COMMISSIONER: Good morning. The topic for today's discussion is transportation of nuclear materials. We have Dr Edwin Lyman from the Union of Concerned Scientists; Mr Frank Boulton, an expert in transport; Dr Samir Sarkar from the Australian Radiation Protection and Nuclear Safety Agency; and Mr Hefin Griffiths from ANSTO. Counsel.

MR JACOBI: An analysis of the security and safety of transportation of nuclear and radioactive materials arises for consideration under each of the Commission's terms of reference. Transportation of those materials is a necessary element of the operation of facilities to mine or mill uranium, process nuclear fuels, generate electricity through the use of nuclear fuels or to store or dispose of radioactive wastes. The management and coordination of the transport of nuclear materials is essential to the safe and secure conduct of those activities.

This analysis arises against a backdrop where nuclear and radioactive materials have been transported throughout Australia, particularly within South Australia, for many decades. Most relevant to South Australia, this includes uranium ore for processing and export, sealed radioactive sources for use in medicine and industry, and radioactive wastes which are produced by those and other industrial operations.

The Commission has received submissions which raise concerns as to the risks that such materials present to human health and the environment while being transported, particularly in the scenario of an accident or an inadvertent error, and the possibility that such materials might, in the process of transport, be vulnerable to deliberate attempts to acquire those materials the issue of security. Before it could consider recommending any expansion in mining or the establishing of further nuclear activities in South Australia, the Commission would need to consider the magnitude of the risks, the likelihood of an unintended outcome taking place during transportation, such as accident or theft, and the measures which are in place to manage those risks during transport.

In the case of nuclear materials, these measures include physical barriers which are built into their packaging for transport, approvals processes and emergency management strategies. In the context of the packaging of nuclear materials, the Commission will turn its mind to the appropriateness of the testing requirements which apply and whether they sufficiently simulate accident conditions. As part of its inquiry, the Commission will today speak to those who have analysed the risks associated with transport to manage the transportation of nuclear materials in Australia both domestically and those who are responsible for giving approvals for the safety of the packages in which those materials are transported.

The Commission's first witness today, Dr Edwin Lyman, is a senior scientist in the global security program at the Union of Concerned Scientists in the United States. His areas of interests include nuclear proliferation, terrorism and nuclear power safety and security, and he's published articles in a number of journals and magazines on these topics. Dr Lyman is a member of the Institute of Nuclear Materials Management and has given evidence before the US Congress and Nuclear Regulatory Commission, the NRC, on multiple occasions.

Prior to joining the Union of Concerned Scientists, Dr Lyman was president of the Nuclear Control Institute, the NCI, in Washington, an organisation concerned with nuclear proliferation. The Commission calls Dr Edwin Lyman.

COMMISSIONER: Thank you, Dr Lyman, for joining us this morning our time, this afternoon your time. In a paper that you presented in Kuala Lumpur on the carriage of ultra hazardous radioactive cargo by sea you chronicle a number of accidents that occurred and you drew a conclusion that said, in essence, the general erosion in quality control, maintenance, respect for procedure, regulatory oversight, which is manifest both from an increasing need on the part of nuclear industry to cut costs and from a complacency which resulted from the excessive and unjustified confidence the industry has in its own safety record. Then you go on to say that it's a very dangerous trend, with serious ramifications. Is there anything that's occurred since that paper was written in 1999 that you think might have changed those circumstances?

DR LYMAN: Thank you for your question. With the caveat that I have not followed transport “action” live transportation accidents of nuclear materials since then but I have become more interested in general issues with nuclear safety, including nuclear power safety, then I would say that certainly the Fukushima accident in 2011 was a confirmation of those words that I wrote back in 1999. I think it's generally accepted that it was complacency, lack of advanced planning, lack of consideration of severe accidents that all contributed to the inability of the Japanese to cope with the Fukushima accident. So I certainly think that that mindset was prevalent and continues to be prevalent regarding the management of nuclear activities, whether it's power generation, transport or waste disposal.

COMMISSIONER: I might ask counsel assisting now to move on and discuss some of those transportation issues that arise from your paper.

MR JACOBI: Dr Lyman, I'm hoping to pick up one of the key themes of the paper was a view expressed with respect to the adequacy of the protection which was provided by the Type B standards which are recommended for the packaging of transport. I'm just wondering perhaps whether you might expand on your view with respect to the adequacy of the protection that's provided by those standards and the views you'd expressed.

DR LYMAN: Thank you. With Type B standards for transportation casks govern land or sea shipment of spent fuel, high-level radioactive waste and especially nuclear materials like plutonium or plutonium oxide, the standards have not changed in many decades and so I think the objections that I raised within this paper are still true today; that the standards represent a certain percentage of the kinds of conditions that might be experienced in a transportation accident but it still is not well defined exactly what percentage of plausible transportation accidents those standards would provide protection against. Also, the governing philosophy behind those standards is the notion of graceful failure; that is, in the real world, yes, you may experience accidents that are far more severe than the Type B standards would simulate but the packages are designed so that they would not fail catastrophically if you just exceeded those conditions by a small amount but they would fail gracefully.

In my analysis back then I called into question the issue of whether graceful failure is something which is built into many different types of radioactive material transportation casks. So if you look at the case of the seal design or elastomer seals for the lids of radioactive material transportation casks, those generally do not exhibit in my view a graceful failure property of the duration required by the Type B standards, and especially talking about long duration fires and we've certainly seen transportation fire within the United States that was the famous Baltimore tunnel fire which greatly exceeded 30-minute fire transportation. So certainly we can experience accidents that (indistinct) are greatly in excess of those parameters.

I argued then, and I continue to argue, that if you want to understand whether or not these packages actually (indistinct)

MR JACOBI: I'm sorry, Dr Lyman, we've just lost the audio for a moment.

DR LYMAN: (indistinct) shipping casks to actually represent - I'm sorry, can you hear me now? Can you hear me at all?

COMMISSIONER: No.

DR LYMAN: Sorry.

MS BYERS: We can hear you but it's cutting in and out, Dr Lyman.

DR LYMAN: Can you hear me now?

COMMISSIONER: Yes.

MR JACOBI: Yes, we can.

DR LYMAN: Should I go and try to call back?

MR JACOBI: No.

DR LYMAN: Can you hear me?

MR JACOBI: No, I think - - -

DR LYMAN: Does that sound good?

MR JACOBI: I think we're fine. Perhaps we can move on. Because I think we missed part of your answer, perhaps if I could ask this question because I did want to come to this question of the view with respect to graceful failure and I was interested to understand, is there any evidence that in fact, that the packages or the flasks that have been designed for Type B purposes would exhibit cliff edge effects beyond the scenario for which they're designed.

DR LYMAN: Well, I think I gave some examples in the paper, of failure mechanisms that may actually be cliff edge effects, but I think the larger issue is that there's no regulatory requirement or standards do not encourage or require the graceful failure to be built into packages. They're standards which are set, and the package designer (indistinct) comply with those standards, so having a graceful failure which we call defence and depth is not a separate requirement.

So you might have packages more robust than others because of their purpose, but they were not designed for graceful failure, so the only way to really demonstrate it is to do full scale testing under - beyond design basis conditions. So to that end, I would point to a study that was proposed here in the US by the Nuclear Regulatory Commission, it was a package performance study. It was actually proposed that they would conduct tests under greater impact and fire conditions than Type B standards now represent.

But that study, for budget and planning and other reasons, was actually never carried out, so I think there's still a large uncertainty that that study was meant to address, that has not been addressed.

MR JACOBI: Can I just pick up part of your answer there, and that is that I've read a number of reports of studies conducted by flask manufacturers and others, where they've tested components or indeed, scale versions of their flasks beyond their design limits. What's the reason for your emphasis on testing a full scale model, given some of the difficulties associate with for example, using compression chamber and the size of a compression chamber for an immersion test?

DR LYMAN: Well, not being a mechanical engineer. I would just say that I think there is a recognition that testing scale models does not always accurately capture phenomenon that may occur at full scale, and that's because generally, let's say these collision, these processes are non-linear and may not scale. So you may lose some effects that you'd only see at full scale.

So I think there is a recognition that scale models may not capture all the physical phenomenon that you would see at scale, and that's why, for instance, the package performance study on a full scale package was recommended. So I refer you to the rationale for that study, for further (indistinct)

MR JACOBI: As I understood it, the package performance study was to be a fire and impact analysis. The particular question I was raising was with respect to immersion. Do you think there - - -

DR LYMAN: (indistinct)

MR JACOBI: - - - might be a possibility for differentiation, depending upon the nature of what it is you're seeking to analyse?

DR LYMAN: So the question of whether scale on models, accurately capture immersion - I don't - I can't really answer that question at this point. I would just say that the immersion test simply does not capture the scenario that I outlined in the paper, that is if you lose a package, a radioactive material, transport package, in a region of the ocean where it can't be salvaged and it has to be abandoned, then the question is what kind of long term radiological contamination can result from that package. And I think it was demonstrated that because of the very large concentration of radioactive isotopes, particularly caesium-137, as well as certain actinides like americium 2.1, and a lot of spent fuel in a high level waste transport package, but that could lead to significant long term contamination if the package is not retrieved.

So long term immersion, and the impact of salt water on elastomer seals and other phenomena I raised need to be considered.

MR JACOBI: Okay. Can I come back to a part of your answer from before, and that is you expressed a view about whether the testing took account of the full range of, I think, the realistic accident scenarios, and I'm just interested whether you can indicate that you're of the view that there are scenarios that are likely to be more severe than the testing regime.

DR LYMAN: Well, I think the guidance document for the package performance study, part of that was going to update the statistics of transportation accidents, because the IEA standard (indistinct) a certain period of time (indistinct), a certain database of transportation accidents and that has not been updated at least to the standard that the NRC would have confidence in. And in the US, we're in a period where if we do proceed towards siting of (indistinct) fuel there's going to be significant increase in the frequency of transportation of spent fuel for decades.

So there needs to be a greater assessment of the current standards and the current conditions for transport. So in the United States, speed limits have increased significantly over the last couple of decades in many states, and that was not taken into account in the US government's incorporation of IEA standards (indistinct) so issues like that need to be fully addressed, at least from the point of view of the United States.

MR JACOBI: I think, to pick up something you said before, are you of the view that the standards ought contain a very clear statement of the probability of the sort of scenario that they're protecting against? That is, that it's something that could be quantified and ought be expressed in those terms.

DR LYMAN: Well, it can be quantified, the uncertainties however can be large, because it's hard to see if extrapolation from you know, transportation statistics - we're talking about events that are low probability, but it's hard to actually define how low probability they are, because in some places you're extrapolating from known events to less frequent but more severe events, and you know, how you do that extrapolation is not necessary well defined.

So you know, you can get a rough sense I would say based on that approach, but you can't get a very precise quantitative estimate of how much protection any given standard is going to afford. Then the other issue is the prospect of terrorism, which I hope we can touch on, because in that case, if you're going to do a nuclear act, then you can't quantify the probability of other ways to achieve confidence in safety and security.

MR JACOBI: The issue of security associated with transportation of these materials: much of the views expressed with respect to security are expressed with respect to the package, and I'm just interested to the extent to which the package in your view can provide relevant security against those sorts of risks.

DR LYMAN: I mean, clearly the institutional managers and the human factors and problems of protection are significant, but certainly a raw form of the type of package to increase the resistance to certain types of sabotage. So you know, there is (indistinct) design better or worse packages, but for sabotage we'd need to know what particular scenarios you're talking about to find the (indistinct) so in the US, there are a range of dry casks which are certified both for storage and for transport, and they vary with regard to the potential of radiological release if that occurred in a given attack of say, a shape charge attack.

We certainly can design better packages, but that is not going to solve the problem completely as any package will have failure modes and depending on the ability of an adversary to access that package will determine to what extent they can damage it and potentially release the contents. So with defence in depth, again it's going to need physical protection and all the elements associated with that but also better packaging would certainly provide an additional layer of security.

MR JACOBI: I was hoping that we might be able to discuss - because we're aware that you've published with respect to IFRs and I was just hoping you might be able to pick up some things with respect to fast reactors this morning as well, in addition to dealing with transport. I understand you've expressed some views with respect to the ability of IFRs to reduce the longevity of the need to store waste; that is, the ability for them to use and burn up the transuranics. I'm just interested if perhaps you might express those views.

DR LYMAN: The IFR or the integral fast reactors were a concept of a liquid-metal cooled metal-fuelled fast reactor with an integral higher processing system that would extract actinides from spent fuel and fabricate fresh fuel from that. So the idea that that system could be used to "burn" actinides unquote (indistinct) advocates of the technology, but there's been substantial work published on the potential performance of fast reactor systems in general or the IFRs types in particular that demonstrate that it's a misleading picture to say that these systems can simply burn up nuclear waste and eliminate or greatly reduce the need for a geological repository. Those I think are a gross exaggeration of the capability of those systems and possibly the overarching aspect is that the systems actually are very sluggish with regard to the quantity of actinides that they can actually consume in any given cycle.

So certainly there are many analyses and references that look at fast reactor systems (indistinct) reactors but they consider the impact of this fast reactor systems on the total quantity of actinides within the system. That means not just the actinides that are left in the high level waste after extracting them but also the actinides that are incorporated into the cores of fast reactors. So you have to look at the entire fuel cycle. If you do that, you see that even if you have a system with very high performance burner reactors with a very high or very low conversion ratio meaning that in each cycle they would consume a large fraction of the actinides in the fresh fuel, it still takes hundreds or even thousands of years to make a significant dent in that total quantity of actinides in the system.

So the question is, if you're trying to reduce the need for a geological repository for power generators, you'd like to see a system where you could actually saying you can achieve that within our own lifetime. But if it takes many hundreds or thousands of years to make a significant dent in that total quantity of actinides then we're not really achieving that. Instead of bequeathing to future generations a geological repository, you're saying you'd need to have the system of fast reactors almost ad infinitum in order to achieve the reductions that you have originally anticipated. So I don't see that as really fulfilling the intergenerational equity aspects of nuclear waste disposal if our generation spends hundreds of billions of dollars to construct a fast reactor and a processing system to burn off actinides when 50 or a hundred years from now only a fraction of that total quantity will actually be fissioned. So leaving 90 per cent or 80 per cent of that to the next generation I don't think achieves that goal. It's not a very efficient approach.

MR JACOBI: Can I just pick up your answer then in terms of the duration of the time period for actually burning up the actinides in such a system. Is it possible to design the system in such a way that it's possible to reduce or limit the sorts of time periods we're talking about, such that we can be quite precise about the time period that it would take to burn up the transuranics that are used in the fuel?

DR LYMAN: Well, you can calculate it precisely, but again referring to studies that do just that but there's no (indistinct) parameters of such a system, even again with very high - if your goal is burning up actinides and maximise the burning capability of the fast reactors, even then it still takes a very long time to achieve these goals. So you can do those calculations but there's seems to be practical limits - not just practical but theoretical limits - on how quickly we could actually fission actinides, and that doesn't even take into account a whole host of other associated problems with a fast reactor fuel site.

MR JACOBI: I will deal with a couple of those in a second. I'm just interested to understand even if one was seeking to do it on the shortest time period, are we still looking at a period of time beyond the lifetime of the particular piece of plant itself?

DR LYMAN: From the studies I've seen, the best performance would still take a hundred years or more to, let's say, reduce - and this is just off - I'd have to consult the references - but to reduce the quantity of actinides by a factor of 10, which I would think would be the minimum requirement for such a system. That would probably take upwards of a hundred years or more and that's assuming very aggressive deployment of burner reactors and there are actually a lot of safety issues associated with fast reactors generally but the burners introduce additional questions about safety. So it's not even - these are just theoretical studies that don't even consider all those additional issues. But even if it's doing as well as we might think theoretically, it would still take a long time.

MR JACOBI: The Commission would be interested in receiving the references. So if you'd be prepared to send them through, it would be assisted by those that point to certainly the limits of the time periods that we're talking about.

DR LYMAN: I'd be happy to.

COMMISSIONER: Dr Lyman, you may not have a view on this but if you've been following IFRs do you sense how long before they might become commercial?

DR LYMAN: In my view, and the view of many other experts - I mean it's really a country-dependent issue but the question of development and deployment of advanced reactors, just taking the United States as an example, it's a very, very challenging issue because we haven't established fully light-water reactors and our industrial experience, operating experience, industrial base and regulation are all keyed towards light-water reactor systems. What's needed to actually develop a licence in advanced reactors like a fast reactor is very expensive and best estimates of organisations like the National Academy of Sciences, and the DOE, and it’s an enterprise around the order of tens to hundreds of billions of dollars to actually bring an advanced reactor design to the point where it could be commercialised, and it would take several decades (audio malfunction) the United States went full bore to try to develop and employ an advanced reactor but still not occur before the 2040s at the earliest and it could cause many tens of billions of US dollars.

MR JACOBI: Okay.

DR LYMAN: So it’s quite a challenge, and it also raises the issue of government versus private investment for utilities, which will be the customers for advance reactors are very conservative and they’re not interested in long term investment to support R & D, and that investment right now, there’s no (likely support)? in the US.

MR JACOBI: Can I just come to address a number of the other issues associated with reactors - sorry, those reactors that you’ve spoken about, and can I come first to the issue of the proliferation related consequences associated with those reactors? The Commission has heard competing views with respect to those matters, depending upon particularly the proliferation resistance and the pyroprocessing, and I’m just interested, perhaps you can express your views with respect to what you think the proliferation related impacts might be.

DR LYMAN: Yes. I’ve studied in great detail pyro processing systems and the so called proliferation resistance, and it's my view, and there a number of published papers on this, that pyroprocessing does not confer any significant advantage over aqueous reprocessing with regard to proliferation and terrorism. The separation of actinides in pyroprocessing systems leads to products which are attractive for an adversary that seeks to make nuclear weapons, both because many actinides other than plutonium-239 are weapons useable, but also because the radiation barrier associated with the products of pyroprocessing does not act as a significant deterrent to theft or diversion.

So there's been a great exaggeration with regard to the proliferation resistance of pyroprocessing. I might also indicate that one of the largest components of a pyroprocessing product with regard to the radiation barrier appear in the isotopes that are highly radioactive, that emit penetrating gamma rays and create a very high radiation dose that would be a deterrent for someone seeking to physically handle or transport that. The radiation barrier that is conferred by certain lanthanide fission products, and those lanthanide fission products are not desirable in fuel fabrication or fuel irradiation in fast reactors, so most current concepts for fast reactor or IFR-like systems would require additional steps to remove lanthanide fission products, therefore reducing the permanent radiation barrier.

So if we actually look at what is practical to be done for the system, we find out that we don't really get that advantage. Certainly, nothing would be a significant amount for us to say (audio malfunction) around the world without significant concern for proliferation.

MR JACOBI: As I understand it, the view you've expressed there is that the removal of certain elements, which are the lanthanide elements in the period table diminishes its radiation deterrence. I'm just interested, with respect to the balance that's left, does that not still pose a significant radiation deterrence?

DR LYMAN: No, because what's left is primarily plutonium, uranium and minor actinides. Some of the minor actinides have a neutron or gamma dose, but if you actually look at the dose rate from those products, it's still nowhere near what's considered to be a self-protecting material right now the International Atomic Energy Agency defines one Sievert per hour at one metre radiation dose as what they consider self protecting which leads to a definition of what's irradiated material in IEA guidance.

The dose rates associated with the minor actinides in pyroprocessing product generally well below that, one Sievert per hour. And I would also add that the even one Sievert per hour of one metre is not really considered to be a significant deterrent to a suicidal terrorist, for example. In the United States, there is serious consideration to increasing that threshold to something like 50 Sieverts per hour, so the one Sievert per hour is probably at the pyro processing product does not get anywhere near this and I could certainly refer you to the papers where they actually calculate the radiation dose from pyro processing products and find if it’s going to be a one Sievert per hour.

MR JACOBI: Just stepping aside from the issue of radiation deterrence, and I just wanted to pick up the other aspects. You expressed a view that pyro processing didn’t offer any particular advantage over the aqueous processing, which I understand is used to make MOX fuels. I’m just interested to the extent to which it shares characteristics that it would mean that it would have the same proliferation associated risks.

DR LYMAN: Yes. I mean, when you’re talking about proliferation, you have to also keep in mind the primary role of material accountancy and let’s say IAEA and accountancy safe guards. But accurate accounting for special nuclear material is critical to be able to safeguard facilities against diversion and for handling facilities like aqueous reprocessing plants. For instance, like a plant like (indistinct) in Japan produced, if they were operating full scale, would produce many thousands of nuclear weapons worth of plutonium (indistinct) and that means a safeguard against the diversion of one significant quantity.

It’s an extremely daunting task (audio malfunction) now, when you talk about pyro processing systems, they have lower (indistinct) generally than let’s say, an integral fast reactor, but there’s no safeguards approach currently defined for pyro processing systems. Material accountancy is even harder in a pyro processing system than an aqueous system, because the material flows are very heterogeneous, so sampling is very difficult. The materials tend to plate-out on cathodes and you get very hard deposits that are hard to remove and to characterise, so there are big safeguards issues associated with pyroprocessing, and that would be a concern if there was a greater move toward (indistinct) systems.

And the IAEA is still struggling to provide even technical approaches for how you would conduct materials accountancy in pyro processing, and that’s a great concern.

MR JACOBI: I’m interested in your view as to the - I’ve read in the submissions materials that suggested that the material produced from pyroprocessing and some other re-processing techniques would not be suitable for use in an atomic weapon, in the sense that the plutonium would still contain impurities that would make it unsuitable for such use. Do you have a view with respect to that?

DR LYMAN: Yes. There of course are many types of aqueous and non-aqueous re-processing flow sheets that would separate different types of materials, but if you're talking about let's say the pyroprocessing flow sheet that would have plutonium, uranium and minor actinides of plutonium-237 and depending on the flow sheet americium mercurium. Most of those minor actinides themselves are weapons (audio malfunction) comparable to (audio malfunction) 235, so the fact is - - -

MR JACOBI: I'm sorry Dr Lyman, can I just get you to repeat the last couple of sentences? I'm sorry, we've just had a minor drop out.

DR LYMAN: Many minor actinides that would be in the pyroprocessing product were also weapons useable, fissile materials with critical masses comparable to U-235 in the United States, neptunium-237 and americium-241 are required to be accounted for as if they were (audio malfunction) and so they are considered sensitive and weapons useable materials in the United States.

So minor actinides will not reduce the attractiveness of that combination for nuclear weapons. Now, that said, they present different technical challenges, but those technical challenges (audio malfunction) solutions, so you can't bank on the presence of minor actinides to render the material unusable for nuclear weapons.

It's also easy, if that combination were to be stolen, to separate out plutonium from the minor actinides. In fact, the PUREX flow sheet could do that. So if you were able to actually to steal the material and process it a glove box if you wanted to separate plutonium (indistinct) but the bigger is because it's uranium and the dilution factor, but again uranium and plutonium can be separated using an aqueous flow sheet.

So that brings me back to the presence of fission products that provide a radiation barrier, and those, like I said, generally would be removed from the current (indistinct) of fabricated fuel for your fast reactors, because they would have undesirable effects in the reactor. So that means that pyroprocessing itself would have to be supplemented with some other purification process to make the fuel useable or practicable (audio malfunction)

MR JACOBI: Dr Lyman, I understand those matters underpin a view, and I hope I've got this correct, your view, that you have a preference for ultimately geological disposal, that is, a once-through fuel cycle, as compared to the use of these techniques?

DR LYMAN: That's correct. We think that, for the same reasons that the United States decided not to pursue re-processing and fast reactors in the 1970s, that the proliferation and terrorism risks of a fuel cycle is based on weapons useable fuels, production and processing of weapons useable material of a very great quantity, and that that is certainly an unmanageable enterprise, and that nuclear energy can be generated using low-enriched uranium or natural uranium, which is not a direct weapons useable material, and so there's certainly something they'll need from a fuel point of view to use weapons useable fuels.

So we use the once used fuel cycle, based on low-enriched uranium fuel, and direct disposal is the safest and the most prudent approach for nuclear power. And, there is no good rationale for close recycles in which the benefits have actually outweighed the risk.

COMMISSIONER: Dr Lyman, thank you very much for joining us this afternoon, your time. It's very useful to have both those perspectives on transport and IFRs. We'll now adjourn - - -

DR LYMAN: Thank you.

COMMISSIONER: Thank you - until 9 o'clock.

**ADJOURNED** **[8.14 AM]**