RESUMED **[1.03 pm]**

COMMISSIONER: We resume, and I welcome Dr Carl-Magnus Larsson. Counsel.

MR JACOBI: The Australian Radiation Protection and Nuclear Safety Agency, ARPANSA, is the Commonwealth government's primary authority on radiation protection and nuclear safety. Its functions are multifaceted and include regulation, research and promotion of radiation protection standards that are consistent across Australian jurisdictions and in line with the international standards. Dr Carl-Magnus Larsson commenced as the chief executive officer of ARPANSA in 2010, and prior to that, Dr Larsson worked in senior positions at the Swedish Radiation Safety Authority.

He has coordinated multinational European commission- supported research projects, Facet and Erica, both on environmental assessment and protection, and has been a member of the OECD, NEA, Radioactive Waste Management Committee, RWMC, and the chair of the RWMC regulators' forum. He is the Australian representative to the United Nations Scientific Committee on the Effects of Atomic Radiation, UNSCEAR, and was the chair of that committee between 2012 and 2015, and the Commission calls Dr Carl-Magnus Larsson.

COMMISSIONER: Dr Larsson, thank you very much for joining us. Before we start with the evidence, I want to trace some of the evidence that we were given earlier today in relation to UNSCEAR, and I'm particularly interested to understand how information as collected, what sort of information was collected, and perhaps you could start with explaining broadly how that happened, over what period.

DR LARSSON: I assume that we are talking about the Fukushima assessment here.

COMMISSIONER: Yes. Fukushima.

DR LARSSON: Because obviously UNSCEAR's work expands over many, many different areas. The assessment was based on available information, scientific information that was being generated in Japan and by international organisations, and was published, and we had extensive access to extensive datasets gathered by all these organisations, including also a number of non-governmental organisations that we can also use to benchmark our databases against. UNSCEAR is not an organisation. That's something that we probably need to point out. It's a scientific committee which is set up by 27 United Nations member states and it reports directly to the United Nations General Assembly.

So it's not an organisation that has its own staff and own laboratories. It collects scientific information, analyses the information and provides information to the General Assembly on sources and effects of radiation. That's the way it works.

COMMISSIONER: So within that group that did the Fukushima accident, could you just give me an explanation of the sorts of scientific staff that were associated with that particular investigation?

DR LARSSON: Well, there was a team of about 80 international experts.

COMMISSIONER: 80?

DR LARSSON: Yes, around about 80, and they were all nominated by the member states of UNSCEAR, but also from a number of other United Nations member states. But my personal estimate would be that probably the total number of scientists that were involved in the study was maybe three times larger, because all of these individuals would have also worked with people back in their own laboratories and their own institutions. So I would estimate that around about 200 people would have been involved in this, as we did at ARPANSA, although I'm the representative and we had a number of other members of our staff that were also members of the group. We interacted with other people that we had back home in our organisation.

So that's basically a very big international effort involving 80 scientists that were directly nominated, but also a number of other - - -

COMMISSIONER: And what sort of qualifications would those 80 (indistinct)

DR LARSSON: They were generally scientists or have a scientific background and be used to this kind of work in the particular specialised fields. The project was divided into different work packages, so to speak. You were

last week discussing these matters with Dr Solomon of ARPANSA who was in charge of the dose estimates to the public and also dose estimates in the environment.

COMMISSIONER: Were there doctors engaged with this group?

DR LARSSON: Are you referring to medical doctors or scientific doctors?

COMMISSIONER: Medical doctors. Yes.

DR LARSSON: Yes. Some of them, some of their representatives and some of the experts that participate in the deliberations of UNSCEAR. They have expertise in medical fields. Some of them are practising doctors.

MR JACOBI: Can I just ask as well, was information collected from physicians working within Japan in terms of health effects or information collected from organisations such as hospitals or other organisations providing treatment?

DR LARSSON: Well, over the years that the report was prepared, there has been a lot of interaction with the medical profession in Japan, in particular the Fukushima Medical University which also of course is responsible for running the Fukushima Health Management Survey. So, yes, there has been a lot of interaction.

COMMISSIONER: In terms of understanding the impact of radiation on foliage and crops, did the organisation have access to that information?

DR LARSSON: The organisation - as I said, it's not an organisation. It's a committee.

COMMISSIONER: Sorry, the study group.

DR LARSSON: Yes. So we don't have the staff that can go out and do the sampling or do the experimental work and the laboratory work themselves. However, a number of the members of the study team, they went to Japan for specific purposes, for specific questions, and in particular, the group that was set up to work on the radiation exposure workers went to Japan to on site get in-depth information on the methodology, the equipment and so forth, that was used in order to get information on the exposure of the workers.

COMMISSIONER: Thinking about that exposure, did the group examine cancers beyond thyroid cancer?

DR LARSSON: Well, absolutely. Thyroid cancer was one subset of the

investigation, obviously a very important one. We know from the experience from Chernobyl of course that this is something that we need to give due attention, but the Committee examined all cancers.

COMMISSIONER: All cancers.

DR LARSSON: All solid cancers as one group, and also special cases of thyroid cancer obviously, breast cancer, and outside of solid cancer, also leukaemia.

COMMISSIONER: Okay. In terms of - and if you don't have the background for that, that's fine - in terms of - in terms of the investigation and Chernobyl, was it a similar size body with the same principles?

DR LARSSON: It worked basically on the same principles. It was obviously 1986. It was pre-Internet time, pre the enormous flow of information that we have seen since, and it had to rely on a lot of information that was being provided and was also very generously provided by the Soviet Union, as it was at the time. But of course the premises for the whole study was different, because it was 25 - more than that - years ago, almost 30 years ago.

COMMISSIONER: Did you collect in the Fukushima activity evidence about caesium and iodine?

DR LARSSON: Well, UNSCEAR didn't for the reasons that I just stated, hasn't collected those data but data has been made available by various sources and also from going through the open scientific literature. And it's not only caesium and iodine. It's obviously all radioactive substances that would be of interest in an assessment like this. So the UNSCEAR assessment considered all relevant elements, but in the early phase obviously iodine is a very significant portion of the exposure, and also because of the specific exposure pathways that potentially could end up with radiation exposure are children, it's something that needs to be considered.

In the long run, the caesium-137, in particular caesium-137 and 134, at least in about a 1:1 ratio, caesium-134 has a half-life of two years, so it disappears relatively quickly, but caesium-137, obviously a half-life of 30 years, and in the long run that becomes the dose dominant radionuclide, but UNSCEAR also considered other radionuclides and in particular in the early phases also the very short-lived radionuclides. So they have all been considered, but focus is, as you mentioned, on iodine and caesium for the reasons that I just gave.

COMMISSIONER: And finally, it's been put to us that UNSCEAR is a pro-nuclear body and therefore there should be some question about the findings.

DR LARSSON: Well, all the 80 participants in the study signed forms where they had to indicate whether there was any particular interest, declaration of interest, and to my knowledge, there was none of them where we concluded that there was a conflict of interest. UNSCEAR is not pro-nuclear or anti-nuclear. It was set up in 1955 to report on sources and effects of radiation to the General Assembly, and that was obviously at a time when there was still ongoing atmospheric weapons testing, and there were 15 counties that were invited by the Secretary General at that point in time, Australia was one of them.

It's now grown to 27 countries and all these countries nominate a national representative, and I have the honour of being the Australian representative at some point in time. And the countries can also nominate alternates and expert advisors to these representatives. It doesn't have any coupling to the nuclear industry or to the anti-nuclear movement. It's a scientific committee that works on science purely.

COMMISSIONER: Thank you.

MR JACOBI: Perhaps if we can start with some of the issues that we want to discuss with you today, perhaps at the level of some fundamentals.

DR LARSSON: Yes.

MR JACOBI: I'm just wondering about whether you could offer a brief explanation of the distinction between dose absorbed and effective dose. The document is going to be significant for some of the issues we're going to cover.

DR LARSSON: Yes. Well, the basic physical quantity when we talk about the radiation dose is the absorbed dose, and the absorbed dose is the amount of energy that is being deposited in the receiving matter, in the body, for instance. So it is essentially energy deposited per kilo of that matter. That's the basic physical unit. Now, in order to transform this into something that can be used for radiation - - -

MR JACOBI: And that's measured in gray? Is that right?

DR LARSSON: That's measured in gray, yes. That's measured in gray. And in order to be able to use that information in radiation protection, for instance, we need to convert it to something where we can start to understand what is the relationship between those and the effect that it can have. And we have a number of other quantities that we are discussing then, and that may sometimes be confusing. We can multiply the absorbed dose with a quality factor which is dependent on what type of radiation that you're receiving, whether it's alpha,

beta, gamma and so forth, and that gives an indication of the biological effect that it would have, which is higher for alpha radiation, for instance, than it is for beta and gamma.

We can also go to the next step where we include the different sensitivities of different tissues in the body, and we weigh that together and we get something which is called the effective dose, and normally when we're talking about exposure, as you probably are going to discuss here a little bit later, we are talking effective dose. The effective dose is a quantity that is used for radiation protection purposes, but it is risk related. It is not possible to convert it so that you can say that it's exactly a risk per unit effective dose, but it is risk related, and therefore it becomes useful also in radiation protection. And the equivalent dose and the effective dose is measured in unit sievert.

MR JACOBI: As I understand, it's sometimes in a thousandth or a millionth. Is that right?

DR LARSSON: Well, what we are supposed to hear during a year when we are doing work like this is in the order of a few millisievert.

MR JACOBI: Now, again as just a basic question, fundamentals, in terms of the sources of radiation, could you offer just a very briefly outline about what the sources of radiation are to which we are exposed?

DR LARSSON: Yes. We can move to that pie chart, which is a completion of the information that we have. Now, this is obviously information that is lumped together for what we call here the average Australian. So it can vary dependent on where you live, what are you doing, whether you are actually exposed to medical examinations or undergoing medical examinations or even medical treatment. But for the average Australian, if we lump all that information together you will see that you have a large portion there which is to the left, which is the exposure to the average Australian from medical examinations, and you will see that this is actually more than half of the exposure.

Of course if you don't go through any medical examinations you won't have that, but a lot of people will also have much more than that. The other contributors are mainly what we refer to as natural background radiation. You've got cosmic radiation, which is coming from outer space. You've got a terrestrial source, which is radiation from bedrock and so forth. Radon and progeny is - we are fortunate in Australia. It's a relatively small problem in Australia compared to many other countries. There is a contributor.

Potassium 40 is a primordial element. It was there when this planet was created and it contributes to some internal exposure as well, and we've got

uranium and thorium in the bedrock and their decayed chains that also contribute some of it. Atmospheric weapons testing is now something which is down to a very low level, and so with the exception for atmospheric weapons testing, we can call all the others background radiation. The background radiation in Australia is about - for the average Australian, once again - round about 1.5 millisievert in a year, and then you have an extra component there which is about the same, which comes from medical diagnostic tools of radiation and medicine.

MR JACOBI: Yes, and perhaps we should just unpack. What is the average Australian, for the purposes of this?

DR LARSSON: The average Australian is just looking at all the sources, pulling that together for the whole Australian population, and dividing it like this for the average individual and for one year.

MR JACOBI: And given our focus on source, I notice that on the bottom it's referred to as a publication put out by ARPANSA itself.

DR LARSSON: Correct.

MR JACOBI: How is that calculated and who calculates that?

DR LARSSON: Well, ARPANSA has over the year done a lot of measurements. There's radon mapping. We know the geology of the country of course. The cosmic radiation can be measured. What can be difficult to get really precise information around is of course the use of radiation in medicine, although we know roughly how many procedures that are being used in Australia in a year. There is also a little bit of difference in that they could be different kinds of procedures, there can be different doses from different procedures. You have brand new equipment versus equipment that is one or two years old and so on but the best information that we – the best information that we can get, or by using the best method that we can use we have compiled the data and that indicates that the medical exposure would be in the order of 1.7.

COMMISSIONER: Is that a conservative assessment?

DR LARSSON: No, that’s a relatively realistic, I would say - - -

COMMISSIONER: Realistic.

DR LARSSON: All of this would be realistic but I would also emphasise again that the - - -

MR JACOBI: It's an average.

DR LARSSON: - - - average Australian doesn't really exist, we – none of us is really average but if you lump everything (indistinct)

MR JACOBI: It invites the question, I guess perhaps if I can deal with just the – what you might describe as radiation from natural sources as opposed to the anthropogenic ones about what the variability is. I think you mentioned it is different elsewhere. Are you able to give an idea about the sorts of ranges that are involved?

DR LARSSON: For - - -

MR JACOBI: For natural radiation sources.

DR LARSSON: Yes. Well, globally, if you look globally that would range widely and UNSCEAR has estimated that the range is between one and 10 millisievert, actually between one and 13 millisievert. But also stated that there are very significant population groups that would be exposed to a much higher level than that, we are talking about tens or hundreds, or thousands of people that would be above that. So it varies, as I said, a lot between different countries. Some of the contributors to that variability are radium, some of the northern countries for instance where I come from, the radium country (indistinct) substantially higher than what it is here in Australia. And the contribution from medical, that's not (indistinct) sorry, that's not natural cause but if we look at that as well, that will also be dependent on the level of health care in different countries and it is certainly higher in countries like Japan and US than it is here, but in some of the European countries it is also lower.

COMMISSIONER: I understand from some of my readings that it can be up around 30 and 40 in places - - -

DR LARSSON: There are such places. There are - - -

COMMISSIONER: Yes.

DR LARSSON: - - - such places, yes.

MR JACOBI: If I can come just to deal with the average for the anthropogenic medical, I am just wondering whether you can give some context in terms of what dose in millisieverts a person would expect to get if, for example, they undertook a CT scan or something like that?

DR LARSSON: That could be up to in the order of 10, so – and if you have multiple of course that would be just accumulate. There is a drive to get those

doses down and we are probably going to talk a little bit later about that. So we can see some positive progression here of the exposure. But it's also the use of CT; it's also something that is increasing. Obviously it's increasing for good reasons because it is in the interest of the patient that it is in the interest of health care. One of the issues that we are looking at is whether it's always necessary to use a CT, or whether alternative procedures are at hand that would not lead to this exposure. And this is something that has to do with how we look at radiation protection of the patient in the long run.

MR JACOBI: Perhaps we can move on from the fundamental - - -

DR LARSSON: Sure.

MR JACOBI: - - - and I just wanted to deal with a question of methodology and that is that we have read a lot in submissions about the attribution of health effects to radiation. And I am just interested to understand whether there is an agreed approach to how one approaches that, if one is doing a retrospective as opposed to a prospective analysis?

DR LARSSON: Yes. No, going back and I am not sure that we are deviating from the fundamental (indistinct)

MR JACOBI: Right.

DR LARSSON: But fundamentals as we were just discussing but yet again, if we go to UNSCEAR's work and in this particular case, this particular figure comes from the 2012 report to the General Assembly to the Scientific annexe A after that report, which is specifically about attribution of health effects and inferring risks. What this slide tries to illustrate is that you can look at radiation effects, you can – in some cases, you can detect radiation effects in individuals. These are individuals that have received a very high level of exposure and you can take what is called tissue reactions or deterministic effects and that can be safely attributed to radiation in – by a suitably qualified medical practitioner, usually, by eliminating other potential sources and looking at the diagnosis as such and how these injuries present themselves.

MR JACOBI: Are we in the area of ARS or acute radiation sickness at this point?

DR LARSSON: We are approaching that. We are approaching that, it doesn't necessarily lead to acute radiation sickness because some of these effects can be localised. For instance if – in the case of radiation therapy where you have a very localised beam, which is to treat a localised cancer, but there are occurrences of course where localisation is not correct and you can have these kind of effects presenting themselves. They are rare but they do occur. In that

case, you have an effect which you can – with certain attributes to radiation. When you have – when you look at the population and look at what we call stochastic effects and stochastic effects are not – are statistical effects in a population. The higher the exposure is of that population, the more of these cases you will get. You will not get more severe cases but you will get more of these cases. Whereas with deterministic of tissue reaction effects it is actually the exposure of the individual and the more you expose the individual, the more severe is the effect. You can with – if the population is exposed to relatively high levels of – or moderate and high levels of radiation, you can with statistical certainty detect an increase in the number of so-called stochastic effects. And what we are talking about here is mainly cancer.

That is being – that kind of research is being carried out within the scientific field of epidemiology. There are a number of such studies that have been carried out over the years and the most well known is probably the so-called life span study which was started in 1950 in Japan with the survivors of the atomic bombings in Hiroshima and Nagasaki and that has obviously now been running for a good 65 years. The most recent report on cases up to, I believe it was 2003, so 53 years follow up, 58 years or 60 years since the event. But there are a number of other studies as well. We have seen recently published a fairly big study on nuclear workers called In Works, that just released its data, so we have got plenty of information there. The problem with this of course is that you run in to situations where the statistics does not allow a resolution of any effects when you come down in the low dose region. We will move to another slide that could illustrate that a little bit more graphically. Well, we can do that already now. This is again coming from the UNSCEAR 2012 report annexe A and what it tries to illustrate here is both what you can see and what you cannot see. Or what you cannot see when we look at the probability of a health effect versus the dose. The red curve that is to the right there is actually those tissue reactions or - - -

MR JACOBI: That - - -

DR LARSSON: - - - (indistinct) effect.

MR JACOBI: What I think was box A in the last slide?

DR LARSSON: Yes. Exactly. And there you can see that after you have reached certain threshold, you will see these effects becoming manifest and when you go up to sufficiently high doses, you will have that manifesting 100 per cent of the population and you will – at those levels also go through what you referred to before as the acute radiation syndrome and so on, and different levels of those, and it may certainly lead to death. It's a little bit more difficult with the stochastic effects and let's talk about cancer and what the sloping blue field there tries to illustrate is that at radiation doses which go

above 100 millisievert or 100 milligray there is clear evidence that there is an increase of cancer in the population. That's been demonstrated in many cases. Certainly the life span study shows that very well.

The problem here is when we go down below a hundred millisievert and very low doses because even though we know with certainty let's say at about a hundred millisievert we have this effect, we don't know - we can't detect when we go down to just a few tenths of millisievert. That is just because the baseline variability and the frequency of occurrence - there's statistical noise if you like. But you also enter into some which is indicated by the grey slope to the left there where there are uncertainties about the exposure because you come very close to the natural background and the natural background variable, as we have already seen.

So unfortunately that also means that most of the exposure that most of us - for instance, when we are sitting like we are doing here are encountering over there down in the bottom left corner where we have got the statistical difference which is caused by the variations in the background and the statistical noise, which is about the baseline frequency of disease occurring. So in that area it's almost impossible statistically to be able to demonstrate any occurrence of cancer.

We can deduce from other studies that it's suddenly - and certainly we cannot think we have evidence above a hundred millisievert and when we go to 99 millisievert it doesn't just disappear of course. We can with certainty think about that we also have an increased risk when we go below that. But we don't know what the dose response curve looks like in that particular area and I think there is the next one - - -

MR JACOBI: Can we come there in just a moment. I just wonder whether we might go back because I'm just concerned we don't move on from the last graph. So I think we dealt with the retrospective aspects. I'm very interested to deal with the issue of predicting because we've heard quite a lot about predictions. I'm just wondering whether you can explain what that shows with respect to prospective prediction.

DR LARSSON: We can do prediction in some cases when we actually have clearly established from the retrospective analysis that we are certain that we have a cause and effect linkage here. We can look at predictions (indistinct) predicted with regard to some of the workers, predicted that they were increased risk of cancer. The numbers would probably be low was also what was concluded but there was an increased risk of cancer. In that area that I was just talking about where we do have the statistical uncertainties, we don't know for certain that there is a risk. We don't know how big that risk is. What we are doing then is that we infer on the basis of a hypothesis, which may be a

very sound hypothesis but not proven, what the risks might be. That means that in the terminology that we're using here, we are only attributing effects if we can actually see them. So it's a retrospective exercise.

Whereas when we look prospectively we can do some predictions if the exposures have been sufficiently high. The rest are inferences, and those inferences are very, very uncertain. In particular, when we come down to very, very low doses within the variation range of the natural background, those inferences become extremely uncertain.

MR JACOBI: I think that might actually bring us to what was the next slide in terms of - I'm just wondering whether you might explain what the alternative hypotheses are. We've heard a lot about the LNT hypotheses in the submissions that we've received and I just wonder whether you might explain what those hypotheses are and what the evidence is that might be said to underpin any of them.

DR LARSSON: I mean at the end of the day what we need to rely on when we talk about affects on the human population is epidemiology and the radiation biology should contribute and explain epidemiology. It's very difficult to start with radiation biology and extrapolate what's going to happen in the human population because a lot of the experiments that we have, they are relatively short-term, whereas a cancer may take years or decades to develop and we don't know exactly what happens in that window in between. But there are various proposals for dose response curves in the low-dose range, which this is showing. So the data points that you've got there are the ones that we would obtain probably at a hundred millisievert and above.

There are various proposals for dose response curves in the no-dose range which this is showing. So the data points that you have got there are the ones that we would obtain probably at 100 millisievert and above. The LNT hypothesis is the linear no-threshold hypothesis, postulates that you can just extrapolate down to zero so that any additional dose will also lead to small but still an additional risk.

And that is what underpins radiation protection. Radiation protection doesn't talk about a linear no-threshold hypothesis but an assumption. It's a linear no-threshold assumption and that assumption underpins radiation protection. So we assume for radiation protection purposes that there is a linear relationship.

MR JACOBI: What's the reason for making that assumption?

DR LARSSON: Well, it's supported by some evidence and you - - -

MR JACOBI: No, sorry. I was interested in it from the perspective of why would you use that hypothesis for the purpose of radiation protection?

DR LARSSON: Well, it is considered that it is a prudent approach. We are extrapolating into an area where we actually don't have evidence, but we think it's a prudent approach to assume that we can extrapolate the curve that we have for the higher exposures down to zero which effectively means, as I said, that any additional exposure is also associated with a small but still additional risk. So that's for radiation protection purposes. We don't have epidemiological evidence to actually support it.

MR JACOBI: Am I right in understanding that because it's used for radiation protection, it underpins the frameworks, the guidelines and the standards that are developed?

DR LARSSON: Correct, and we do consider that that would be a conservative approach that adds an element of extra protection to the protection framework.

MR JACOBI: And is that the framework that's used in Australia at present?

DR LARSSON: Absolutely, but as I was just alluding to, there are other possible ways by which you can look at and hypothesise around the response curve in that dose range, and there are various models here and each of those models can actually be supported by some biological reasoning. You can look into the biological mechanism and you can develop a sequence of events that would potentially lead to that kind of dose response curve. One of the most put forward dose response curve would be that we will actually have a threshold. You see curve D there which is a threshold. You see that there is nothing happening and you increase the dose and then all of a sudden it happens.

There are some biological reasoning that could support that, like stimulation of the immune response would increase the detection of transformed cells and eliminate those as the exposure increases. The E curve is a so-called hermetic curve which actually indicates that - and could be supported by a biological reason that an exposure to radiation would actually trigger the response mechanism in the body and make the body less susceptible to radiation, and then of course you reach an exposure level where it would start to increase again.

Curve A would potentially be suggestive of radiation at low doses being more detrimental in terms of a health effect and then it would be - when we come up to the higher doses there are some biological models that can support that as well. There have been demonstrations of effects where it's not the cell itself that is being hit by radiation that is responding, but also adjacent cells, which

seems to indicate that there is some sort of communication mechanism between the cells, the cell that was hit and other cells and so on.

What we also in the radiation protection community think about curve A here is that if the radiation risk at low exposures had been seriously underestimated we would have seen it in the epidemiology. So we don't believe that it's seriously underestimated. But we do have a situation where we have those different models. We don't have the epidemiological data. We do have data from radiation biology, but they are very, very difficult to use in terms of predicting what the outcome is going to be in an exposed population.

MR JACOBI: Yes. I think that evidence was given this morning; I think it was expressed in terms that no dose of radiation is safe.

DR LARSSON: But that's radiation protection assumption, that's – from the use of radiation protection. It doesn't translate in to risk assessment or epidemiology because we just don't have that data but we use that approach on radiation protection.

MR JACOBI: Now I think I just want to ask another question in terms of making predictions about – sorry, forming a view with respect to causation - - -

DR LARSSON: Yes.

MR JACOBI: - - - of illness or cancer as a result of radiation. I am just interested to understand the extent to which it is appropriate to reason from that LNT, I understand it's used for radiation protection purposes - - -

DR LARSSON: Yes.

MR JACOBI: Is it appropriate to use it for predictive or causation base purpose of those lower doses?

DR LARSSON: No.

MR JACOBI: Why not?

DR LARSSON: Well, you can do it if you want but in that case you have to do the calculation, when you can do the calculation but you will also have to communicate very clearly what are the assumptions that you have made. This figure that we got here illustrates different assumptions that can be made. And the other factor is the uncertainty and the uncertainty – the relative uncertainty when you come down to these exposure levels, increases dramatically. So you will have a situation where you have made your calculation but you have assumptions that are uncertain and you have the uncertainty which is caused by

the statistical variation and so on. All of that contribute to what you have calculated in terms of a data appoint here. May have very, very little informational value and it might even be misleading. We can still do it and it is still being done in some cases, if you do massive screen studies, or if you do – want to make – take decisions with regard to how to fit out your health care system in order to deal with different diseases, you can still do it but what you will come up with is a number that might be indicative to you that there is no need to make any particular action in the health care system but it has very, very little informational value in terms of actual protections.

MR JACOBI: Perhaps if I can apply that to a specific example. I think in some of the submissions we have seen, we have seen risk factors from low doses - - -

DR LARSSON: Yes.

MR JACOBI: - - - multiplied against large population - - -

DR LARSSON: Yes.

MR JACOBI: - - - cohorts to predict risks. Is there any value in that, or does that face the same difficulty?

DR LARSSON: That is what UNSCEAR in the 2012 report recommends against, for exactly the reasons that I was giving. You can do the calculation but in that case, be honest and communicate what assumptions that you have involved in doing that calculation and what are the uncertainties and give that range of uncertainty. But that is rarely done, it's often done as a precise number and that precise number carries large – very large uncertainties.

MR JACOBI: I am just wondering whether we can translate some of the discussion in terms of low, very low, in to some numerical terms so that we get some numbers around that. I think the next slide might pick - - -

DR LARSSON: Yes.

MR JACOBI: - - - that up.

MR JACOBI: Just wondering whether you might explain why we have come to classify some things as very low or low and then come – then come to the question about the effects - - -

DR LARSSON: Yes.

MR JACOBI: - - - are likely to be?

DR LARSSON: Well recorded very low and low and so on, that is of course a little bit – just a question of nomenclature. I think that the exposure that we are receiving in every day life should be very low and then we have – we go up to the higher exposure levels here. Now this is a compilation of information which doesn't take in to account for instance that some of the exposures may be acute and some may be over a long time but it is just helpful to discuss those ranges that we are talking about. So - - -

COMMISSIONER: This is per year I take it?

DR LARSSON: This is per year, yes. That is correct. So let's say - yes, well it doesn't have to be per year, it can also be acute but let's say that the one to 10, which is very low here, is really what most of us would experience within that range, would experience within a year. The average Australian that we were talking about before, would experience around about 3.2 but if you have a couple of medical examinations you might get to 10 but it's nothing really there that deviates from normal life. It is part of life and we are within the one to 10 millisievert range. Based on the models that we have, we might infer that there are risks associated with that exposure as well but models will also tell us that those risk are extremely small. And we don't know exactly, based on what we were talking about previously, whether there are any risks at all. But if there are risks, they would be very, very small.

If we go up to the next range, which I have indicated here, which is 10 to 100, well if you have a series of CT scans or if you have an unusual work situation, you might come up to a few tens of millisieverts. Yet again, there are studies there that suggest to us that the risk while still low might have increased and it is also supported by some observations, for instance some studies that have been done recently of children and exposure to CT, John Matthews in Australia for instance had done a major study on children and exposure to CT and there are certainly observations that would support that there is an increased risk in that dose range. If we go to the hundreds and one thousand, well here we have – for instance there were 174 workers in Fukushima that experienced more than 100 millisievert. There were many, many thousands of them in Chernobyl. The liquidators in Chernobyl that experienced such doses and if you come up to the high range there which is 1,000 that is where we start to see the tissue reactions and the symptoms of radiation sickness if there is whole body exposure. If you go to higher than 1,000 then the deterministic effects would be all the tissue reactions would be certain and if you go up to a few thousand, you will – and it's a whole body exposure that will result in death.

Now these are – these radiation doses are fortunately very, very rare. They might happen during accidents but most of the cases where we have doses like that is of course in radiation therapy and the radiation therapy is intended to kill

cells, that is the whole purpose for it. It is being administered in a way that would also spare the surrounding tissue.

MR JACOBI: Now I don't know whether the next slide adds to anything that we have just discussed?

DR LARSSON: Now I think that this is really wraps up what we have been talking about so far, so it really lumps all the information together that we have mentioned. When you go to the lower end there, the effects are not well known and there is a very high uncertainty, but if we go to the other end of course the cancer and hereditary effects where we see those risks increase and we get very high doses to harmful tissue reactions. Whilst I indicated there that we've got hereditary effects, hereditable disease has not been diagnosed or has not been – there has not been demonstrated in the human population, not even after the atomic bombings. But there is ample evidence from animal studies and so on that that can certainly occur and there is no reason to believe that it can't occur in the human population and actually even though it hasn't been demonstrated, it is also part of the radiation protection system where we also protect against hereditable disease, even though it hasn't been demonstrated.

COMMISSIONER: It hasn't been demonstrated even Chernobyl?

DR LARSSON: No.

MR JACOBI: Can I come to issues of radiation protection and I am just interested to understand, we have already picked up that we make an LNT assumption for the purposes of that. I am just interested to understand what are the broad principles or underlying rationales that inform decision making with respect to radiation protection? (indistinct) insight to that?

DR LARSSON: Well, there are three basic principles and the first principle is justification, justification for a practice that involves radiation and in simple terms, justification is do more good than harm and that can be a relatively simple consideration if you look at medical application for instance. Diagnosis through diagnostic imaging procedures, you do that in the interest of the patient, in the interest of the patient's health. You do it because it does good. You might do some harm, but the harm is clearly outweighed by the good.

In other areas where we talk about industry using radiation and so forth, the justification is not based solely on radiation protection and health considerations. There's a whole raft of different other considerations that come into play (indistinct) but nevertheless, justification is one of the cornerstones here. The other is optimisation and optimisation essentially means that you optimise the protection as much as you can. You take all reasonably

achievable steps in order to reduce the exposure, that is, the exposure of individuals, the exposure of a whole population, and also reduce to the extent possible the probability of accidents. So that's driving the exposures down.

The third principle is then the principle of dose limitation, because you can theoretically think that you have a situation where you optimise, but that also leads to an acceptable exposure of certain individuals, and in order to protect those individuals you also have dose limits.

MR JACOBI: Now, I'm just interested in understanding, perhaps you can explain what, as they currently stand in Australia, the dose limits are, and then what you understand to be the proper interpretation of those dose limits.

DR LARSSON: Well, the dose limits from all sources for members of the public is 1 millisievert. So it's well within the background range that we were discussing here before. And of course for those practices that can actually generate exposures in the environment, the driver driving them down should also be optimisation. For people that are exposed in their work life to those limits it's 20 millisievert, and so that's obviously 20 times higher, but there is here of course also a knowledge about what you are doing. There is monitoring of the exposures. There is a very active optimisation that goes on within the workplaces where you're occupationally exposed and that drives the doses down. So in reality, in most of those areas we are down to exposures of the occupationally exposed population which is in the order of those limits for the public.

In other areas it's more difficult to control the doses, because they are mainly resulting from sources that cannot be controlled, cosmic radiation being, for instance, something where we are discussing with airlines about the radiation protection of aircrew and also frequent fliers and so on. It's hardly a controllable dose, but you can still control the exposure of the individuals to radiation that they are also well within the occupational dose limits.

MR JACOBI: So they're well within the 20. Is that right?

DR LARSSON: Well within, well within, round about 3, 4, 5, maybe up to 6 millisieverts.

MR JACOBI: Now, I'm just interested to understand, the Commission has heard about, again in the submissions, the ALARA principle, and I'm just wondering whether you could explain its practice application.

DR LARSSON: Well, that's optimisation as low as reasonably achievable, and that becomes simply the acronym ALARA. Essentially what you do is that you take all reasonable steps that you can to reduce the exposure. We reduce

the exposure of individuals, the number of individuals exposed, and also the probability of accidents, and you do that on the basis of doing cost effective implementation or implementation measures that are cost effective so that you actually get some result for the money that you invest, and that can be a complex analysis in some cases and a very simple analysis in other cases.

MR JACOBI: And is ALARA a legal requirement in Australia?

DR LARSSON: Optimisation is part of the legal requirements. We don't call it ALARA but we call it optimisation.

MR JACOBI: I think we'll just skip over a slide and come to monitoring.

DR LARSSON: Yes.

MR JACOBI: And I think we've got some figures for uranium industry workers, and I'm just interested whether you can, first, offer an interpretation of the information that's contained there.

DR LARSSON: Well, what this illustrates is - the sort of blue, violet, purple curve at the bottom there is the average individual dose to uranium industry workers, and we got this data because a while back we set up what we call a dose register and that's a centralised repository for uranium mining workers, and we have got data from all the active uranium mines and also from the mine (indistinct)

MR JACOBI: Are they obliged to provide that information?

DR LARSSON: They are obliged to provide that information and they do that here in South Australia, for instance, as part of licence conditions, and they provide that information to us as a repository for this information. And it allows us of course to look at drains with time, and the conventional wisdom is of course that often what you measure you will also probably achieve. If you monitor something you will automatically strive for improvement, and what we can see here in terms of the individual doses over the years that we have collected for here, some of the data are actually old and predates the dose register, but anyway have been submitted by the uranium mining industry.

There is a decrease. You can also see the orange line there which is the maximum exposure of a single worker over the years, and you see a decrease there as well. It's probably a little bit pessimistic here, because those data normally don't take into account the use of protective equipment. So the data will be representative of not using protective equipment, whereas the real data would then probably be lower than that. It's just a demonstration of the evolution of the exposures in one occupationally exposed category.

MR JACOBI: Just so I understand, that part of the answer about the distinction between what's measured and what the person is in fact exposed to, is that because measuring the tags or other things, the measurements are made at a point that doesn't use - there's not such protective equipment or - - -

DR LARSSON: No. If the protective equipment is used, then the actual dose would be lower than the one that is estimated, and this is something that we have no ongoing dialogue with the industry and also with other regulators in Australia in order to get the best available data, because if you want to use this data in the future for whatever purposes - there are the international pool studies and so on - then you'll want to know exactly what it measures. The point I'm making here is that there is a decreasing trend and to monitor the exposures is not a bad way of actually making that happen.

MR JACOBI: And the blue dotted line?

DR LARSSON: The blue dotted line is just the number of workers that have been included in the dose rate study.

MR JACOBI: I'm just interested to understand, what's the protective equipment that you're referring to in uranium mining?

DR LARSSON: That would be protective equipment for inhalation mainly.

MR JACOBI: And why would that change the result?

DR LARSSON: Because the monitoring data is based on measurements. There can be measurements that are carried by the individual workers, but of course there would be monitors and so on, and they wouldn't know, they wouldn't take into account, the protective effect.

MR JACOBI: And the inhalation equipment, I gather, would exclude the dust?

DR LARSSON: Yes, that's right. That's right.

MR JACOBI: Is it effective on radon or not, or is that - - -

DR LARSSON: Radon is a gas, but it's also often attached - or the radon progeny also attach to the dust, so definitely there would be an effect.

MR JACOBI: Now, I think, beyond the question of uranium industry works, we've got some outputs for diagnostic exposures. There's one on that slide.

DR LARSSON: Yes, that's right, and this is also a slide and it's a complicated one. It's the so-called national diagnostics reference level database which is something that has been assembled yet again by ARPANSA on the basis of surveys that we have done with the clinics. These have a different computer tomography, CT procedures, and you see it's part of his chest, head, lumbar spine and so on. The diagnostic reference level is based on the information that we have got and it establishes a reference level above which we have about 30 per cent of the data and below which we have about 70 per cent of the data.

The idea with this is to explain to say that, well, there's 70 per cent here that can do it at a dose which is lower, so maybe you can as well, and that drives down the exposures. That's one element of it, but there are also other elements that contribute here, the equipment, modern equipment can use the exposure more efficiently and there is also some changes in procedures and so on, but what you can see for all these procedures is that they are actually going down. That's not all because we have a diagnostic reference level, but I think it's a contributor and yet again its an illustration of the point that if you actually monitor it you may see how you're tracking and that in itself is an incentive for implementing new actions.

After three or five years or so you can make another survey and you get another diagnostic reference level, it would presumably be lower and we will then drive down the exposures without losing, of course, the quality of the medical imaging and the diagnostic relevance of it.

MR JACOBI: Just so I'm clear on the interpretation, we have changed here from effective dose to absorbed dose. Is that right?

DR LARSSON: This is absorbed dose, yes, and normally if you look at organs you would prefer it to work with the absorbed dose.

MR JACOBI: The black cross, is that an average of all treatments that have been provided in that year in that part of the body? Is that right?

DR LARSSON: Well, on the basis of data that we have been able to collect, yes, and that is because we have an ongoing collection of data and we have covered now two-tenths of the clinics but there are more data coming on all the time and we see this happening.

MR JACOBI: So the datasets are supplied by hospitals. Is that right?

DR LARSSON: Yes. Clinics that are using these kind of procedures.

COMMISSIONER: That's not mandatory.

DR LARSSON: Sorry?

COMMISSIONER: That isn't mandatory, the reporting.

DR LARSSON: Well, it's actually part of - this is actually something that comes out of radiation protection series number 14 which is the code, the medical code, as we call it, which has got also three separate guidance to it, one on diagnostic imaging, and that is being implemented through the health authorities in the different jurisdictions. All of this is an outcome of the work that is being done between ARPANSA and states and territories in Australia, it goes through what is called a radiation health committee which brings together all the radiation regulators in all jurisdictions in Australia and develop the codes and agree on the codes, and then they become implemented in the states and territories.

MR JACOBI: I'm sorry to take you out of sequence. This slide has reminded me of something that's in evidence that was given this morning. Perhaps we can come back to the slide on LNT, that one there. I'm just interested, we were told in evidence this morning that - perhaps I can put it this way to you, are you aware of a statement that it's known that about 30 per cent of cancers are induced by background radiation, and the other 70 per cent are induced by anthropogenic sources? Are you aware of there being such a statement?

DR LARSSON: No. The percentage of radiogenic cancer or induced by radiation are significantly lower.

MR JACOBI: I think that the division wasn't between radiogenically caused cancers and all cancers, this was the idea that of radiogenically caused cancers, 30 per cent were induced by natural background sources, and the other 70 per cent were induced by anthropogenic sources.

DR LARSSON: Well, yes, that's another way of raising it and I misunderstood your question there, but if you go back to the pie chart, if we look at the distribution of sources or the sources of radiation exposure yet again on the average Australian here, then of course what you see here is that the anthropogenic sources, they are dominating, and that's the medical use of radiation. Now, the medical use of radiation is in the interests of the patient, because it's actually to improve the health outcome of the patient. Of course, if some of these procedures are not justified because there are alternatives that we can use instead of maybe it wasn't justified in the first place, then that exposure is unnecessary, but this is the best picture we can give you on the sources of exposure.

MR JACOBI: Are you aware of the 30/70 per cent division? It's not something that I can say I've read in the submissions.

DR LARSSON: No, I think that would be an extremely uncertain statement for all the reasons that we have been discussing, in particular, in the first part of this session.

MR JACOBI: I am just wondering, and perhaps we could come back, we have dealt with information that ARPANSA has collected from diagnostic purposes, I am just interested to deal with the reporting of radiation incidents. Perhaps if we can first deal with what the obligation is to report radiation incidents in Australia.

DR LARSSON: Yet again it's mandatory and it's set out in what is called the national directory for radiation protection which yet again is uniformly applied across all Australian jurisdiction and there is a particular schedule in that publication, schedule 13, which details the incidents that should be reported to the Australian Radiation Incidents Register. For 2014, from memory now, there were in the order of 300 such incidents and the incidents are of various kinds and, for instance, medical use of medicine that could be that the radiation dose in a diagnostic procedure deviated a certain number of per cent from the one that it should be, therapy the same, that you have a deviation a certain number of per cent from what it should be. It could also be mistaken identity and so on, or the wrong tissue being subject to the diagnostic examination.

So there are a variety, in a nuclear field that could be a criticality which is, of course, something that is extremely rare, but a number for 2014 that have been reported to us is in the order of 300. If we look at the number of procedures in the year, in particular in the medical field, only CT, that's several million, maybe 3 million, in the order of that, so even though if we considered that most of these incidents are in the medical field, it's a very small number in relation to the use of radiation in medicine.

The pie chart to the right is a breakdown in what are the causes, to the extent they have been reported and can be assessed, which is not surprising, human error is the largest contributor here and some of them aren't clear. In some cases it might be that a patient that was undergoing examination using diagnostic procedures, a female patient didn't know she was pregnant, it turned out later that she was pregnant, and there are some procedures that may be unusually uncomplicated, unexpectedly complicated and so on, and all of this contributes to these incidents.

MR JACOBI: Can you give me an example of what's a non-medical, that would be shown in the purple? This is on the left-hand side back to the pie chart.

DR LARSSON: Yes, well, it could be things like for instance using a

radiation source and overriding the so-called interlock system, the passive safety systems, where you cannot access the facility when the radiation source is - or when you're able to be exposed by the radiation source, and other kind of deviations from the protocols.

MR JACOBI: These are radiation sources used in industry in sensors and so on. Is that right?

DR LARSSON: Yes, by industry and research and so on.

MR JACOBI: Now, I think you've also collected data on what was required to be done as a response. Can you offer an interpretation of that?

DR LARSSON: Yes, that's right, and has to be treated with some caution, because obviously if we are looking at some two or 300 accidents, it's difficult to be completely sure about the distribution of preventive measures between different kind of measures, but training and education is always something that is used; reinforcement, by simply reinforcing the rules and procedures; changing the procedures; changing the equipment; and other types of improvements, and we also have about 20 per cent there where actually the information that we have received, we haven't got any information by the user of what preventive measure they implemented after these incidents.

Yet again, I think this is something that is important, that you're vigilant and you monitor, and if you have a system where you can monitor the radiation incidents, if you have a reporting system that actually goes to the root causes, you can evaluate that information and you can provide advice, your requirement or what have you, to the industry that is using the radiation sources for other activities on how to improve the safety.

MR JACOBI: I might at this point change and perhaps focus on regulatory aspects given that's a significant part of ARPANSA's role. I'm just wondering whether we can perhaps skip over a slide and come immediately to dealing with the source of the content of Australia's current radiation protection obligations. I'm just wondering perhaps whether you can offer some explanation of the source of that content.

DR LARSSON: Yes. This outlines, in an idealised fashion, if you like, the transfer of information through different international bodies which eventually end up with the national regulation, but if we start from the end with the national regulation, what we have in Australia is very well aligned with international best practice and very well aligned with the international framework that has been developed over many years for radiation safety. And we already spoke about UNSCEAR, and UNSCEAR's role since 1995 is to report on sources and effects and risks to the United Nations General

Assembly, and periodically collect that information into the scientific annexes and they are being used and widely respected as state-of-the-art knowledge of the sources and the effects of radiation.

That doesn't mean that you don't have individuals or organisations that would criticise the information, and we spoke about that earlier. And that's fine. That's the way it should be. There should be a robust scientific debate otherwise you won't have the momentum in the scientific development if you don't have that robust debate. And I should mention here also the World Health Organisation which perhaps doesn't appear here in the way that it should be done, but also the World Health Organisation obviously collects a lot of information on radiation effects and radiation risks and translates that into advice.

COMMISSIONER: Is that work that WHO does independent of the IAEA?

DR LARSSON: Yes.

COMMISSIONER: Is this is a mandate that they have collect - - -

DR LARSSON: Well, the matter for the World Health Organisation is to provide advice in health issues in general, but when it come to radiation, for instance, in relation to radiation accidents as we had in Fukushima, the World Health Organisation produced two reports. One was a first initial dose assessment, which is called a preliminary dose assessment, and they followed up with a health risk assessment. That is their role, because they are advising health authorities and the UN member states.

COMMISSIONER: We just had evidence to suggest that they weren't allowed to look in this particular area without approval from the IAEA.

DR LARSSON: Well, I've heard comments being made many times. I think that the best way of looking at that is to go to the preliminary dose assessment and to the health risk assessment that WHO produced and that, I think, gives evidence for the high quality and the independence by which they have produced this report.

COMMISSIONER: Okay.

DR LARSSON: The next block there is the International Commission on Radiological Protection, which is a different organisation in many respects. It's a small organisation. It's an NGO. It's a non-governmental organisation. It's actually constituted as a charity, located in England because it's governed by the laws in England. I can't remember. It's not UK. It's England and probably some other area of UK as well. So its operations are governed by the law that

governs the operation of charities, and it was established already in 1928 actually. It was then established as the International X-Ray and Radium Protection Commission, changed its name to the International Commission n Radiological Protection around about 1950.

It is an NGO that works on a small budget but with a lot of contributions in kind from - and the total number of experts working within the ICRP is in the order of 200, 250, depending on how many task groups are working on different recommendations at one point in time. There is a main Commission with 13 members and then there are five standing committees that work on various aspects. They work on radiation effects on symmetry, medical use of radiation on application and on environmental protection, and they issue on the basis of scientific - on the supporting scientific evidence issue recommendations on radiation protection.

So they translate, if you like, scientific information into recommendations on radiation protection. So it forms a link between the pure science and the pure application, and currently it has issued about 130 such publications over the years. The radiation protection framework that has been developed by the ICRP is actually being implemented by the IAEA and their safety guides. The IAEA produce safety standards that are developed into specific hierarchy. You start with the safety fundamentals which is about the principles that are going to be applied.

Then you have a set of safety requirements and the safety requirements are written in "shall" formats, "You shall do this and you shall do that." And underneath there you have the guides, and the guides are such that they inform the user how they can work in that particular area in order to comply with the safety requirements. The safety requirements are not mandatory for all countries. They are mandatory for all the countries that in one way or the other are receiving support from the IAEA, and they are also mandatory for IAEA itself because IAEA carries out a lot of activity itself, not mandatory for a country like Australia, but we see it as international best practice, and the State and Territory regulators, we have agreed that we shall, to the extent possible in the Australian context and relevant in the Australian context, make use of this framework, and that goes then into what you see right there, which is national regulation. What that results in is that regulatory framework that we operate here in Australia is very well aligned with the international framework.

COMMISSIONER: Can I just understand, does the ICRP peer review UNSCEAR's reports?

DR LARSSON: No.

COMMISSIONER: So they are taking the outcomes and turning it in to

regulation?

DR LARSSON: Yes, they do but they also do scientific evaluations of its own because there might not be for a particular radiation protection purpose, a relevant or up to date report from UNSCEAR and it is being done by ICRP then. So the ICRP is about the advancement of radiation protection science for the public good and the public good comes out from the recommendations that be issued by the ICRP.

MR JACOBI: Perhaps if we can move on to what is the last (indistinct) and I think on the next slide it deals with the idea about ARPANSA implement those - - -

DR LARSSON: Yes.

MR JACOBI: - - - particular fundamentals and guides in Australian law.

DR LARSSON: Yes, that's right. And yet again, I come back to the Radiation Health Committee which is a statutory committee set up by the ARPANSA Act and with members from all the states and territories and the regulators from – radiation regulators from all the states and territories and jointly we develop the framework that is then being applied across all the Australian jurisdictions. And we do have a fundamentals document that was released just one or two years ago which is a protection against ionising radiation. We are working on one for non-ionising radiation as well. Underneath there we have the codes and standards and the codes and standards are being implemented through various means in the states and territories. That could be by inclusion in the regulation, specific regulations or licence conditions and so on. Of course also, in this particular case we produce the guides and the recommendations that can be applied by the user and which guides the user, so that the user is able to comply with the codes and standards which are yet again, in the "must" or "shall" language.

MR JACOBI: Now could I come actually to one, because I'm reminded we have skipped over it and that is to deal with RPS SG1 with respect to environmental effects? We have dealt with the effects on humans.

DR LARSSON: Yes.

MR JACOBI: And if we could perhaps come back to slide eight. I am just wondering whether perhaps you could explain the – when one is not dealing with effects on humans, when one is seeking to make an assessment on the environment, what the hierarchy is and what the approach is to making such - - -

DR LARSSON: Mm.

MR JACOBI: - - - an assessment.

DR LARSSON: Yes. The approach to environmental protection is slightly different than it is when we talk about radiation protection on people because I explained to you before, the principles of justification, optimisation and those limits that we apply when we talk about radiation protection of people. Those limits is nothing that applies so far in protection of the environment and it would be impractical probably to set a dose limit because we know that the human population is very variable but that is of course nothing if you compare it to the variability of what you have in nature. Instead, we have – this is still a draft but I'm going to put it to the Radiation Health Committee very soon, if you look at the right part of the curve here, the left part essentially just elaborates on that, but the right part of the curve is that you can in many situations do a simplified assessment of the exposure scenario that you have. You can do that simplified assessment against so-called screening level. The screening level is something that we have to find what dose rate in the environment should be. What is a reasonable screening level? If you are on your simplified assessment, below that screening level then there is ample evidence to support the conclusion that you can carry on with this activity without the environment being at any significant risk.

If you are above the screening value, well then that is an indication to you that you should stop and pause and think and maybe do a renewed assessment but with less – that is less simplified and more specific and take in to account the specifics of that environment that you are working in. You might then end up with a much lower value than what you had in your initial conservative screening and you can still draw the conclusion that this is fine.

MR JACOBI: You have referred to a screening value and I notice that it is expressed in terms of ten micrograys per hour.

DR LARSSON: Correct.

MR JACOBI: Could you explain the significance of that particular figure? Why that is a relevant threshold for screening?

DR LARSSON: That is based on an enormous amount of analysis done of laboratory experiments, ecological information and aggregating that and drawing conclusions as to under relatively conservative – with relatively conservative assumptions would be a level that we would call safe for environmental purposes. There is a huge amount of science that has gone in to that so it's underpinned – that is also why I say that if you, through a simplified assessment, can conclude that your underneath – under that screening level,

there is a huge amount of scientific information that would support your conclusion that the activity that you are looking at is safe.

MR JACOBI: When dealing with human exposure with a later – one microsievert per year to activities that humans are engaged in - - -

DR LARSSON: Yes.

MR JACOBI: - - - are you able to relate the 10 micrograys per hour to some - - -

DR LARSSON: That would – as you say, we have got the background level which is indicated with a broad band there which is indicative of the fact that the background radiation for those (indistinct) are going to be highly variable and dependent on - - -

MR JACOBI: Yes, well I mean there's - - -

DR LARSSON: This would probably in most cases be about that background value but it is at the level where we don't anticipate you will see any effects in the natural environment.

MR JACOBI: And just with respect to such an assessment, what is it that we are seeking to avoid in terms of conducting such an assessment? What sort of outcomes are we seeking to (indistinct)

DR LARSSON: The protective – aim for environmental protection would be avoid any effects that could have – or could be detrimental to biological diversity or to the conservation of species and in other ways the health and integrity of ecosystems.

MR JACOBI: Now can I come – just come back just very quickly to one of the inferences to which I think we have already had reference with the NDRP and I am just wondering if you could explain the significant of that, you were at slide 16.

DR LARSSON: Yes, that's right. And this was something that goes back to the establishment of the ARPANSA Act and the discussions within COAG and so on on a national uniform framework and you could say that the National Director for Radiation Protection first published in – a few years back but then gradually revised with time, is a collection of the agreements that have been made between different jurisdictions, the Commonwealth and the state and territories in Australia. So it is a repository for the uniform approach to radiation protection in Australia and all the requirements. So there are other requirements on the authorities in the different jurisdictions, what they should

do, what is being considered in licensing , what should be considered in protection and there are a variety of schedules there. And I was talking before about schedule 13 which is part of the national directory, which is about incident reporting and so forth. So it is a central – plays a central role in the radiation protection series but then we have all the specific and more specialised codes and standards and also guidance, which is also part of the radiation protection series but this, if you like, is the central repository of agreed requirements.

MR JACOBI: Moving off these topics to deal with one of the issues that the Commission needs to consider, which is prospective regulation - - -

DR LARSSON: Yes.

MR JACOBI: - - - just – and we have discussed international framework as it relates to activities that Australia's currently engaged in. I am just interested to understand the extent to which there is international guidance available should a government be minded to implement. This a safety guidance available, where a government might implement nuclear energy.

DR LARSSON: Yes.

MR JACOBI: And I think we have got a slide that might pick that up, which is the next one. I just wonder whether you could - - -

DR LARSSON: Yes, true.

MR JACOBI: - - - explain?

DR LARSSON: And of course the source for a lot of guidance n this particular is the International Atomic Energy Agency and in particular there are some guidelines and I have quoted here one of the, which is the specific safety guide number 16, which is establishing the safety, infrastructure for a nuclear power program. It essentially outlines a series of 200 steps that one should go through in order to successfully establish a nuclear power program should that at all be the preferred option of Australia at some point in time.

Obviously this is something that requires to be rolled out over a number of years and the first slide here indicates maybe the initial phase where you establish an infrastructure to launch a nuclear power program and then Australia can make a decision whether to go forward with it or not. If it does not go forward then obviously nothing more happens. But then a lot of development of work is required in the regulatory area in order to create safety and security - a safeguard infrastructure really for governing this program and to construct an NPP.

The indicative time this may take is some three to seven years, according to the IAEA. Build up a safety infrastructure and implementation of the first power plant extends into seven to 10 years. Then start the operations, and the operations of course is going to continue for a very long time. Currently we are talking about 60 years of operation, maybe extending beyond that. Then the post-operational phase is another perhaps - even a century, where we are talking about the decommissioning, the waste management. Depending on what waste management solution that is being preferred, disposal of spent fuel and so on. Which meant that if we talk about a nuclear power program we are talking about a commitment that lasts for maybe one or two centuries.

So the more thinking that is done in the beginning of that phase and get it right, that is of course important for the subsequent years. There is a lot of specific guidance that has been developed by the IAEA in relation to this and one of the sources is there at T16 that I've quoted here. There are also guidance and also other review service missions that the IAEA provide in order to monitor the development of this infrastructure in the country.

MR JACOBI: I want to come to those review service missions just at the end. I'm just interested to understand Australia's experience in actually having undertaken these review missions or participated in an invitation to the IAEA for such a mission.

DR LARSSON: Yes, there was a review mission - yes, you've got here the integrated regulatory review service, which is only one example of the different review service missions but maybe in the regulatory area, the flagships so to speak. It was something that the IAEA started back in 2006 and over the years. I've got another slide on that that we can look at later if you want and see that 70 such missions have been carried out. Australia was actually one of the first countries. The first country, if I'm correct, to invite one of these missions and it was with ARPANSA. So in 2007 my predecessor, Dr Loy, invited one of these missions and when I came to ARPANSA in 2010 I invited a follow-up mission that we then had in 2011.

I'm now looking at inviting a new mission for the year 2018. It's good international practice that has been established by these missions maybe every 10 years or so. It's actually mandated in the European Nuclear Safety Directive and also in the West Safety Directive to have these kind of missions every 10 years. What has been done here is not only that you have a review mission that comes to your country and your organisation for a period of two weeks, it's actually very significant preparatory work that starts one and a half to two years before that. You go through a self-assessment according to a prescribed format and that is being supplied by the IAEA. That's usually a six to nine-month exercise to go through the self-assessment. You develop a

preliminary action plan on the basis of that and you collate the high-level information into something which is called the advance reference material, which you submit.

The IAEA will then take the responsibility to organise a review mission and we assemble an international team and, depending on whether you have a large program or a small program, that team can be anything between 10 and 25, and even more than that, international experts that the IAEA seek from all different countries. The review team will have access to all this material that has been assembled: the advanced reference material, the self-assessment, the draft action plan. We will review that material and we'll then spend normally around about two weeks in the country and in the organisation verifying the information, and eventually we'll issue a report that lists a number of suggestions where there is room for improvement but there is no real deviation against the IAEA safety requirements.

We also issue recommendations where there is a deviation in the host country relative to the IAEA safety requirements. It will also, for the benefit of everyone, identify good practices that they have detected in the host country. You will then amend, on the basis of the review report, the action plan. Good practice is to put the action plan on the web as well as the review report, and as far as I have been informed all countries that have had these kind of review missions have actually done that. Then of course you implement the action plan and you take the actions that you have planned.

Within two to four years you should invite a follow-up mission and a follow-up mission would obviously go through all the recommendations and suggestions and monitor progress against them, and we'll consider that some of them are being closed, some of them are perhaps being closed on the basis of confidence in what's happening but it takes time, and also leave some of them still open and still for the host country to consider.

MR JACOBI: I think the next item might just pick up your (indistinct) with respect to total numbers that are involved.

DR LARSSON: I think if you add all these up you will come to a number which is slightly higher than 70 and this is a major activity and it's also a major consequence of this also, that you establish a very homogenous view globally on nuclear safety and radiation safety because obviously we will send members of ARPANSA staff to some of these missions. I have had the honour to lead missions myself to the United Arab Emirates, both the original mission and the follow-up mission, and more recently to Indonesia. I will go in January and be the deputy team leader for the mission that goes to Japan. That is obviously going to be a very interesting following in the post-Fukushima area time and with regard to the new regulatory agency, the Nuclear Regulation Authority in

Japan.

COMMISSIONER: Dr Larsson, thank you very much for your very clear evidence.

DR LARSSON: Thank you very much.

COMMISSIONER: We will reconvene at 1600, when we will have from the United Kingdom Prof Thomas from the Imperial College London.

ADJOURNED **[2.39 pm]**