in every one of these presentations here someplace. And I know I can find it every one of the presentations, even those from EPRI and the NEI that were at our last meetings -- had this call for an independent regulatory authority that has independent knowledge and that we're continually running into this, especially for the advanced reactors because we're starting somewhat from scratch. The political bodies say, you guys don't need to do research, just have the licensees do -- get you whatever you need.

MEMBER BLEY: The think I hadn't really thought of earlier dealing with that issue came up this morning, and that's to maintain that independent capability, you need this excellence of experts. And the only way to do that is to be out in front on the research to get the right people and that sort of thing. Putting together the case that explains why that has to be so, although it seems self-evident, is not an easy one I think.

CHAIR POWERS: We've -- I mean in our looking at the research, we've identified areas where having expertise is a tour, because the universities aren't producing the -- there aren't consultants I can go to because all those consultants have been hired by the industry --

UNIDENTIFIED SPEAKER: Or have retired.

CHAIR POWERS: and retired or died, and we've done that. I've been very intrigued by this concept that, which I happen to have personal experience, it's true, that by providing a research forum, you can attract people into a field. And the digital electronic field is one of those that we can continuously get people to come work in the digital field rather than going to Intel where they can make vast sums of money compared to what we can offer, because we do provide them a research forum.

MR. REPUSSARD: Sorry. I think we had exactly the same questions when we came up to that committee at the end of the year. I mean I've been meeting my -- okay, you know, the bosses are five ministers in the government -- defense, research, industry, environment and health and several of them have exactly the same questions, so we commit to this committee. But we came out quite well, and I think we -- it was a big effort. But we tried to show them -- you know, it was very concrete; say, okay, these are the questions. Now who is going to answer these questions if we don't do it? Nobody because the industry is not doing it that way, universities, nobody else has this knowledge or could have this knowledge. So if it's not done, it's not going to -- if we don't do it, nobody will do it.

And there is some neutralize, and do you know what is the cost of an accident, a facility accident. So we came out with a status quo, with a slightly improved budget. That's something because the pressure has gone off to say, okay, yes, they made the public statement that safety is strategic for a country which relies massively on nuclear. But for politicians to say that was -- it took them a little --

MEMBER ARMIJO: Took some courage which there's not a lot of in politicians.

MR. REPUSSARD: Yes, but we put real questions on the table. We showed them; said, look, these are concrete -- but it's not just a question of -- there are generic arguments by the public's confidence, etcetera, but we also say, okay, if this severe -- a severe accident can occur, and this -- and we need radio-oncology because if there is a leak somewhere, what do we do. We can't afford to ruin the whole society because of lack of a few people.

MR. VIKTORRSEN: And independent assessments of a regulatory body doesn't mean that we redo what the industry has done.

MR. REPUSSARD: No. It's a different --

MR. VIKTORRSEN: I think this is extremely important also to point out to the politicians -- that we are doing something different. We are -- in some very sensitive areas, we have developed our own tools and we use them and to see what the results were. And then we are using research to be able to ask the right questions. There are several arguments, because if we try to say or if they believe that we are redoing what the industry has done, that, of course, it doesn't work.

CHAIR POWERS: That doesn't work. What I'd like to do now is just take a 15 minute break. When we come back, I'd like to touch a little more on the safety cultural aspects of things and given factors aspects of things, because those look like generic issues that are transcended in time as long as -- well, up until we get this no operator reactor in Galino or whatever.

MEMBER BLEY: Then the I&C issues will be really --

CHAIR POWERS: So let's come back in 15 minutes.

(Whereupon, off the record at 3:34 p.m. and back on the record at 3:53 p.m.)

CHAIR POWERS: We are ready to come back into session. The plan, Ashok, is to complete at 5:00 o'clock?

MR. THADANI: Yes.

CHAIR POWERS: So I'll turn it back to you.

MR. THADANI: I have a question and it's

not necessarily a pure research-type question but nevertheless, it goes along with a lot of the discussion we've had. For future designs, I think there has been a lot of discussion that parts will be built different places, questions will be asked about safety in one country versus another country of a design. Does it make sense to have some effort to try and establish some high-level safety requirements that different countries can agree to? I'm talking about above, higher than the safety standards, for example, your safety standards.

Of course, the standards would, presumably, play a very important role depending on the technology that one is talking about. And Said had said earlier about maybe -- I don't know that he used the word technology-neutral, but an you establish some high-level safety principles that could really form the basis for whatever is done in more detail, if you will, so at least countries can say, yes -- I'll give you a specific example -- core damage frequency, is it appropriate to say that internationally people have agreed that the mean -- that means you have considered uncertainties -- the mean value of core damage frequency will be 10 to the minus x or less, whatever that x is. I'm talking about in those terms that such high levels. Under MDEP Phase II, the initial information provided indicated that there are differences and different countries use different safety limits, if you will.

Do you think it makes sense for these, particularly, the non-LWR designs, to have some international agreement on some high-level principles? Because if the answer is yes, then it is not a simple process. It will be a long-term effort. It won't be something you can do like in a year or two years. It will be a multi-year effort to be able to do that. Is that something worth considering?

MR. REPUSSARD: I can make a remark. I have the example of the EPR as mentioned earlier. This was the approach that was taken. That means that the French and German government decided that there should be a new Franco-German technology. But at the same time, there was a political decision to choose some common safety, not principles, objectives, safety objectives. In other words, from GENERATION II, what would be the safety improvements that they were jointly expected to design. We knew it would be a PWR but we -- the design wasn't there. There was just no design for it apart from the fact that it was a pressure water reactor.

And there were things such as -- quite simple things -- well, I should say weren't simple -- precise. Let's say, for example, we want to exclude, de facto, large-break LOCA. Okay? We want to have no -- limit the off-site consequences by avoiding the China Syndrome. Okay, so there are a number of other things like that which were kind of a safety charter. We say, okay, we are here with GENERATION II. We want to be here. These are the set of safety requirements or objectives. And then the designers went around and said, okay, how can we solve this issue; how can we reach this level. And they did it. Well, then we are still currently reviewing because some -- the French EPR is not exactly the same as the Finnish EPR, so we are still discussing the design details with -- and we don't have but that's okay.

Now if you look at GENERATION IV, could there be an international agreement to say, okay, we want no off-site consequences. Do whatever design you want, but we want absolute proof that there will be no accident with off-site consequences. Is that a challenge that can be handled or not? That's just one example.

MEMBER BONACA: So you have defined objectives more in terms of certain specific outcomes

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MR. REPUSSARD: Functional objectives.

MEMBER BONACA: -- that purely a numerical?

MR. REPUSSARD: Yes, because of probabilities.

MR. VIKTORRSEN: I mean to put a number like ten to the minus five or ten to the minus six, we don't have an agreed tool, internationally, to verify this.

UNIDENTIFIED SPEAKER: That's right.

MR. VIKTORRSEN: So it's sort of useless.

UNIDENTIFIED SPEAKER: Right.

MR. VIKTORRSEN: So to me, it's much better to put more in the terms that Jacques mentions or to at least say that we have to have several barriers in between the core and the environment and leave possible -- that would be, of course, an extremely important improvement if we can say there will be no off-site consequences. But how do we prove this? Is this again as long as we have efficient process and residual heat in the core, we will have always the challenge to contain it and to cool I for a certain time. And you need probably human beings there to make sure that this is the case.

So I wonder if it's possible to develop numerical principles. I think it's better to try -- but I think the effort is commendable. I think we should, in this case, we should be a little bit better off than we have been before from the safety community when we develop the new reactors, GENERATION IV, for example, and put some very challenging goals to the industry. And in what frame it will be done? I don't know, because the safety standards and the requirements are already on a rather high level. And I also, difficult it is to see that we develop completely a different process than the safety standards, because we want them to apply for all countries building nuclear power plants, not for a few.

I think we should try to discuss them in the terms of safety standards or safety requirements. It could start in a small group and then be enlarged. I mean a process, it's always possible discuss how to do it, but some effort is needed. That's for sure.

MEMBER ABDEL-KHALIK: But don't you think that in the early days, that people had the same sort of functional goals that you're talking about?

MR. VIKTORRSEN: I am sure.

MEMBER ABDEL-KHALIK: And it's only after we learn that we sort of discover the fallibility of whatever design people came up with albeit their ultimate goal was no off-site releases, etcetera?

MR. VIKTORRSEN: I am sure you are right.

MEMBER ABDEL-KHALIK: So if that is the case, you know, we may have the same kind of history repeating itself if we go along a new path where our initial condition is pretty much the same as the original initial condition for the current reactors. So I think the likelihood of repeating history would be relatively high if we go on a completely new path, new technology where we don't know quite as much. But I think if we follow -- if we have just evolutions of the current technology, then I'm sure we can meet these functional objectives.

MEMBER BONACA: And that's really where the PRA will be valuable, which is although we cannot compare plant A to plant B of different design built in different countries -- it would not be the approach -- but you can -- you know, I still have comfort looking at a Westinghouse plant analyzed with current technology. And then the same technology applied to AP1000 and I see that core damage frequency is significantly reduced, I mean, because I'm using the same technology. It gives you at least -- it gives me an assessment that based on the same technology, PRA, I have improved results.

Now granted I've covered only what I know. But that's true of anything in life. I mean --

MR. THADANI: Right. No, I want to clarify, because I didn't mean to say that that's it, that's your high-level safety principle and you can go forward. No. I certainly said that -- I picked a controversial example deliberately. But that doesn't mean that you will not consider concepts of defense in depth, multiple barriers, all kinds of good, sound considerations including a lot of the stuff that's -- I know in the U.S. general design criteria for example.

But where I was headed with this issue was U.S. NRC has taken a crack at it as to what the future should look like in terms of safety requirements. It's not -- Commission hasn't approved it. It's work-in-progress and the Committee, I know, has written letters saying you should continue to work for the next several years on this. Where I was headed was do you think there's even some -- and then Christer said that he thought there would be value in going forward -- is it something -- I mean beyond -- I'm now sure, Chuck, your views; or Carlo, your views; or Michel.

Where do you see this?

MEMBER ARMIJO: How does this fit in with the safety research program? This is safety policy, I think, that you're talking about --

MR. THADANI: No --

MEMBER ARMIJO: -- or safety goals for new advanced reactors. But I don't see how that's --

CHAIR POWERS: Well, where it fits in is explicitly in what we say about technology-neutral frameworks and things like that.

MR. THADANI: Yes, framework.

CHAIR POWERS: Right now we'd say pretty much what Ashok says is that I think we grant that the current product is disappointing. I think that's the word we use.

MR. THADANI: I think that's what you said.

CHAIR POWERS: Or you said non-functional or something like that, not useful. And attendant to that is this letter that we've written in which there are more added comments than there are comments, but they were born of -- a lack of top-down thinking was one of the approaches; another one is lack of practicality. I mean there are a lot of things associated with -- so that's how it relates to the research program is what we do here to get to a regulatory system that allows for substantial deviations from the current design. That doesn't mean we abandoned light water reactors, but it allows for more adventuresome activity.

And that's one of the -- overall, that's one of the issues that we have to address is if the regulatory system is so constrained that it inhibits innovation and design, then that's not a good regulatory system. And certainly we've had it telegraphed to us that one of the reasons that the industry is not bringing forth higher technology is that they fear the delay in the regulatory review. And that's very distressing to us.

MR. VITANZA: Dana, I think this is still policy more than research, or at least in --

CHAIR POWERS: We get close to the edge here.

MR. THADANI: You still have to go to Commission ultimately to get their approval, because policy decisions have to be made by the Commission. But you don't just come up with policy statements. You got to do a lot of work before you can get to the point of developing sound policy. And in this case, research has been working on technology-neutral framework for, I don't know, six-seven years, and they still, presumably, need to continue to work on that.

And I'm stepping back and I'm saying, if NRC research is working on something like that, listening to the conversation we've had all day long about global aspects, is it really efficient for NRC to be working on issues like that alone, or does it make more sense to see if there's some international interest. That's the issue. It's research, presumably, is going to continue to work for the next several years on something like that.

CHAIR POWERS: Yes, well, the -- I mean I think it goes beyond that issue -- is that research has worked on that issue some time and though some are enthusiastic about the product, some are not.

MR. THADANI: Yes.

CHAIR POWERS: But the question is do people have a better approach and are they wrestling the issue. And I think the -- just look in the B graphs -- the answer is unequivocally yes. But how do we approach it, and --

MR. THADANI: I think to their credit, as a result of the work they've done, they have identified seven policy issues that clearly require Commission consideration, but this -- I'm sort of thinking liquid metal reactors -- there's so much more knowledge within France.

CHAIR POWERS: We have a lot of knowledge in the U.S. We just threw it away.

MEMBER ARMIJO: We have a lot --

CHAIR POWERS: A few years later, you threw yours away.

MR. THADANI: Yes, they still have it.

MR. VIKTORRSEN: I think the key point is to -- we have to drive down the probability of accidents.

CHAIR POWERS: Yes.

UNIDENTIFIED SPEAKER: Yes.

MR. VIKTORRSEN: I think, to me, that is the key, because if we maintain a probability of accidents of 10 to the minus four, it's far too high if we are to continue to utilize the reactor, because then we will have new accidents quite soon, mathematically. So we have to drive it down to at least a couple of magnitudes lower. And if you can suggest a reactor which with some good proof can show that, then it should be pursued I believe.

If your metal reactor is such a reactor, I don't know. If you think that it can easily go down and it's capital investment is of a reasonable size, I think then it would be perhaps wise to start supporting this. But if it's questionable, I think the evolutionary approach would be more attractive to me --

UNIDENTIFIED SPEAKER: Well, sure.

MR. VIKTORRSEN: -- because we know so much today about the operation and safety of LWRs, so why not continue to develop slowly and better.

MEMBER ARMIJO: Revolutionary reactors always look great, wonderful until you start working on them and then you start finding problems and you add costs and --

MEMBER BONACA: And, you know, I was pointing out before one bullet you have on your presentation on licensing -- if factory nuclear records tend to encourage a reduction of public spending on safety research because there is this comfort that, you know, we know everything about it, I agree. It's very important to communicate to our politicians that if you do not go away from evolutionary reactors, not light water reactors, you're opening Pandora's box. This statement is not acceptable anymore because probably you have to go back to spending that we had for light water reactors.

MR. VIKTORRSEN: Yes.

MR. VITANZA: I understand that in the U.S. NRC, there will be -- there are already or maybe there will be soon some application for gas reactor, at least one design, and I also understand one, I think it's a Toshiba liquid-soluble reactor -- so I don't know how realistic that is, but this is what I hear. And so how are we going to cope also with these systems if they're coming on the table and for which the knowledge is not there?

MEMBER BONACA: Well, I think that --

MEMBER ARMIJO: You've done it before, licensed gas reactors and where there's no knowledge, you'll do defense in-depth with other requirements. You might put a containment on a gas reactor, you know, if they approve your fuel so hot.

MEMBER BONACA: Okay, got it.

MEMBER ARMIJO: You know, there's a lot of things you can do, but I don't that's our highest priority. Our highest priority is the remaining light water reactor issues, the existing ones, the materials degradation, or emerging new phenomena that we haven't seen due to aging and all the issues with the new light water reactors, the passive systems and the new designs, digital I&C, passive safety, severe accidents for these kind of things. Then we get to GENERATION

IV and fast reactors and --

MEMBER BONACA: I think for that one, I mean isn't there -- and is the question from Congress to know what it takes?

MEMBER ARMIJO: Yes. And somebody's going to tell them. But they're going to tell them and --

MEMBER BONACA: There is an expectation to --

MEMBER ARMIJO: This year.

MEMBER BONACA: This year?

MEMBER ARMIJO: That's right.

MR. THADANI: There is a Commission meeting coming up on this month, in two weeks, on February 20th. The topic of that meeting is advanced reactors and that is these are non-light water reactors except -- I should correct that -- it includes designs like IRIS, and so -- and they're unique, very unique designs. There is some sense out there that there may well be some applications coming in between 2010 and 2013 to the NRC. A question that's been raised has been, okay, well, how can we be ready as an agency if that were to be the case. 2010, 2013 may well be 2013, 2015, 2016, but nevertheless, it is not 20 years away. We're talking about maybe within a decade or so based on the discussions that are going on.

And the Commission will have to then make some decisions on how to partition resources, if you will. Obviously, light water reactors are going to be around for another century or 50, 60, 70 years you would think, so they have to get the substantial fraction of the resources. But the question that they'll have to deal with is how much to invest in our light water reactors. And I think this meeting may will shed some light on really how serious the industry is. You know, it's we've heard before --

MEMBER ARMIJO: The investment will be the U.S. Congress? The industry isn't going to invest much.

MR. THADANI: Well, yes, we know that and --

MEMBER ARMIJO: The U.S. Congress changes its mind readily, so I just won't hold my breath. But the Commission has an obligation to give their assessment this year.

MR. VIKTORRSEN: That would be the opportunity also to highlight these points we have had here of the need for real strong safety case -- they are going forward. Put all the burden on the NRC.

MR. THADANI: I mean, we can't have it all ways. We can't say we need good infrastructure; this is what good infrastructure is, but we cannot put any resources; this is a long-term effort. And when the time comes, what's the agency really going to do. So the point, in my mind, is you let the appointed officials make decisions on priorities and timing, you let the technical people tell the Commission if we have to do these things, here's what would be needed. And ultimately, policy decisions would have to come from the Commission, at least in this country.

MR. REPUSSARD: But in an interim period, there is something, surely, which is not unreasonable to do, is to spend some resources, not too much but just to salvage and not let die completely the knowledge on false breeders, because from an --

UNIDENTIFIED SPEAKER: Oh, yes.

MR. REPUSSARD: --

policy point of view, fast breeders are something purely unavoidable in the long term, and there is a lot of knowledge just in the past 30 years.

And to let it die completely is a guarantee that we'll have to start from scratch in 20 years time in another generic. There will be nobody left. All the codes will have been running on computers which nobody will know how to use anymore and things like that. So -- and it makes sense because it's not so expensive to maintain some actions to keep it alive. And that's what we are doing already.

We have the perspective of for prototype -- okay, it's been a political decision, we don't. There's no design at the moment, there's -- but we have stopped -- we have decided inside the RSN to allocate some resources to salvage and to try and think, okay, what is transferrable. For example, when we continue to develop codes on light water reactors, we add this other question -- okay, don't forget the other -- the sodium reactors; could this code be adapted. This is a question we ask. And if it can be, please -- it's like when you make a building, you need -- in some countries in the Middle East, you need the iron for the next floor up, you know, so that, well, if somebody wants to build another floor, it's ready.

UNIDENTIFIED SPEAKER: It's already there, right.

MR. REPUSSARD: It's not such a bad concept.

MR. SCHWARTZ: Even if we don't have a firm design, we can start to work with a small group on some generic issues like the accidents or propagation of -- so less severe accidents. And that would be sufficient to start --

MR. REPUSSARD: I mean it's not very expensive.

MR. SCHWARTZ: -- the process.

MEMBER ARMIJO: Well, that's the first step in doing any research is accumulating the past information, reviewing it, learning about it, digesting it and then start to formulate your research plan.

MR. REPUSSARD: I mean we've had also the participation --

MEMBER ARMIJO: It's not very expensive.

MR. REPUSSARD: -- the debate about safety objectives for a new generation will come up and some input will be expected from our community. And if you don't have specialty, still be talking only in the very general and not very useful terms. You won't be focused.

CHAIR POWERS: Should we be -- are we arriving at a consensus that this should be a recommendation?

MR. THADANI: I would think -- my sense says, listening to all and the discussions that we've had, that some sort of state of knowledge report on these selected non-light water reactor designs -- we'll include gas, I think --

MEMBER ARMIJO: Gas and --

MR. THADANI: -- is essential in the near term, and the results of that state of knowledge assessment, if you will, would or should then play a big role, as Sam was saying, in defining if you have to go further, where do you go; what are those selected areas where you want to move on. But I would say the only other dimension that it should be done in an international context.

MEMBER ARMIJO: That would make it more effective.

MR. THADANI: Yes, for liquid metal reactors, France has a whole bunch of good -- so does Japan, too. Yes.

CHAIR POWERS: What I'm wondering is if we should draft up a recommendation that says, okay, with respect to gas reactors, NRC has gone through a phenomena --

MR. THADANI: I did.

CHAIR POWERS: -- identification and ranking exercise --

MR. THADANI: Yes -- yes.

CHAIR POWERS: -- and presumably done a very good job on that?

MR. THADANI: Yes, I think so.

CHAIR POWERS: And it's now is the time to take that as one input to a more international examination of what needs to be done and how it needs to be done on these issues. I mean it's an input into a discussion rather than anything definitive. But I can see us drafting that. And that the NRC then encourage the same or a similar group to go through a similar exercise with respect to the knowledge that exists on liquid metal-cooled reactors and arrive at a discussion of here are the major issues that need to be resolved sometime with the understanding that maybe it doesn't need to be done tomorrow, but it needs to be done before we get into a certification process.

Because once we're into an actual certification process, the people doing the certification simply are not going to wait for research results.

MR. THADANI: But I would certainly be careful not to delay that process, starting that process because of the concern that you lose --

CHAIR POWERS: Yes, it seems to me that we have a pretty good driving force right now. I mean tomorrow we're going to sit down and review some things, and that looks like that's a pretty good input on gas-cooled reactors.

MR. THADANI: Yes.

CHAIR POWERS: I mean it is an input certainly. It may not be a definitive input, but it's an input. And maybe it's a springboard to create a similar set of inputs for the gas reactors and get the process started with that.

MR. VITANZA: The sodium --

CHAIR POWERS: Yes. I mean sodium -- maybe it's lined up. I'm not sure what you're doing there --

MEMBER ARMIJO: LMR.

CHAIR POWERS: I mean it seems to me if we -- I mean we have this section of our report where we equivocate right now but that's not the consensus I'm getting here. I'm getting a there's more of an imperative that's move forward. And certainly, from our own licensing authorities, they said, we're not going to wait for you. I mean they're very clear about that. They're not going to wait for research to do their certification. They're driven by other kinds of concerns, and we've already said that you don't need to have the research to do the certification.

You just clap another lay of defense in-depth on top of things or something like that.

MEMBER ARMIJO: Yes, until you can prove, you don't do it, don't need it.

CHAIR POWERS: Okay. That's a useful -- I mean that's --

MEMBER ARMIJO: That doesn't have to be a big effort. It can be a pretty mall --

CHAIR POWERS: No, no, no. Then it's -- a few people just to become your experts.

MEMBER ARMIJO: Well, that's why we're already here.

CHAIR POWERS: When you -- I mean when it gets expensive is when you say, okay, here are the things that we need to do, let's do a couple of them. Then it -- then the costs start to go up and you can make that decision when you think you have the resources to do it. But right now, you need to have the options in front of you. That seems like a very useful, tangible result coming from this.

MR. REPUSSARD: It's true. If there is some international thinking of these issues, it makes it a lot easier afterwards to say, okay, you have a set of more operational developments to do. If this is a result of joined more or less informal work, it's a lot easier to say, okay, you can basically -- we'll do this, I'm sure, because we have a global industry in front of us and we ought to think global as a response. Because I always think that, you know, safety's okay when you have a balance between the industry and the safety regulatory people. And if the industry is global, well we'd better get our act together as well, because otherwise there is much more chance of unbalance.

CHAIR POWERS: I think I have arrived at the time to see if there are other comments that need to be made, so Mr. Bonaca?

MEMBER BONACA: No, I think it was a very interesting debate on the issues. I like the organization that Said is proposing -- technical -- non-technical-independent issues that we can focus on and then the technical-dependent, the separation of light water reactors technology from the rest. But I think we pretty much covered the ground I would like to see covered, so I have no further comments.

CHAIR POWERS: Mr. Armijo?

MEMBER ARMIJO: Yes, I agree with Mario's comments. I think it's been a very good meeting. I appreciate your coming here and talking to us. And I think this idea, particularly on the advanced reactors, of developing, even on a small-scale, your own expertise and to identify regulatory issues, safety issues and then working with equivalent small groups internationally to compare the questions we ask the concerns we have with the rest of the world and see if we've really covered the waterfront of safety issues. I think that's very good.

I think there still is -- I guess I'm a light water reactor person -- and I still think there's work to be done in emerging or even existing light water reactor current designs and materials degradation being my principal concern. But I think the advanced reactors, we talked more about them, but I think where the real issues that we have to remember is on operating reactors and the new ones that are being proposed, the ESBWR, EPR. These reactors are going to need a lot of research. And we've already covered it's whether it's digital I&C or passive system safety issues. We have to identify what we have to do pretty quick. It may be too late.

CHAIR POWERS: Said?

MEMBER ABDEL-KHALIK: I really have nothing to add except to thank our guests for a really stimulating discussion. Thank you very much.

CHAIR POWERS: Dennis?

MEMBER BLEY: Yes, the presentations', the discussions' done. If I could have guessed where I'd like to see it, it's pretty much where it's gone. I'd like to sneak one little particular question in if I may. Jacques, in the beginning of your talk, you went through a lot of particular potential problems in the future.

And one you mentioned I've been very interested in, because I've seen some real problems in the railroad industry, and we've all seen some in the drug industries lately, this issue of multinational equipment, equipment coming from suppliers in all parts of the world. It seems like there's a lot of problems there. Is there any aspect that you thought about of research that could help deal with that or is it just an administrative control issue?

MR. REPUSSARD: Well, it's both I think. The risk is that it is both, and I think I put it in the -- as part of our environment as a kind of warning bell for our expert to say if you don't think that you see one design as a -- or just one single thing which fits nicely together, because somebody else, another somewhere else will change something, then will we be able to analyze the differences. So it's more of a kind of a mental framework than a specific research program. And Michel, if you want to comment --

MR. SCHWARTZ: For fuel, for instance, because in France, we are used to only one kind fuel from Areva, but now we have fuels coming from Westinghouse and so on. And so we have to make reserves which is already the case for the CABRI program, using other types of fuel for instance. Or we may find other examples like that where we have simply to extend, in fact, the field of our research.

MR. REPUSSARD: It's the -- for me, it's also an incentive to move even more to generic thinking rather than or functional requirements rather than specific technology-related solutions, you know, expertise, because then if something changes, then you are lost if you don't have a frame which is functional. So it's for -- I don't see any strictly speaking related research program. It's just part of the environment which is going to be different from what we have known in the past, at least in France.

MEMBER BLEY: I don't have any good thoughts on that. I'm just worried about --

CHAIR POWERS: I think there are some real mechanical issues associated with the regulatory system that come up. I mean, in the past, we've intensively reviewed suppliers. Well, that becomes a good deal less feasible as your supply network becomes non-national and more disburse. And it really impacts on how you interpret Appendix B and the Quality Assurance requirements, and so I think we're going to have rethink those. But I think we rethink those in a regulatory framework and less in a research framework and --

MEMBER BLEY: That's probably right. I guess the things I've seen in the railroad industry that they've had real troubles with, are they certify a supplier in some countries and the Far East and think everything is set up right; they have represented it was a go there regularly. And all of a sudden, they'll start having significant problems with certain pieces of equipment, and they'll find that, in violation of all the agreements, the party they certified is getting them from one or two steps further away and they're not meeting any of the expected requirements.

MEMBER ARMIJO: That's a safety culture issue.

CHAIR POWERS: That's what I call more disperse supplier network and it's one that we've got to wrestle with. And that's why these debates on Appendix B versus ISO-9000 systems become much more interesting. Ashok, do you have any thoughts --

MR. THADANI: Yes, a question on this point. Under MDEP, there is actually a working group. MDEP is the Multinational Design Evaluation Program. There is a working group on codes and standards, and that includes not just the regulators from several countries but also includes the standards organizations from the international community. This is just the point Jacques was making that people are still trying to come to grips with how would you deal with that.

Is it going to be ASME standards or something else, ISO-9000? How do you deal with it. And in fact, again, it's probably going to be a multi-year effort, but at least I think they deserve a lot of credit. They've actually started working in an international way. There's a group. France is a member of that group also. So I think people at least are trying to move towards and see how would we come to this --

MEMBER ARMIJO: Well, that would -- you know, the industry has been dealing with that --

MR. THADANI: Yes.

MEMBER ARMIJO: -- for 40 years, and, I mean, procurement, everything from vessels in one country and assembly in another and fuel components and meeting the safety requirements of different countries. I mean I think the industry's -- the regulatory bodies could make the industry's job easier, you know, but that's not likely to happen.

MR. THADANI: No, no.

MEMBER ARMIJO: But, you know, the industry really is meeting all these various requirements and has sorted things out for materials specifications, unique requirements in Finland and Spain and Japan and it's been around for a long time.

MR. THADANI: Not to get the details of -- there are some interesting issues of ISO-9000, for example, where the NRC was and what happened.

But two things -- first, I want to thank you very much. I thought, and speaking for myself, I learned a great deal from your thoughts on long-term research. You've got lots of truly outstanding ideas there and issues that you think would need attention. And I know that -- I think that would be very helpful to the Committee in its deliberations, both in the near term and in the long term, because there's a continuing expectation that the ACRS will provide recommendations to the Commission. It's not just -- this is not the last stage. There'll be continuing needs for that. So it's been very, very helpful.

Second, I want to thank you for your heroic effort. I know you flew to the U.S. from Europe yesterday and you're flying back this evening, and that's quite an undertaking. And I just think at least we're very, very fortunate that you were able to take the time and take, really, the trouble to come and talk to the subcommittee. I certainly want to thank you very much for that.

MR. REPUSSARD: Thanks to the carbon print of the ACRS.

MR. VIKTORRSEN: Are we allowed to add something?

CHAIR POWERS: Absolutely.

MR. VIKTORRSEN: Okay. So one area which I believe that there also should be continued research in is in safety culture. We know that safety culture can be an extremely powerful barrier if it's there, if the workforce have the same strong feeling about the importance of safety. If it's not there, we have a weak safety system.

And this is not only in relation to operating at your facilities. We have been approached by PBMR, for example, to assess their safety culture under the design phase. We are seeing, in Finland, problems they are having to manage all the construction, all the projects, all the consultants they have or all the people working on the projects. There are contractors, subcontractors, sub-subcontractors, etcetera.

And how can we promote -- probably through effective leadership -- but how can promote a strong safety culture in all these phases? Because we know how important it can build in quality. I mean part of the problem within our containments today is lack of quality or in construction. There is a need for more research on how to promote better culture in organizations.

So this is one suggestion that we can make also. And there are methods by the way. There are methods now to assess safety culture. I know IMPO is working with this and we are working with this with other organizations, etcetera. It's not yet maybe mature. It's just in the beginning.

CHAIR POWERS: We devoted some time, as a Committee, looking for quantitative metrics for safety culture. And we're surprised to discover yes, there are metrics that do correlate with safety. We've not been able to make the next step in saying okay, can we institutionalize these or make use of them. Safety culture is still a disperse concept for us and because we can't -- we don't want to trace into the area of managing facilities. And though I think we have succeeded in putting it in as part of the inspection process, but as far as quantifying it and eventually putting it into the PRA, that's a challenge that remains for the future for us. We'll say more on than human reliability aspect.

If there are other people who want to make closing comments, I'll give you an opportunity here.

(No response.)

CHAIR POWERS: In that regard, I'll echo the thanks for the presentations. I could not have asked for more. They were superb. They were right on target. They helped us a lot, so much so that I think we'll have to prepare something in documented form, at least for the ACRS, if not the Commission itself on this meeting. They need to be aware of it.

I come away with a reinforced sense that there are opportunities for international collaboration that we're not exploiting adequately right now and that we should begin to exploit those. Two that look to me as ripe for exploitation include fire and human reliability analyses. I would like to explore further the thermohydraulic as an area for collaboration.

I'm especially intrigued about virtual collaborations, though I recognize virtual collaborations develop only after you've done some physical collaborations. But it looks like that's something that we can exploit a lot more effectively. I'm going to be intrigued to see how this top-down strategy develops, and I've asked Said to take that on as an area of focus to work with NEA in that area, and as that develops, to see if that's a productive avenue.

With that, I can say this has been an extremely productive session for us. And like I said, I think we'll have to prepare something in writing for this.

MEMBER BONACA: That so much, so that I propose that we meet in Paris now.

(Laughter.)

CHAIR POWERS: I will point out to you that you do have a meeting in Paris in October.

MEMBER BONACA: Yes, and this would be good opportunity for you to --

MR. REPUSSARD: Anyway, you're always welcome to Paris.

CHAIR POWERS: Well, you haven't been

around me much then, or you wouldn't say that.

CHAIR POWERS: It's opportunity.

CHAIR POWERS: With that, I'll close this meeting and thank you very much.

(Whereupon, at 4:44 p.m., the foregoing meeting was concluded.)

CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: Advisory Committee on Reactor Safeguards

Docket Number: n/a

Location: Rockville, MD

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and, thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

Charles Morrison
Official Reporter
Neal R. Gross & Co., Inc.

OECD-NEA approach for long term nuclear safety research

Carlo Vitanza
Deputy head, NEA Nuclear Safety Division

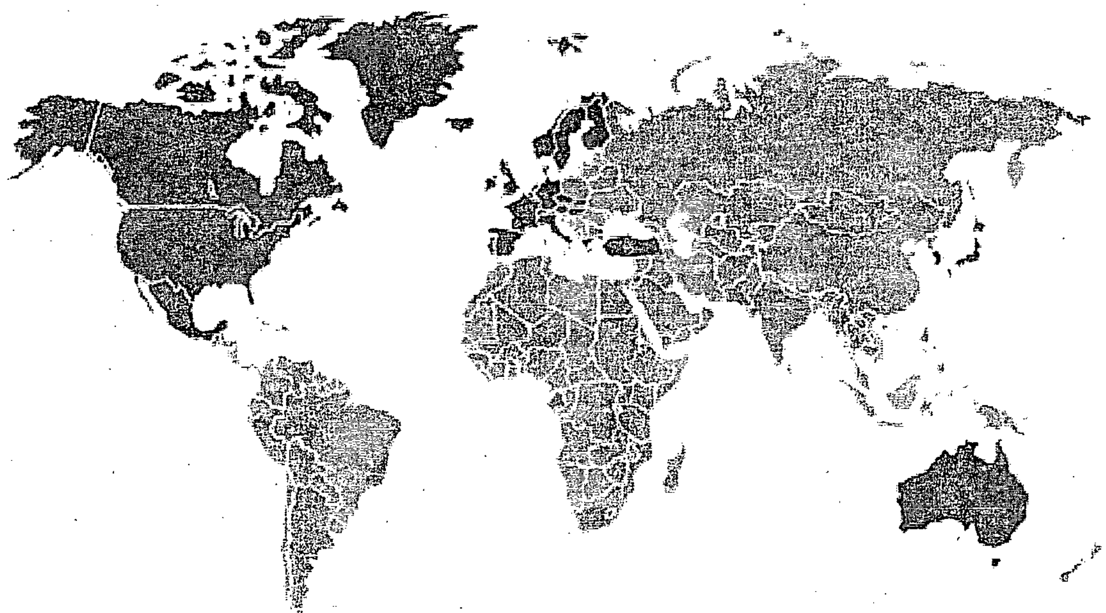
Content

- Brief overview of OECD-NEA
- Outcome of a recent NEA Workshop on the "Role of Research in a Regulatory Context"
- OECD-NEA international research projects (joint projects)
- Possible NEA options for long term safety research

Brief overview of OECD-NEA

What is the OECD ?

- 30 Member countries
- < 20% World's population
- > 3/5 world's exports
- produce > 2/3 goods & services
- generates > 4/5 nuclear power in world.
- 346 reactors units in 17 OECD countries. 10 more units under construction.



The OECD Nuclear Energy Agency (NEA)

"*The mission of the NEA is to assist its Member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for the safe, environmentally friendly and economical use of nuclear energy for peaceful purposes.*

- Small size and budget: (80 staff members; budget of 13 million euros, + voluntary contributions and projects)
- Tries to pool world's best nuclear expertise among member countries
- Organised by specialised committees. The committees dealing with safety and regulations are:
  - Committee on Nuclear Regulatory Activities (CNRA)
  - Committee on the Safety of Nuclear Installations (CSNI)

The CSNI deals with safety research

CSNI Working Group Activities

- Risk assessment
- Analysis and management of accidents
- Integrity of components and structures
  - Metal components
  - Ageing of concrete structures
  - Seismic behaviour of components and structures
- Human and organisational factors
- Fuel safety
- Fuel cycle safety

[illegible] RESEARCH PROJECTS

Brief overview of the NEA Workshop on the Role of Research in a Regulatory Context

Paris, 5 December 2007

Objectives

- Review the progress made since the 2001 Forum on the same subject
- Set forth the high priority safety issues currently and in the near-term for operating plants and new reactor construction
- Identify challenges for the safety evaluations of advanced reactor designs, and for organising the long term research & infrastructure that will be needed
- Through the above, provide input to the CSNI regarding strategies for new research programmes and support facilities

Programme

- **Opening:** **Scene Setting - Changes and CSNI/CNRA achievements since 2001**

  L. ECHÁVARRI, NEA DG — *J. REPUSSARD, IRSN, FRANCE*; *K. SODA, NSC, JAPAN*

- **Session 1:** **Research needs and facility utilisation for operating reactors**

  M.P. COMETS, ASN, FRANCE; *R. YANG, EPRI, UNITED STATES* — *K. ABE, JNES, JAPAN*; *J.C. MICAELLI, IRSN, FRANCE*

- **Session 2:** **Research and facility needs for new reactors (G-III, G-III+)**

  L. REIMAN, STUK, FINLAND; *J.P. HUTIN, EDF, FRANCE* — *J.J. HA, KAERI, KOREA*; *W. BORCHARDT, US NRC, USA*

- **Session 3:** **R&D and facility infrastructure for advanced (G-IV) reactors**

  J.L. CARBONNIER, CEA, FRANCE; *Y. SHIMAKAWA, MFBR, JAPAN* — *Y. SAGAYAMA, JAEA, JAPAN*; *M. JOHNSON, US NRC, USA*

- **Closure:** **Summary and Recommendations**

  J. REPUSSARD, IRSN, FRANCE — *K. SODA, NSC, JAPAN*

RRRC-2 Main Conclusions

- Regulators research institutions and industry should promote stronger research co-operation (in data gathering, maintaining independence in the data interpretation).
- There are different new and advanced reactor designs, many non-water reactor concepts. New infrastructure will be needed to assess safety for these systems
- The OECD-NEA joint projects are a good means for ensuring facility infrastructure and for maintaining a competence network in a practical manner. The OECD-NEA joint project approach should also be used for the long term research

RRRC-2 Main Conclusions

11. Multinational co-operation enables to save money and increases credibility; considering its experience, OECD-NEA should play a major role to promote and support such co-operation through efficient project arrangements

12. A Task Group should be set up to address NEA (CSNI) long term strategy and approach to joint efforts for infrastructure build-up, aiming at defining
    a) Key safety and risk issues as related to specific design concepts
    b) Issues that will require experimental data
    c) Infrastructure needed for developing the required data, including key infrastructure elements, timing and roles for regulator, TSO and industry

OECD-NEA Experience with International Research Projects in Nuclear Safety

CVit ACRS February 2008

OECD-NEA Safety Research Projects

Motivation and goals

- Address safety issues relevant for the nuclear community by means of research shared by many countries
- Enhance technical exchange, co-operation and consensus-building internationally
- Support the continued operation of unique test facilities which are of value to the OECD/NEA nuclear community
- Help to retain OECD/NEA technical expertise and infrastructure in strategic fields of nuclear energy
- Facilitate the above through cost-sharing arrangements where many countries contribute to programme funding

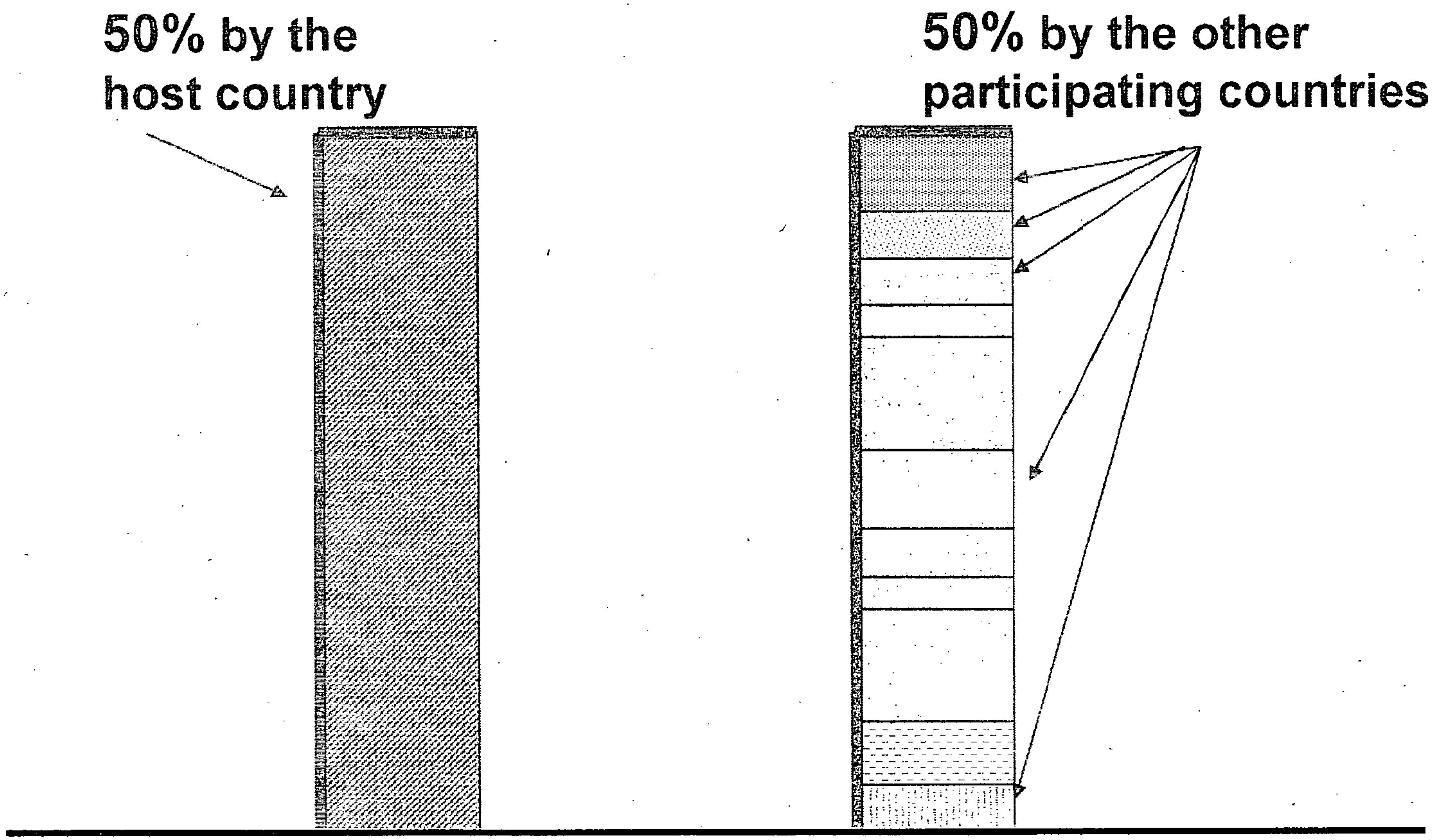
OECD-NEA Safety Research Projects

Way to operate

- Overall priorities are set in CSNI ad-hoc reports on "Nuclear Safety Research in OECD Countries". Catalogue of relevant facilities in CSNI SFEAR report
- Projects focus on experimental programmes carried out at unique test facilities, based on host country initiative
- There is no funding available upfront, money has to be found on a case by case basis; hence
- Project progammes must interest and attract as many prospective participants as possible
- The OECD-NEA has long term experience with these type of arrangements. Experience is generally good

OECD-NEA Safety Research Projects

Typical cost sharing



OECD-NEA Safety Research Projects

HALDEN	Fuel and Materials, I&C, Human Factors	Norway	Ongoing
CABRI	Fuel in RIA transients	**France** (Japan)	Ongoing
SCIP	Fuel integrity	Sweden	Ongoing
Paks-2	Fuel integrity, with IAEA	Hungary	Completed
MCCI	Severe Accident (ex-vessel)	USA	Ongoing
ROSA	System TH	Japan	Ongoing
PKL-2	PWR Boron dilution	Germany	Ongoing
SETH	Containment (CFD)	Switzerl/**France**	Ongoing
PSB-VVER	T-H for VVER 1000	Russia	Ongoing
THAI	Containment behaviour	Germany	Initiated
BIP	Containment behaviour	Canada	Initiated
SERENA	Steam Explosion	Korea/**France**	Initiated
PRISME	Fire safety	**France**	Ongoing
SCAP	Ageing	Japan	Ongoing
Databases	1. FIRE 2. ICDE 3. OPDE 4. COMPSIS		Ongoing

OECD-NEA Safety Research Projects

Thermal-Hydraulics
- PKL
- ROSA-LSTF
- PSB-VVER

Severe accident, in/ ex-vessel
- SERENA (ex-vessel)
- MCCI (ex-vessel)

SA, containment issues
- SETH
- THAI
- BIP

Databases
- ICDE
- FIRE
- OPDE
- COMPSIS

Fuel safety
- Halden
- CABRI (NSRR)
- SCIP
- ~~PAKS-2~~

Fire risk
- PRISME

Ageing
- SCAP SCC, Cables
- Halden SCC, I&C HOF, Cables

Possible NEA options for long term safety R&D

- Countries agree that the OECD Joint Projects are a good way to perform experimental research, especially when cost is high. The Joint Project approach can also be used for long term research
- Joint Projects also provide the ground for an efficient regulator-industry-TSO cooperation for producing data (but maintaining data interpretation independent)
- Incidentally: NRC participates in virtually all OECD safety projects. Given the size of its program, the USNRC may consider initiatives for hosting projects in the future.

Possible NEA options for long term safety R&D

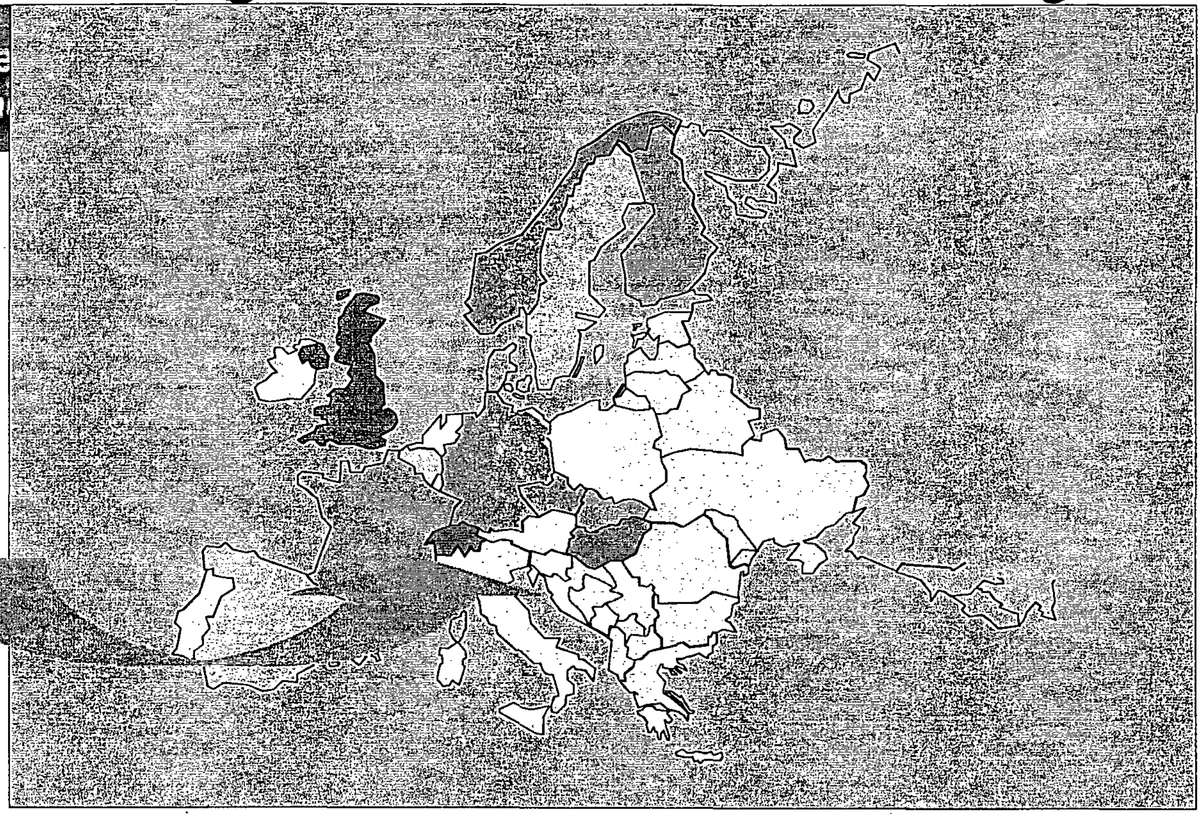
- Based on a NRC proposal, the NEA will set up a task group addressing the long term strategy and approach to joint efforts for infrastructure build-up in and safety research for advanced reactors. For this, the NRC contribution will be very important
- Challenges and questions for advanced reactors
  - Reactor designs not always clearly identified
  - Long term research may be too abstract
  - How should programmes be organised?
  - Where to find the money?
  - Role of industry? Regulators? TSOs?

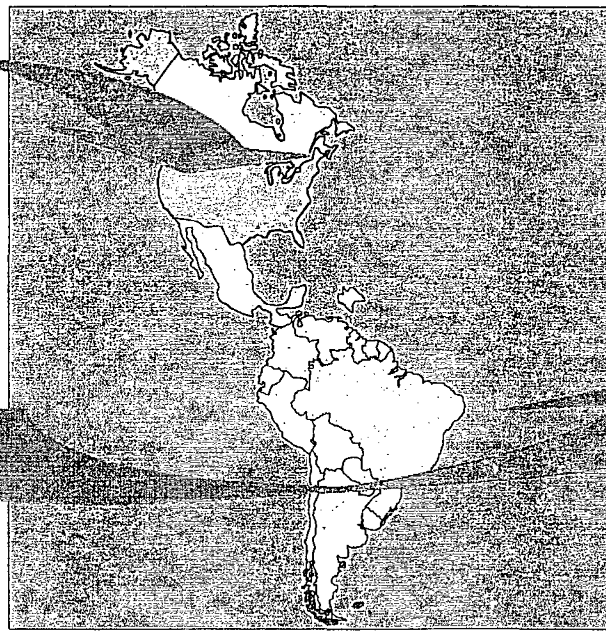
Possible NEA options for long term safety R&D

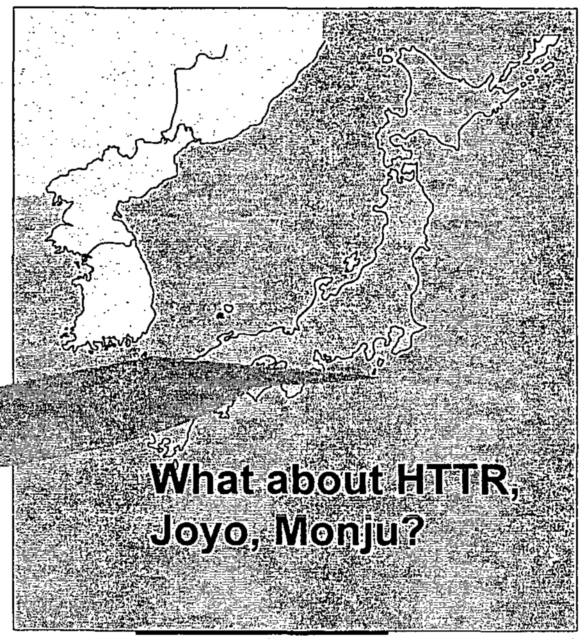
- Example:
  - To what extent will the existing fleet of test reactors be usable in the long term, e.g. for water, gas, liquid metal:
    - Fuel studies
    - Materials studies
    - Coolant-Fuel interaction studies
  - Are big adaptations needed? Will new reactors be needed? When? Who will pay for it?
  - How to get started: Start with sub-programmes within existing OECD Projects? Initiate new projects? Pool different test reactors in one comprehensive project?

Main test reactors

- Europe
  - ❑ BR-2 Belgium
  - ❑ LVR-15 Czech Republic
  - ❑ OSIRIS (JHR), France
  - ❑ HFR, The Netherlands
  - ❑ Halden, Norway
  - ❑ Cabri
- North America
  - ❑ ATR, USA
  - ❑ NRU, Canada
- Asia
  - ❑ Hanaro, Republic of Korea
  - ❑ JMTR, Japan
  - ❑ NSRR, Japan







Thank you

International Atomic Energy Agency

Long Term Research Needs

-

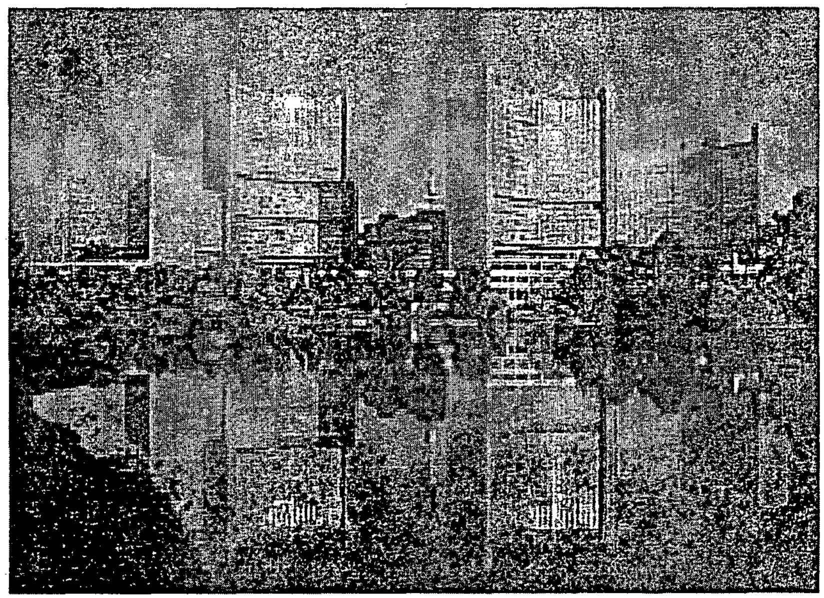
Considerations by the IAEA

Christer Viktorsson
Section Head
Nuclear Installations Safety Division

Content

- The IAEA role
- The Safety and Security pillar
- Issues and Trends in Nuclear Safety and Related Research Needs
- Summary of Research Needs

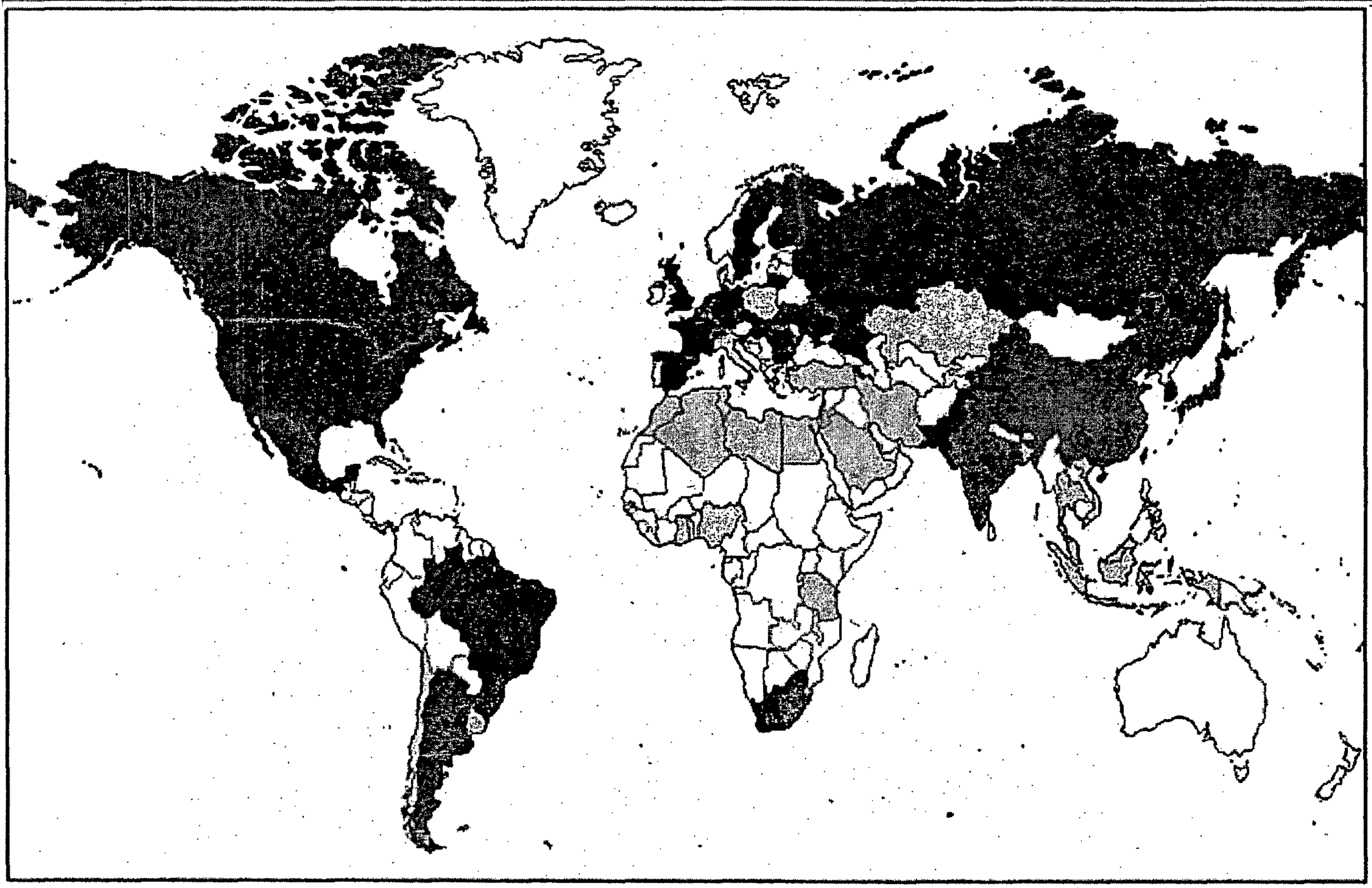
Role of the International Atomic Energy Agency (IAEA)



- "Atoms for Peace"
- Established in 1957
- 148 Member States
- 2,200 staff
- Three Pillars:
  - Nuclear Technology
  - Safety and Security
  - Safeguards

- **Globalization**
- **Nuclear "Renaissance" and Safety**
- **Security threat**

Rising Expectations for Nuclear **Developments**



☐ *Considering NP*

Algeria
Bangladesh
Belarus
Chile
Egypt
Indonesia
Iran
Jordan
Malaysia Morocco
Nigeria
Poland
Saudi Arabia
Thailand
Tunisia
Turkey
Uruguay
Vietnam...

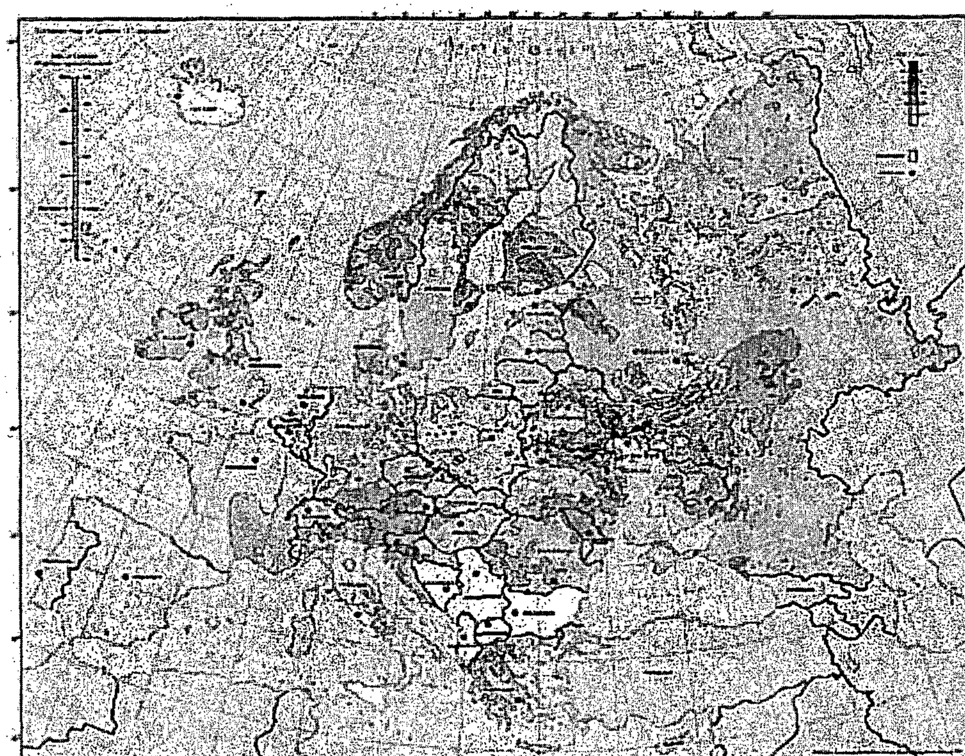
☐ Countries operating npp's

☐ China and India

Changing World and Challenges to the International Nuclear Community

- **Important developments since Chernobyl**

An accident anywhere is an accident everywhere



- -Safety Culture and Safety Management
- -Regulatory Independence
- -Severe Accident management
- -Stakeholder involvement
- - Creation of WANO, INSAG
- - New Conventions

Global Security Evolution

Cold War - Post Cold War - Post 9/11

Main Actors

- Nation-states
- Bi-polar
- Superpowers

→

- Non-States
- Small states
- Global network

Threats

- High density, high intensity
- Lower Probability
- Physical overkill

→

- Low density, low intensity
- Higher probability
- Socio - psychological terror

Motives

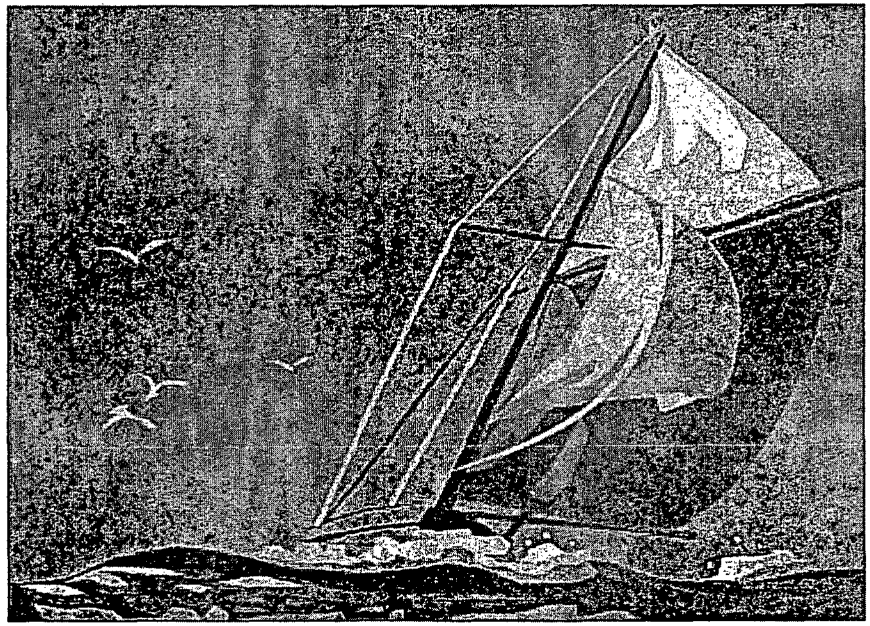
- Geopolitical
- Predictable
- Calculable

→

- Malicious
- Unpredictable
- Incalculable

Changing World and Challenges to the International Nuclear Community (continued-2)

- **Globally Shared Perceptions**
  - **All in the same boat now**
  - **Prevent another watershed event at all cost**
  - **Act together through international cooperation and coordination**



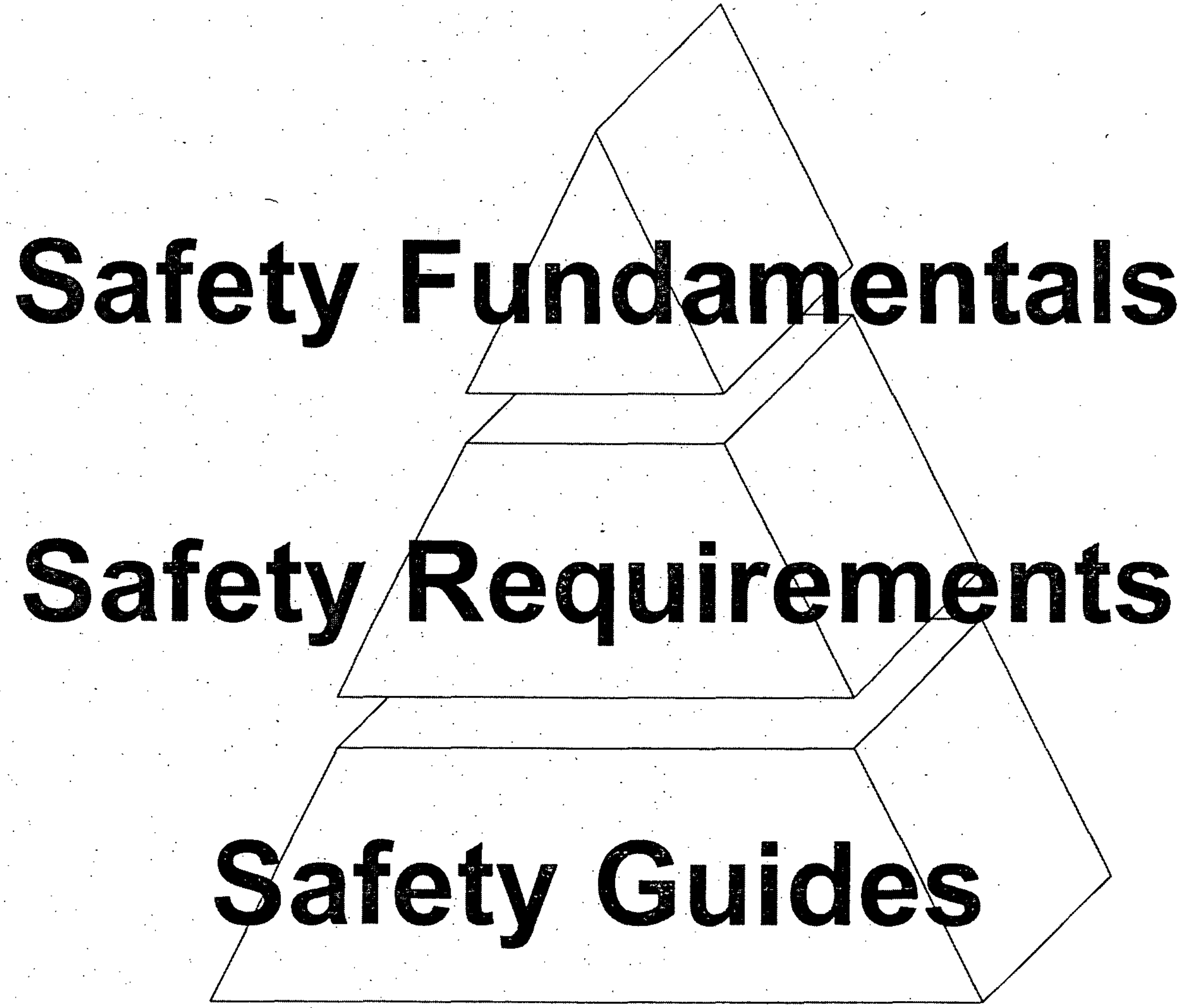
IAEA Nuclear Safety Activities

- *Establishment and Revision of Nuclear Safety Standards*
  - **Fundamentals, Safety Requirements and Safety Guides**

- *Safety Standards Application and Feedback*
  - ***Advisory and Review Services***
  - ***Training Courses and Workshops***
  - ***Sharing Experience and Knowledge through Networking***

- *Support for Implementation of Conventions and Codes of Conduct*

SAFETY STANDARDS HIERARCHY



STRUCTURE OF THE STANDARDS

Safety Fundamentals

- Thematic standards
  - Legal and governmental infrastructure
  - Emergency preparedness and response
  - Management systems
  - Assessment and verification
  - Site evaluation
  - Radiation protection
  - Radioactive waste management
  - Decommissioning
  - Remediation of contaminated areas
  - Transport of radioactive material
- Facilities specific standards
  - Nuclear power plants: design
  - Nuclear power plants: operation
  - Research reactors
  - Fuel cycle facilities
  - Radiation related facilities and activities
  - Waste treatment and disposal facilities

- General safety (cross-cutting themes)
- Safety of nuclear facilities
- Radiation protection and safety of radiation sources
- Safe management of radioactive waste
- Safe transport of radioactive material

IAEA Safety Review Services

Regulatory Framework and Activities

- *IRRS* – **Integrated Regulatory Review Service**

Operational Safety

- *OSART* – **Operational Safety Review Team**
- *SEDO* – **Safety Evaluation of Fuel Cycle Facilities During Operation**
- *SCART* – **Safety Culture Assessment Review Team**

Research Reactors

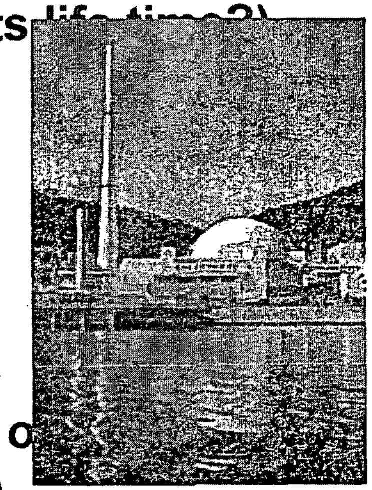
- *INSARR* – **Integrated Safety Assessment of Research Reactors**

Engineering and Technical Safety

- *DESAR* – **Design/Engineering/Assessment Safety Review Services**

Issues and Trends in Nuclear Safety

- Ref. IAEA Safety Services, Assistance Requests and IRS
- **Ambitious Nuclear Development Plans (life extensions and new builds) and Globalization of the Nuclear Community**
  - **LWR technology dominant today and decades ahead**
    - **Present fleet only served for some 30 years (half of its**
    - **Reactors built, or ordered today are evolutionary**
  - **Major safety issues**
    - **Ageing of facilities and people**
    - **Maintenance and modernization of facilities**
    - **New technology (in old facilities)**
    - **Safety culture and management of safety**
    - **Safety Assessment and Work Management (large nb o**
    - **Education & training (new people, new technologies)**
    - **Research facilities ageing and closure**



Issues and Trends in Nuclear Safety

- **New Reactor concepts emerging**
  - **Require research into materials, fuel, core physics, operation, accident management, inspection and maintenance, safety systems, ..**
  - **Support of fuel cycle facilities**
- **Globalization**
  - **increasing cross-border responsibilities, few reactor vendors**

Issues and Trends in Nuclear Safety

- **Need for Nuclear Safety Infrastructure and International Cooperation**
  - **Nuclear infrastructure has "degraded" in many countries**
  - **Nuclear infrastructure weak in countries considering nuclear power plants**
  - **Infrastructure building important, incl educational and research institutions**
  - **International cooperation important**
  - **TSO organisations important**

Issues and Trends in Nuclear Safety

- **Global Nuclear Safety Regime is getting more support**
  - **Conventions, safety standards, national structures, expert networks**
  - **Support from major nuclear countries essential for strong worldwide safety**
  - **IAEA safety standards utilized more or less directly in many countries, e.g China**
  - **Demand for independent safety peer reviews increases**
  - **The quality of the GNSR essential**
- **Regulatory Effectiveness and Legal Framework a key to successful utilization**
  - **Independence, competence and capabilities of regulator. Independent safety assessment capability**
  - **Licensing (new reactors, renewals) today different from licensing during 80's (safety margins, public participation, international interest, new technology)**
  - **Review of advanced designs, including passive systems (lack of experience, data)**
  - **Demand for harmonization and regulatory stability**

Issues and Trends in Nuclear Safety

- **Operational Safety Performance**
  - **Safe performance, but recurring events happen**
    - **Root cause analysis**
  - **Safety issues**
    - **Electrical systems behaviour, reactivity control systems**
    - **Natural hazards (seismic events, flooding, ..)**
    - **New technology (digital I&C, ..)**

- **Strong Leadership, Management for Safety and Safety Culture**
  - **Understanding and assessment of safety culture**
  - **The relationship between management systems and strong safety culture**
  - **Safety and security culture**
  - **The development of strong safety culture in weak infrastructures**
  - **Management of change**

Issues and Trends in Nuclear Safety

- **Openness and Transparency on the part of operators and regulators**
  - Public confidence, ensuring feedback
  - Security issues, balance openness and confidentiality
- **Technical Developments in Safety Analysis – led to enhancements of safety/plant modifications need continuous attention**
  - Assessment of new technologies, upgrades of power and long term operation, modifications
  - Better understanding of risks and safety margins
  - Human and organisational factors
  - Management strategies to cope with uncertainties in severe accidents
- **Long Term Operation require good ageing management**
  - Safety assessment for structures and components, qualification of equipment
  - Integrity of RPV, ageing of cables, integrity and leakage of containments
  - Development of plant ageing management programmes

Issues and Trends in Nuclear Safety

- **Sharing of Experience and Lessons Learned have improved, but needs continuous enhancement**
  - **Effectiveness of risks elimination**
  - **Difficult to learn from others experience**

- **Human and Knowledge Resources – a key to successful "renaissance"**
  - **Part of infrastructure building**
  - **Knowledge management and creation of safety networks**

- **International Cooperation for Research & Development, Education and Training**
  - **Regional training centers**
  - **National Centres supported by IAEA**
  - **Closer links between TSOs**
  - **Joint research more and more important (NEA)**

Coordinated Research Projects

Summary of Research Needs in Reactor Safety

- Existing reactors
  - Need to keep basic technical safety research alive (reactor physics, thermo-hydraulics, structural mechanics, human and organisational factors, ...). Of importance for safety, but also for knowledge management.
  - Specific emphasis is needed on
    - Weaknesses seen from operation experience
    - Topics related to new designs
    - Power up-rates and life extension
  - External phenomena influencing reactor safety (natural and human)
    - Seismic issues
    - Extreme weather conditions (flooding, tsunami, ..)
    - Security issues, interface safety-security

Summary of Research Needs in Reactor Safety

- Barriers and safety margins confirmation
  - Fuel (burn-up, use of mixed fuel, ..)
  - RPV and primary systems (material ageing, failure mechanisms, ..)
  - Containment (integrity, leakage, NDT-methods, ..)

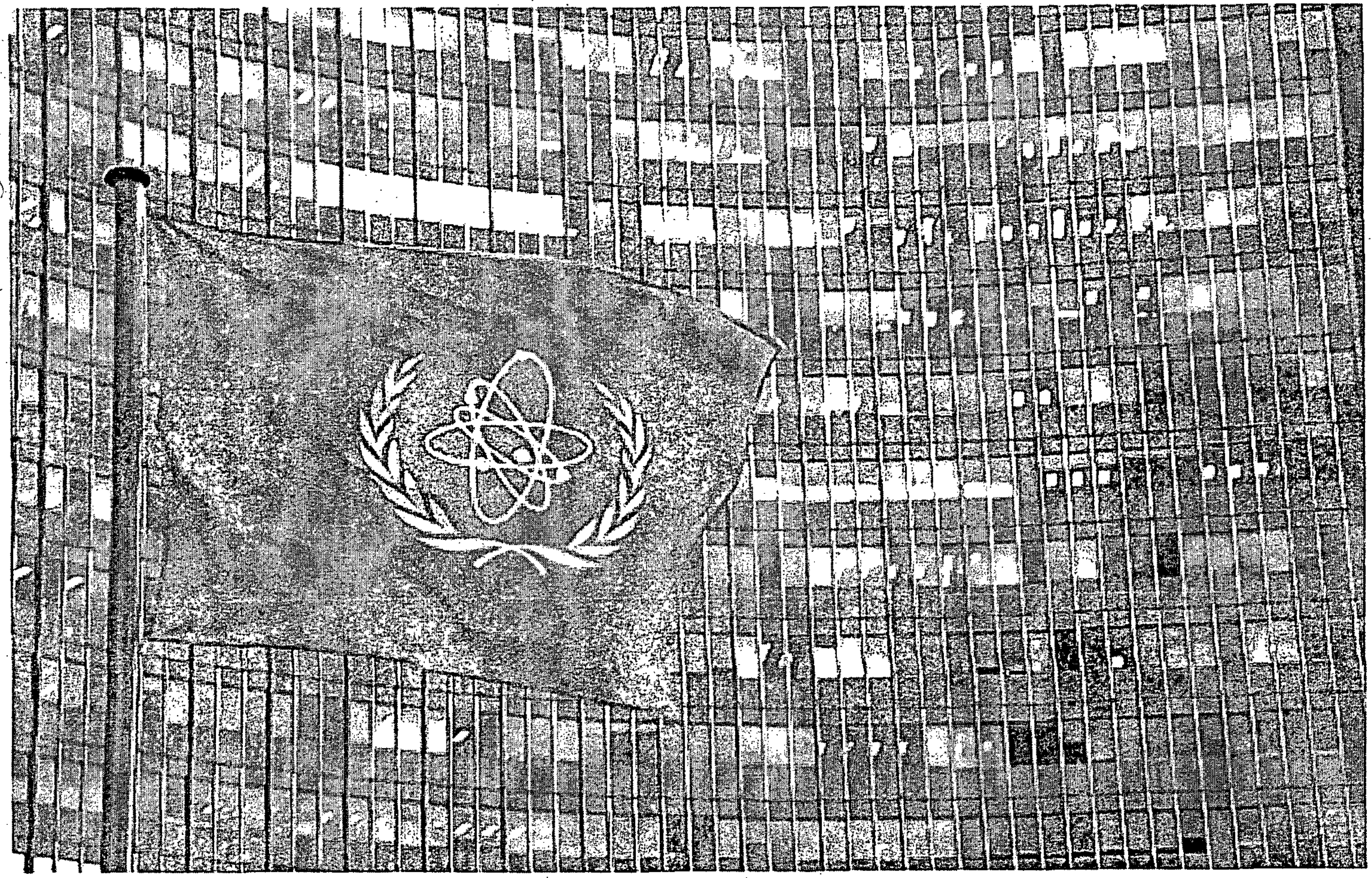
- Reactor systems
  - Reliability of digital systems
  - I&C (CCF, licensing, ..)
  - Electrical systems (ageing of cables, barrier considerations, ..)
  - Reliability of safety systems (grid considerations, diesel generators, ..

Summary of Research Needs in Reactor Safety

- New reactors
  - Require research into materials, fuel, core physics, operation, accident management, inspection and maintenance, safety systems, ..
  - Support of fuel cycle facilities
- Safety Assessment
  - Plant modelling, root cause analysis, new material, handling of uncertainties, reliability of passive systems, restart of plants after severe events, "simplified methods" for safety analysis
- Verification and tests
  - NDT of metals and concrete
  - Fire safety
  - Severe accident and accident management (I-chemistry)
  - Simulators for severe accidents

Summary of Research Needs in Reactor Safety

- **Maintenance of large scale test facilities**
- **Safety culture and management**
  - Understanding and assessment of safety culture
  - The relationship between management systems and strong safety culture
  - Safety and security culture
  - Safety culture involving contractors (Modernisation and maintenance)
- **Regulatory effectiveness**
  - Licensing (new reactors, renewals), safety margins, public participation, international interest, new technology
  - Review of new and advanced designs, including passive systems (lack of experience, data)



...Thank you for your attention

International Atomic Energy Agency

IRSN
INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

REACTOR SAFETY

LONG TERM RESEARCH IN FRANCE

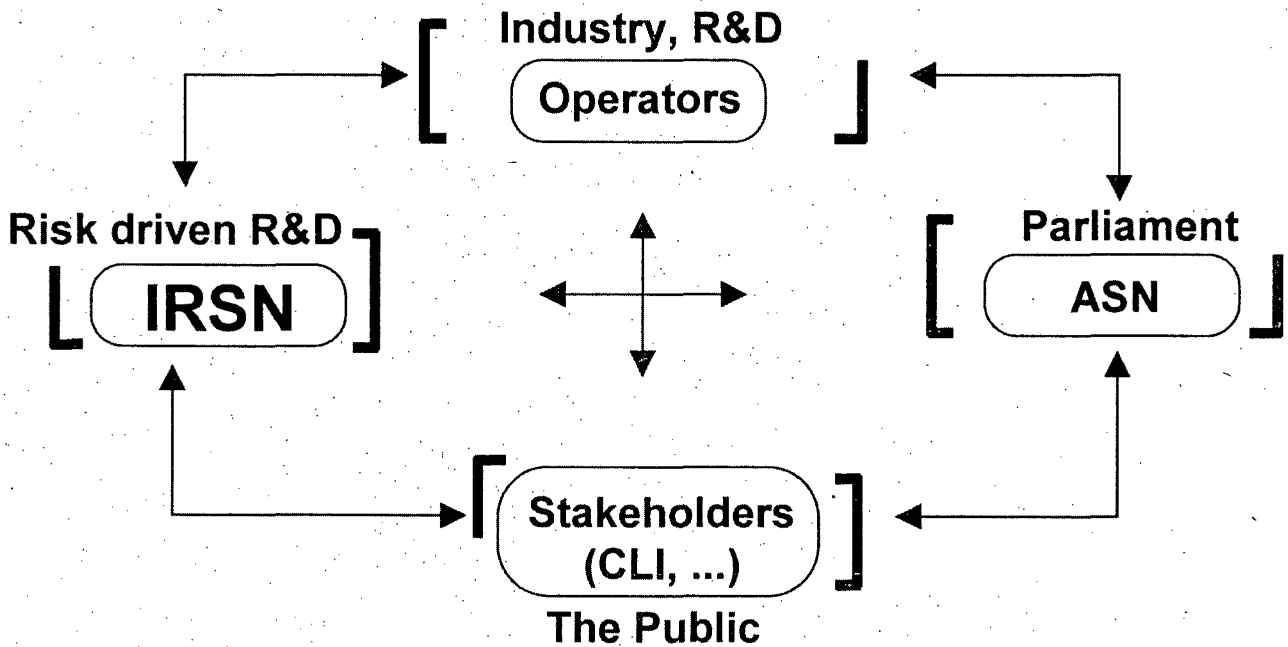
IRSN VIEWPOINT

Jacques REPUSSARD
Director General

Michel SCHWARZ
Director

IRSN: the French TSO

Mission: to provide independent research and expertise in support to public policies in nuclear safety and security, & radiation protection



- a wide field of competence allowing a broad vision of safety, security and radiation protection issues
- risk assessment capability at the heart of IRSN's R&D and operational support missions
- a strong international involvement
- 1700 people, 280 M€ budget

Summary

- Key determining factors and main assumptions

- Long term reactor safety research objectives and priorities
  - Cross-cutting issues
  - PWR specific issues
  - GEN IV specific issues (Sodium/Gaz fast reactors)
  - ITER: Fusion reactor specific issues

- Economy of reactor safety research
  - Human resources
  - Experimental infrastructure
  - Funding

Key determining factors and main assumptions

- Electronuclear national policy and technology
- Societal and environmental evolutions
- Generic progress of science
- Reactor safety research economy

Electronuclear policy and technology (next 10 / 20 years)

- Mainly GEN II and GEN III PWR nuclear plants
- Closed fuel cycle
- No new nuclear sites, but more than one nuclear utility
- Requests to operate some PWR reactors beyond 40 years
- Multinational designs (fuel assemblies, I&C, ...)
- Increased sophistication of methods and tools to support licensing requests
- 1 SFR demonstration plant ; licensing of large SFR Plants and GFR prototype considered
- 1 Fusion large scale reactor (ITER)

Environmental and Societal evolutions

- Climate change to be considered (heat waves, flooding, strong winds)
- Security always a key issue
- Grid reliability may lessen
- Pressure from the public on low dose exposure health issues and on environmental risks
- Pressure from industry to increase licensed domain of operation ; trend to reduce margins (increased burn-up, new fuel design, increased power rating, ...)
- Development of nuclear energy in "emerging" countries without necessarily appropriate competence. Need for technical and scientific support resources.

Generic progress of science pertinent for reactor safety research

- Computer sciences and mathematics progress fast
  - unprecedented modelling sophistication, available to industry for safety case demonstration, and to reactor safety research labs
  - generalisation of digital I&C for reactor safety functions

- Advanced materials are used in reactor technology: fuel elements, piping,...

- Better understanding of interactions between radiation and living material may lead to a review of radpro system and possible new requirements for future reactor systems

- Social sciences offer improved methods to assess human related aspects of safety (main cause of past severe accidents)

Reactor safety research economy

- Increased use of cost/benefit approach to evaluate relevance of proposed research projects. Industry more reluctant to fund longer term safety research projects.
- Lasting satisfactory nuclear safety records tend to encourage a reduction of public spending on safety research.
- Large demand of high level human resources by nuclear industry, thereby increasing training needs and making it more difficult in the next decade to hire specialists and keep high level of competence in IRSN. R&D activities are key to attract and train the best people.
- Progressive globalisation of nuclear industry induces increased multinational cooperation on regulatory issues, and in safety research.

Long term reactor safety research objectives and priorities

Key objectives

- To maintain over time an independent assessment capability, based on the excellence of experts, and on state of the art techniques and data.

- To maintain at all times the state of the art knowledge and operational expertise necessary to deal efficiently with major nuclear accident consequences.

- To contribute in key areas to cutting edge R&D in order to drive industry towards making the best use of scientific and technological progress for improving safety, environmental protection and health.

- To allow regulatory policy to anticipate the evolution of safety, security and radpro related risks.

Long term reactor safety research objectives and priorities

10 Cross-cutting issues

Note: will be applied first to PWR technology

1. Advanced computational methods:

Development of more sophisticated and more accurate coupled modelisation tools, based on multi-scale approach, in the following domains:

- material physics and mechanics (fuel, piping, ...)
- thermal-hydraulics
- neutronics

Development of advanced methods to assess uncertainties.

Cross-cutting issues (cont.)

2. Development of PRA tools and methods for more systematic use. Extension of PRA to assess effects of aging, earthquake, fire, flooding and other severe climate events, grid reliability.

3. Development of research on human factor.

4. Development of research on reliability of Digital Instrumentation and Control. Note that hiring of specialists in this domain is difficult. Not specific to nuclear safety.

5. Research on fuel behaviour in reactor and fuel cycle for new fuel designs and burn-ups (reactivity accident and fuel transportation, intermediate storage, reprocessing accidents).

Cross-cutting issues (cont.)

6. Offsite consequences
   - Development of decision making tools for mid-term and long term post-accident management
   - Research on low dose effects on man and environment

7. Develop an economic approach of the cost of nuclear safety (safety research vs. accident cost estimate including offsite consequences).

8. Research on efficiency of passive safety features.

9. Keeping research on criticality at a "reasonable" level to maintain competence.

10. Consideration on how to manage knowledge. Development of centres of excellence.

PWR specific issues

1. Aging

   - Research on aging of PWR plant components (internal structures, concrete structures, electronics, cables)
   - Development of tools on default initiation and propagation to anticipate problems

2. Development of in-situ real-time inspection and monitoring techniques.

3. Keeping research on severe accidents and Source Term at a "reasonable" level to maintain competence (core meltdown accident considered in GEN III design!).

S(G)FR specific issues

1. Reappropriation of past R&D on SFRs
   - Whole core accident codes as SAS4A, SIMMER and associated qualification experiments (Cabri, ...)
   - Local accident codes and associated qualification tests (Scarabée, ...)
   - Fire propagation code and associated qualification tests (Esmeralda)

2. Develop advanced codes common, when needed and as far as possible, to LWRs and S (G)FRs, and capitalize in them all past R&D results.

S(G) FR specific issues (cont.)

3. Performing complementary research in support to code development and qualification, and to (re)develop competence (research on fuel behaviour under accidental conditions).

4. Research on material and fuel behaviour under high neutron flux and high temperature.

5. Research on inspection and monitoring under sodium environment.

Fusion reactor specific issues

1. Development of codes for simulation of accidental scenarios (possible on basis of LWR codes)

2. Research on the following phenomena :

   - resuspension of dust (graphite, beryllium, tungsten),
   - risk of hydrogen/dust explosion,
   - behaviour of tritium,
   - behaviour of plasma in accidents (particular need to acquire competences in this new field ...)

↳ Need to enter international collaborations ...

Economy of reactor safety research

Human resources

- To attract high level scientists and maintain reference experts in a very competitive environment, it appears necessary on a long term basis to:
  - develop multinational Networks of Excellence operating around large data acquisition and code development programmes,
  - mix R&D and operational safety assessment activities,
  - provide for mobility, including internationally.
- Capitalisation of knowledge and nuclear safety harmonisation can foster manpower savings in a lasting constrained resources environment.

Economy of reactor safety research
Experimental infrastructures

Reactor safety research infrastructures are key to the long term pertinence of regulatory action, and to the continued high level competency of experts

IRSN intends to run experimental programmes to validate reactor safety codes for LWRs and future reactors as well in the following main areas:

- *fuel behaviour in reactivity accidents*: in particular in the CABRI research reactor (to address safety criteria issues and test new fuel designs),
- *whole core severe accidents* (including source term issues): replace PHEBUS by specific safety programmes in the reactor Jules Horowitz (2014) (to address non-anticipated LWR safety issues, and safety issues in future reactors)
- *fire propagation* (Cadarache large scale platforms)
- *criticallity* (« appareillage B ») for code development validation with respect to new materials

IRSN looks to cooperating with partners in all R&D areas where significant experimental facilities are needed.

Economy of reactor safety research

Funding

- Enough public resources to ensure that regulatory reactor safety research remains industry independant.
- Think systematically multinational to operate cost-efficiently large experimental facilities. The Halden Project can be considered as a reference management model.
- Multinational R&D is in the long run the fast track to regulatory harmonisation. As such, it should deserve some industry investment.
- NEA provides an exceptional platform for establishing such R&D programmes, under the scope of CSNI. All nuclear countries should, one way or another, be able to contribute to reactor safety research programmes and to access to relevant knowledge through IAEA.

Thank you for your attention

Long-term research activities in India

1. *High Temperature reactor (HTR) research*

High temperature heat removal technology including heat pipes
Experiments and code development for high temperature reactor core heat removal systems under various normal and postulated accident conditions

Corrosion studies with molten lead/molten salt based coolant
Experiments to estimate corrosion behavior of structural materials at different temperatures and under various flow conditions coolant

Integrity of high temperature reactor fuel under normal, transient and accident conditions
Experiments and code development to study behavior of TRISO coated particle fuel and fuel elements under various reactor-operating conditions

Design rules for brittle materials
Development of design rules for ceramic materials like graphite, which are extensively used in high temperature reactor. Validation of design rules with extensive test programs.

Safety studies related to HTR
Experiments and code development to carry out safety studies under various postulated initiating events

Structural material compatibility studies for HTR
Experiments to study behavior of in-contact structural materials subjected to high temperatures

Seismic design of HTR components
Investigate the seismic response of high temperature reactor core by carrying out detailed modeling and validating it with experiments on a shake table

Developments of components and instruments for HTR applications
Experiments for development and testing of components like high temperature heat exchangers, Fuelling/de-fuelling systems, special pumps, reactor control and shutdown systems, decay heat removal systems, neutronic instruments, high temperature instruments and control systems for use in high temperature and corrosive coolant environment

2. *Advanced heavy Water Reactor (AHWR) research*

Computer codes
Develop and validate neutronic/Thermal-hydraulic/severe accident codes for AHWR, passive system reliability assessment methodology development

Natural circulation in advanced reactor concepts
Experimental and analytical studies, Steady-sate, transient and start-up behavior, melt coolability, core concrete interaction, steam explosion, fission product behavior, in-vessel and ex-vessel phenomena during severe accidents etc.

Uncertainty analysis of best estimate computer codes
Error estimation in code prediction by comparison between code and test data, Methodology for uncertainty analysis

Dry out and post-dry out studies
Experiments and code development for dry out and post dry out phenomena in rod clusters

Nuclear hydrogen generation
Experiments and code development for hydrogen production processes, Integration schemes with nuclear reactors

Containment thermal hydraulics safety evaluation
Blow-down phases, aerosol behavior, hydrogen issues and uncertainty assessment, internal and external events related to impact, hydrogen and fire loads.

3. ***Fast Breeder Reactor (FBR) research***

Computer codes
Develop and validate neutronic/Thermal-hydraulic/severe accident codes for FBR considering the transient behavior of the fuel melt propagation from fuel to single subassembly and then to whole core, molten fuel coolant interaction, melt fuel debris relocation on the core catcher based on experimental test data available from various publications.

Material research
Development of advanced structural materials for the clad and wrappers to achieve high burn up; numerical simulation of fuel and structural materials under high irradiation conditions and generation of material data for out of core components for long life (> 60 years). Evaluation of design of metallic fuels, development of constitutive models for binary and tertiary alloys, development of oxide dispersion strengthened (ODS) ferritic steels for clad, design safety limits for fuel, clad and coolant.

Safety system performance assessment
Confirmation of passive safety features of fuel behavior, post accident heat removal, shutdown systems and decay heat removal systems, adopting advanced digital C&I control systems.

Seismic research
Establishing robust seismic design: rationalization of site seismic parameters, design criteria, analysis methods and seismic qualification tests. Elimination of OBE from the design and reduction of seismic loads through adopting state-of-the-art base isolation system.

R&D towards improving Economy
Optimization of plant layout giving due consideration for safety and maintenance, optimization of number of heat transport loops and components, homogenization of structural materials, development of high temperature design rules and establishment of thermal hydraulic design criteria such as thermal striping, thermal stratification, thermal ratcheting, sodium free level fluctuations, flow induced vibrations, steam generator flow instabilities etc.

R&D towards achieving enhanced safety
Numerical simulation of sodium fire and sodium water reactions, sodium aerosols behavior, developing sensors for efficient sodium detection system, demonstration of leak before break justification, gas entrainment in sodium pools, mitigation of consequences of core disruptive accidents (CDA), post accident heat removal and establishment of severe accident management guidelines.

R&D for fast reactor fuel cycle management
Development of robust fast reactor fuel cycle, design for longer plant life, simplification of waste management and minimization for the repository space and lower exposure potential, robust fabrication technologies.

4. ***Safety research***

Nano fluid applications to water-cooled reactors
Fundamental experiments on nanofluids applications

Annular fuel development
Development of annular fuel for advanced reactors, Optimization of design parameters

Molten lead/molten salt based coolant chemistry monitoring and control
Experiments to establish methodology for monitoring and control of coolant chemistry under various temperature regimes

Ageing research
Flow assisted corrosion, low temperature (about 300 degree C) sensitization and low temperature embrittlement of stainless steel, environment assisted fatigue, Fatigue and fracture behavior of bi-metallic joints (SS with Low Alloy Steel), thermal fatigue and aging of C&I cables.

Seismic research
Pushover analysis and testing, fatigue-ratchetting behavior of piping components and seismic re-evaluation of existing structures

Probabilistic safety analysis
Probabilistic safety analysis applications for operation and maintenance of NPPs, probabilistic fracture mechanics

Containment structural and thermal hydraulic safety evaluation

Experimental and analytical simulation for severe accidents

Uncertainty analysis for severe accidents

ACRS Subcommittee on Safety Research Program

Rockville, MD
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OBJECTIVES

- **Should a portion of safety research activities be devoted to the development of the technical infrastructure that may be needed in the 10 to 20 year time frame and to the development of user friendly tools (taking advantage of the computing power) to support more effective and efficient line organizations' regulatory work?**
  - **Timely**
  - **based on sound technology and science**
  - **make maximum use of realistic assessments consistent with the state-of-the-art and the available data**

OBJECTIVES (Continued)

- **What should be the scope of long-term research that a regulatory authority should consider ?**
  - What Should the research focus be on LWRs?
  - How long might it take to develop a technical infrastructure to support sound safety decisions on non-LWRs (e.g., Gas-Cooled Reactors, GNEP, GEN-IV) ? What non-LWR research should be undertaken?
  - Advances in technology (e.g., new materials, sensors, computing power) make it possible to further enhance safety (and improve economics). What areas may deserve long term research?

ASSUMPTIONS-1

- **Use of nuclear power in the USA (and perhaps worldwide) will grow over the next 20 years**
  - light water technology will be dominant
  - reactors using non-LWR technology may be a small part of workload of most regulatory authorities but may well require long term research to develop safety requirements and support future licensing decisions

ASSUMPTIONS-2

- **Utilities will continue to seek to utilize the current margin that exists between operations and regulatory limits**
  - **Submittals will become more technically sophisticated and complicated. Analysis tools, used by regulatory authorities, would need to assure appropriate limits and margins are maintained**

ASSUMPTIONS-3

- Nuclear power will become an ever more international field leading to greater collaboration in research
- Staffing at many regulatory authorities may not grow at a rate commensurate with the growth of nuclear power

ASSUMPTIONS-4

- **The average experience of regulatory staff will decrease over the next decade**
  - matter of demographics
  - exacerbated perhaps by the competition for manpower within the nuclear community

DISCUSSION

- Do you agree with the objectives?
  - Should there be other objectives?
- Do you agree with the assumptions?
  - Should other or different assumptions be made?