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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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SUBCOMMITTEE ON RADIATION PROTECTION

AND NUCLEAR MATERIALS

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TUESDAY

SEPTEMBER 18, 2012

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ROCKVILLE, MARYLAND

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

COMMITTEE MEMBERS:

MICHAEL T. RYAN, Chairman

J. SAM ARMIJO

DENNIS C. BLEY

STEPHEN P. SCHULTZ

JOHN D. SIEBER

GORDON R. SKILLMAN

NRC STAFF PRESENT:

KATHY D. WEAVER, Designated Federal Official

GORDON BJORKMAN

JOHN COOK

EARL EASTON

ANITA GRAY

ALSO PRESENT:

DOUGLAS AMMERMAN

A G E N D A

P R O C E E D I N G S

(8:31:40 a.m.)

CHAIR RYAN: The meeting will come to order. This is a meeting of the Advisory Committee on Reactor Safeguards, Subcommittee on Radiation Protection and Nuclear Materials.

I'm Michael Ryan, Chairman of the Subcommittee. The Subcommittee members in attendance are Sam Armijo, Dennis Bley, Dick Skillman, Steve Schultz, and Jack Sieber. That's it so far. Oh, and let's see, sorry. Kathy Weaver is the Designated Federal Official for today's meeting.

The Subcommittee will hear presentations by and hold discussions with representatives of the NRC Staff on Spent Fuel Transportation Risk Assessment. The Subcommittee will gather information, analyze relevant issues of facts and formulate proposed positions and actions, as appropriate, for deliberation by the full Committee.

The rules for participation in today's meeting have been announced as part of the notice of this meeting previously published in the Federal Register on September 12th, 2012. A transcript of the meeting is being kept and will be made available as stated in the Federal Register notice.

It is requested that speakers first identify themselves and speak with sufficient clarity and volume so they can be readily heard.

We ask at this time that you silence your mobile phones and other electronic devices.

The ACRS full Committee briefing is scheduled for December. We'll now proceed with the meeting, and I call upon John Cook, Senior Project Manager in NMSS to begin. John.

MR. COOK: Good morning.

CHAIR RYAN: Good morning.

MR. COOK: This morning we'll be providing you with some information about the Spent Fuel Transportation Risk Assessment that the NRC has recently completed. We've designated as -- we refer to it as SFTRA, but has been -- the report from that effort has been designated as draft NUREG-2125.

Today's agenda, I'll be providing some opening remarks, some background about the study, and I will also provide some preliminary findings of the report. And then we will turn for a more detailed discussion to Doug Ammerman from Sandia National Laboratories, who will present additional information on how the study was conducted, and its results.

Towards the end of the presentation, we

will discuss some of the public comments received, and what our proposed resolution to those comments are. And then make some concluding remarks.

The outline for this morning's discussion, I already talked about what we'll be going through first. Again, the additional details is what we'll go through, and then finally about public comments that we just discussed.

With respect to the origination of SFTRA, where it originates from -- excuse me. First, let's go through the project teams, who's actually been involved with this activity.

We had the work done at Sandia National Laboratories. Dr. Ammerman has been the principal investigator. He's been assisted out there by Carlos Lopez, who has provided the thermal analysis. Dr. Ruth Weiner, who has provided the risk assessment.

I would point out that Sandia National Laboratories is well regarded in this arena, that many other countries, in fact, come to Sandia National Laboratories to have work done with respect to packages that they may be seeking to get tested, so Dr. Ammerman and his group are not only analysts with respect to the package performance under severe accident conditions, but are also practitioners in that activity.

Within the NRC, we had our own technical review team to review the work from Sandia. And today we are joined by some of those seated to the table to the right. We have Dr. Gordon Bjorkman who is one of SFST's senior-level advisors who did the review on structural activities. Chris Bajwa, who is not available today did the thermal review. Dr. Robert Einziger was our fuels and source terms expert. He also is unavailable today. And we have Dr. Anita Gray who did the health physics review, also from NMSS.

Now, after the NRC Staff had conducted its review of the work from Sandia, we had the project subjected to an external peer review. That was conducted at Oak Ridge National Laboratories. That external peer review team was headed by Matt Feldman. He was assisted by Dr. Cecil Parks and a number of other professional staff at Oak Ridge.

With respect to SFTRA's purpose and goal, you can consider the origins of SFTRA from the first Final Environmental Statement that was conducted in this area. That was NUREG-0170, which was completed in 1977. That study included a Spent Fuel Transportation Risk Assessment, and it was based on that assessment that the Commission concluded in a Federal Register notice that the level of risk associated with spent fuel, that the regulations in Part 71 that govern spent fuel transportation we adequate to provide adequate public health and safety during spent fuel transport. But they went on to say that spent fuel -- that transportation of radioactive materials should be subject to close and continuing review. And it is -- and SFTRA satisfies that internal commitment to continue to look at transportation safety.

And as you can see, we've done these reviews on about a 10 to 12-year review cycle. And you can also note that the level of analysis has improved so these studies have been about 10 years apart. So, for example, the 0170 effort was basically based on engineering judgment to a large degree. The modal study which followed it 10 years later was the first time finite element analysis was used in looking at package performance, but that did not investigate sealed region or releases to any great extent.

Most recently, the reexamination done in 2000 was the first time in which the finite element models also included the seal region, but in a relatively low-resolution mode by today's standards. And if you consider that to be a low-resolution version, then today's SFTRA review is more of a highdefinition version in which the cask and its seal regions have been modeled in very great detail, including the impact limiters, as well.

MEMBER SKILLMAN: Would you please say more about the seal regions, explain what you mean by that, please?

MR. COOK: The seal region is where the cask lid is bolted to the cask container. And there are either metallic or elastomeric seals between the lid and the cask body, so the behavior of how that interface between the lid and the cask behaves during severe accidents determines if there's going to be a release path. And if there is, what size is it, so that's why that area is important.

MEMBER SKILLMAN: Thank you. I understand the technology. The administrative point that you were making was the previous study did not examine that as thoroughly?

MR. COOK: That's correct. That's only because the technology was not available to do so.

MEMBER SKILLMAN: Oh, thank you.

MR. COOK: Another purpose that NRC, or that SFTRA serves is that we not only want to provide an updated basis for our regulations, but also in this effort to obtain public comment on the results of

SFTRA. That was done for the FEIS back in 1977, but neither of the other contractor reports were provided for public comment, so this is the first time we've done that in a while.

We also, since the transportation of spent fuel is subject to NRC's Part 71 transport regulations, providing information to the public about those shipments is our responsibility, as well, so we do want to provide information to the public.

The basic message here is pretty straightforward, that is that risks are low. They're very low, so that safety provided is high. And we hope to improve the public's understanding of the shipments hopefully leading to greater acceptance on the part of the public with respect to future spent fuel shipments.

Now, at the time when this study was begun in 2006, potential future shipments were also a consideration, but with the current inactivity in that regard, this is much less of a driver at the current time. But, nonetheless, SFTRA's overall method certainly would be applicable to future shipments.

In trying to explain what SFTRA is sometimes it's helpful to look at what it's not. It is a generic Spent Fuel Transportation Risk Assessment.

It is an informational report, essentially, and it is not, as we see here, an EIS. It's not driven by any external commitment or requirements, not major federal action. It's not required to license any facility or to certify any package. It doesn't contain any regulatory change proposals, and it does not include any analysis of transport security concerns.

Now, this --

MEMBER BLEY: That part, I know you have Memos of Understanding with other agencies.

MR. COOK: Yes.

MEMBER BLEY: So, the NRC's role is primarily just dealing with the cask itself?

MR. COOK: Primarily, yes.

MEMBER BLEY: And you didn't look at the security aspects because they're done elsewhere, or why?

MR. COOK: Correct.

MEMBER BLEY: Okay.

MR. COOK: There's another office, NSIR, within NRC that would be looking at the security aspects. We're primarily focused on safety within SFST.

MR. AMMERMAN: And part of the reason we didn't want to consider security in this report was because we wanted it go out to public comment. And if you address the security issue, then it becomes protected information.

MEMBER BLEY: Okay.

MR. COOK: In this slide, what's the basic method? We're looking at radiological impacts only when we're doing the Spent Fuel Transportation Risk Assessment. We don't look at traffic fatalities, we don't look at the environmental effects of the fuel in making shipments. It's only radiological impact, and those come in two types; routine conditions in which the shipment is completed without any accident or incident. Then which is strictly dose consideration, and then for accident conditions, there you're looking at how does the cask perform under various accident scenarios.

But since this is a risk assessment, we look not only at how the cask might perform but we look at what's the probability that the cask is going to encounter conditions which might lead to a risk. And this -- the way we've done SFTRA is similar to the previous studies we've had. In fact, RADTRAN 1 was used to do NUREG-0170, and we use RADTRAN version 6 in order to do the study itself.

MEMBER SKILLMAN: Let me ask about the --

you're using event trees developed by the Department of Transportation. To what extent do the states buy into that data? For instance, you might say gee whiz, here is this package and it meets all the requirements of DOT. We have used all of the risk information that the federal regulations guide us to use, and as far as we're concerned this package is good to go.

So, you have Ohio, and Wyoming, and Pennsylvania say no, our standards are higher still. And for that package to cross our roadways or our railways you've got to meet our requirements in addition to the DOT requirements. To what extent are the DOT requirements accepted, if you will, for the lower 48 states?

MR. COOK: Well, for DOT transport requirements, those are national standards with which all states would comply, that should a local government decide that they want to impose restrictions that go beyond what the Department of Transportation has in their regulations, the Department of Transportation can preempt local regulations that are found to be inconsistent with DOT's national transport standards, because we can't have a system in which states can have different levels of requirements for these types of transport.

Not necessarily restricted to the radioactive materials, for any hazardous material, there needs to be a national system. That is what's in place. And, again, should one state try or enact regulations that are essentially a prohibition against transport, those can and in fact have been overturned by DOT in the past.

I would also mention that we have used in the study statistics that reflect state-by-state accident rates, so we are trying to be -- we are trying to consider there are variations within states. But once we look at the accident rate, then the response to those accidents, that we use the event trees that we're mentioning here, and those are the same.

MEMBER SKILLMAN: Thank you.

CHAIR RYAN: John, I think it's fair to say, too, that states are pretty well versed at coordinating. Very often for some shipments, and we've seen high-activity waste or fuel, or spent fuel, there's essentially a handoff from one state police organization to the next along a transport route. And that's all -- correct me if I'm wrong, you don't have to agree, but I think that's all fairly well established as to how well that works, and the handoffs are pretty well managed, and it's really not any argument, other than we want to know what's coming in. We want to notify you when it's leaving to make sure those border cross and handoffs are well orchestrated. So, I think that's probably the only sort of challenge there, is how do you plan a route, and then get everybody on board. Because as you might expect some places you can't do things on Saturday or Sunday, and some places that's okay, so there tends to be a lot of coordination that has to go. But I don't think there's any disagreement about the fundamental requirements for a package or a transport unit.

MEMBER SKILLMAN: Okay, thank you.

CHAIR RYAN: Is that --

MR. COOK: Yes, that is very correct.

CHAIR RYAN: And those are the followers in the handoffs, not in the basic unit rolling down to the road.

MR. COOK: And each state is notified.

CHAIR RYAN: Right. No, it's a pretty well exercised system. Yes.

MEMBER BLEY: Before you leave this overall description of the study, are we going to go into detail on the fire analysis later?

MR. COOK: We will.

MEMBER BLEY: Okay. Let me just pose two quick questions that maybe you were going to get to there. The last National Academy study on the transportation left with saying a completely engulfing fire hasn't been fully analyzed. Does the analysis we're going to see really go into the details of the seals and their response during the fire?

MR. COOK: It does.

MEMBER BLEY: Okay. And the fire you look at is at least as bad as the Baltimore Tunnel fire?

MR. AMMERMAN: Actually, one of the public comments that we received from the State of Nevada was about that, and we are going to address the public comment, add a discussion specifically about the Baltimore Tunnel fire into the report.

MEMBER BLEY: Okay. Well, when you get to the fire maybe you say something more about how it relates to --

MR. AMMERMAN: Yes.

MEMBER BLEY: Okay, thank you.

MR. COOK: So, kind of jumping ahead to provide some of the findings which we'll review again later at the end of the presentation, but -- so, we haven't gone into how this derived, but still just to go give you what the insights in the report are going through.

First, with respect to routine transportation we find that the collective dose from routine transportation are very small, that those doses are a small fraction of the background dose that a population along the route would receive during the same time period that a shipment might be conducted, and that the --

CHAIR RYAN: One thought on that point, and I find myself being asked about that kind of comparison a lot. In terms of collective dose, you're always troubled with facts of how many people are involved in one side and then the other. So, I'm guessing that this really represents the collective dose they get from background to a set population, and then the additional dose that would be involved in a transport unit going by that population. So, that's the increment that you're looking at.

JUDGE PARCHMENT: That's correct.

CHAIR RYAN: So, it is -- you know, if we give an analogy, it's an apples to apples comparison in terms of the population exposed, first the background and then to what's added by transport units going past that population along the route of choice.

MR. COOK: That's right. We're looking at the population that's within an 800-meter band on either side of the transport route, be it roadway or railway.

CHAIR RYAN: Right.

MR. COOK: So, what is that total population? What is the dose to that population from natural sources?

CHAIR RYAN: Yes, so we're not deleting the route of transport by the population and the entire metropolitan area.

MR. COOK: No, we're not.

CHAIR RYAN: So, it very much is a fair apples to apples comparison of population.

MR. COOK: Right. And then we'll go into more detail --

CHAIR RYAN: Okay. I just want to clarify.

MR. COOK: Sure. And we found little variation in the routes. I mean, we're going to show you the routes that we selected. They're just examples, you could pick other routes, but essentially the results are not changed if you do use other routes.

We find that radioactive material would not be released in a fire if the fuel is contained in an inner-welded canister, which is a design. Both of the designs that we have selected have that capability.

MEMBER ARMIJO: Are there any designs that don't have that capability?

MR. COOK: Yes. In fact, one of the casks we analyzed can go either way. It can be either direct loaded, which there is no welded inner canister, or it can be loaded with an inner welded canister, so we have both options. The truck cask does not have an inner welded canister, so you -- so, only -- and our study, in fact, to your point, only the real cask without an inner welded canister would release any radioactive material, but only then in exceptionally severe accidents.

We estimate that if there were an accident during a spent fuel shipment sort of additional probability here, there is less than a one in a billion chance that the accident would result in a release of radioactive material. And we'll show you why that is, the derivation of that result.

We then decided to take a non-probabilistic look, kind of ignore the probabilities that this ever occurs, just look at the consequences. And we found that the release -- if there were such a release, that the does to the maximum exposed individual from that release would be non-fatal.

MEMBER ARMIJO: I had a question on that.

MR. COOK: Sure.

MEMBER ARMIJO: And I think the number that you -- that's in your document was the maximally exposed individual getting -- would get less than 200 rem. And, first of all, is that accurate? And, secondly, non-fatal means immediately non-fatal or long-term non-fatal?

MR. COOK: Well, it's immediately non-fatal.

MEMBER ARMIJO: Okay. But long-term, whoever got this 200 rem --

MR. AMMERMAN: There's a chance that they would develop a latent cancer.

MEMBER ARMIJO: Yes.

MR. COOK: Yes.

MEMBER ARMIJO: And then maybe later we'll talk about what are the chances.

MR. AMMERMAN: And this is different than both 0170 and the reexamination study that was done in 2000, in that we stopped the analysis at exposure. We didn't report latent cancers. And that was a conscious decision on our part not to report latent cancers.

CHAIR RYAN: Good.

MR. AMMERMAN: And it's because the -- I think primarily the science isn't there to demonstrate that a micro dose to a megapopulation ending up with the same collective dose as a large dose to a few people causes the same amount of latent cancers.

CHAIR RYAN: It's kind of equivalent to saying you've got a 100-mile an hour wind for an hour, or 1-mile an hour wind for 100 hours.

MEMBER BLEY: If that were really true we still would -- we wouldn't have any debate about this.

MEMBER ARMIJO: I still want to get -- let's assume there was only one individual exposed. He got the 200 rem. He didn't die right away. Based on what the health physics people know, what are his chances of getting cancer within his lifetime from this exposure, that you can actually distinguish it from normal probability of getting cancer.

MR. AMMERMAN: That's a true statement, yes. I mean, the -- a 200 rem exposure is -- has a certain probability, and I don't know off the top of my head what that probability is, but it's not an insignificant probability that that person will develop cancer due to that exposure.

MEMBER ARMIJO: Yes.

CHAIR RYAN: Well, you know, you can put

some at least order of magnitude number on it. Everybody talks about three times ten to the minus four of cancer per rem, so 100 rem is roughly, you know, a few percent. That's another risk of getting cancer by being a human being on earth.

MEMBER ARMIJO: Yes.

CHAIR RYAN: It's .3, so I think all that has to somehow come into some sort of view that we understand the probability of getting cancer anyway, the added risk of cancer from some activity, whether it's smoking or transportation unit going by your house, or whatever it might be. So, all that has to come together in sort of a -- I think a coherent view of the risk instead of picking on one element and saying this added risk is huge compared to not having that added risk. That's not the right way to look at it.

MEMBER ARMIJO: Yes. Was that three times ten to the minus four?

CHAIR RYAN: Cancers per rem.

MEMBER ARMIJO: Cancers per rem, and I multiple that times 200, I get .06.

CHAIR RYAN: There you go.

MEMBER ARMIJO: Is that a fraction, so 6 percent chance of getting cancer?

CHAIR RYAN: In addition to the 30 percent or 33 percent --

MEMBER BLEY: But with nothing near the precision, the way you just said it.

MEMBER ARMIJO: I understand that. I just want to get into the ball park.

CHAIR RYAN: Near bar is interesting.

MEMBER ARMIJO: Yes, near barge big. Got it. Thank you.

MEMBER SCHULTZ: John, you mentioned that this portion of the study was to back up and now take a deterministic look at the maximum exposed individual dose. And in doing that, does the report include in your view enough evaluation and reporting of uncertainties associated with that calculation to describe -- I mean, we say 200 as if that's it, and back when you're doing a deterministic analysis you want to describe as completely as possible what the assumptions have been, what the uncertainties are in that estimate of 200 rem. Has that been done and reported?

MR. COOK: Well, I think our look at uncertainty is at the probability of getting into the accident that might lead to an event that might lead to the 200 rem. And I do believe that we have addressed that in the report, so you will see I think later on that our estimate of less than one in a billion, there are still residual conservatisms; that is, factors which would overstate the risk that we're reporting. So, we can describe those later so that we believe the less than one a billion is -- it is less than that in our view. So, in that regard we've looked at the certainty or uncertainty in that estimate.

MEMBER ARMIJO: Just to make sure I understand from Dr. Schultz' question. The uncertainty -- you use a term maximally exposed individual receiving less than 200 rem. To me that says you added up all your uncertainties and said this guy is never going to get more than 200, you know, with high confidence. Is that correct?

MR. AMMERMAN: That's correct.

MEMBER ARMIJO: You've already got the uncertainty built into that number.

MR. AMMERMAN: Yes.

MEMBER ARMIJO: Okay.

MR. AMMERMAN: I think the biggest factor on that is the assumption of where that person is.

MEMBER ARMIJO: Sure.

MR. AMMERMAN: Is there actually a person at the location that receives the maximum dose? Highly improbable that that is the case, because that distance is actually I think 22 meters from the accident site, 22 meters down wind from the accident site. So, is there a person at that location? Most likely not, so the --

MEMBER ARMIJO: But you just placed him there --

MR. AMMERMAN: We said yes, if he was there, this is the dose he would get.

MEMBER ARMIJO: Got it.

MR. COOK: If the accident occurred and it was that severe, and the person was there, then you'd get this result.

CHAIR RYAN: But I think there are other conservatisms built into that, as well, how long is he there?

MR. AMMERMAN: Yes.

CHAIR RYAN: He's got to --

MEMBER ARMIJO: He's got to stick around to get --

MR. AMMERMAN: And our assumption is that he's there for a day.

MEMBER ARMIJO: For 24 hours.

MR. AMMERMAN: For 24 hours, yes.

MR. COOK: This is, of course, 21 meters

from an accident severe enough to cause a release from one of these spent fuel packages, which we'll get into the forces needed to do that in just a minute.

MEMBER ARMIJO: Okay, not a very smart guy.

MEMBER SCHULTZ: The reason I asked the question is that as we were describing one of the -- what I think is one of the chief goals of the study that we've added in this case at this time is the communication with the public of the information, and allowing public comment is one. We can talk later about those comments, and what the plan is to go forward with those in terms of public communication.

In regard to this piece, it's important to understand that those in the public that either don't understand or have a difficulty with probabilistic analyses will instead go to this number. So, an appropriate description of that in a way that someone in the public can fully understand what has been stated here is very important because as a member of the public, one may be likely to focus on this number, and the concern that's associated with a dose of 200 rem, so I think we need to discuss this further.

CHAIR RYAN: Steve, I agree. I find myself in situations trying to explain all that. And the real sort of central point of the conundrum is you're trying to convince people that it's -- this is a worthwhile exercise in spite of the fact it's never going to happen. And that doesn't pass the every man kind of common thinking test.

MEMBER SCHULTZ: That's right.

CHAIR RYAN: So, why are you spending all this time and energy analyzing something that's an extremely low probability, and what are you getting at? So, it's not well grasped why we do this, so that I think is a very important point that you're raising, is we really have to figure out a way to explain why this informs the scientific assessment side of it, and then how do we translate it into routine risks that we accept every day.

MEMBER SCHULTZ: That's what I believe we need to work toward.

CHAIR RYAN: I agree. I mean, I think that should be something we think about how we address it.

MR. COOK: I would just add that it's somewhat ironic I think that the reason -- or one of the reasons we did this analysis is because of the difficulty of trying to explain the point that comes before or how unlikely these events are, trying to explain that the probabilities here are very, very small using scientific notation terms that are difficult to grab. So, let's try to get them explained in that issue, so we'll go to the health effect issue. And that has it's own -- in fact, it's potentially confusing, as well.

MEMBER SCHULTZ: But I believe both can be explained --

MEMBER ARMIJO: I think it can. I think this is very good.

MEMBER SCHULTZ: On both parts really.

CHAIR RYAN: Yes, and I think it can be done. We address everybody's concerns or interests, perhaps not, but I think we can at least lay it out in a logical way so people will get a grasp of the scientific kind of thinking about this, is we want to assess things we don't think can happen just so we understand how it would if it did, even with a remote probability, happen. You know, people understand that plane crashes don't happen every day, but when one happens it's a big deal. So, that's really what we're trying to get across.

MEMBER ARMIJO: People buy lottery tickets and the probabilities of winning are very small, but they believe it's going to happen to somebody, and why not them.

CHAIR RYAN: Line up --

MEMBER SCHULTZ: If you turn that around that's a concern, because that could happen to me.

MEMBER ARMIJO: People don't --

MEMBER SCHULTZ: So, that's what I'm concerned about.

MEMBER ARMIJO: Yes. No, I understand.

CHAIR RYAN: But I think Steve's point is right on target, that is a communication issue that we need to do some more serious thinking about.

MEMBER SKILLMAN: I wonder if there are other shipments that pose very similar risks. I'm thinking about transportation of propane. I'm thinking about transportation of gasoline.

MEMBER BLEY: Much higher likelihood.

MEMBER SKILLMAN: Much higher likelihood, and it some cases just stunning damage and fatalities. I mean, we saw the, what was the bridge on the west coast, the Bay Bridge with the gasoline tank. So, maybe a way to begin this discussion is to point out that in comparison to other rides that you drive next to on the interstate, these are benign compared to some other things that you simply accept as a consequence of living in our culture.

MEMBER BLEY: That requires extraordinary caution. If you go back to when WASH-1400 was published, the thing that caused the greatest confusion with the public were the comparison things. Most engineers appreciate them, most people in the public turn them around and there's been just a myriad of studies on risk communication that show trying to do those kinds of comparisons to bolster your case is generally much more trouble than it is good to you. It backfires almost every time, so it requires a great deal of care.

MEMBER ARMIJO: I don't know if this is fact, but I read or was told that when comparisons were first made about radiation exposure from nuclear operations to x-rays, dental x-rays, chest x-rays people stopped taking x-rays because they said well, if it's that bad, you know, instead of being comfortable about it. They got even more nervous, so it's a tough --

MEMBER SIEBER: Well, I think there's one way to look at it. There was a study I think in the late 1960s or early '70s at MIT related to how people -- the general public perceives risk. And in general, if it's some -- if they are taking or undergoing a risk that they can't see or feel, they are much more afraid of that than if a fire was burning right in front of you.

Secondly, people are much more afraid of somebody doing it to them rather than they making a choice to expose themselves. And if you study that thoroughly you come up with a number of risk aversion, it is something like ten to the third, so there's a factor involved there in people's willingness to accept certain risks.

You get on an airplane, you know that there's some kind of a risk there in your heart, and I as a pilot probably knew it more than a lot of ordinary people do because I saw them. And on the other hand, people fly every day, don't worry about it. They drive cars every day, and there's tens of thousands of people killed every year in automobiles.

On the other hand, radiation you can't see, and in the case of commercial radiation not medical, you don't get to choose either. It's just there and you don't know it, whether you're exposed or not, and people fear that. And so that has to be taken into account and dealt with carefully when you communicate to the public. The fact is they just won't -- they won't accept this compared to other things that are riskier that they will accept.

CHAIR RYAN: Go ahead.

MR. COOK: Okay. So we said previously that in the study kind of following along with the methodology that's been used previously, and yet the study also introduces some new, we call them improvements.

We used certified casks in this assessment, and what I mean by that is that the designs that we used here are casks that have been certified by the staff at SFST, so the previous work was based on generic casks. Those were casks that were modeled to just satisfy NRC's transport regulations in 10 CFR Part 71. So, both 0170 and the modal study, and 6672 all used these generic representative casks, but SFTRA actually uses casks that have been certified. And what we found is that certification of casks, there are additional robustness in casks that are actually fabricated, and certified, and used. I think the study reflects that.

MEMBER ARMIJO: So, the generic was a hypothetical cask?

MR. COOK: Yes.

MEMBER ARMIJO: It met the minimum requirements.

MR. COOK: Correct. That's exactly right.

MEMBER ARMIJO: Okay.

MR. COOK: We've used updated event trees, so we have what we believe is a better handle on the probability of severe accidents and what those rates are for both truck and rail in the study. We used improved thermal analysis model in the study, and we've used better and more finely detailed finite element models.

And on the routine -- well, kind of in between the routine dose and accident dose we've also studied for the first time in this study an accident, essentially considered a fender bender, there's no real damage to the cask at all. But, of course, in one of these shipments if any of these casks were involved even in a minor incident, it would be pulled over to the side, or escorted. There's police. It would be a long time before that shipment would be allowed to continue, so what we're looking at here is the stop time dose to people around the cask should one of those events occur. And that's not been looked at in previous studies either.

MEMBER BLEY: I don't remember. Did that end up being any significant part of the risk?

MR. COOK: Well, it's separate. We didn't -- we kind of kept it separate since none of the previous studies looked at it. But it is with respect to the routine transport analysis, because it involves stop time. And as soon as you stop one of these shipments, then it's easier for dose to accumulate for people that are in close proximity to it. So, it is something that we've looked at. It's not dissimilar from let's say fuel truck stops, or inspector stops, but it's just longer.

MEMBER BLEY: The assumptions on where it was stopped?

MR. COOK: It could be in a rural area, or an urban area, or --

MEMBER BLEY: You looked at all of those.

MR. COOK: Yes.

MR. AMMERMAN: Yes. And as a matter of fact, we report both the collective dose and the MEI dose for that event, as well.

MEMBER BLEY: Okay. I missed that.

MR. COOK: And we're just briefly taking a look at the accident conditions that are required to be satisfied for a package design to be certified by NRC in Part 71. We have free drop, puncture thermal, and immersion. Those are in themselves very robust conditions, and to be certified you must demonstrate that not only does the package withstand these events, but that there is a specified but very small release of material that is approved, that is provided for in the regulations. So, you have both, a very severe set of accidents, but also very stringent criteria acceptance, as well.

MEMBER BLEY: Can you something about how things like the drop test correlate with the finite element, or is the finite element tuned to match the drop test that you have, how those things relate?

MR. AMMERMAN: As a matter of fact, yes. The finite element analyses are benchmarked by available test data from physical tests. And most casks are certified by a combination of drop testing of scale models, not a full scale test, and finite element analysis with probably in modern certifications -- and, Gordon, correct me if I'm wrong here, modern certifications leans more toward the analysis side than the test side. I think the staff requires a lot more detail in the analysis than was the case 10 or 20 years ago. And at the time when the original study, 0170 was published, there was a lot heavier reliance on test data than there is today primarily because our analysis tools have gotten so much better in the intervening 35 years.

MEMBER ARMIJO: These various tests have been around for 40, 50 years.

MR. AMMERMAN: Yes, they have. Yes,

exactly.

MEMBER ARMIJO: Long before the more modern analytical tools became --

MR. AMMERMAN: Yes, that's right. And that's why I say, that 40 years ago people demonstrated -- were more likely to demonstrate compliance with these environments by testing as opposed to by analysis; although always there was analysis. Might not have been finite element analysis, it might have been hand calculation analysis, but there has always been a component that has been analysis, as well as a component for testing.

CHAIR RYAN: And I guess there hasn't really been too many new designs of casks. I mean, they're all fairly standard these days. Is that right? Have there been some new ones here?

MR. AMMERMAN: There is nothing radically different I would say. Yes, that's true.

CHAIR RYAN: Changes here.

MR. AMMERMAN: I mean, the capacity of the cask is it keeps on going up. You know, there are now casks I think are certified up to 37 maybe PWR assemblies per transport. And if you were to look at 20 years ago, maybe 30 years ago, 12. So, I mean, we've taken essentially the same cask and we've crammed three times as much fuel into it.

MR. COOK: Because the fuel is much cooler.

MEMBER SKILLMAN: What sets that upper limit? Is that the 80,000 gross vehicle weight for a tractor trailer, or is it the maximum for a railroad car? What sets that upper limit?

MR. AMMERMAN: There are several factors that set that. One is the external temperature of the cask, so how much decay heat can you put inside of it. So, if you're transporting older fuel you can transport more, similar decay heat, of course.

I think a big one is the criticality analyses. And we have changed the way we do criticality analysis. Older design casks have flux traps within the basket inside, so it had air space in between cells to reduce the neutron flux that was going from one assembly to another one. And in our more detailed analyses that we've been able to do today on criticality has said that those are needed. So, now you have essentially a thin steel plate that separates Assembly A from Assembly B. And that's one of the reason why we can -- so we can physically fit more. And you're also geometry limited. You can only transport -- you know, legal width on a rail car is 10 feet 8 inches. It's 128 inches wide. That's all you can go down the rail tracks. On the highways it's even less, 102 inches. So, you're limited by geometry, how much more can we go above the 37 that we have now? Not a heck of a lot I don't think because of that restriction.

MEMBER SKILLMAN: Where I was really going is if you had an infinitely decayed fuel assembly, a lot of them, what sets the maximum, the combination of the number of fuel assemblies plus the mass of the cask plus its over pack. And I'm thinking it's either the 80,000 gross vehicle for a tractor trailer, or it's whatever the limit is for a rail car.

MR. AMMERMAN: For rail there really isn't a limit.

MEMBER SKILLMAN: It's 100 tons.

MR. AMMERMAN: You can have rail cars that go significantly more. They just put more axles on them. Now, at a certain point they have a hard time making curves because they --

MEMBER SKILLMAN: It's really the tractor trailer, 80,000.

MR. AMMERMAN: Yes, for truck transport it's been 80,000. And there's movement to change that, so the next one of these risk assessments is done 10, 12 years from now maybe, you might see truck casks that are heavier.

MEMBER SKILLMAN: Okay, thank you.

MR. COOK: So, the casks that were selected for this study include two rail casks, the Holtec HI-STAR 100, which is a steel-shielded rail cask that's always transported with an inner welded canister. The NAC STC, which is a lead-shielded rail cask that can be transported either direct loaded or with an inner welded canister. And the GA-4 which is a DU-shielded truck cask. And we selected those for a variety of reasons which you see here.

Just some quick pictures here to give you a feeling for what we're looking at. These are the rail casks, are about 120 tons, 100 to 120 tons, and the truck cask is close to the vehicle -- well, it's about 55 tons to allow a little bit of head room for the truck and the rest of the vehicle.

In order to do risk assessments you need to use routes that are probably close, so we selected -- I'm going to first, I guess, put our disclaimer out that these are -- what we've used are example routes only, and they do not represent in any fashion any current or planned transport of any spent fuel from any of these destinations to -- or from any of these points of origin to any of these destinations. We just selected these to be generally representative of wide geographic regions across the United States. They represent thousands of miles of both rail and highway through the rural, urban, and suburban areas across the country.

MEMBER BLEY: So, there is a claim that they're at least representative.

MR. COOK: Yes, we don't -- again, you could select different routes, certainly. But would they be significantly different over these kind of mileages that we're talking about, probably not. There's a different code that's used to take -- to do not only routing but to calculate the number of people along the routes, as we were talking about earlier. That's WebTRAGIS, and we used that as input to the RADTRAN code which is the code that actually aggregates the doses for both individuals and to collective populations, as well.

MEMBER ARMIJO: Where is Deaf Smith and Skull Valley? What states are they in?

MR. AMMERMAN: Deaf Smith is in Texas, Skull Valley is in Utah.

MEMBER ARMIJO: Texas and Utah.

MR. AMMERMAN: And Deaf Smith is right on the border of New Mexico. It's in the same salt formation that the WIPP site is in.

MEMBER ARMIJO: Okay.

MEMBER SKILLMAN: Was there an intentional action to make sure that for these exploratory routes places like the Cross-Bronx Expressway, Fort Lee, the Baltimore tunnel, Interstate 90 where it weaves its way through Chicago, those types of very high population areas received the attention that might disarm an angry population?

MR. AMMERMAN: I think yes, and that's part of the reason why we chose Maine Yankee and Indian Point as origins, is that you get those -- the routes that you would take from those northeastern reactors to sites, and so we have routes that go -- the railroad from Indian Point goes right down the eastern seaboard. You know, it goes --

MEMBER ARMIJO: You can't find a --

MR. AMMERMAN: Yes, you know, Philadelphia, Baltimore, goes past the Mall in DC.

MEMBER SKILLMAN: What I was really wondering is if the antagonists would say it's dandy that you have identified those routes, but in Indian Point you went off to the west and you went into the great State of New York where there's no population, for Kewaunee you found your way down through the center of Wisconsin where there are more dairy cows than people. So, the antagonists would say this is dandy, but you really didn't get to the heart of where there's an extremely high population where if the shipment stalled, by golly, there's a real issue. That was the real question I was --

MR. AMMERMAN: Yes. And, actually, I think the highway routes from both Maine Yankee and Indian Point go into -- especially Hanford, they go through Chicago. I mean, they don't go through downtown. They take the route that a spent fuel shipment would take. I mean, it's the real route that shipments would take if --

MEMBER SKILLMAN: That's where the truckers would be assigned.

MR. AMMERMAN: Exactly.

MR. COOK: Just for truck routes, I'd point out that the Department of Transportation does have routing rules. And if there is a bypass, supposed to be on the interstate highways, of course, but if a city has a bypass then you take the bypass, you don't take the direct route like through a city. So, these routes comply with existing DOT regulation with respect to their routing rules. So, other than that then we'd pick routes that we believe do exercise, like the urban corridor on the eastern seaboard, and rural areas, as well.

MEMBER SKILLMAN: Okay, thank you.

MR. COOK: And with respect to our report here, we did have in mind that we thought that the -- you try to ask yourself well, who's going to be the audience for this report, and the answer to that could be just about anyone, everyone from members of the public to other technical organizations both in the U.S. and elsewhere. So, we're tried to use a graded approach when we put the report together. We have both executive and public summaries in the report. Those were written hopefully to be clear to all audiences.

The main body of the report, because this is a technical effort, we tried to keep that information accessible as best we could to a general science for an informed public audience. And then everything else of a more detailed and technical nature were put in the appendices which others could study at their leisure. So, we're trying to make the information as transparent and available as we could.

MEMBER BLEY: So, the public summary is an appendix.

MR. COOK: The public summary is an appendix, yes.

MEMBER BLEY: Was the idea that -- I'm not even sure of the question.

MR. COOK: Well, with the --

MEMBER BLEY: It's --

MR. COOK: The public is probably, if they ever look at this, they're probably going to start in the front.

MEMBER BLEY: It seems likely -- this isn't the thing the public would look at, in a way they'll probably never find it.

MR. COOK: Well, it's odd you mention -- I think we've had it in both locations, but when we put the executive summary, which we wrote with -- there's no numbers in it at all.

MEMBER BLEY: Right.

MR. COOK: It's only two pages, so we thought that that would be -- and if anyone was only going to just take a brief look at this, that's what they would see so we went with the executive summary up front. And then, essentially, the public summary is sort of like a built-in brochure.

MEMBER BLEY: Yes. It almost -- see, it would seem to me that it would be right up front like a brochure or something would be helpful. I don't remember if the executive summary actually pointed people to the public summary.

MR. AMMERMAN: I don't know -- don't think that it does. That's a good point. It could. That could be helpful --

MEMBER BLEY: Because otherwise I think the likelihood of --

MEMBER ARMIJO: That might be very --

MEMBER BLEY: -- the public ever seeing it is pretty low. But maybe we're intending to actually come out with a brochure at some time. I'm sorry.

MR. AMMERMAN: The -- I think the first place we see it is this public summary in the appendices is at the very front of Chapter 1. Chapter 1 has the outline of the report, and I think it's --

MEMBER BLEY: It does, but I don't think it calls it out in the text.

MR. AMMERMAN: It may not.

MEMBER BLEY: I just searched for it when you said it, and the first place it popped up was actually back in the appendix. It is Chapter 6 in Appendix F. It's there.

MR. AMMERMAN: Yes, a plain-language study of the summary. Right.

MEMBER BLEY: Yes.

MR. AMMERMAN: Yes.

MR. COOK: We can certainly add another reference.

MEMBER ARMIJO: Yes, make it a little more visible.

MEMBER BLEY: I would just think -- yes, and actually call it the public summary or something like that, or the brochure. One of your colleague groups over in Research actually put out a brochure on one of their recent studies, maybe not a bad idea. Go ahead. It just seemed to me it was tucked away in a place.

MEMBER ARMIJO: Are you talking about the SOARCA?

MEMBER BLEY: Yes.

MEMBER ARMIJO: Yes. I thought that was a good idea.

MEMBER BLEY: I thought it was a good idea. There were -- never mind. And it was very beautifully presented.

MEMBER ARMIJO: Yes. It takes work to do it right.

MR. COOK: I think we could certainly at least put in additional references to the public summary.

MEMBER BLEY: I think, and the executive

summary, just let people know.

MR. COOK: Sure.

MEMBER BLEY: For the general public there is a smaller -- I mean, a little bigger introduction than this thing you're seeing up front.

MR. COOK: Yes, exactly right.

MEMBER BLEY: Okay.

MR. COOK: Well, if there are no further questions at this point, I would turn it over to Doug for a more in depth discussion of the method and the results, et cetera.

MR. AMMERMAN: Okay. So, my presentation now is going to primarily follow along with the chapters of the report, so I'm going to be talking first about routine transport. Then I'm going to talk about the impact analyses, and then the thermal analyses, and then the accident risk studies, and then the conclusions of the report. So, for routine transport --

MEMBER BLEY: Where is criticality talked about?

MR. AMMERMAN: It's not.

MEMBER BLEY: Yes, and I'm just thinking —-- I mean, it's precluded even if you fell into water and it somehow leaked, it's precluded but it doesn't say that anywhere I don't think.

MR. AMMERMAN: It doesn't.

MEMBER BLEY: So, maybe in the appendix where it talks about certification it might --

MR. AMMERMAN: Actually, I suspect that the word "criticality" is not in this report.

MEMBER BLEY: Well, it's in the appendix, but it's under some compliance or something.

MR. AMMERMAN: Yes, and the reason is because the probability of a criticality event is zero.

MEMBER BLEY: Well, wouldn't it be good to tell people that?

MR. AMMERMAN: Yes, it probably should be—-

MEMBER BLEY: We considered this accident and it's impossible for the following reasons.

MR. AMMERMAN: Yes, yes.

MEMBER BLEY: It's not low probability. It can't happen by design.

MR. AMMERMAN: Yes.

MEMBER BLEY: I think it would be really useful to tell people that. You don't get any public comments like that.

MR. AMMERMAN: No, we didn't, and --

MEMBER BLEY: That surprises me.

MR. AMMERMAN: That is a very good point, is that no -- we sort of just brushed it off because it --

(Simultaneous speech.)

MEMBER BLEY: -- into the water and if it should leak, it can't, you can't have a criticality problem.

MEMBER SIEBER: Well, you have to make sure that this applies only to civilian fuel as compared to all fuel.

MEMBER BLEY: I think that's true, but these casks are for civilian --

MEMBER SIEBER: Criticality is I think possible for some types of high-enriched fuel.

MEMBER BLEY: But for what this study is looking at, I think these guys are right. And I just think I would say so. I'm astonished nobody brought that up. I'm sorry for the diversion. I was looking for the criticality accident --

(Simultaneous speech.)

MR. AMMERMAN: Yes, where it should be is in Chapter 5 that is talking about accident risk.

MEMBER BLEY: Yes.

MR. AMMERMAN: So, yes.

MEMBER BLEY: It doesn't take much.

MR. AMMERMAN: It's very easy to add a paragraph in there. You know, give them the results of these impact and fire analysis that there is no probability of an -- zero probability of a criticality accident.

So, for routine transport the key factor is the dose rate that's coming off the cask while it's going down the road. And the maximum permitted dose rate is ten to the minus four sieverts per hour, or 100 millirem per hour at two meters from cask, of 10 millirem per hour at two meters from cask, or RADTRAN actually uses the dose at one meter from cask which is the shielded TI, transport index, which is a number that people are required to provide. So, that's available for every package.

MEMBER BLEY: Can you give us a two-minute tutorial on RADTRAN, what does it do? What goes in, what comes out?

MR. AMMERMAN: So, for routine transport what goes into RADTRAN is the size of the package and the external dose rate. And then, of course, the route parameters, and how fast you're driving, and all those sorts of things.

MEMBER BLEY: So, RADTRAN looks at maybe you might in traffic, and somebody might be sitting next to you, and all that kind of stuff?

MR. AMMERMAN: It considers all the possible -- well, maybe not all the possible receptors, but it doesn't consider the hitchhiker sat down and jump on the back of the truck. They ride it to, you know -- but it considers the public that is along the route, it considers people that are at stops, it considers people that are sharing the route, we call on-link. It considers workers, it considers inspectors, so the truck driver, the escort vehicles are all -- all those people are considered in the dose that they get, and those are presented in this report.

Essentially, what it does is it's an adding code. It says okay, I have this person, what's the dose he gets? I'm going to add that in and does a summation to calculate the dose of all the possible receptors.

MEMBER BLEY: Okay.

MR. AMMERMAN: Ask me that question again when we get to the accident part, and I'll tell you —-

MEMBER BLEY: Okay.

MR. AMMERMAN: So, in this study the external dose rate at one meter was the number that was presented in the Safety Analysis Report for each package. And for the HI-STAR 100 cask that was 1.03

ten to the minus four sieverts per hour. For the other two casks it was 1.4 times ten to the minus four which is the regulatory maximum. And whether that is the actual -- I think this is one of the places there's some conservatism because what RADTRAN does is it assumes that there's that same dose emitted in all directions at all points from a search of the cask. In reality that number that the cask designers report is the peak dose at any location, so the rest of the cask may be having lower dose and, therefore, we're over-estimating. And then this is, of course, the dose for the hottest fuel that that cask could transport.

MEMBER BLEY: Just to put that in a little perspective for me. This would be the highest legitimate dose you could have, which if you're shipping older fuel it wouldn't be there probably.

MR. AMMERMAN: Exactly.

MEMBER BLEY: But from what I hear from the folks in Europe who have been shipping fuel all along, that is a limiting thing. They hold stuff until it just meets the shipping criteria and then they go. So, at some point in time if we ever catch up we might be doing the same thing.

MR. AMMERMAN: That's right. Yes, exactly. And people say well, how do you transport these casks without testing? Well, this is one place where there is testing. They measure that dose before they let that cask go. They know that external dose is not bigger than this number, so there is a physical test on every transport relative to external dose --

MEMBER ARMIJO: At the peak locations where people expect the dose to be --

MR. AMMERMAN: Yes, they know where the peak location should be, but they don't just measure that one spot. They go check all the way around.

MEMBER SKILLMAN: I've watched that occur, and it always impresses me that the health physicists get done with their survey, and they're out a meter, and a half a meter, and there's a whole document that identifies all of those radiation levels. But in almost every case I've seen the same inspector say are you sure that tire is okay, or are you sure that gizmo in the truck is okay. And I've seen the packages pulled not because of the radiation package or the cask that's on the vehicle, but an actual physical issue pertaining to the trailer. I've seen tires changed, lights changed, license plates that are bent fixed, placards with their broken holders are repaired before the shipment is released. So, there is an inspection part of that that's worthy of respect.

These people really know what they're doing.

CHAIR RYAN: I don't recall the exact number, but there's handfuls of permits on packages this thick to get transportation unit safely in the northeastern United States to the southeast. So, radiation survey is clearly important, and as you pointed out there's a slew of other high-quality documentation packages that have to go with that, it's one of many that gets addressed.

MEMBER SIEBER: It actually goes beyond that. I've seen in every instance that I can recall where the truck driver does his own surveys, and documents everything because he's responsible while that shipment is on the road for everything about that shipment. And they're very -- the ones I have met and talked to are very knowledgeable and very thorough.

MR. AMMERMAN: And, actually, we'll see here at the end of this section on routine transport.

CHAIR RYAN: I'm going to suggest we pick up the pace just a little bit. We're kind of getting—-

MEMBER ARMIJO: Yes, you have a lot of good stuff back here.

MR. AMMERMAN: Yes, the people who get the most dose are those inspectors.

MEMBER BLEY: If you ever say thing about the hitchhikers again, you better tell your audience why there won't be any hitchhikers --

(Laughter.)

MEMBER BLEY: I'm seeing that riding the rails has become more popular again like it used to be, and a lot of young folks are jumping railroad trains around the country these days, so some way we know there isn't somebody sneaking a ride on this. If you're going to say that, I think you've got to tell them why it isn't going to --

MR. AMMERMAN: Okay. So, this slide answers your question about the routes. These show a couple of our -- half of our example routes, and you can see the Maine Yankee route. The interesting thing about this slide is how the Maine Yankee rail route to Oak Ridge goes. You would think it would follow pretty much along the same way as the highway route does, but it doesn't. It goes way west and then comes down.

Indian Point rail route does not. It follows along the eastern seaboard. But you can see we go right through Chicago right here.

MEMBER ARMIJO: Is there any of this route on barges or ships?

MR. AMMERMAN: No, we only looked at rail casks transported by rail, and truck casks transported by truck. Now, there is the possibility that rail casks could be transported by heavy haul truck, or by barge. We did not consider that in this study. Although, if you were to do a real risk assessment for some proposed shipments from some proposed power plants that would be part of the mix because they would transport some by barge, or they would transport some by heavy haul truck. And we also did not consider truck casks transported by rail, which does happen. That's not an impossibility.

MEMBER BLEY: What's the orange route from up in New England down to Oak Ridge?

MR. AMMERMAN: That's the -- you mean what highways is it?

MEMBER BLEY: No.

MR. AMMERMAN: It's the route from Maine Yankee to Oak Ridge.

MEMBER BLEY: Oh, okay.

MEMBER SKILLMAN: Yes, that appears to be the I-95 corridor from New York. That's the one I was talking --

MEMBER BLEY: So, it goes right adjacent to the city.

MEMBER SKILLMAN: Oh, it goes -- it's the Cross-Bronx Expressway. It comes down Long Island, Cross-Bronx, George Washington Bridge, comes across to Pennsylvania and comes down 81. And that is the normal -- that's the vacation route for anybody going to Maine. That's how you do it.

MR. AMMERMAN: Yes.

MEMBER ARMIJO: Now, you didn't extend from Skull Valley down to Yucca Mountain.

MR. AMMERMAN: No, we did not.

MEMBER ARMIJO: Nobody lives there anyway, so I don't -- I can't imagine that would add much to the risk.

MEMBER BLEY: Well, that's where some folks -- they're riding right next to this truck for a long time.

MEMBER ARMIJO: Would you call that analysis?

MR. AMMERMAN: So, the roads that we've looked at span many states, thousands of miles through rural, suburban, and urban areas, and they are adequate to represent other routes. Yes, you could get a little bit different numbers if you have -- for example, a lot of risk assessments that we do we look at the Crystal River to Hanford route. We can't get a longer route than that, so for a shipment from one reactor to one destination site, that one is going to give you the biggest total shipment doses, but it doesn't -- you know, the per exposed mile, the routes are all the same. And then we're stressing again that no shipments are planned from any of the SFTRA's points of origin to any of the SFTRA's destinations.

MEMBER BLEY: Those DOT rules preclude being on single tracks or tunnels. Right? Or not?

MR. AMMERMAN: No.

MEMBER BLEY: No?

MR. AMMERMAN: Yes, first off those rules are AAR, American Association of Railways. And what they say is that they preclude a passing of two trains in a double bore tunnel, or a single bore tunnel with two tracks. So, if there's a single bore tunnel that has two tracks, while they're in that tunnel they're not allowed to pass another train.

MEMBER BLEY: So, they have to hold up.

MR. AMMERMAN: So, they have to hold up one or the other.

MEMBER BLEY: Okay.

MR. AMMERMAN: Right. To prevent the two-train accident in the tunnel.

MEMBER BLEY: Yes.

MR. AMMERMAN: The WebTRAGIS route tool determines the urban, suburban, rural route segment --

here's an example of the I-80 corridor through Salt Lake City, and you can see that on the east and west of town you rural populations. In the suburbs you have suburban populations, and going through the heart of the city you have urban population. And it's a little bit confusing, I think, the nomenclature that's used for between urban and suburban, and it's somewhat arbitrary.

The way RADTRAN treats urban is that it assumes that urban is heavily built up, which it is. And it's primarily multifamily dwellings, brick buildings as opposed to wood frame buildings or concrete buildings. And that's not always the case in places that have urban population. If you have wood frame houses cheek to jowl, people with no yards, essentially, you're going to be in an urban population density. So, if you look at some places that are suburban, it's not New York, it's Trenton or something like that, it still has urban population density, and some parts in the center of the city, nobody lives there maybe, and so it could not have urban population density.

The factors that affect the routine dose, how long you're exposed, so how fast the vehicle goes, how often does it stop and how long does it stop, how often is the package inspected, the number of people exposed, so the population as to traffic density and number of people per vehicle, and what is the dose that they're getting? So, the external dose rate from the package which is not listed on here but probably should have been, the shielding provided by housing. For rural areas we assume that people are outside, suburban areas there's 13 percent of the dose that's shielded by the housing, and 98 percent is shielded for urban population densities. And then how far they are from the cask at stops.

These are different types of exposed populations that are considered by RADTRAN in the study which I've talked about earlier, residents along the route, the people on the route, people at stops, and inspectors. So, who's getting the biggest dose?

The maximally exposed individual is -- now, this is the maximally exposed public individual, so this is not counting workers and inspectors. We consider the person at 30 meters as the closest that RADTRAN assumes people are to an interstate. Vehicles we're looking at 24 kilometer per hour, so it's pretty slow. I think that's 15 miles per hour for both truck and rail. And you could see that the total dose that they get there is pretty small. And that's about the same as one minute of average background dose. So, the maximally exposed individual from a shipment going by gets about the same dose that he gets from background from being alive for one minute.

And you can see the total collective dose for truck -- this is truck transport is on the order of ten to the minus three person-sieverts for the various routes studied. And that the -- you look at the numbers on the right in the longer routes at the higher dose, as you would expect.

And I think this slide really demonstrates, first off, that total dose is negligible compared to background. That big blue circle is all background, and that teeny tiny little slice is the dose that you get from the transportation of radioactive material. And you can see how that's broken up, that the inspector is the lion's share of that. It's almost half of it is the inspector dose.

MEMBER ARMIJO: Just to make sure I understand this chart. The blue represents the total background dose during the same period of time that this transportation is occurring, it's not an annual thing?

MR. AMMERMAN: It's not -- for the 10 hours, I think this is 10 hours from --

MEMBER ARMIJO: Okay.

MR. AMMERMAN: This is the Maine Yankee to Oak Ridge, assume that it took 10 hours, 11 hours, something like that.

MEMBER ARMIJO: So, in that same period of time this is what you get from background.

MR. AMMERMAN: Yes, exactly. So, in summary for routine transportation the individual and collective doses are very small. The maximum individual dose is comparable to background dose, and the collective doses for routine transport are several orders of magnitude smaller than the collective background dose.

MEMBER BLEY: How does it treat the person traveling the same route? Does it assume they're always at a constant distance from the truck? I mean, in the real world you wouldn't be there very long, but you could be there --

(Simultaneous speech.)

MR. AMMERMAN: Actually, there's --

MEMBER BLEY: So, what does it do? What does the code assume?

MR. AMMERMAN: The code assumes that -- I believe that somebody is next to the truck --

MEMBER BLEY: They're escorted, aren't

they?

MR. AMMERMAN: Well, there's the escorts as well, yes. And that's part of the worker dose that's included there. But an individual could be next to the truck, and I don't know exactly what the period of time is. It assumes the truck is traveling at two different rates of speed. Well, in urban areas at different rates of speed, 90 percent of the time it's not during rush hour, and 10 percent of the time during rush hour. So, for rush hours it halves the speed and it doubles the traffic density so there's a lot more people on the road. And it considers both traffic going -- that you're meeting is exposed for a very short period of time, and traffic that is going in the same direction. And, actually, one of the backup slides that we have shows a model of that.

MEMBER BLEY: Why don't you go ahead. If we have time at the end you --

MR. AMMERMAN: Okay. So, it considers traffic flowing in the opposite direction in its top lanes, as well as traffic flowing in the same direction.

MEMBER BLEY: What I was after was that guy who's nearest to it, how long does --

MR. AMMERMAN: I think it doesn't count the person next to it for very long. I think it -- you see this min here, it says that that's the closest person that he's following, not adjacent.

MEMBER BLEY: Okay.

MR. AMMERMAN: Okay, now do you remember which line I was on?

MR. COOK: Yes, 22.

MEMBER SKILLMAN: I guess these guys, whoever designed RADTRAN never went home on 270.

(Laughter.)

MR. AMMERMAN: Actually, the people who designed it live in Albuquerque, so --

(Simultaneous speech.)

MEMBER SKILLMAN: I know you could be forced to be adjacent to a tractor trailer for an extended period, for a long time.

MR. AMMERMAN: Yes, and I'm not positive that that is accounted for in RADTRAN. That is a good comment.

MEMBER BLEY: That's the one I was -- I was wondering how you did that.

MEMBER SKILLMAN: Abiding time that you're forced -- and I would say that that is particularly true on 270, and 95, 495, but particularly that corridor coming down out of New England, that 95 corridor across the Cross-Bronx, George Washington Bridge down into New Jersey on the 95. I had seen that closed for an hour, two hours, and people are in lock step. They can't get off, can't get on.

MEMBER BLEY: I second that. I've been in—-

MEMBER SKILLMAN: And you've got a riding partner with you.

MEMBER BLEY: Or no speed.

MEMBER SKILLMAN: Yes. And you might put on your brakes and let the truck go ahead. You'll probably get shot.

MEMBER BLEY: I would probably try not to go through there at those times, but if they get caught in that --

CHAIR RYAN: We're getting to the halfway point. We've got to take a break.

MEMBER SKILLMAN: I think it's worth adding some consideration into this long --

CHAIR RYAN: We probably are behind schedule by a good bit on this part. Is that right?

MR. COOK: We are about -- there are 50 slides in the package, so 25 is halfway.

(Simultaneous speech.)

CHAIR RYAN: We need to be done with that at 10.

MR. AMMERMAN: Actually, this is a very good time to take a break because this is the last slide on routine transportation, and now I'll start talking about accidents.

MEMBER ARMIJO: Well, before you do that, you know, routine -- years ago I had to ship fuel, spent fuel from California to Sweden and back meeting all the DOT stuff on a ship went through the Panama Canal, up the eastern seaboard, Port of Halifax across the ocean, very complicated stuff. But it was also preplanned, so a lot of these route issues and everything else, the times when the shipments are made, where they go, the escorts, all that stuff is preplanned, so a lot of the things that maybe we're raising as a concern, people have --

MEMBER BLEY: Things happen, Sam.

MEMBER ARMIJO: Yes.

MEMBER BLEY: Railroads hold the cars for a lot longer than you thought they would because of other needs on their track. They do that, and all of a sudden -- you didn't want to be there.

MEMBER ARMIJO: I understand that. But, I mean --

MEMBER BLEY: An accident on the highway and all of a sudden you're backed up and you're sitting there for three hours.

MEMBER ARMIJO: They don't pick the rush hour to take the truck.

MEMBER BLEY: It doesn't take a rush hour to shut down a freeway.

MEMBER ARMIJO: At 2 and 3 in the morning, I think it's --

MEMBER BLEY: Doesn't, takes an accident.

MEMBER ARMIJO: It takes an accident, yes.

MEMBER BLEY: Shuts you down.

MEMBER ARMIJO: The number of people on the road is much smaller and your normal heavily congested, so --

MEMBER BLEY: Especially out where you live.

(Simultaneous speech.)

MEMBER BLEY: At 3 in the morning you stop that traffic and in not long it's going to be completely filled up.

MEMBER ARMIJO: The other question I had is, you know, the -- we do have a lot of eastern seaboard plants. And I can mention Crystal River. I just wondered why analysis wasn't made about shipping over water on ships or barges, or whatever. Is that going to be done in the future?

MR. AMMERMAN: I think the biggest reason is because, you know, we said the nearest person is 30 meters from here. Well, if you're shipping out on the open water the nearest person could be --

MEMBER ARMIJO: It's a crew.

MEMBER BLEY: Yes, and you have no dose to public essentially because everybody is far away. And I think that's the biggest reason that it's not in here, because the answer isn't very interesting.

MR. COOK: And another consideration is when we do these studies we try to keep a commonality amongst them so that we can do comparisons as we go forward in time. And that the large transport, for example, is not considered in the previous studies, but would be considered in any site-specific assessment that would be done. But in order to keep the results comparable with the previous efforts we have kind of stuck to the simple truck, simple --

MEMBER BLEY: Very good.

MR. AMMERMAN: Mike, do you want to take the break now, or do you want me to continue?

CHAIR RYAN: It's up to you. I mean --

MR. AMMERMAN: I would like --

CHAIR RYAN: This is the entire packet of slides that you're doing?

MR. AMMERMAN: Yes.

CHAIR RYAN: Oh, okay, so we're in pretty good shape then. If this is a good breaking point, we can take a 15-minute break here, if that suits everybody.

MEMBER BLEY: So you want us back at 10 after?

CHAIR RYAN: That would be 17 minutes, but I guess so.

(Whereupon, the proceedings went off the record at 9:51:50 a.m., and went back on the record at 10:06:22 a.m.)

CHAIR RYAN: Let's go. I'm going to turn it back to you, John. You're up.

MR. COOK: We're still with Doug at the present time.

MR. AMMERMAN: Okay. So for impacts, casks are required to stand a 30-mile per hour, 48 kilometer per hour impact onto a flat essentially unyielding target in the most damaging orientation. And the NRC requires conservative approaches to demonstrate this. We have a limited set of materials that you're allowed to use. You want to use ductile materials. You'd use minimum material properties instead of actuals. You don't allow stresses that are up to the failure point.

So, all these things combined assures the cask will survive an even more severe accident than this 48 kilometer per hour one.

So, we did finite element analysis of casks at 30, 60, 90, and 120 miles per hour, or 48, 97, 145, and 193 kilometers per hour on the rigid targets. Now, recall on this slide I said essentially unyielding. A physical test is always on to an essentially unyielding target because there is no such thing physically as a rigid target. But in finite elements rigid is possible.

MEMBER BLEY: You can make things rigid.

MR. AMMERMAN: So, that is what we used.

MEMBER BLEY: And rigid means it doesn't move at all.

MR. AMMERMAN: It does not move, exactly. It absorbs zero energy. The response was determined using a Sandia-developed code PRESTO. It's a non-linear transient dynamic explicit dynamic finite element code. It's very selected in commercial code, LS-DYNA.

The fuel region was treated as a homogenized mass, and I'll get into a little bit more detail on that why that was. Actually, the fuel, of course, is made up of individual assemblies and when we started this we thought well, the response of those assemblies is going to be important, but we didn't want to include the level of detail in this global model that you need to determine the response of the assemblies, so we did an assembly model separately.

As it turned out, the response of the fuel wasn't important because you had to have such a severe impact in order to fail the casks, and we never failed the casks by fire, the seals by fire.

MEMBER BLEY: You never failed the seals.

MR. AMMERMAN: We never failed the seals in a fire environment. None of the fires we looked at caused seal failure.

MEMBER ARMIJO: But was that limited by the 30-minute fire --

MR. AMMERMAN: No, we looked at all fires.

MEMBER ARMIJO: Okay.

MR. AMMERMAN: So, because we only got cask failure when we got to severe, very severe impacts, at that time it doesn't matter how the -- the fuel is just all going be banished. It's going to all -- you're going to get cladding failure in all the fuel assemblies.

MEMBER BLEY: You used two terms that I don't know what they mean in that sentence.

MR. AMMERMAN: Okay.

MEMBER BLEY: Cask damage and severe.

MR. AMMERMAN: Okay, so the only impacts -- and I'll get into this in a couple of more slides, the only impacts that cause seal failure were the 90 mile per hour, 120 mile per hour impacts in the side orientation.

MEMBER BLEY: And that would -- but the seals are protected by those cushion things. So, what did you do about those? Did they get hit directly --

MR. AMMERMAN: They're in there and you'll see that in a couple of slides.

MEMBER BLEY: Okay. I'll wait.

MR. AMMERMAN: And at those high-speed impacts the acceleration on the cask is sufficient enough that it's going to fail all the fuel. So, how well you modeled the fuel didn't make a difference because it's all going to be --

MEMBER BLEY: That means cladding will crack.

MR. AMMERMAN: Cladding is cracked.

MEMBER BLEY: You've cracked others then.

MR. AMMERMAN: Yes.

MEMBER BLEY: Now, just for my orientation, and I don't know if you can do this, but the cask drop test onto the pin on that unmoving surface, or almost unmoving surface, is there any way you can correlate that to one of these speeds? I know this is a pretty severe event.

MR. AMMERMAN: The cask drop is a 30 mile per hour impact, so the regulatory impact is 30 miles per hour onto the rigid target.

MEMBER BLEY: It's actually moving at 30 miles an hour?

MR. AMMERMAN: It's moving 30 miles per hour. Right.

MEMBER BLEY: And it's hitting the --

MR. AMMERMAN: And it's hitting a --

MEMBER BLEY: -- target that's more fixed than anything it's going to hit in the real world.

MR. AMMERMAN: Most likely --

MEMBER BLEY: And maybe more pointed.

MR. AMMERMAN: As a matter of fact, when we do tests at Sandia, the target that I have is two kinds of concrete on top of 10 inches thick of battleship armor. So, that's what I call an essentially unyielding target.

MEMBER BLEY: And that's pretty good. And that's not like much of anything --

MR. AMMERMAN: You don't see that in the

real world, exactly. Yes.

MEMBER BLEY: So, it's 30 mile an hour onto that --

MR. AMMERMAN: Yes.

MEMBER BLEY: -- which there's no real way to correlate that to a real accident at a higher speed, is there?

MR. AMMERMAN: We attempt to.

MEMBER BLEY: Okay, that's what I wanted you tell me about if you can. I've never seen that before. I know it's very severe, but I don't know how severe compared to these others.

MR. AMMERMAN: So, this is an example of worst case impact for lead slump. This is 120 mile per hour impact onto a rigid target in CG over-corner orientation. There is no leak path formed so there's no release. But there is lead slump, and you can see the amount right here.

MEMBER BLEY: So you could get some streaming.

MR. AMMERMAN: So, you get some streaming, exactly. And here you can see that impact unfolding. Let's try that one more time.

MEMBER ARMIJO: How exaggerated are these scales?

MR. AMMERMAN: This is not exaggerated. This is --

MEMBER ARMIJO: This is actual

MR. AMMERMAN: Actual, yes.

MEMBER ARMIJO: Okay.

MR. AMMERMAN: So, you can see that you get some buckling down here at the bottom of the lead liner area, or the shell outside the lead. And that area grows. And primarily that buckle is caused by the hydrodynamic stress caused by the lead. And at this kind of accelerations that lead acts like fluid. And it's going out and push out that liner.

MEMBER SKILLMAN: Is the lead -- are the properties of the lead such that the lead is limiting on the strain rate. It is the flow rate of the lead that causes that dimple and nothing else as material properties that will also flow?

MR. AMMERMAN: No, actually you may get buckling in that area even if you didn't have lead in there, so instead of lead you had that with an influid rigid -- well, not --

MEMBER SKILLMAN: So, rigid steel it might still -- it would probably still buckle.

MR. AMMERMAN: Yes, yes.

MEMBER SKILLMAN: But you get the void as a consequence of the strain rate when the lead actually goes fluid.

MR. AMMERMAN: Yes, exactly.

MEMBER SKILLMAN: Yes, okay.

MEMBER BLEY: And this is 120 mile an hour into something that doesn't move at all.

MR. AMMERMAN: Exactly.

MEMBER SKILLMAN: And that's a corner --

MR. AMMERMAN: That's a corner, yes. And then now to get to your question on the side impact that happens. This is -- this picture is from a 90 mile per hour impact, but the behavior is similar at 120 as well. And you can see right at this location that you've got deformation enough that you have a leak path, and this particular cask has two lids, an inner lid and outer lid. And the deformation on the inner lid is also enough that you get a leak path right through here.

MEMBER ARMIJO: So, those are bolted lids?

MR. AMMERMAN: Those are bolted lids, correct.

MEMBER BLEY: Both of them.

MR. AMMERMAN: Both of them, yes.

MEMBER BLEY: And that inner lid, there's not much of a leak path but there's a leak path.

MR. AMMERMAN: Exactly. And it's enough that you get blowdown quickly. So, any internal pressure is blowing down in the order of seconds, not minutes or hours.

MEMBER BLEY: And you also said all the fuel is cracked so anything that's --

MR. AMMERMAN: Exactly.

MEMBER BLEY: -- gaseous and pressurized will come out.

MR. AMMERMAN: Exactly, yes. So, this is our worst case response.

MEMBER BLEY: In terms of material.

MR. AMMERMAN: In terms of material release, exactly. Yes.

MEMBER SCHULTZ: But the case chosen here, the previous slide was 120 miles an hour. This happens to have been chosen at 90 miles an hour.

MR. AMMERMAN: Yes.

MEMBER SCHULTZ: So, in the cases your analyzed this is the worst one. Is that what you're saying?

MR. AMMERMAN: Yes, the response --

MEMBER SCHULTZ: It could have been higher than 90 miles --

MR. AMMERMAN: The response at 120 miles

per hour isn't any different than this.

MEMBER BLEY: Really? The gaps are --

MR. AMMERMAN: The gaps are bigger, but the cask blows down in a short period of time. The consequences are the same. Accelerations are already enough that you failed all the fuel.

MEMBER ARMIJO: In those cases, the 120 miles an hour and 90 mile, if you had an inner welded canister you would not have a leak?

MR. AMMERMAN: Correct, there would be no release if you had an inner welded canister.

MEMBER ARMIJO: Okay.

MEMBER SKILLMAN: That assumes that weld does not tear. That assumes you --

MR. AMMERMAN: The stresses in that weld are not high enough to make a tear.

MEMBER SKILLMAN: Understand.

MR. AMMERMAN: So, we modeled that region.

MEMBER SKILLMAN: Okay.

MR. AMMERMAN: So, in the side orientation at 60 miles per hour onto a rigid target we didn't get any leak path, so in that case this gap here on the inner lid was small enough that the seal was able to remain sealed.

MEMBER BLEY: Now, is it -- I asked this

before and maybe you're still coming to it. Is there any way to correlate a side impact onto a rigid target to some other speed into some normal things you might really crash into?

MR. AMMERMAN: I think in our backup slides we have a set of slides that talks about how we --

MEMBER BLEY: Do we have your backups?

MR. AMMERMAN: Yes, you have them in your packet.

MEMBER BLEY: That's not in the report, is it?

MR. AMMERMAN: It's in the report, yes.

MEMBER BLEY: Oh, it's in the report?

MR. AMMERMAN: Yes, yes, yes. It's called impact --

(Simultaneous speech.)

MR. AMMERMAN: Okay. And I'm going to not go through -- jump to that right now, but --

MEMBER BLEY: That's fine.

MR. AMMERMAN: -- but if we have time at the end we'll look at this, and we'll show you that.

So, from the side impact at 60 miles per hour we assume -- the risk assessment assumes that if it's an impact into hard rock which is 5 percent of the target above 50 miles per hour because that's what the advantage ring has as a branch point in it, result in a leak path. So, we add some conservatism there.

If you don't hit hard rock no impact no matter how fast it is at recorded accident velocities is severe enough to cause a release.

MEMBER BLEY: A bridge abutment is like hard rock, or no?

MR. AMMERMAN: A bridge abutment is not like hard rock.

MEMBER BLEY: Okay.

MR. AMMERMAN: A bridge abutment is like soft rock.

MEMBER BLEY: Okay.

MR. AMMERMAN: Or concrete, and we did analyze concrete.

MEMBER BLEY: Right.

MR. AMMERMAN: So, that's one of the things that's in that. And you'd have to be going, I don't remember exact number, but let's say over 150 miles an hour in order to impact the target to cause this level of damage. And there are no accidents that are that fast.

MEMBER BLEY: So, the event tree is 50 mile an hour into hard rock, or just 50 mile an hour?

MR. AMMERMAN: The event tree is 50 mile --

- well, that's an interesting question.

MEMBER BLEY: Does it ask that, or is it conservative in a sense?

MR. AMMERMAN: The event tree, the real event tree says accidents at 50 miles per hour. And then we said okay, independent of impact target. But we did a survey of what is the possible targets, and that actually is in the rail-- in the truck event tree, not in the rail event tree. But rail going the same place as the truck lines do, so the wayside surfaces are the same. So, that's where that 5 percent hard rock number came from.

MEMBER BLEY: Okay.

MR. AMMERMAN: The accident is a free drop onto a rigid target with the accident velocity perpendicular to the target. So, it's -- normally speaking you don't drive straight into the surface that you're driving on. You drive along it, so there's some probability that -- and most likely it's the case that if you have an accident it's a glancing accident. You have a low angle of impact, in this picture is close to zero. We assumed a triangular distribution on impact angle with theta being zero the most likely, theta being 90 the least likely, and you come up with these different probabilities binning those into 10 bins or 9 bins of impact angle. And then in the second column you see what the velocity would have to be, the accident velocity, how fast the truck would have to be going or the rail car would have to be going in order to have the component that's into the surface be equal to in this case 60 miles per hour. And you can see that it has to be less than 30 degrees in order for that to be -- or if it's less than 30 degrees, I mean, if it's less than 30 degrees or maybe even less than 45, you have to be going more than 120 miles per hour in order to have the same response as 60 miles per hour. And only above 10 percent of the accident are greater than 45. Well, we assumed a third, actually. So, if only a third of the accidents, because of impact angle are going to cause that --

MEMBER BLEY: Was that a judgment kind of distribution, or did that come out of some actual accident --

MR. AMMERMAN: That was a guess.

MEMBER BLEY: Okay.

MR. AMMERMAN: There is no data to support that, and the previous risk assessments have assumed that it's a uniform distribution as opposed to a triangular distribution. But I think that is overly conservative because, like I said, you don't track it.

You never travel perpendicular to the surface you're traveling on.

MEMBER BLEY: Not for long.

MR. AMMERMAN: You travel parallel to it, so the skew is going to be towards the low angle impacts as opposed to the high angle impacts. Whether the skew is triangular or it's parabolic, even a higher probability at those low impacts is probably more close to reality.

So, in summary only one in 2,000 accidents is more severe than the regulatory hypothetical accidents. Only one accident in 2,000 is worse than that 9 meter drop onto a rigid target.

MEMBER BLEY: Just to put this in perspective for me, I could see sliding, a skidding accident somehow or a flip into a bridge abutment or tunnel entrance as a possibility, but it's low in likelihood. The other one would be coming off of a bridge and falling onto hard rock.

MR. AMMERMAN: Yes. And, actually, falling off a bridge we assumed a uniform distribution as to impact.

MEMBER BLEY: That's fair enough.

MR. AMMERMAN: So, yes.

MEMBER ARMIJO: If there's a truck

overturns and the cask just tumbles down a mountainside, many impacts, all of them small compared to what --

MR. AMMERMAN: Right.

MEMBER ARMIJO: Have you analyzed multiple impacts?

MR. AMMERMAN: We have not but we assumed that those are -- like you said, they're all small. None of them are going to cause --

MEMBER ARMIJO: Well, they're small --

MR. AMMERMAN: Yes, right. So, the impact number is going to be able to absorb that energy because they're all small impacts.

MEMBER BLEY: Just for the heck of it, in an accident like that could those limiters, they get dinged a bunch of times, can they actually get knocked off?

MR. AMMERMAN: Possible but highly unlikely. You could perhaps postulate an accident --

(Simultaneous speech.)

MR. AMMERMAN: -- there's a cushion up here, and then you're coming down at an angle and you hit a rock here, and it drives the --

MEMBER ARMIJO: Yes.

MR. AMMERMAN: You can postulate that

accident.

MEMBER ARMIJO: Yes, I don't know that these are routes that anybody would take, but in the Sierras in the Nevada area where I live --

MEMBER BLEY: Well, in Utah there's a lot like that --

(Simultaneous speech.)

MEMBER ARMIJO: -- pretty bad cliffs and things.

MEMBER BLEY: Yes.

MR. AMMERMAN: And rolling down a slope is not a severe accident though, I think.

MEMBER ARMIJO: Bouncing down --

MEMBER BLEY: A 30-foot bang, a 50-foot bang.

MEMBER ARMIJO: You may have all sorts of things you could never --

MR. AMMERMAN: Exactly, right. So, one of the 2,000 accidents is more severe than your hypothetical accident, but only --

MEMBER SKILLMAN: Say that again.

MR. AMMERMAN: One in 2,000 is more severe than the regulatory accidents. I mean, the 9 meter impact onto a rigid target. But because the conservatism of cask design only one in a billion accidents is severe enough to cause a release or loss of gamma shielding.

MEMBER SKILLMAN: How do you derive the one in 2,000?

MR. AMMERMAN: The one in 2,000 comes from the event tree. And looking at, okay, if I'm impacting onto --

MEMBER BLEY: So, that's got your judgmental distribution factored into it.

MR. AMMERMAN: Exactly, yes.

(Simultaneous speech.)

MR. AMMERMAN: It has the distribution of wayside surfaces, so the difference --

MEMBER BLEY: Now, that's more -- that's not completely judgment.

MR. AMMERMAN: No, that's data.

MEMBER BLEY: That's data.

MR. AMMERMAN: That's data. So, by impacting onto soil it takes a much more severe accident than -- what do you hit most of the time when you go off the road, you know, soil.

MEMBER BLEY: Depends where you live.

MR. AMMERMAN: In some places you hit rock, and -- but when you're going across Nebraska, good luck finding a rock.

MEMBER BLEY: It's hard.

MR. AMMERMAN: Yes.

MEMBER BLEY: And you're going across Utah, and --

MR. AMMERMAN: So, that's what in that one in 2,000. The one in a billion comes from the finite element analysis saying that you have to have these very severe impacts in order to cause a release. So, what is the event tree that leads to that? And, actually, in the backup slides there's a detail of where that one in a billion comes from.

MEMBER BLEY: So, that's starting with one in 2,000 to have any chance of doing this?

MR. AMMERMAN: Actually, it's -- yes. Well, it's starting with -- assume that you have an accident, and then that the accident is faster than 60 miles per hour, and then that the accident is on to a hard target, and that the angle is less than 30 degrees.

MEMBER BLEY: And that's all in that first one in 2,000, right?

MR. AMMERMAN: No, that -- because it has to be more than 60 miles per hour now. It's not in that one in 2,000.

MEMBER BLEY: Oh, the 60 mile an hour isn't any more severe.

MR. AMMERMAN: The 60 mile an hour is in —-- yes, because -- the one in 2,000 is more than 30 miles per hour onto a rigid target.

MEMBER BLEY: Oh, okay, because that's the -- okay.

MR. AMMERMAN: Yes, yes.

MEMBER BLEY: I'm sorry. Mixed some things up.

MR. AMMERMAN: Okay. And then if you have a real cask, an inner welded canister, no release in any accident. You never fail that welded canister.

MEMBER BLEY: In anything you both did.

MR. AMMERMAN: In any of the accidents we looked at.

MEMBER BLEY: Well, what kind of -- now, that's a never. Now, there's a guy we work with who's just been looking -- I'm not saying this to pick on you, but been looking at meteorites of different sizes. You're up in numbers that are getting close to meteorites of this size, which would go through all this stuff like nothing.

MR. AMMERMAN: Yes, exactly.

MEMBER BLEY: So, we've got to be careful with these numbers.

MR. AMMERMAN: In order of probability the sun supernovas. I mean --

MEMBER BLEY: Well, you aren't there yet.

MR. AMMERMAN: Actually --

MEMBER SCHULTZ: You have to multiply by two, and then you have the meteorite --

MR. AMMERMAN: It's close. It's real close. The probability of the sun supernovas is something like one in 10 billion. So, it's --

MEMBER BLEY: Pretty soon you have --

MR. AMMERMAN: Yes, right.

MEMBER ARMIJO: Then you have a number beyond which, you know --

MEMBER BLEY: It doesn't happen.

MEMBER ARMIJO: Yes.

MR. AMMERMAN: It's how fine do you want to cut your zero. But when you start cutting it any finer than this you really get in trouble.

MEMBER ARMIJO: Yes. You actually --

MR. AMMERMAN: Not that it matters, but you start --

MEMBER ARMIJO: It becomes less feasible even though it should be.

CHAIR RYAN: You know, I think the message is whether it's the media or the other one in a billion, the supernova, the takeaway message is the probability of those events is orders of magnitude to model what are important events from a more realistic perspective. And rather than getting sucked in the vortex of solar explosions, I think we ought just kind of -- the takeaway message for me is you have clearly identified a range of reasonable accidents. And it's very unlikely to get anything more severe than what you've already told us.

MR. AMMERMAN: Yes, so that 60 mile per hour side impact into a rigid target that can cause damage to the cask and result in seal failure produces a force of 45 million pounds, is equivalent to 115 mile per hour impact into a concrete roadway or a bridge abutment, so there you have -- and it's equivalent to 153 mile per hour impact into hard soil. So, if it hits soil you never have impacts more than 153 miles per hour, so you're never going to fail the package if you hit soil.

MEMBER BLEY: What I remember is that your wonderful driving trains full of stuff into your solid walls is generally a much lower impact than this simple drop test.

MR. AMMERMAN: Exactly.

MEMBER BLEY: It isn't spectacular.

MR. AMMERMAN: It's spectacular, you better believe it. Yes.

MEMBER SKILLMAN: There is an assumption that is woven through your presentation, and that is that the mechanical closure for the not welded cask, that the mechanical closure is properly fixed. I know of a number of instances where the bolting pattern was missed. The key was not recognized and while the container was snug and tight, it was not truly leak-tight because the bolting allowed the seal plate to be affixed in one segment out on the bolting pattern. We discovered that with dimples on the underside where the key was actually impacted by the torque on the bolt.

What is it that assures that your assumptions are sound in terms of the mechanical closure being where it needs to be where you have elastomeric seals engaged for the sealing.

MEMBER BLEY: Or have you built in a human error component?

MR. AMMERMAN: Somewhat a little bit of both of those things. In the analyses we did, we did not assume that you -- we had pre-torqued the bolts, so that was a conservatism that we had in our analysis, so that the -- now, the offset if you have

-- and I don't believe that any of the casks that we had that we looked at have a key way so that any hole pattern is adequate. If you cock the lid one hole over it doesn't matter. They don't have that fixed orientation on them. So, that we did not consider, but we did consider the fact that what if they improperly torqued them? So, we'll just assume they didn't torque them at all. So, that was built into our analysis, that human error. The other human error that you talked about was not, if you had a cask that was --

MEMBER BLEY: And if they didn't torque them at all what did the results say?

MR. AMMERMAN: That's what these analyses are. All of these analyses are untorqued bolts.

MEMBER BLEY: Oh, is that right?

MR. AMMERMAN: Yes.

MEMBER BLEY: All of the cases were opening again?

MR. AMMERMAN: Yes.

MEMBER ARMIJO: That's hard to believe. I'm sorry, but that's hard to believe. Untorque -- you just basically finger-tight bolts --

MEMBER BLEY: But remember within the last year we had a reactor vessel --

MEMBER ARMIJO: Yes, I know. No, it's hard to believe it wouldn't leak.

MEMBER BLEY: Oh, I'm sorry.

MEMBER ARMIJO: Yes, I totally believe people can forget to torque the --

MEMBER BLEY: Okay. I'm sorry, I misunderstood your comment.

MR. AMMERMAN: All these casks are subjected to a pre-shipment leak test, so they -- at least the cask -- the lids are tight enough that they don't leak because they've been demonstrated by a pre-shipment leak test.

MEMBER ARMIJO: But even if they're not leaking, they're not really torqued up to their specified values. And you're saying in these severe impacts they still won't leak until you get over 60 miles an hour.

MR. AMMERMAN: Right. Well, actually, that's probably not completely true. We assume that the starting place was metal to metal. If you had no torque in the bolt you wouldn't get down to metal to metal on the lid onto the sealing surface.

MEMBER BLEY: So, the kind of error we saw in the reactor vessel -- now, would it have passed a leak test though?

MEMBER ARMIJO: It depends on the seal

material.

MEMBER BLEY: Do they test both inner and outer seals?

MR. AMMERMAN: Yes.

MEMBER SKILLMAN: Let me ask one more. So, now we've got this cask. It's almost ready to be --

(Simultaneous speech.)

MEMBER SKILLMAN: -- applied, and one who's standing back looks at it and say it looks okay, but say the nuts are just finger-tight. They weren't torqued down to their sealing value. Is the torquing on those bolts essential for the design of that plate to prevent ovaling the entrance. In other words, is the tightness of those bolts required for the structural integrity of the cask itself should the cask be impacted in its most adverse geometry?

MR. AMMERMAN: This is very typical of a lid design that you have an offset in it like this. And that's actually done for -- primarily one of the main reasons for streaming, so you don't get a streaming path. So, the prevention of ovaling is done by that surface, that lid that --

MEMBER SKILLMAN: That lid?

MR. AMMERMAN: Exactly.

MEMBER SKILLMAN: Now, let's say that even if your bolts are finger-tight, and even though the cask might weep or leak, the finger-tight bolts does not defeat the ability to prevent ovaling of the entrant in.

MR. AMMERMAN: Yes, correct.

MEMBER SKILLMAN: Got it. Okay, thank you.

MR. AMMERMAN: Okay.

MEMBER BLEY: I don't know if this is the right time to ask, but I suggested that I ask about the RADTRAN and how it's handled to make sure --

MR. AMMERMAN: Two more chapters.

MEMBER BLEY: Okay.

MR. AMMERMAN: I'm on Chapter 3 now.

MEMBER BLEY: Right.

MR. AMMERMAN: I'm sorry, that's --

(Simultaneous speech.)

MR. AMMERMAN:

CHAIR RYAN: I just want to crack the whip. I don't want to miss anything.

MR. AMMERMAN: Similar to the impact for fires, canister design group to withstand a fire accident, hydro carbon fuel the fire for 30 minutes, generally demonstrated by analysis using a prescribed monitor condition of 800 degrees C. Real fires have temperatures that vary both with time and location, but the average heating is similar to that for that uniform monitor condition, and review requires both the CO and fuel temperatures to stay below failure thresholds. So, just like we have conservatism in the impact analysis, we have conservatism in the fire analysis, and casks will survive a longer than 30-minute fire.

We looked at three different fire scenarios all burning for three hours, the first one with the cask engulfed in the fire so that the fire is this orange region. You can't see the cask at all, it's completely engulfed during the fire.

MEMBER BLEY: This is an oil fire?

MR. AMMERMAN: This is a kerosene fire.

MEMBER BLEY: Kerosene fire.

MR. AMMERMAN: Jet fuel.

MEMBER BLEY: Jet fuel fire.

MR. AMMERMAN: In our case where the fire is offset by three meters, so three meters from the edge of the cask at the edge of the fire. That's one rail car width. Or another case where the cask is offset by 18 meters, that's one rail car length.

MEMBER BLEY: Let me ask a quick question. The reason you did more than the fully engulfing fire, is it because you might get some kind of differential expansion in this thing if it's not in the middle of the fire?

MR. AMMERMAN: No, it's because the fully engulfing fire has a lower probability.

MEMBER BLEY: Okay, so you wanted each case to work into the risk assessment.

MR. AMMERMAN: Yes, yes.

MEMBER BLEY: Okay. Fair enough. You weren't just doing a bounding analysis.

MR. AMMERMAN: Correct. Exactly. And it turned out it wouldn't have mattered because the fully engulfing didn't cause a failure either, but actually it does matter a little bit for lead melt because the lead melt is different, and we'll see that.

So, as I said, the flame temperature varies both spatially and temporally here in the static view. You can see how it varies spatially, cold for example, underneath the cask especially, but even around the cask above it cooler in this region, hotter in the corners. That's a very typical kind of distribution. We'll see how that goes in time.

MEMBER ARMIJO: The maximum temperatures here are about 1300 Centigrade. Is that --

MR. AMMERMAN: Correct. Yes.

MEMBER ARMIJO: Okay. I didn't know it

would get that hot.

MR. AMMERMAN: So, now you see that as time goes on, even once that fire is fully developed right now, you can see that there's times when it's cooler here, and times it's hotter here in this region right above the cask right in here. You see there's a cool spot, there's a cool spot. So, that 800 degrees C is a pretty good average temperature, but you do get peak temperatures that may be as high as 1300 C.

MEMBER BLEY: Not actually on the cask structure itself. It's in the flame --

MR. AMMERMAN: In the flame, exactly. And the 800 degree is the skin -- is the surface temperature that's assumed to be, so it's saying it's right at the surface of the cask it's 800.

MEMBER BLEY: Anything they carry on railroads that can burn hotter?

MR. AMMERMAN: Pretty much in a large fire it doesn't matter what the fuel is. It's how much oxygen you can get in. So, yes, if you carry -- if you were burning something like rocket fuel that has its own oxygen with it, yes, it can get hotter. But if you're relying on pulling in air to get your oxygen source, doubt it.

MEMBER BLEY: What if you have a car full of aluminum that the kerosene sets on fire adjacent to you, does that burn --

MR. AMMERMAN: Well, if it's part of the aluminum --

MEMBER BLEY: Well, that's not likely.

MR. AMMERMAN: Yes, that -- but, yes, I mean, you can postulate very severe fire accidents now. So, what happens in that three-hour fire, concentric fire? The peak fuel temperature about 730 degrees C, failure threshold is about 750, so it's getting real close to failing the fuel. The seal temperature is about 330 or 340, also pretty close to its failure temperature of 350, so just -- if we had gone with a four or five-hour fire, this concentric fire, we may have seen failure of the cask in the fire.

MEMBER ARMIJO: Why is the fuel running so much hotter than the seal which is closer to the fire?

MR. AMMERMAN: Because of decay heat.

MEMBER BLEY: Okay. So, it's --

MR. AMMERMAN: It's starting --

MEMBER BLEY: They're starting at almost the same temperature. I mean, one is at a little over 100 and one is at about 150 it looks like, but it's trapped in -- okay. But that is reasonable.

MR. AMMERMAN: Yes, because during the fire you can't -- you don't have any outward path for that decay heat.

MEMBER BLEY: So it builds up.

MR. AMMERMAN: Yes, it builds up. Exactly.

MEMBER ARMIJO: Now these seals are elastomers or are they the stainless steel O-rings?

MR. AMMERMAN: These are the metallic O-rings that are typically used in this package. Actually, no, this is the lead cast. The lead cast has elastomer seals.

MEMBER ARMIJO: Elastomer seals.

MR. AMMERMAN: I think the metallic seals are 500 degrees C is what their limit is.

MEMBER ARMIJO: Okay.

MEMBER BLEY: Let me go back to what I asked you along time ago because I was on that Academy Committee that did the Going The Distance Report. I thought that somebody told us that either AAR or some agreement between DOE and the railroads said that they wouldn't run spent fuel trains through single track tunnels. And the reason was because -- I think they argued that the Baltimore tunnel as I remember was a single track tunnel and they couldn't get firefighting equipment inside because of that. Having the extra track would have let them run some sort of firefighting equipment in and put that thing out. But that's not -- there is nothing like that that you're aware of.

MR. AMMERMAN: No, I don't believe so.

MEMBER BLEY: It could be in a single track tunnel.

MR. AMMERMAN: I think it's not possible to avoid single track tunnels because there's a lot of them.

MEMBER BLEY: Yes.

MR. AMMERMAN: That is by far the most common type of tunnel.

MEMBER BLEY: Maybe they said single track tunnels in urban areas.

MR. AMMERMAN: Yes.

MEMBER BLEY: I guess -- okay. I was just trying to remember that.

MR. AMMERMAN: And, actually, I'm glad that you brought that up. The -- one of the findings of Going The Distance, that report was that long-duration fires have the possibility of failing casks.

MEMBER BLEY: Haven't been shown to --

MR. AMMERMAN: Yes, yes, exactly.

MEMBER BLEY: We were a little more

careful.

MR. AMMERMAN: And I think part of the reason for that was that the database that was used for fire durations was not a accident database, it was a theoretical database, and it was durations of fire based upon fuel availability, and independent by the size of fire and the co-location. And what we have -- what we found looking at the accident database is that long duration large co-located fires don't happen. That 10-hour, 11-hour fire that was included in the study and included in 6672, those accident environments don't happen, they never happen. They cannot happen. And you'll see in the backup slides I talked about this three-hour fire, what the probability of this is, and it's something like ten to the minus 18, this fire. Now, to get even more severe you're --

MEMBER BLEY: How long did the Baltimore tunnel fire burn?

MR. AMMERMAN: It burned longer than that, but most of the time it was a smoldering fire, not high temperature.

MEMBER BLEY: So, it's the long duration high temperature.

MR. AMMERMAN: It's the long duration high temperature co-located.

MEMBER BLEY: Can't be sustained.

MR. AMMERMAN: Those three things can't -- exactly. Yes.

MEMBER BLEY: Okay.

MEMBER SCHULTZ: So, is there a fire modeling scenario that will support that in terms of a fuel supply?

MR. AMMERMAN: The fuel that was used was how fuel is transported in a railroad tank car, so one railroad tank car. We said okay, it's possible that you can have that amount of fuel, highly unlikely, of course, that you can have that amount of fuel, it all gets released from that tank car, and it all ends up in this -- the pool size is just the right size to fully engulf the cask but not be so large that it -- you waste that fuel that's away from the cask. And that amount of fuel is enough to burn for three hours. That's where we came up with the three-hour duration.

MEMBER SCHULTZ: Thank you.

MEMBER BLEY: But you ran a longer case.

MR. AMMERMAN: No, three hours is the longest one.

MEMBER BLEY: That's the longest one.

MR. AMMERMAN: Yes.

MEMBER BLEY: Okay, I thought you ran a longer one.

MR. AMMERMAN: So, in that three-hour fire what does happen, like I said, you never fail the seal but you do get the lead to melt. And when lead melts, liquid lead is less dense than solid lead, so it expands the region that it's in, the area between the two shells. And then as it resolidifies it shrinks back down and it leaves a gap at the top.

MEMBER BLEY: That swelling can't crack anything?

MR. AMMERMAN: It could, and the -- and Sam, those tests that you were talking about earlier, the train running into the rigid surface, well, we did a fire test after that and did melt the lead in that cask, and its expansion actually caused a crack in a weld, but it was a poor QA issue. It was not -- and now --

MEMBER BLEY: That happens.

MR. AMMERMAN: That happens, exactly.

MEMBER BLEY: During construction?

MR. AMMERMAN: Yes, during construction of that cask. It was a poor quality weld. It was -- and I think if Rob Temps, the QA inspector for SFST was here he would bear this out, that the failure -- the error in that weld is very likely to go unnoticed today. And this is a cask that was done -- it was probably fabricated in the '50s or maybe early '60s, and we've come a long way in QA space since that time.

CHAIR RYAN: Does it raise any questions in your mind about requalifying these older casks for more uses? You said you couldn't actually inspect this today and probably see it, but I just wonder if you pull that string a little harder.

MR. AMMERMAN: Actually, part of the reason that we picked the casks that we picked here is that these were very modern casks. And they -- if there were to a large transportation -- these casks aren't ones that are just sitting in somebody's warehouse. They haven't been built yet, so they would be built 2010.

CHAIR RYAN: All right. So, there's not a lot of them sitting around waiting for --

MR. AMMERMAN: There's not a backlog.

CHAIR RYAN: -- the design is robust, and a new fabrication won't have some of the flaws of the 1950s.

MR. AMMERMAN: Yes.

CHAIR RYAN: Is that a fair summary?

MR. AMMERMAN: That's a fair summary, yes.

CHAIR RYAN: Okay.

MEMBER SCHULTZ: Was that manufacturing defect known before the test, or was it --

MR. AMMERMAN: It was not.

MEMBER SCHULTZ: This is why we have a failure there.

MR. AMMERMAN: Yes.

MEMBER SCHULTZ: That's how it was found.

MR. AMMERMAN: Yes.

CHAIR RYAN: So, the budget goes up because you've got to build new casks to do these tests, not use old ones.

MR. AMMERMAN: Right.

CHAIR RYAN: Okay.

MR. AMMERMAN: So, in summary for fire accidents no loss of containment, fuel rods not unveiled, reduction in neutron shielding is likely and it's assumed in the certification of the cask so all the cask designs assume that the neutron shield goes away after a fire accident, reduction of gamma shield is possible for very severe fire of lead shielded casks. If it's a concentric fire that fire has to burn longer than 65 minutes. If it's an offset fire that —-- offset by 10 feet that fire has to burn longer than two and a quarter hours.

MEMBER BLEY: I guess that's a worker risk issue on the shielding change, but --

MR. AMMERMAN: Primarily, yes, exactly.

MEMBER BLEY: And a pain in the neck to take care of.

MR. AMMERMAN: Yes. You're not going to have any members of the public -- if you've got a fire burning for a few hours, you're going to evacuate, and people that are close are not going to -- are going to be the first ones to evacuate. They're going to be gone before -- and remember that exposure doesn't happen until it cools back down, so not until after the fire is over. And by that time workers are going to come in and they're going to have dosimeters or Geiger counters and they're going to be measuring dose rates. And they'll say hey, this dose rate is too high for us to go in, we're going to bring in a portable shield before they get close.

This study did not examine confined fires such as tunnel fires or fires at overpasses, Baltimore tunnel fire, MacArthur Maze fire because they were previously analyzed by other industry studies, and the result of those studies show that those fires have very low consequence.

MEMBER BLEY: They couldn't be anywhere

near your fully engulfing fire, could they, in terms of this insult to the --

MR. AMMERMAN: The result of -- the worst case assumptions for Baltimore tunnel fire was a little bit more severe. They looked at I think the same cask, the NAC STC cask, and showed that they would get a small release from it, less than regulatory release which maybe two per week, but that they would get some release from that cask. And our study showed no release.

MEMBER BLEY: Even though lower -- they used the actual --

MR. AMMERMAN: They used the -- the assumption of this fire environment that occurred, and if the cask would have been as close as it possibly could have been to the trichloroethylene or whatever it was that was burning in that. And that's how that came up with that answer.

MEMBER SKILLMAN: Isn't there a design fix for that reduction in shielding? Is there a wrapper or another material that could be in place between the lead and the outer hull or the lead and the inner hull such that there is a built-in capability to address the lead slump on -- its change in density as it goes through the temperature changes, where there's actually a provision for that already built in? It seems to me that clever designers could do that without too much trouble. Something more durable than lead and it's going --

MR. AMMERMAN: Actually, some of them get around that problem by using steel shielding, which like the HISTAR cask that we analyzed, steel shielding, it doesn't have that issue. I think the designers don't look at lead melt because they're only required to look at the 30-minute fire, and the 30-minute is like -- you need to have a 65-minute fire in order to get -- to start to get lead melt. So, the designers say regulations say 30-minute fire, I get no lead melt, I don't have a problem.

Now, if you were to require designers to look for a three-hour fire and maintain some level of shielding after the fire, then they would start thinking of clever ways to avoid that, or else they'll all just use steel cask instead of lead casks.

MEMBER SKILLMAN: I mean, it seems that maybe given the potential for aggressive pushback one might say this is fixable for the new fleet of casks, and we do it this way. And you buy -- if you're got guns or you have a safe in your home that's fire rated for three or five hours and 1400 degrees Fahrenheit.

We know how to do that.

MR. AMMERMAN: Yes, and we could do that, but I think that the risks are so small that it's not warranted.

MEMBER SKILLMAN: Okay, thank you.

MR. AMMERMAN: Okay.

MEMBER ARMIJO: Just before you leave that chart.

MR. AMMERMAN: Okay.

MEMBER ARMIJO: You say the fuel rods do not fail in the fires analyzed. Does that include the three-hour fire?

MR. AMMERMAN: That includes the three-hour fire.

MEMBER ARMIJO: So, and the reason is that the highest temperature that the fuel -- going back to your Slide 34.

MR. AMMERMAN: Yes.

MEMBER ARMIJO: The green curve never exceeds -- just barely up to 700, and what's it -- how high would it have to go before you assume the fuel starting to fail?

MR. AMMERMAN: 750 is where we assume the seal burst rupture occurred.

MEMBER ARMIJO: So, it would be as a result of pressure stress.

MR. AMMERMAN: Yes, it's a combination of two things. One, that the cladding material becomes less strong as the temperature increases and, two, that the internal pressure goes up, so you have those two curves that are approaching each other. The pressure building up and the strength going down, and at about 750 is where those curves cross.

MEMBER ARMIJO: Okay.

MEMBER SCHULTZ: Is that a side calculation or a computer code calculation?

MR. AMMERMAN: That is a reference number.

MEMBER SCHULTZ: Okay.

MR. AMMERMAN: So, we did not calculate that. We used a reference that said that number.

CHAIR RYAN: Where did it come from?

MR. AMMERMAN: I think it came from experiments that were done at Oak Ridge.

MEMBER ARMIJO: Just like something in a LOCA-type analysis.

MR. AMMERMAN: Exactly.

CHAIR RYAN: Okay.

MEMBER SCHULTZ: And what you've shown here, the lines are the analyses you performed, so that's the peak temperature --

MR. AMMERMAN: Exactly.

MEMBER SCHULTZ: -- calculated throughout the canister. Thank you.

MR. AMMERMAN: Okay, now is your turn. Ask your question.

MEMBER BLEY: You already got it.

MR. AMMERMAN: So, RADTRAN also looks at accidents, and there are in this study we looked at three different types of accidents. The first case is an accident in which the spent fuel cask is not damaged that John talked about earlier but the shipment is delayed, so this is the extended stop. Second case is an accident that affects the spent fuel cask by causing loss of shielding, so it's a fire of any duration causing a loss of neutron shielding or a fire of sufficient duration to cause loss of gamma shielding, but no release of radioactive material. Oh, and actually there also is the lead slump which falls into that category, as well.

MEMBER BLEY: So, after you have the fire you then run RADTRAN to evaluate the dose to people.

MR. AMMERMAN: Exactly, yes. And then, finally, the accident that does result in release of radioactive material. So, the statistics for both highway and railway accidents are maintained by the

Department of Transportation. The average probability of an accident is about ten to the minus six per kilometer for trucks, and about ten to the minus seven per kilometer for rail cars. And we do our rail accidents in rail car miles, per rail car mile as opposed to per train mile.

MEMBER BLEY: Yes, fair enough.

MR. AMMERMAN: These actions are categorized using an event tree, and for trucks that tree was developed at Sandia National Laboratories not for this project, but for another project. And for rail the event tree was developed at the Volpe National Transportation Center, DOT's Laboratory. Also, NRC paid for that, as well, under the performance study.

MEMBER BLEY: Didn't they already have something like that? Never mind.

MR. AMMERMAN: Yes, with that about from the 1970s, so they updated it, yes. This is a segment of the Volpe event tree for rail, and the most likely way that you get into a severe accident is you have a derailment with no fire. I mean, it doesn't matter if this is a fire, too. You just make this number one, but that's close enough to one, it doesn't change it.

MEMBER BLEY: What do they do in their --

because most derailments don't even damage anything, so this must be some particular kind of derailment.

MR. AMMERMAN: Actually, this is that derailment that doesn't damage anything.

MEMBER BLEY: Okay.

MR. AMMERMAN: 98 percent of them don't damage anything, exactly.

MEMBER BLEY: Okay.

MR. AMMERMAN: So, they divided that up into four speed distributions. This is that 50 mile per hour to 70 miles per hour, and this is greater than 70 miles per hour. And then --

MEMBER BLEY: Off bridge doesn't mean you fall off the bridge --

MR. AMMERMAN: No.

MEMBER BLEY: -- it means you're not on the bridge when it happens.

MR. AMMERMAN: Exactly. It would have been much better if they had called this not on bridge as opposed to off bridge.

MEMBER BLEY: That's better. Really struggling with that one.

MR. AMMERMAN: And the only ones that could possibly cause damage are these ones that are into slope, or into embankment. Into tunnel you would think could but really that is you're inside of a tunnel and you hit the side of the tunnel, always a glancing blow. You never get that impact to any degree that you need to have damage to the cask, so that into tunnel one although you would think it could be a severe impact, it's not because of the impact angle.

MEMBER BLEY: So, even though the probability is higher it just does no damage.

MR. AMMERMAN: Exactly, it does no damage. It skips along the side of the tunnel.

MEMBER BLEY: Now, into structure that does damage?

MR. AMMERMAN: Into structure does not do damage. That's the most likely --

MEMBER BLEY: Yes.

MR. AMMERMAN: That structure is concrete, so it's not going to -- and you have to be going more than 120 miles an hour into structure in order to cause damage, so it doesn't happen.

MEMBER BLEY: So, into slope or into embankment means you tumble down a hill, Sam's scenario. Is that right?

MR. AMMERMAN: Yes. And, actually, what we assume is that we had that triangular distribution so you might run --

(Simultaneous speech.)

MEMBER BLEY: -- at that point.

MR. AMMERMAN: Yes.

MEMBER BLEY: Okay.

MR. AMMERMAN: Yes. And in that example that's in the backup slides, it's in the back goes through this event tree. And all these numbers are in there along with those probabilities, so you can look at that. That's where it comes from.

MEMBER SCHULTZ: Doug, can you help me understand the speed distribution? I mean, you have derailment no fire.

MR. AMMERMAN: Yes.

MEMBER SCHULTZ: And then there are two speed --

MR. AMMERMAN: Actually, there are four, but this is chopped off. You don't see the top two which are -- the first one is less than, I can't remember, 24 maybe kilometers per hour, and then 24 to 80 or something like that, maybe it's less than 50, and then 50 to 80.

MEMBER SCHULTZ: So, what I'm struggling with and need your help is you have shown higher speeds here.

MR. AMMERMAN: Yes.

MEMBER SCHULTZ: And you have a derailment, so this is suggesting that for the lower speed categories less than 80 kilometers per hour the likelihood of the speed distribution seems that that's a large chunk of derailments.

MR. AMMERMAN: Yes, 94 percent of them are less than 80 kilometers per hour.

MEMBER SCHULTZ: Okay.

MEMBER BLEY: But the track speed -- is the track speed for a freight train anywhere around over 80 mile an hour?

MEMBER SCHULTZ: I'm trying to tie this as derailment.

MR. AMMERMAN: This is 80 kilometers per hour.

MEMBER BLEY: Oh, that's kilometers per hour. You're right. Okay.

MR. AMMERMAN: yes, that's 50 miles per hour.

MEMBER BLEY: That's right at track speed for most of the country.

MR. AMMERMAN: Yes.

MEMBER BLEY: Outside of the city, certainly.

MR. AMMERMAN: Yes.

MEMBER BLEY: Okay.

MR. AMMERMAN: Although, AAR has a I think 80 mile per -- or 50 mile per hour speed limit for spent fuel transport.

MEMBER BLEY: Is that right?

MR. AMMERMAN: Yes.

MEMBER BLEY: Okay.

MR. AMMERMAN: So, any time you're going to have -- any accident that is more than 80 kilometers per hour or 50 miles per hour means it's a runaway.

MEMBER BLEY: Right.

MR. AMMERMAN: And that's one of the things that we don't take into account in here, is that what is the probability of a runaway on a dedicated rail? Very, very small. We have instead of --

MEMBER BLEY: Why is it smaller than a regular train.

MR. AMMERMAN: Because you have a much lower weight of consist. I mean, you --

MEMBER BLEY: Even with the spent fuel in it?

MR. AMMERMAN: Yes. It's five cars.

MEMBER BLEY: Are they limited to five?

MR. AMMERMAN: Well, no, but where are you going to get more than that?

MEMBER BLEY: Okay.

MR. AMMERMAN: I mean, how much fuel are you going to ship from one reactor?

MEMBER BLEY: And is it guaranteed that rail shipments will be dedicated?

MR. AMMERMAN: It's not guaranteed --

MEMBER BLEY: It wasn't the last time I heard.

MR. AMMERMAN: Although, Yucca Mountain assumed that they were going to do their own --

MEMBER BLEY: Yes.

MR. AMMERMAN: -- dedicated rail.

MEMBER BLEY: They did but when --

MR. AMMERMAN: There's no requirement.

MEMBER BLEY: But the railroads weren't agreeing that it was.

MR. AMMERMAN: And a big part of that is DOE doesn't want to pay the cost --

(Simultaneous speech.)

CHAIR RYAN: That's --

MEMBER BLEY: Well, it's only moot in the sense that that's an assumption in the analysis. And whether DOE pays it or not, you know, that shifts things around because if you have dedicated trains, they might get held up in places longer than other trains because they aren't -- the railroad's main business is all the other freight.

MR. AMMERMAN: Actually, that's one of the big concerns that DOE has, is that because their train has a lower speed limit, they're going to get shifted off to the side very often so fast trains go by, because the railroads, believe it or not, are in business to make money, and they make money by moving stuff, not by having it sit.

MEMBER SIEBER: It depends. If you're paying by the hour --

(Laughter.)

MEMBER SIEBER: -- which special trains pay because you're paying crews by the hour.

MR. AMMERMAN: Sure.

MEMBER SIEBER: Then it's to their advantage to have a slow train.

MR. AMMERMAN: Yes.

MEMBER SIEBER: In 1960 the speed limit was 35 miles an hour for special trains, so they took a long time to go any distance.

MEMBER SCHULTZ: So, what you're saying for derailments this would -- to validate 93-94 percent of derailments occur at speeds less than 50 miles an hour.

MR. AMMERMAN: Yes.

MEMBER SCHULTZ: Okay.

MR. AMMERMAN: Yes.

MEMBER SKILLMAN: If I could, you mentioned the analyses here does not consider a runaway. Supposing it's not a runaway --

MEMBER BLEY: No, it does.

MR. AMMERMAN: It does. So, these accidents are runaways.

MEMBER SCHULTZ: Okay. Let's go one step further. It's not a runaway, it's a hostile takeover of the train and someone intends to drive that train to destruction by going full tilt as fast as the locomotive will pull the consist. Is there terrorism factored into this thinking at all?

MR. AMMERMAN: No.

MEMBER SKILLMAN: Should it be?

MR. COOK: Not in this one. This is a kind of constraint to a safety assessment as have the previous studies. Now, there are studies that look at security issues, which that sort of scenario would fall into. But I think we would see, nonetheless, it have very elevated velocities. The results here indicate it's difficult, extremely difficult to get to a release pathway is what we're --

MEMBER SKILLMAN: Fair enough.

MR. AMMERMAN: Essentially you've got to be -- unless you're going to hit hard rock you've got to be going more than 120 miles per hour. And I don't think you can get that train to go 120 miles per hour.

MEMBER BLEY: It would be a pretty clumsy way of --

MR. AMMERMAN: Not even a hostile takeover if you tried to.

MEMBER SCHULTZ: What you're saying though is that this is very good evidence to suggest that that would not be a worthwhile terrorist activity because the --

MEMBER SKILLMAN: No, there would be better ways --

MEMBER SCHULTZ: -- chances of creating a hazardous condition is very small.

MEMBER SKILLMAN: Very low, yes.

MEMBER SCHULTZ: Thank you.

MEMBER BLEY: And they're not talking at all about how these trains are guarded?

MEMBER SKILLMAN: Are what?

MEMBER BLEY: Guarded.

MR. AMMERMAN: Right. Exactly. So, the event trees didn't provide us all the information that we needed for --

MEMBER BLEY: Did the numbers on there for the accidents come from DOT?

MR. AMMERMAN: Yes.

MEMBER BLEY: Okay.

MR. AMMERMAN: The event tree didn't provide us with all the probabilities that we looked at in the study. For example, the rate of entry does not include target hardness, so we used the distribution from the truck event tree. Neither event tree includes impact angle or orientation so we had to make assumptions on those, and we made a triangular assumption about impact angle and we used a uniform distribution for impact orientation.

The truck event tree does not include impact velocity, but since impacts at even the highest velocity we analyzed didn't result in release, we didn't care. No truck accident results in release. And then the rail event tree doesn't divide accidents that are higher than 70 miles per hour, so we assumed that 95 percent of them are between 70 and 90, and that 5 percent of them were above 90, which was needed for the lead slump dose calculations, because we had more lead slump at 90 than we do at 70, or at 60.

So, now let's look at the first case of

those accidents, accidents without loss of shielding or release. This is the accident like in TMI, that accident that occurred in suburban St. Louis where a guy got stuck on the track and the train T-boned it, and the train sat there for N number of hours. Almost all accidents fall into this category, all but one in a billion.

Dose depends on the external dose rate of the cask. We assumed a 10-hour stop time is the average for these type of accidents, very little data to back that up. There's been in the history of transporting spent fuel, I think seven accidents, and what was the time that it took to clean those up? I don't have that information. Would it be the same today? Nobody really knows.

MEMBER BLEY: This is probably a security issue and you can say you didn't address it or you're not asking. If a dedicated train gets into a accident that doesn't damage the train, if a passenger or a freight train does and somebody is killed in a car, they sit there forever while the state police come. But with these dedicated trains, do they sit there or does somebody stay behind and these trains keep going? Or is that something you can't address?

MR. AMMERMAN: I think that the TMI

shipment was a dedicated train, and it sat there for -- until --

MEMBER BLEY: It did? Okay.

CHAIR RYAN: Did they get any insight from train accidents of all types in terms of the time range? I know it's kind of a little bit of apples and oranges, but you know, I mean, at least -- the data point says it's no longer than X. You know, no shorter than this, and there's a mean, that at least would give you something to hang your hat on a little bit.

MR. AMMERMAN: I think that if you derail a cask car, it's going to sit for a long time because you're going to have to bring the --

CHAIR RYAN: I don't disagree with you. I'm just saying there's got to be something similar where a car that's got, I don't know, some kind of holder like a cask, maybe it's for some other purpose, tips over, that those on average tend to be four days to clean up. You know, I don't know, but I'm just trying to figure out a way to maybe see if there's a similar kind of data set you could --

MEMBER BLEY: You just made assumptions here.

MR. AMMERMAN: Yes.

MEMBER BLEY: AAR must know that kind of

thing.

MR. AMMERMAN: And that 10-hour stop time is -- really was more based upon truck information. We didn't go and do a detailed look at it, but just --

MEMBER ARMIJO: Well, in a situation like that, and again the 10-hour -- you're putting somebody close to the cask, right, for 10 hours --

MR. AMMERMAN: Exactly.

MEMBER ARMIJO: -- to calculate your dose. But in reality, you -- you know, there would be police, people would be kept away. And if it's 20 hours it probably wouldn't make that much difference until you're ready to move it in the proper way.

MR. AMMERMAN: Yes. I think that that's a very good point, and that you're going to either evacuate people because of the other hazards involved with the accident.

MEMBER ARMIJO: Sure.

MR. AMMERMAN: Or that you're going to say oh, it's not a big deal, and you're going to keep people far enough away that they're not getting dose. You're not going to have people standing up close to the cask. So, with that assumed 10-hour stop time we calculated collective doses using the average rural, suburban, urban populated densities for each route.

And the biggest dose was -- the MEI dose was to an emergency responder, so we assume he's at two meters, and he's getting a dose rate of 10 millirem per hour, so he's at two meters for 10 hours. It's a total of 100 millirem. That's the MEI.

The collective population dose to nearby residents is on the order of seven times ten to the minus five person-sieverts.

MEMBER BLEY: Is that the dose, or is that an expected dose with the probability weighting --

MR. AMMERMAN: That is a dose risk.

MEMBER BLEY: That is the risk. So, that's probably --

MR. AMMERMAN: Yes, exactly.

MEMBER BLEY: And that's true in all your tables. I didn't see anything like a risk or where you have probability versus dose, but you have primarily expected dose.

MR. AMMERMAN: Exactly. Exactly, expected dose. Yes, exactly right.

MEMBER BLEY: And that's what this is.

MR. AMMERMAN: That's that what this is.

MEMBER BLEY: So, it isn't really --

MR. AMMERMAN: And so --

MEMBER BLEY: It's expected person-sievert.

It's not person sieverts.

MR. AMMERMAN: Right, yes.

CHAIR RYAN: Is collective dose just the individual dose multiplied by some assumed population number or --

MEMBER BLEY: Times the probability of it happening.

MR. AMMERMAN: Right.

MEMBER BLEY: That's what I was --

MR. AMMERMAN: Yes. And it's -- you know, this is for nearby residents, so they start at 30 meters, not at two meters. And out to 800.

MEMBER BLEY: So, it's 100, 20, how many people were involved?

MR. AMMERMAN: It depends on whether it's in the rural, suburban, or urban population density, so this one is for urban.

CHAIR RYAN: And that is how many folks.

MR. AMMERMAN: And that's a population density of I think probably about 3,000 persons per kilometer squared. And you've got 800 meters, certainly with a radius of 800 meters is --

CHAIR RYAN: I'm just looking at one certain number, not the whole -- how many people are involved in the calculation?

MR. AMMERMAN: 3,000.

MEMBER BLEY: These are microrems to people.

MR. AMMERMAN: Yes.

(Simultaneous speech.)

MEMBER ARMIJO: That's 3,000 people exposed for 10 hours?

MR. AMMERMAN: It's probably less than microrems because it's got the probability mixed in.

CHAIR RYAN: That's really less than --

MR. AMMERMAN: Yes, yes. These people are getting -- yes.

CHAIR RYAN: You had a dose from the accident and seven times ten to the minus three person rem is who cares.

MR. AMMERMAN: Exactly. This dose is --

CHAIR RYAN: A very small number compared to the natural background.

MR. AMMERMAN: This dose is frankly less than our routine transport dose in person-sieverts, collective dose.

CHAIR RYAN: Okay.

MR. AMMERMAN: So, that's a good comparison to make. This one is seven times ten minus five. Remember that number.

MEMBER BLEY: It wasn't -- I mean, it was kind of clear when you think about it, but I think it wasn't clear that -- it wouldn't be clear to everybody reading the report that when you do these person-sievert risks, that that's got the probability factored in it. Now, if it -- I think you need something there to say this is the expected dose of risk which is probability times consequence. Chapter 6 I think is just not clear in that way.

MR. AMMERMAN: We ought to call it dose risk if that's the case as opposed to dose.

CHAIR RYAN: Please don't change the units. That will confuse everybody.

MR. AMMERMAN: Okay.

CHAIR RYAN: Just explain what you're calculating, but use the unit. I mean, Dennis is right.

MEMBER BLEY: I think it's not transparent.

CHAIR RYAN: That's much better than making up a new unit which nobody can get.

MEMBER BLEY: Put it this way, it wasn't obvious to me until I thought about it a little bit. Maybe it's obvious --

MEMBER ARMIJO: It's probability of the accident. Right?

MEMBER BLEY: That's right.

MR. AMMERMAN: And maybe that's the thing to do, is just whenever we put that number we say what Sam just said, includes the probability of the accident.

MEMBER BLEY: Or you say it real clearly right up front in the chapter, or something.

MR. AMMERMAN: Okay, so those are the accidents --

MEMBER BLEY: Actually, if I can read you the title on one of your charts?

MR. AMMERMAN: Sure.

MEMBER BLEY: Average Collective Dose is Person-Sieverts, doesn't say "risk."

MEMBER SCHULTZ: That's where I was getting confused.

MEMBER BLEY: None of the figures say risk.

MEMBER SCHULTZ: Estimated dose.

MEMBER BLEY: It looks like estimated dose, but I think they all-- I think they're all your risk numbers. I think they all --

CHAIR RYAN: And there's nothing --

MEMBER BLEY: It just isn't there. I mean—-

CHAIR RYAN: Instead of dose saying this is a risk which includes the probability of the event occurring.

MEMBER BLEY: Or if you just say expected dose, and then define that some way.

CHAIR RYAN: Yes.

MR. AMMERMAN: Yes.

MEMBER BLEY: But it isn't what it says despite what you -- it might in the text but on every presentation of tables and figures I don't think you'll find it.

MEMBER SCHULTZ: But expected dose means something to a risk analyst, but --

MEMBER BLEY: Well, what I was saying is if you use expected dose and then define it clearly in the glossary, whatever. If you put a whole sentence on every figure and table it will start getting tedious. Expected dose means something to a statistician or a risk analyst.

MEMBER SCHULTZ: Right, right.

MEMBER BLEY: Risk dose means something to you. It's a term --

MEMBER SCHULTZ: Put it in the glossary.

MEMBER BLEY: -- I don't generally see, and I think whatever you do, if it doesn't just -- all it says now is average collective dose and that doesn't imply either one of those.

MEMBER SCHULTZ: I agree.

MR. AMMERMAN: Okay. The next type of accident is with loss of gamma shielding. The probability this event is about the same as the one of release, about one in a billion. And the collective dose risk expected dose is ten to the minus three person-sieverts, so now --

MEMBER BLEY: This is fires?

MR. AMMERMAN: No, this could be lead slump from impact, as well.

MEMBER BLEY: From impact, as well. But proportion -- I'm not sure I caught that results. Is it mostly --

MR. AMMERMAN: Those about the same, actually.

MEMBER BLEY: Is that right?

MR. AMMERMAN: Yes.

MEMBER BLEY: It's a toss up.

MR. AMMERMAN: Yes. I think --

MEMBER BLEY: I didn't get that. It might say that clearly, but I didn't --

MR. AMMERMAN: Fire is about ten to the minus fifteen, so this number to the significant figures is all from impact.

MEMBER BLEY: Yes. And we'll just say when we toss around these ten to the minus whatever numbers to a lot of people it doesn't mean anything. To other people they think probabilities, which it isn't at all. So, there's -- it's easy to get even technical people confused if in their field these are used a little differently, so I think being real precise about what these are will really help.

CHAIR RYAN: You know, somebody that's not tuned in on the probability aspects of this will look at ten to the minus eleventh person-rem and say how many seconds are fractions of a second background would cause that?

MR. AMMERMAN: Yes.

CHAIR RYAN: So, you know, without some explanation or at least kind of laying that out, it could I think create more confusion than resolve.

(Simultaneous speech.)

MEMBER BLEY: And others have shorthand ways to express things in our own field. I think you're caught up in a little of that.

CHAIR RYAN: Sure. You know, somebody could interpret that slide so, who cares about these accidents? Why are we worried about them?

MR. AMMERMAN: Well, that's the right interpretation.

(Laughter.)

CHAIR RYAN: But it's not true. It's not we don't care about the radiation impacts from it, perhaps, but we do care about not having the accidents. So, I don't know, it's just -- it's a very funny thing to put up that small collective dose.

MEMBER SCHULTZ: It goes back to the comments that we were discussing earlier, and that is when -- in presenting it to the public I think it's really important to talk about the unlikely event, the unlikely situation associated with the event of the accident which you've demonstrated. The event of the accident that could cause a problem, and you've done that. But then to separately say and then --

MEMBER BLEY: If it did.

MEMBER SCHULTZ: -- when that happens, stay away, everyone should stay away because there's a small amount of radioactivity that could be released. And then describe that separately. Combining it here is difficult I think for the public to digest.

MEMBER BLEY: Well, and even for me. I mean, there's one thing, the first risk study I saw on a power plant actually did the same kind of thing. It said the average number of -- the expected number of people killed by this plant is ten to the minus four or something like that, but what does that mean? It means there's a very high probability of zero, and a very small probability of maybe something really bad. And here it's different, there's a very high probability of zero, and a very low probability of something not so bad. And if that doesn't come out when you just see an expected dose, so the idea that the probability and the consequences -- and here even the consequences in the bad cases aren't that bad. I don't think it sings, you don't get that easily unless you read the whole report and understand everything that's inside of it.

MEMBER SCHULTZ: Yes, simplifying that.

MEMBER BLEY: So, it's zero chance -- I mean, a high probability of nothing, a very low probability of something that's not too bad, and it's not even a tiny probability of something really bad. I don't think we have a really bad here.

MR. AMMERMAN: There is no really bad.

MEMBER BLEY: And making that clear would go a long way, I think. And making it clear in the words, perhaps.

(Simultaneous speech.)

CHAIR RYAN: -- essentially sort of explains what Dennis said would very helpful in interpreting these results once you consider it. And then kind of lay that out.

MEMBER BLEY: The people who understand expected dose or expected fatalities -- and every technical area it's a tiny community of people, and even they misspeak and mix up probabilities or frequencies with their doses. So, clarity, and this clarity, it's mostly a very high probability of nothing, and the frequency of all these accidents put together is pretty darned small. And it doesn't -- without having the risk curve of probability and consequences, it's real hard to get that. So, I think you need to -- you could play with some displays or pictures or something to get that concept. Even something like an event tree, although that still doesn't talk to a lot of people, but high probability of nothing, a low probability of an accident, given an accident a very low probability of a consequence, and that consequence is still pretty low. Getting that sequence out in front of people would really help communicate what you found.

CHAIR RYAN: Maybe we should go through the rest of the slides and see what else we can --

MEMBER BLEY: I've been waiting for this, that's why I --

(Laughter.)

MEMBER BLEY: Because I think it's -- I think if you give Chapter 6 to 30 different people and ask them to explain to you exactly what's there it might surprise you.

MR. AMMERMAN: The other case we looked at is accidents with release, only can happen if you don't have an inner welded canister, and the dose depends on what you're shipping. We assumed nine-year cooled 45 gigawatt-day burnup fuel, and then the exposure pathway. Rod to cask release fraction, cask to environment release fraction, and then the dispersion of that release material.

MEMBER ARMIJO: Now, this is strictly an impact kind of analysis. Right?

MR. AMMERMAN: This is strictly impact because we don't have any --

MEMBER ARMIJO: Release with a fire or anything else?

MR. AMMERMAN: Yes, because with fires this cask to environment release fraction is zero.

MEMBER BLEY: Let me play something by you. Just think of a picture that comes in from the top. You say we have transportation. We have accident and no accident. And this is 100 times more likely, so you have an accident, and then these last three slides, an accident with nothing, something here, and accident with something else, and a little bit of -- and how likely these are could be done in terms of how bright or what color they are or something, something to show that you can see this probability versus consequence. And, in fact, that consequence that adds up to an expected dose is pretty -- even if you get this, it's not that bad. It would be the same information you just showed us on the last three or four slides, but in a single picture that conveyed both probability and consequence, leading to an expected dose. Just to me would tell your story. You've done an awful lot of work, and it's kind of -- could be -- I think a lot of people can misinterpret it if they read that. I've got to go back and read your public thing again. Maybe you do that there pretty well, but I didn't study that. I looked at the main report.

MEMBER SCHULTZ: I want to go back and look at that, also, because you're right, Dennis. And you've already acknowledged that you have very good stories to describe the evaluation and analysis on each of the pieces. When it's combined together and you derive a very, very tiny number that even engineers can't comprehend or compare to anything, then it's -- it takes -- it causes an element of perhaps just intellectual confusion as to what we're talking about. But if you step it back and describe each of the pieces, then you've got each -- all of that nailed down.

MEMBER BLEY: When the WASH-1400 guys, Norm Rasmussen saw when he went to Congress, the thing they found worked best for them was they wrote out the five factor formula. I forget what it was, but it was probability of the accident, probability of that going to a problem, so they sort -- it took this chain of things going wrong. You've got it here, but if you could put it together in a more coherent story, especially where you see how the probabilities drop off, likelihoods drop off, and where you end up, even if you look at the consequence by itself, assume it happens, it's not that bad, is a story that tells everything a lot better than a ten to the minus ninth person-rem expected dose.

MR. AMMERMAN: Yes.

MEMBER BLEY: Or ten to the minus person-rem expected dose. Is that bad or is that good? Probably nobody can tell. It looks little, it's just -- I'm sorry to keep harping on that, but I think it's important.

MR. AMMERMAN: So, in the release accident, this table shows the release fractions that you get from both the cask to environment, and the rod to cask, and the probability of the accident that produces those. Doses from release are dominated by inhalation, also includes resuspension which is also inhalation dose, cloud shine, so how much you get from the plume that goes over, ground shine, how much you get from the stuff that's still in the ground and the radiation coming off of it, and ingestion. There was a release in a rural area and you're growing tomatoes and then you ate those tomatoes.

Because the thermal loft due to the -- although the temperature of the cask --

CHAIR RYAN: Just a second on that one. I guess that's one -- ingestion also occurs when you inhale just as a matter of --

MR. AMMERMAN: With what?

CHAIR RYAN: You ingest something -- when you inhale something it also gets ingested.

MR. AMMERMAN: Yes.

CHAIR RYAN: What you mean here is foodstuffs.

MR. AMMERMAN: Yes.

CHAIR RYAN: Contaminants, so a

clarification that you're really talking about eating contaminated foodstuffs, which is kind of a different animal.

MR. AMMERMAN: Yes.

CHAIR RYAN: I would try and clarify that a little bit.

MR. AMMERMAN: Yes, yes.

CHAIR RYAN: Okay.

MR. AMMERMAN: This is digestive tract rate as opposed to --

CHAIR RYAN: Yes.

MR. AMMERMAN: Yes.

CHAIR RYAN: Very good.

MR. AMMERMAN: Exactly. Because we have decay heat, the fuel is hot, when you get release it's going to go -- it's going to rise. You have some buoyancy, and the maximum dose occurs 21 meters down wind from the accident. And an individual located at that location gets 160 millirems.

CHAIR RYAN: What were the meteorological conditions to get you that far down?

MR. AMMERMAN: That was I think F stability, and I can't recall what the wind speed is, five meters per second, I believe.

CHAIR RYAN: So it's hot and windy. I mean it sounds like a very negative assumption, which is fine.

MR. AMMERMAN: Yes.

CHAIR RYAN: Okay.

MR. AMMERMAN: And we actually looked at --- also did another assumption and it wasn't terribly different. Kind of the other extreme.

CHAIR RYAN: Fair enough.

MEMBER ARMIJO: Could you go back to Slide 44?

MR. AMMERMAN: Yes, sir.

MEMBER ARMIJO: On the rod to cask release fractions, you know, I guess the noble gas is about 12 percent, and that assumes that a certain fraction of fuel has failed?

MR. AMMERMAN: That assumes 100 percent of the fuel has failed.

MEMBER ARMIJO: 100 percent of the cladding has failed, but you only release 12 percent?

MR. AMMERMAN: Yes, because the rest of that are bound up in interstitial port space.

MEMBER ARMIJO: Okay, so this is -- this 100 percent of the plenum volume and the gap is released.

MR. AMMERMAN: Yes.

MEMBER ARMIJO: Okay. What is this unit release 100 percent of the crud? Crud is a particulate. How is it going to get out of the --

MR. AMMERMAN: There's particles up above that, too. The crud is on the outside of the rod.

MEMBER ARMIJO: Yes.

MR. AMMERMAN: So, what we assume is 100 percent of the crud spalls off.

MEMBER ARMIJO: It stays inside the cask.

MR. AMMERMAN: Yes. Oh, that's --

(Simultaneous speech.)

MR. AMMERMAN: The cask to environment is .1 percent. You're right, it all stays inside the cask.

MEMBER ARMIJO: Okay.

MR. AMMERMAN: Exactly right.

MEMBER ARMIJO: That's what you have.

MR. AMMERMAN: Yes.

MEMBER BLEY: But the particulates, you have almost 1 percent getting out.

MR. AMMERMAN: 70 percent getting out.

MEMBER BLEY: Oh, 70 percent. Yes, I'm sorry.

MR. AMMERMAN: Yes.

MEMBER BLEY: I put an extra zero in there when I --

MR. AMMERMAN: Yes, and that's because they go out with the fission product gases. They're aerosols.

MEMBER BLEY: Okay.

MR. AMMERMAN: And we have very fast blowdown.

MEMBER BLEY: Okay.

CHAIR RYAN: They're carried in the --

MR. AMMERMAN: Yes.

MEMBER BLEY: Okay.

CHAIR RYAN: So that's bounded by something like 20 microns or so.

MR. AMMERMAN: Ten I think.

CHAIR RYAN: Ten?

MR. AMMERMAN: Yes. So, now the collective dose, ten to the minus twelve person-sieverts. Again, that's expected dose just like -- so, this is on the same order of magnitude as this one, the loss of gamma shield, ten to the minus thirteen for this, ten to the minus twelve for release.

CHAIR RYAN: Just for fun later on I'm going to calculate how many seconds that is for ten to the minus ten person-rem --

(Laughter.)

MR. AMMERMAN: That's not long. So, what's the summary from the accidents? Collective dose risks are very small, the dose risks from release are loss of shielding are negligible compared to the risk, dose risk from that accident that just sits there. It's about seven orders of magnitude lower than the case where all we're having is just the radiation coming off the outside of the cask.

There's no expectation of release if you have an inner welded canister from either fire or impact. Dose risk from loss of lead shielding is comparable to that from release, and both are very small. And the probability of this accident that release or loss of shielding is less than one in a billion given an accident. If you have an accident in about one in a thousand trips, so one in a trillion is the probability of a accident that causes release.

MR. COOK: Per shipment.

MR. AMMERMAN: Per shipment, yes. So, every trillion shipments you're going to - you could have an accident.

MEMBER BLEY: All of these numbers are in terms of per shipment. They're not --

MR. AMMERMAN: They're all per shipment.

MEMBER BLEY: -- per year or anything like that.

MR. AMMERMAN: Yes, everything is per shipment.

MEMBER BLEY: Was that clear to everybody else when you read the report?

MEMBER ARMIJO: Yes.

MEMBER BLEY: Okay.

MEMBER ARMIJO: At least I got it.

MEMBER BLEY: I'm not sure. I just don't remember. I think it probably was, but I asked the question if it was because I don't remember.

MR. AMMERMAN: So, now we're comparing this study to -- this is Chapter 6 we're into now. How does this study compare to previous risk studies? Routine transportation risks are about the same. Accident risks are much lower. This loss of shielding bar, and it's very difficult to compare a stacked bar chart when you have a log scale on a vertical axis, because this loss of shielding bar down here actually is to scale, but up here, this one you wouldn't even see if it were, because of where it is on that bar chart if it were to scale, so that's why the loss of shielding aren't to scale.

The conclusion of 0170 was risks are acceptable. We are now nine orders of magnitude lower, they ought to really be acceptable. Back to the findings slides, and --

MEMBER SCHULTZ: But just on this piece here on the last slide.

MR. AMMERMAN: Yes, sir.

MEMBER SCHULTZ: What's the reason for the huge differences here study to study?

MR. AMMERMAN: The biggest reason is that 0170 assumed that any accident that was extra-regulatory resulted in release. And they actually -- their event tree said about one in a hundred accidents was extra-regulatory. So, they said you only had to have 100 accidents before you got release. I say you have to have a billion. So, there's seven orders of magnitude right there. And the rest of it comes from a better modeling of what that release is, especially the rod-to-cask release fractions.

MR. COOK: And again recalling back in the 0170 assessment, that was primarily an engineering judgment analysis, so many conservative assumptions were used since they analyzed it at that time. What these studies have done over time is by using the greater analytical precision that's become available slowly remove some of those conservatisms, so now we have what we think is a more realistic estimate based on current assessment technology, methodology of today.

CHAIR RYAN: So, what was a bounding analysis might have been a really, really, really huge bounding analysis. And that's not really been evaluated until this study itself.

MR. COOK: And we have moved again in this study to the certified packages versus casks that were just thought to minimally satisfy regulations previously in previous studies. So, all those are contributing factors.

MR. AMMERMAN: We've covered this findings slide before, now you could see what led to those findings. And the general conclusions from SFTRA reconfirms that transport in compliance with the regulations results in very low radiological risks.

MEMBER BLEY: Can I ask you a question about that means since NRC regulations only deal with the cask, that essentially says if you use a certified cask, that's all that says.

MR. AMMERMAN: That's what it says.

MEMBER BLEY: It sounds like it says a whole lot more.

MR. AMMERMAN: Well, actually --

MEMBER BLEY: But we're really talking

about DOT regulations, and DOE regulations, and a whole bunch of other regulations.

MR. AMMERMAN: And, actually, it does include that because conducted in compliance with regulations also means -- yes, that you are following those routes that --

MEMBER BLEY: But it says NRC regulations, which is really only saying use a certified cask.

MR. AMMERMAN: Yes.

MEMBER BLEY: I think that's all it's saying. Go ahead. You've gotten all those other regulations, I'm just curious. If we violate some of those other regulations, do we get worse accidents? That's just an open-ended question I haven't thought about. Can you make a stronger statement then, what if somebody breaks one of this myriad of regulations, do we get a worse accident?

MR. AMMERMAN: We could, or we could get an accident with a more severe consequence.

MEMBER BLEY: Can we?

MR. AMMERMAN: Let's say instead of taking bypass --

MEMBER BLEY: You can't get much faster when you crash. You can't get a bigger fire.

MR. AMMERMAN: No, but you could perhaps

get a larger exposed population.

MEMBER SKILLMAN: You could have a rogue driver going to a different location.

MR. AMMERMAN: Yes, or you could have this cask instead of being on the interstate says you know what, I really want to go to Caesar's Palace when I'm going by Las Vegas. I'm going to stop in there and gamble for a few hours, and he's got the cask parked out in the parking lot exposed to people. I mean, that's -- those are things that --

MEMBER ARMIJO: You can't really do that. Doesn't he have police escorts?

MR. AMMERMAN: Of course.

(Simultaneous speech.)

MEMBER BLEY: I am just -- this statement almost -- the way it is, I mean, it only says a certified cask but, man, it almost says gee, if I don't like the good news of this report, it might say all we have to do is break somebody's regulation, well, we could kill people. None of that is going to happen --

MEMBER ARMIJO: You'd have to work very hard to do that.

MEMBER BLEY: I'm worried that an innocent statement could be taken to imply things well beyond what it says. Now, you're right, you could take it into a place it doesn't belong, but even so, if you got by your escort which ain't going to happen for long, still the dosage you get unless people just sit on top of this drinking beer all night --

MEMBER ARMIJO: That's getting kind of --

MEMBER BLEY: I'm just worried about the statement and the attacks you'll get. All they have to do is break one of DOT's regulations and we get a much worse accident. I don't think that's true.

MEMBER ARMIJO: Those guys are always out there no matter what --

MEMBER BLEY: Well, they are but why do we set them up for the easy --

MEMBER ARMIJO: Yes, you should anticipate it and -- but, you know --

MEMBER BLEY: Think about it, how you present that part, or how you respond if somebody says -- because I think what you've shown is the accidents aren't going to be any worse, maybe you can be in a spot where the routine doses could get higher to the general population.

MR. AMMERMAN: Exactly, right.

MEMBER BLEY: But I think if you can say the accidents won't get worse, it's hard for me to see how they get worse. And it --

MR. AMMERMAN: No, the accidents --

MEMBER BLEY: I just -- I worry about this statement. Go ahead.

MR. AMMERMAN: So, given that, then the regulations are adequate to protect public health and safety, and there's no need to change them. What are the -- stealing a little bit of John's thunder here for the next section on public comments, one of the groups that we had comment on this was NEI. So, an advocacy group, if you will, and one of the concerns that I had when we came up with these conclusions was NRC is over-regulating, that we don't need this amount of safety. We've got more safety than we need. And we did not receive that comment from NEI, which is the group that I would suspect would have had it, so I think that's a very good thing.

MEMBER SCHULTZ: These are storage and transportation canisters, so that may have been part of it, I would hope. That these are designed for more than transportation.

MR. AMMERMAN: Yes, that's true.

MEMBER SCHULTZ: And we're manufacturing them now or will be soon, the designs are approved. And that, of course, is a lot of the engineering and licensing effort that's already in place.

MEMBER ARMIJO: That's right, all the costs are sunk.

MEMBER SIEBER: It's not true, the current storage casks --

MEMBER ARMIJO: Plenty of margin.

MEMBER SIEBER: -- transportation casks are --

MR. AMMERMAN: That's right.

CHAIR RYAN: So, I'm going to ask you to maybe finish up your slides and then we'll go around for a last round of questions.

MEMBER BLEY: Well, let me sneak one comment in because I did quickly look back at the public summary, which is it's pretty nice. It does a nice overview, gives some nice pictures. Two things about it. One, it doesn't deal with that thing I talked about, making this clear how this breaks down in terms of accidents and where the consequences fall out. It's in terms that we saw before of expected dose, some many represented as person-rems as if they were doses.

Two quick comments. The Academy has done -- that's one place they've done a lot of good work I think on risk perception, and they've interviewed lots of people, their studies have, and really looked at how people deal with this stuff. Right in their introduction because of this radioactivity, people understandably have some concerns will be looked on by anybody who doesn't like you as extraordinarily patronizing. Although they said it's understandable would be concerned, delete that word. It will cause you trouble.

And the second bullet on summary of results, the radiological risks from accidents in transporting radioactive materials is very small compared to the non-radiological risk involving accidents with large trucks or freights. Well, we put radiological risk in terms of expected dose, and we put the risk of other accidents in terms of primarily deaths and maiming accidents. Put them on the same bounding, say the risk of death from these is nil compared to the -- something like that. I don't know, think about everything you've talked about radiological risk is in terms of expected doses that are extraordinarily small.

MEMBER ARMIJO: Yes.

MEMBER BLEY: And that that kind of risk which is apples is much less than the risk from non-radiological things in moving trucks which is really death, so it's painting a silly comparison. I know that's not what you meant, but there ought to be a way to reword that to make it clear, what you're telling us. There's really no risk of deaths from the radiological side, and we all know what the risk from traffic is, a thousand deaths a year. Go ahead, I'm done.

MR. COOK: Okay, so then --

MR. AMMERMAN: Do you want to switch back or you want to just --

MR. COOK: No, we've just got these slides. Let's just do it this way. So, as we mentioned earlier, we did publish NUREG-2125, the draft for public comment back in May, and they did receive some comment letters. First one of which was from one of the states requesting an extension to the 60-day comment period. We did consider this, but due to a number of factors including the fact that we lose Dr. Ammerman's services here at the end of the month through the expiration of contract, we really could not extend. Although, when we requested the comments we indicated that comments beyond the 60-day period would be considered to the extent that we could.

The next public comment has to deal with accident. You want to talk about that, Doug?

MR. AMMERMAN: Yes, so this was also a State of Nevada comment. And they said that we've under-estimated the potential fire durations and temperatures. That we should have looked at longer fires and more -- and higher temperature fires. And the draft response to that is that the probability of the most severe accident, severe fire considered here is ten to the minus fourteen. And yes, it's possible to envision a more severe fire accident, you know, instead of having one rail car that dumps all its fuel at the location of the cask, you have two rail cars. That would have even a lower probability, and would not affect the overall risk of spent fuel transportation.

As a matter of fact, in order to -- remember that that one in a billion from impact accidents causes release. In order to have a fire accident that affects the overall outcome of this, I have to be four orders of magnitude more release than I had from that impact accident. So, it had to have a release of 10,000 A2s -- more than 10,000 A2s of material, which there's no way in a fire you can get that.

You got -- the fire isn't going to destroy the pellet nature of the fuel. You can throw away all the cladding and throw away the cask, you don't get 10,000 A2s of release. But to help address that comment when you're going to add discussion on the Caldecott tunnel fire, the Baltimore tunnel fire, and the MacArthur Maze fire, which is a -- that one by Bay Bridge that you were talking about, including their probabilities have shown it doesn't change the risk results.

MEMBER BLEY: I think that's a much better thing than what -- your ten to the minus fourteenth is really --

MEMBER SCHULTZ: Fly in the ointment.

MEMBER BLEY: Besides, it doesn't have a —-- I mean, it's per -- it's just a number, it doesn't have units.

MR. AMMERMAN: It's a probability.

MEMBER BLEY: Per shipment.

MR. AMMERMAN: Yes.

MEMBER BLEY: Which makes it a --

MR. AMMERMAN: No, actually, it's per accident.

MEMBER BLEY: Per accident?

MR. AMMERMAN: Yes, the probability given accident is ten to the minus fourteenth.

MEMBER BLEY: Given the way we modeled it, I mean, you're running into other stuff that you didn't model. Just getting numbers like that I think gets you into trouble. I wouldn't hang your hat on that. I'd hang your hat on what you told me earlier, that the Baltimore tunnel fire, although it lasted longer, had much lower heat release rates, some details that tell why given your's is more severe, and that sort of thing, I think does you a lot more good.

I'll go back. I know for sure the chance of a meteorite hitting your oil car is a lot higher than that. And if you're stopped maybe you have that fire -- that's orders of magnitude higher than your number.

MR. AMMERMAN: Well, and actually --

MEMBER BLEY: So, it's the way you modeled it that leads you --

MR. AMMERMAN: Yes.

MEMBER BLEY: Which isn't unreasonable, but--

MR. AMMERMAN: One of the things that I did once upon a time was I looked at the probability of a meteor the size of a meteor crater hitting the cask.

MEMBER BLEY: Talk about meteor this size.

MR. AMMERMAN: Yes, but I mean even --

MEMBER BLEY: That's a very, very small

number.

MR. AMMERMAN: It's on the order of this. It's --

MEMBER BLEY: I mean, it's a very, very small one. Ones like this can do plenty of damage for you, and they're a hell of a lot higher frequency than that.

MR. AMMERMAN: Yes.

MEMBER BLEY: Sometimes given your train sitting on a siding where it might be, and given there's an oil car next to you, so I'd just stay away from that. All it can do is generate argument that you weren't completed or something.

MR. AMMERMAN: One of the comments we got is that they would like to see, and this is kind of one of the things that you've talked about, too, is calibration of the finite element model. Have these models been compared to test results? And --

MEMBER BLEY: But if -- last question, I'm sorry. But why did they say you were -- your frequency was too low, and your duration too short? Did they give a basis, or they just said it?

MR. AMMERMAN: Because they have postulated fires that are more severe. I mean, I just did, too. I postulated a fire that was twice as severe as the one that we analyzed.

MEMBER BLEY: But your argument that it's real fires, you know, didn't have -- weren't as severe, and that --

MR. AMMERMAN: Yes.

MEMBER BLEY: -- you can take a much more severe fire, takes care of it pretty well, I think.

MR. AMMERMAN: And part of the reason I think is because the previous risk studies, especially the modal study in 6672 looked at 11-hour fires, and we didn't. And we knew when we decided not to look at those 11-hour fires that we were going to get that comment, because -- well, you've just thrown away the more severe fires. Why did you do that? Well, we did that on purpose because they don't happen.

MEMBER BLEY: But I think your argument that it -- even fires longer than the one you looked at have happened, but they're much lower --

MR. AMMERMAN: And, actually, I think that's what the modal study actually looked at, another long duration fire, the Livingston train fire that happened down in Louisiana, burned for I think 20 something hours, but it was all spread out. You know, it was a traveling fire that caught this car on fire, and then that caught the next car on fire.

MEMBER BLEY: Bad for the train but not bad for the cask.

MR. AMMERMAN: Not bad for the cask, it was only location. Exactly.

MEMBER ARMIJO: So, the only places you've had long-term concentrated fires are these tunnels, tunnel environments?

MR. AMMERMAN: Yes. I mean, one of the things that happens in a tunnel, of course, is that there's no place for the fuel to go -- the fuel that leaks out of the car to go. It's confined. And there's no place for the heat to go, yes.

MEMBER SIEBER: The oxygen supply is also confined in a tunnel.

MR. AMMERMAN: Except for if the tunnel has slope, and then it's a chimney.

MEMBER SIEBER: Right.

MR. AMMERMAN: And it sucks air in.

(Simultaneous speech.)

MEMBER SIEBER: It's the railroad standard.

MEMBER ARMIJO: Yes.

MR. AMMERMAN: So, this comment was asking us to provide more information on the calibration of the finite element model, so we said that we will include -- we do have a reference in Appendix D to comparison of analysis to tests for a large pool fire, and we'll make some references for impact analysis, as well.

MR. COOK: And we also got a comment regarding one of the destinations that we selected as an example for SFTRA. And the comment was to perhaps select a different destination. Again, we considered this comment, as well. However, it turns out that there are issues with other transportation routes, as well.

Another factor is that the routing code that we used in the study to do our assessment, the WebTRAGIS code was temporarily, I guess you'd say suspended from being supported. And while it's just now being brought back up there are some issues, apparently, with getting it working again, and we understand. So, switching off to other routes is not a very practical resolution at this time, so we intend to repeat the disclaimer that we put in again, that the routes that we selected were just examples. And, again, there's no intention for any actual shipments to be conducted from the originations to the destinations.

And the last comment I believe --

MEMBER SCHULTZ: Perhaps if you clarified that Hanford could be an origination point as well as a destination point, it may help. That's all right.

MR. COOK: Okay.

MEMBER SCHULTZ: I understand the point of the question, the comment.

MR. AMMERMAN: Actually, that was almost an answer to that response is that yes, the risks are identical.

MEMBER SCHULTZ: Yes, exactly.

MR. AMMERMAN: If you transport from Hanford to Maine Yankee.

MR. COOK: And Doug had already responded to this comment, that we see -- well, I guess we're on the risk management. And yes, this is an activity that will be provided as input to consideration of risk-informing activities that we need to have in SFT regarding spent fuel package certification guidance. And that completes our presentation.

CHAIR RYAN: Thank you. Any other comments or question? Jack.

MEMBER SIEBER: No, I think the presentation is consistent with my knowledge and experience for civilian fuel.

CHAIR RYAN: Very good. Steve?

MEMBER SCHULTZ: I appreciate the

presentation and the amount of effort that's gone into the documentation with a variety of stakeholders. And it's certainly an advance forward from the publications in the past and provides a great deal more understanding of both the risk and the consequences associated with the risk.

I would highlight what we've discussed many times in the -- during the morning, and that is whenever one has a figure that's less than even ten to the minus seven, it really is incumbent to try to describe that in -- by breaking down why the number is so low, and describing why each of the pieces is so low. Because once you derive something, even one in a billion, there is no conceptual frame of reference for it. And when you get to ten to the minus fourteen, it is just -- there's no really sense talking about it. It's hard to describe it that way, so you need to frame it in terms of it is -- you've got this result because this, as Dennis said, it's your five factor formula or whatever needs to be multiplied in order to gather that and derive that number, is as follows, Part A is low, Part B is low, Part C is low. And all of these have to happen together in order to cause an effect.

MEMBER BLEY: And they're independent.

MEMBER SCHULTZ: And they're independent, describe that. But I encourage, also, that more work I'm thinking, and thought be given to this public presentation, whether it be a brochure or perhaps even an augmentation of that appendix because as you look at those results of this report versus previous reports, there's a tremendously large difference that has been explained, and needs to be captured going forward. It would be very valuable to be able to present that. And if it's done well here, it can apply to other investigations that are also ongoing at the NRC.

CHAIR RYAN: Thank you. Sam?

MEMBER ARMIJO: Yes, I endorse the prior comments, and Dennis' as well, a nicer way of presenting the important findings of this study, make it easier for the general public to understand the significance. It's a great piece of work. I am glad it was performed. I think it's going to have a lot of use by this Agency.

What it does show is that historically this Agency and the other agencies that regulate transportation of spent nuclear fuel have been -- have done a very good job creating -- requiring actions that created a lot of margin, more margin than maybe we realized at the time. And you've just quantified, you know, how much margin we really have, so I think it's an excellent piece of work. And thanks for a good presentation.

CHAIR RYAN: Dick.

MEMBER SKILLMAN: I echo my colleagues. I would like to build on what Dr. Schultz provided. I'm wondering if a pictogram, just a picture perhaps of a flow model that shows the winnowing of the probability to end up with very low number might not deliver the real punch. And here's how I come to that.

I recall when we were trying to convince the public that venting the krypton from TMI 2 was safe, and when we began the shipping campaign for the fuel from TMI2, the discussions were almost identical to these last several hours. But what carried the day was language at about an eighth grade level, and a number of pictures. And that was effective.

It's easy for highly trained and educated scientists to talk about small numbers and flip risk and probability, but speaking the public doesn't interpret that as we might interpret that. So, a pictogram with a very simple breakdown that shows a very small number may be very useful as the lead-in to the kind of thing Dr. Schultz was talking about.

My other comment is, I think this parallel roadway automobile being locked in next to the cask needs to be part of the analysis, and explain why criticality is not in there, are two technical items that rise to the top for me. Thank you very much for a thorough presentation.

CHAIR RYAN: Okay, thanks, Dick. Dennis?

MEMBER BLEY: I, too, compliment you. It's a great presentation, good answers to everything. As far as the risk area, I think this is the best thing I've seen out of NMSS yet. I would hold it up as an example. I think you've done a lot of great work. And you've heard the other stuff I've talked about. But thanks for your presentation, thanks for your good work. And if you we can tell the story even better that ought to --

CHAIR RYAN: I take Steve's comments and everybody's comments, Dennis' as well, and endorse those. It struck me as the conversation was going back and forth of some experiences I had of trying to explain low-level waste and all kinds of cities all over the country. You know, it's a very difficult thing to communicate a very technical topic to a non-technical or lay audience with varying levels of comprehension and understanding of technical issues.

So, I don't know if you've done this, but it may be to your advantage to try and get somebody with those expertise, that expertise to maybe look at how do we deliver this message in the public arena about this risk assessment, because it will be of interest in public arenas. And that's really why we're doing it, is to really understand the public risk, and then communicate it. So, having a communications expert who really understands enough of the technical information to work on it, or can help you maybe craft it, because I know that in my own experience that having the technical knowledge doesn't get the whole job done. I would explain it in some fabulous way from a technical perspective, and communicate nothing.

MR. AMMERMAN: Actually, do you know Hank Jenkins-Smith?

CHAIR RYAN: I do not, no.

MR. AMMERMAN: Actually, he'll be coming to Sandia on Thursday this week.

CHAIR RYAN: Oh, that's a --

MR. AMMERMAN: He can help.

CHAIR RYAN: That will help a lot.

MR. AMMERMAN: He's really talking about —-- coming to talk about reactor accidents and public perception, but I can pigeon hole him a little bit.

MEMBER SCHULTZ: And Dr. Weiner is engaged in this.

CHAIR RYAN: Yes.

MEMBER SCHULTZ: She's still engaged in the process?

MR. AMMERMAN: Yes.

MEMBER SCHULTZ: She'll be helpful --

MEMBER BLEY: Actually, something else you can do is just get some of your folks who aren't technical and run it by them. You know, we developed something I thought was dynamite. We took it down, showed it to engineers who didn't do risk, they loved it. We showed it to managers, technical managers, they loved it. I was so pleased. We ran it by our support staff at a lunch time seminar, and they said that's the single most confusing thing I've ever seen.

(Laughter.)

MEMBER BLEY: So, you've got to take some folks who aren't technical, and let them take a look and see if it offends them, helps them, or what.

CHAIR RYAN: So, the short message is the work looks terrific, and now we've got to work on delivery. So, that's the key thing, I think the takeaway message. And, again, I want to thank you for a very thorough briefing. You've all been very forthcoming and gave us a lot of detailed information to help us really understand what you've got, and how well you've got it. And I second Dennis' comments that it really is a very nice piece of work. And I'm sure that when you put your hard thought process to delivering the message of what the work says, it'll be even better yet. So, thanks very much. Are there any other questions or comments from the audience, or from anybody here?

MEMBER BLEY: Do we have a full Committee on this?

CHAIR RYAN: Yes, we're going to have a full Committee next time on this, and write a letter, I'm sure. So, hearing no other comments or questions, we'll call the Subcommittee being closed and adjourned. Thank you very much.

(Whereupon, the proceedings went off the record at 12:01 p.m.)

Spent Fuel Transportation Risk Assessment (SFTRA) Draft NUREG-2125

Presentation to the

Advisory Committee on Reactor Safeguards Subcommittee on Radiation Protection and Nuclear Materials

Sept. 18, 2012

U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

Agenda

Item	Topic	Presenter(s)	Time
1	Opening Remarks and Objectives	Dr. Michael Ryan, ACRS	8:30 – 8:35 a.m.
2	Draft NUREG-2125 Background	John Cook, NMSS	8:35 – 9:00 a.m.
3	Draft NUREG-2125 Method and Results	Dr. Douglas Ammerman, SNL	9:00 – 10:00 a.m.
4	Break		10:00 – 10:15 a.m.
5	Draft NUREG-2125 Method and Results (continued)	Dr. Douglas Ammerman, SNL	10:15 – 11:15 a.m.
6	Public Comment and Proposed Resolution	John Cook, NMSS Dr. Douglas Ammerman, SNL	11:15 – 11:45 a.m.
7	Committee Discussion	Dr. Ryan, ACRS	11:45 a.m. – 12:00 p.m.
8	Adjourn		12:00 p.m.

Outline

- Background and introduction
- Risk analysis of routine transportation
- Cask response to impact accidents
- Cask response to fire accidents
- Risk analysis of transportation accidents
- Findings and conclusions
- Public comments and draft resolution

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SFTRA Research and Review Teams

- NRC Project Manager – John Cook
- Sandia National Laboratory Research Team [9/06-9/12]
  - Dr. Douglas Ammerman – principal investigator
  - Carlos Lopez – thermal
  - Dr. Ruth Weiner – risk assessment
- NRC's SFTRA Technical Review Team
  - Dr. Gordon Bjorkman – structural
  - Chris Bajwa – thermal and overall content
  - Dr. Robert Einziger – fuels, source term
  - Dr. Anita Gray – health physics
- Oak Ridge National Laboratories External Peer Review Team [9/10-3/12]
  - Matt Feldman
  - Dr. Cecil Parks
  - et al.

SFTRA Purpose and Goals

- Continuing review
  - Final Environmental Statement (NUREG-0170, 1977)
  - “Modal Study” (NUREG/CR-4829, 1987)
  - Reexamination of Spent Fuel Shipment Risk Estimates (NUREG/CR-6672, 2000)
- NRC’s safety mission
  - Considering public comment, provide updated basis for NRC’s safety regulations applicable to spent fuel transportation
- Outreach responsibilities
  - Reassure public regarding spent fuel shipments
    - Basic message: Risks are low, so safety is high
    - Improve public understanding and acceptance of spent fuel shipments
- Potential shipments
  - Significant issue when study began (2006) – much less so now
  - Method applicable to future shipments, may need to consider different casks, long-term aging of canisters, and high burn-up fuel
- SFTRA is a generic SNF transportation risk assessment and is not
  - Driven by any external requirement or commitment
  - An EIS or major federal action
  - Required for any licensing action, nor does it contain any regulatory proposals
  - An analysis of transport security

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SFTRA Basic Methods

- Radiological impacts of spent nuclear fuel (SNF) shipments
  - Routine conditions
    - Determine doses to various populations from cask during routine transport
  - Accident conditions
    - Perform finite element analysis of cask response to impact and thermal accident conditions
    - Use “event trees” developed by U.S. DOT to estimate probabilities of accident conditions
- Use RADTRAN to calculate routine doses and accident dose risks for representative truck and rail shipments
- Approach similar to that in NUREG-0170 and NUREG/CR-6672

SFTRA Findings

- The collective dose risks from routine transportation are very small. These doses are about four to five orders of magnitude less than collective background radiation dose over the same time period and exposed population as the shipment.
- There was little variation in the risks per kilometer over the routes analyzed.
- Radioactive material would not be released in an accident if the fuel is contained in an inner welded canister inside the cask.
- Only rail casks without inner welded canisters would release radioactive material, and only then in exceptionally severe accidents.
  - If there were an accident during a spent fuel shipment, there is less than one in a billion chance the accident would result in a release of radioactive material.
  - If there were a release of radioactive material in a spent fuel shipment accident, the dose to the maximum exposed individual would be non-fatal.

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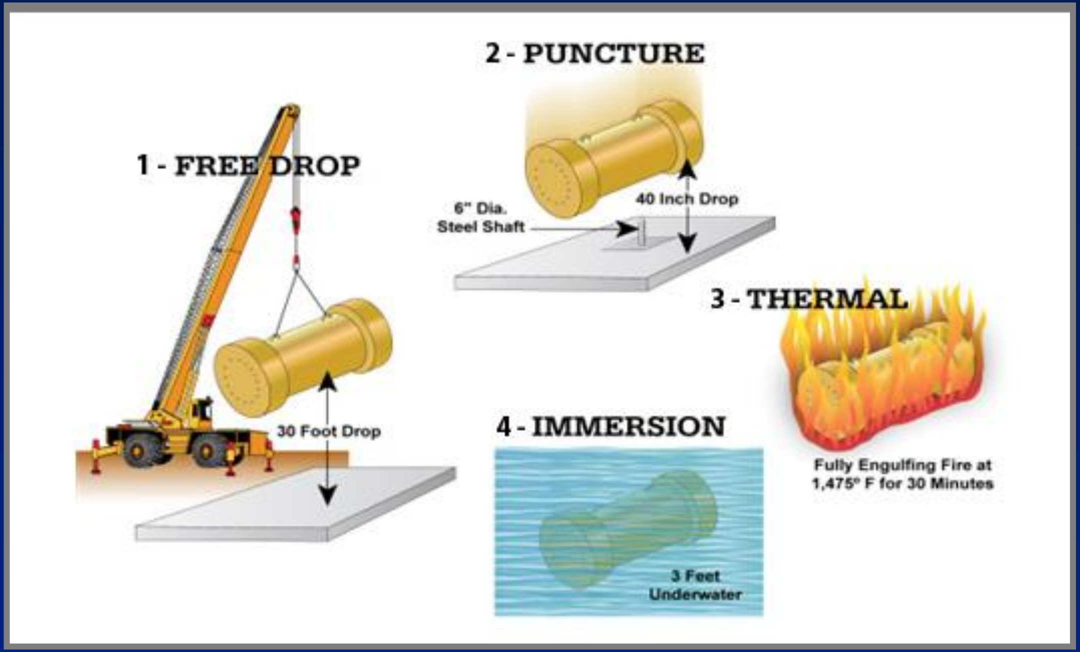
How did this study differ from previous NRC risk studies?

- This study utilized certified casks instead of generic casks.
- This study used updated accident event trees instead of relying on accident data from the 1970s.
- This study performed detailed 3D finite element analyses of the thermal events.
- This study used more detailed finite element models for the impact events.
- This study considered the accidents that do not damage the cask as long-duration stops.

Use of certified casks

- Prior generic risk assessments have used generic casks.

- This assessment uses casks that have been certified to meet the requirements of 10 CFR Part 71.

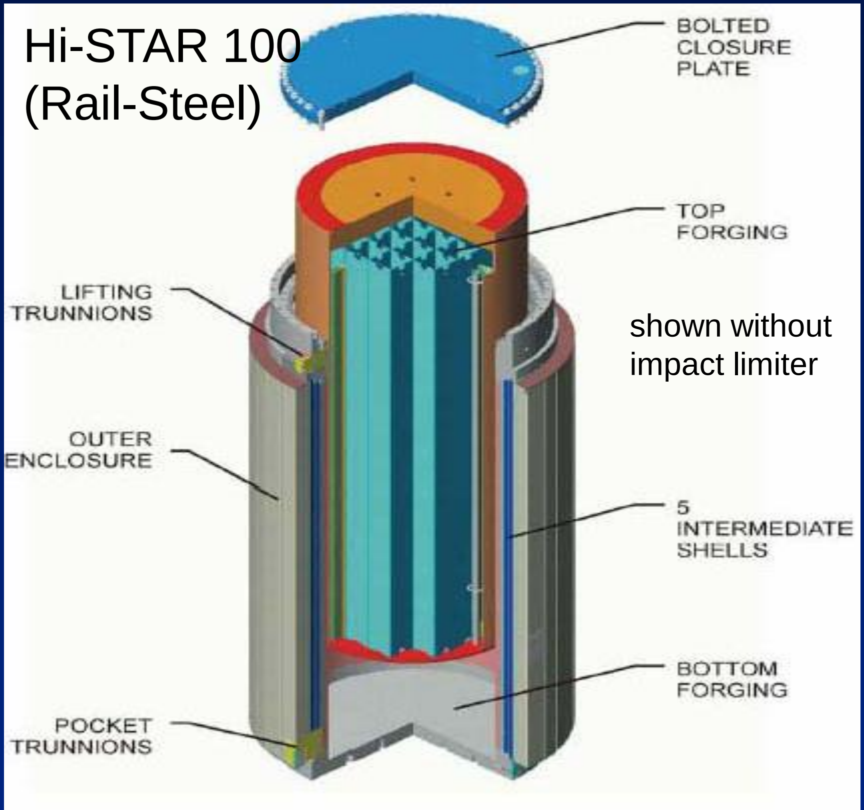


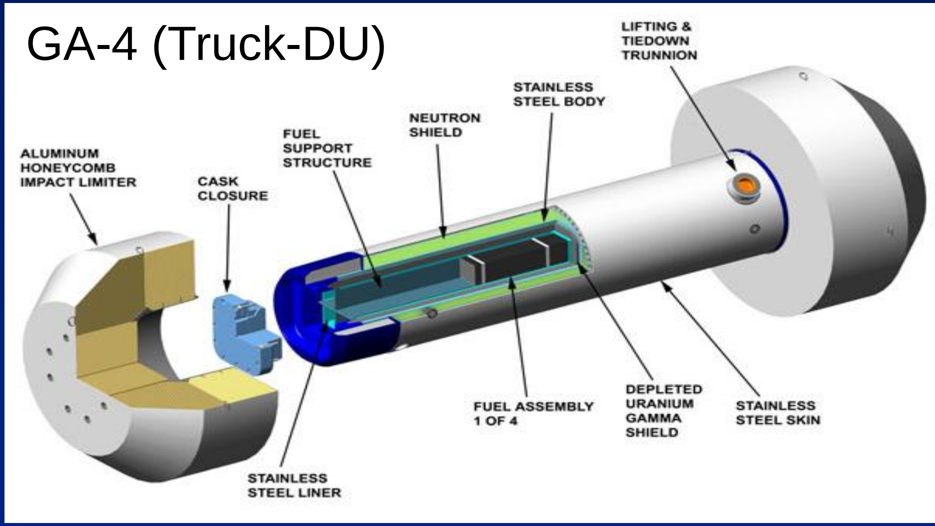
Casks selected

- The Holtec HI-STAR 100, a steel-shielded rail cask transported with an inner welded canister
- The NAC STC, a lead-shielded rail cask transported with direct loaded fuel or with an inner welded canister
- The GA-4, a DU shielded truck cask
- These selections encompassed all the gamma shielding types, both common modes of transport, the use of inner canisters, three different cask vendors, and modern casks that could be used in any future large-scale transportation campaign

Cask illustrations

NAC-STC (Rail-Lead)





- Each cask represents a type (Rail-Lead, Rail-Steel, Truck-DU)
- Casks of the same type would perform similarly

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Investigated example routes

- Example routes do not represent current or planned transportation campaigns

Origin	Destination
Maine Yankee	ORNL
Kewaunee	Deaf Smith
Indian Point	Hanford
INL	Skull Valley

- WebTRAGIS routing code determines rail and highway routes and exposed populations
- Rail casks only by rail (no heavy haul or barge), truck casks by legal weight truck (no overweight truck or rail)

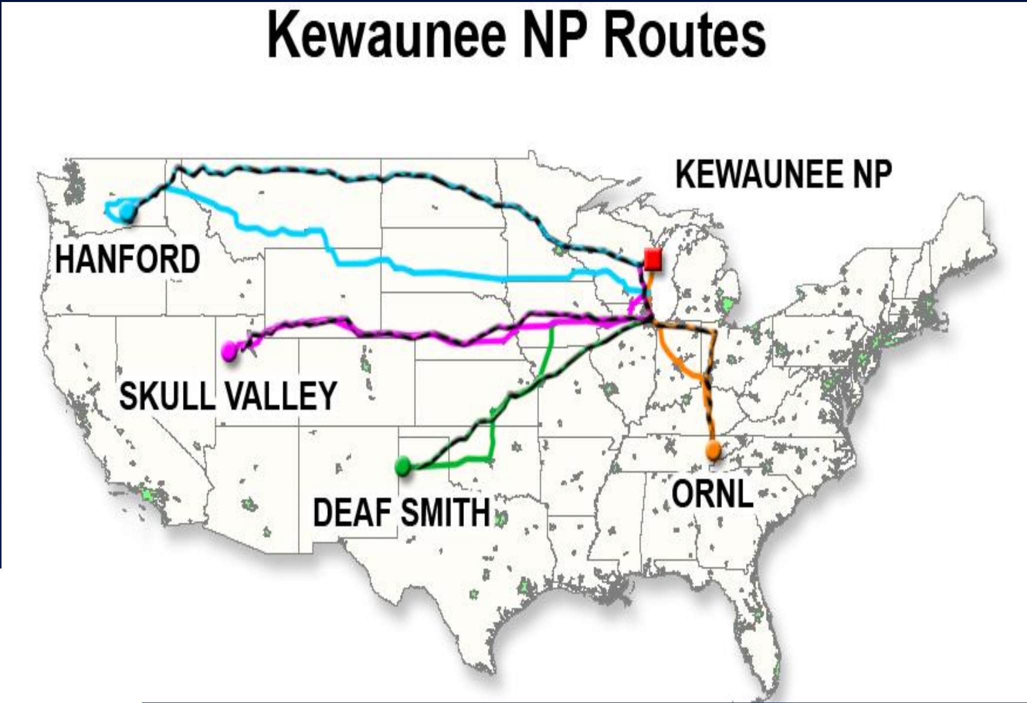
Report Structure and Format

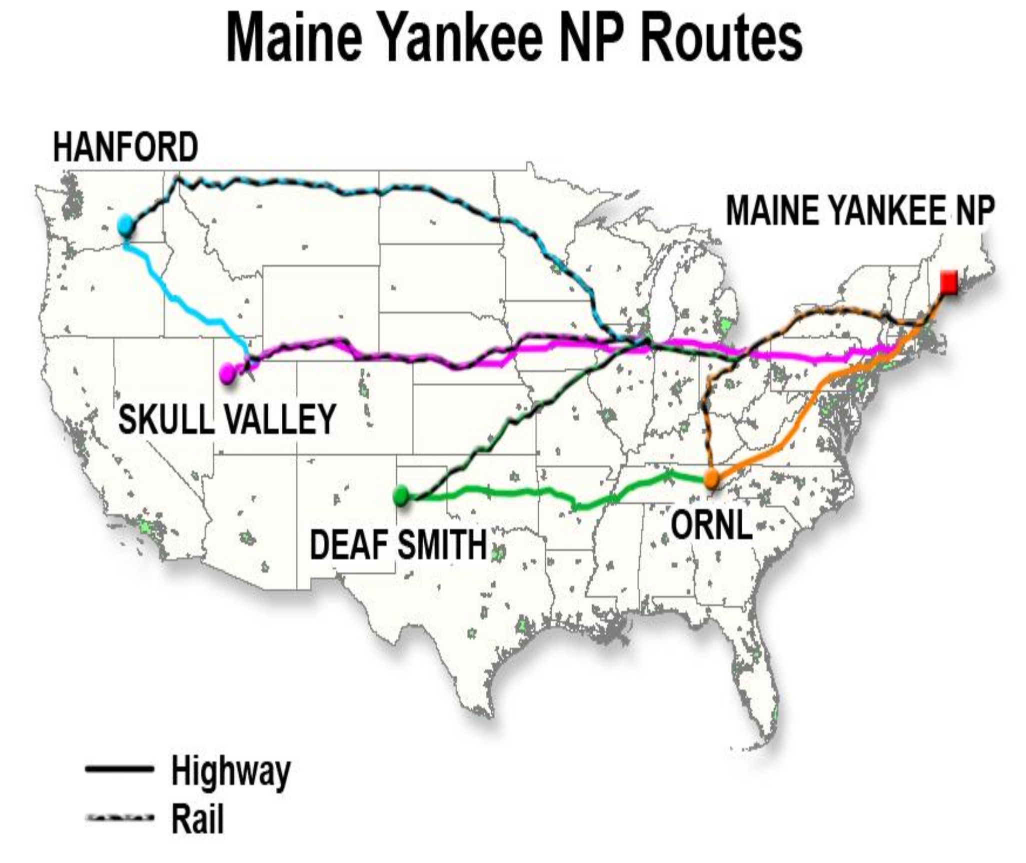
- Audience
  - Public, state and tribal governments, elected officials, federal agencies, industry, and media
- Graded structure and content
  - Executive Summary and Public Summary - all audiences
  - Main body text - informed public, science media
  - Appendices - industry, other federal agencies
- Electronic and printed versions
  - NRC ADAMS Accession Number: **ML12125A218**
  - Printed Draft NUREG in black and white only (CD inside back cover contains color version)
  - Final NUREG in full color

External radiation from casks

- The maximum permitted dose rate is 10^{-4} Sv/hour at 2 meters from the cask, or about 1.4×10^{-4} Sv/hour at 1 meter (input to RADTRAN).
- The external dose rate at one meter from each of the casks was the maximum value from its Safety Analysis Report, 1.03×10^{-4} Sv/hour for the HI-STAR 100 and 1.4×10^{-4} Sv/hour for the other casks.
- The total dose to each receptor is calculated by RADTRAN.

Example Routes





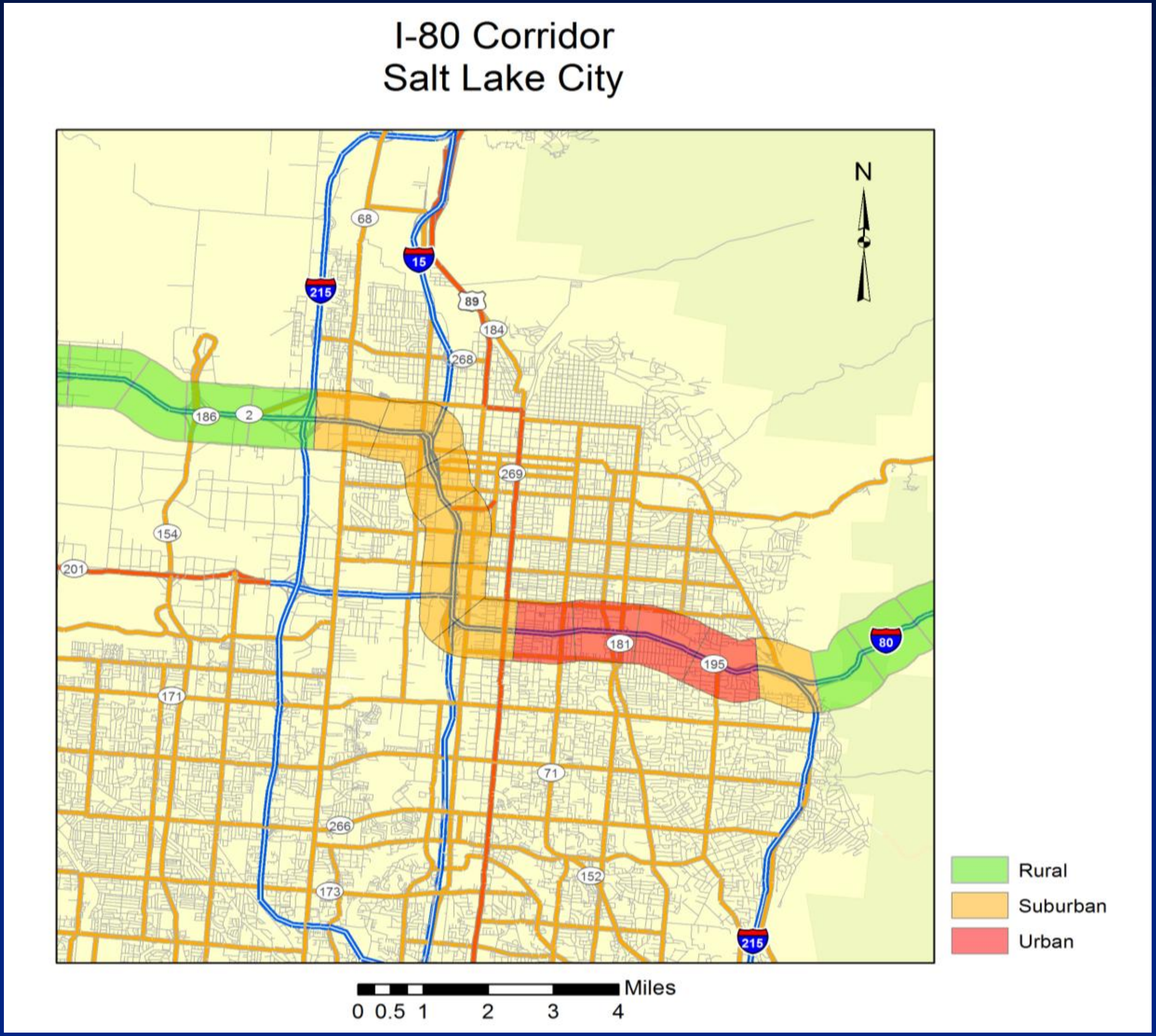
These routes represent a variety of route lengths and populations. They include the eastern and western states, and cross-country routes.

The routes studied

- The destinations include
  - two proposed repository sites (Deaf Smith, TX, and Hanford, WA)
  - the proposed private fuel storage facility (Skull Valley, UT)
  - ORNL
- SFTRA's road and rail routes span many states and thousands of miles through rural, suburban, and urban areas across the country, and are adequate to represent other routes.
- No SNF shipments are planned from any of SFTRA's points of origin to any SFTRA destination.

Routine Conditions: Truck Route Segments

WebTRAGIS was used to determine the urban, suburban, and rural segment population densities and lengths on a state-by-state basis.



Factors affecting routine doses

- Exposure time
  - Speed of the vehicle
  - Stop times and number of stops
  - Number of inspections
- Number of people exposed
  - Population density
  - Traffic density
  - Number of people per vehicle
- Dose
  - Shielding provided by housing
    - 0% for rural, 13% for suburban, 98% for urban
  - Distance from cask at stops

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Types of exposed populations

- Residents along the route
- Occupants of vehicles sharing the route
- Residents near stops
- People sharing the stop
- Crew of the transport vehicle (truck or train)
- Inspectors

Maximally Exposed Individual (MEI)

- A member of the public who is at a distance of 30 meters from the route.
- Vehicle is moving at 24 kph for both truck and rail.

Cask (mode)	Dose, Sv (rem)
Rail-Lead (rail)	5.7×10^{-9} (5.7×10^{-7})
Rail-Steel (rail)	4.3×10^{-9} (4.3×10^{-7})
Truck-DU (truck)	6.7×10^{-9} (6.7×10^{-7})

- These doses are about the same as 1 minute of average background: 6.9×10^{-9} Sv.

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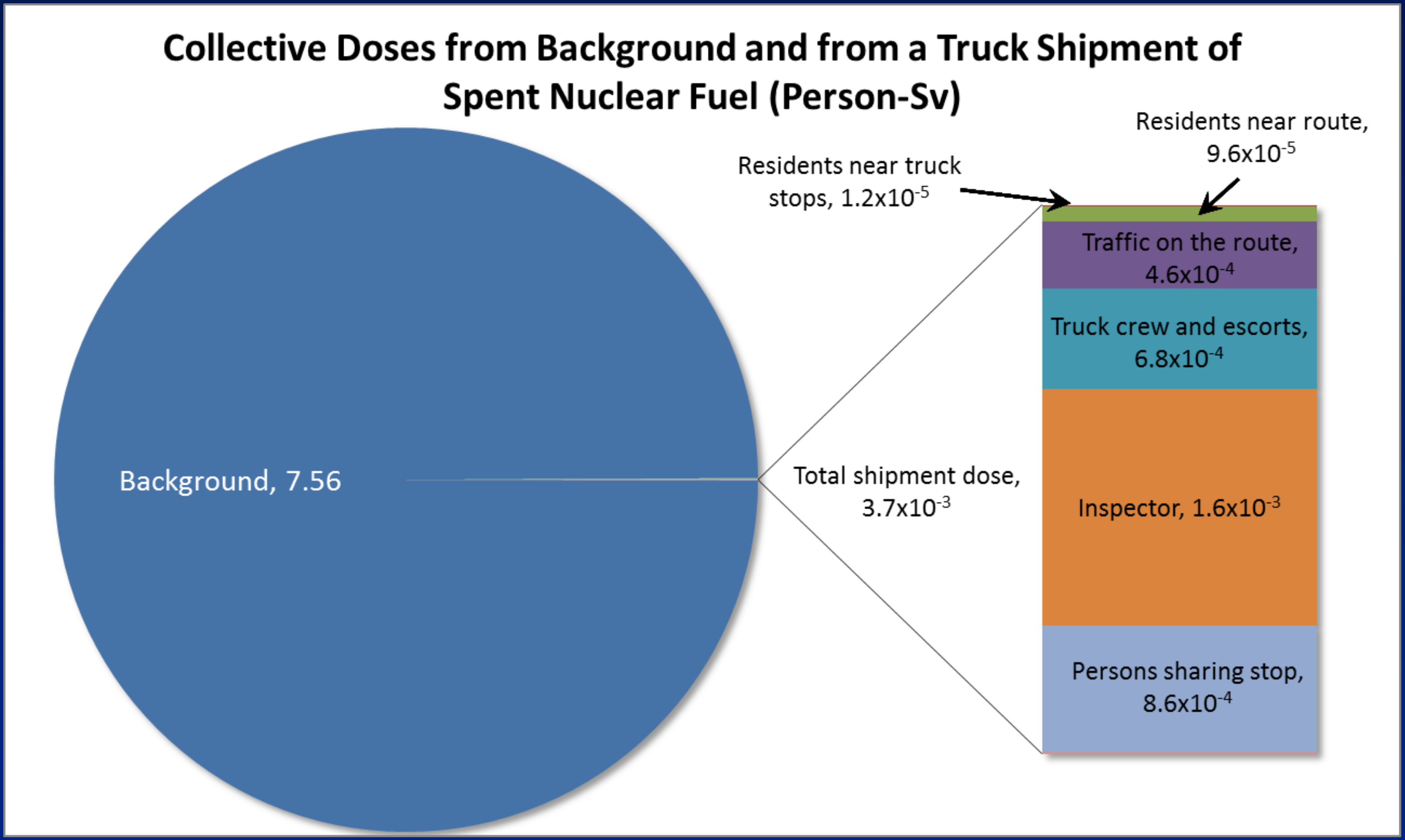
Sample Collective Doses for Routine Truck Transportation

Origin	Destination	Residents Along Route	Occupants of Vehicles Sharing Route	Residents Near Stop	Persons Sharing Stop	Crew/ Truck Stop Worker	Total
MAINE YANKEE	ORNL	$9.6x10^{-5}$	$4.6x10^{-4}$	$1.2x10^{-5}$	$8.6x10^{-4}$	$6.8x10^{-4}$	$2.1x10^{-3}$
	Deaf Smith	$1.4x10^{-4}$	$7.3x10^{-4}$	$1.8x10^{-5}$	$9.2x10^{-4}$	$1.4x10^{-3}$	$3.2x10^{-3}$
	Hanford	$1.2x10^{-4}$	$8.3x10^{-4}$	$1.4x10^{-5}$	$1.3x10^{-3}$	$1.9x10^{-3}$	$4.2x10^{-3}$
	Skull Valley	$1.1x10^{-4}$	$7.0x10^{-4}$	$1.4x10^{-5}$	$1.1x10^{-3}$	$1.6x10^{-3}$	$3.5x10^{-3}$

Total Collective Dose (Person-Sv)

Results from Routine Transportation:

Example for Maine Yankee to ORNL truck shipment



Routine transportation summary

- Individual and collective doses are calculated for a single shipment and are very small.
- Maximum individual doses are comparable to background doses.
- Collective doses from routine transportation are orders of magnitude less than the collective background dose.

Response to regulatory impacts

- Casks are required to withstand a free fall from 9 meters (impact velocity of 48 kph) onto a flat, essentially unyielding, target in the most damaging orientation.
- The NRC requires conservative approaches in demonstrating the casks withstand this impact.
  - Materials
  - Material properties
  - Allowable stresses
- This assures the cask will survive more severe impacts.

Finite element analyses of casks

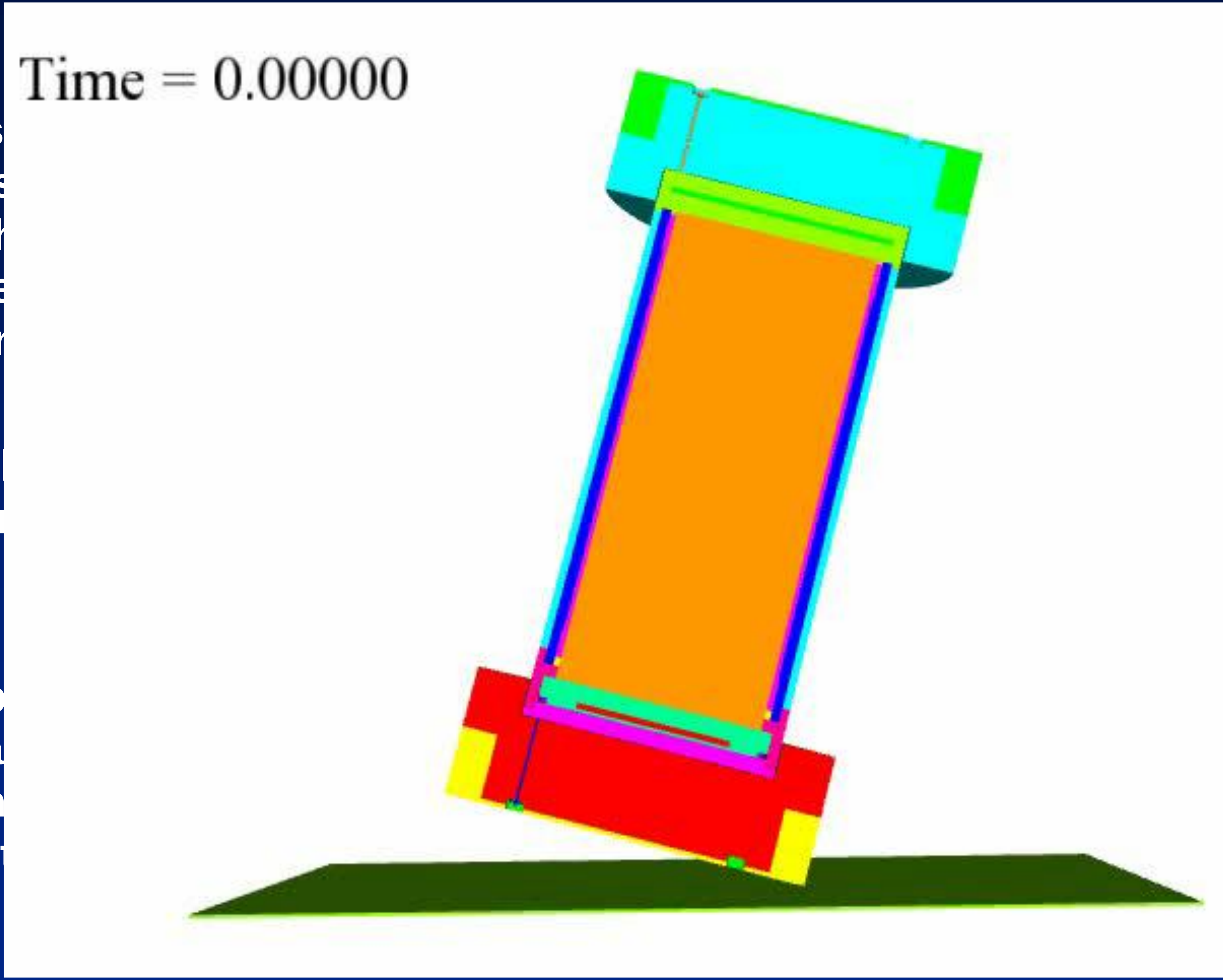
- The response of the two rail casks studied to impacts of 48, 97, 145, and 193 kph (30, 60, 90, 120 mph) onto rigid targets.
- The responses were determined using the nonlinear transient dynamics explicit finite element code PRESTO.
- In the cask models, the fuel region was treated as a homogenized mass.
- The response of the truck cask was inferred based on finite element calculations carried out for other projects.

Rail-lead cask impact analysis

- Deformed s
rail-lead cas
the 120 mph
a rigid targe
corner orien

- No leak-path
there is no r
contents

- Lead slump
a loss of ga
shielding in
assessment



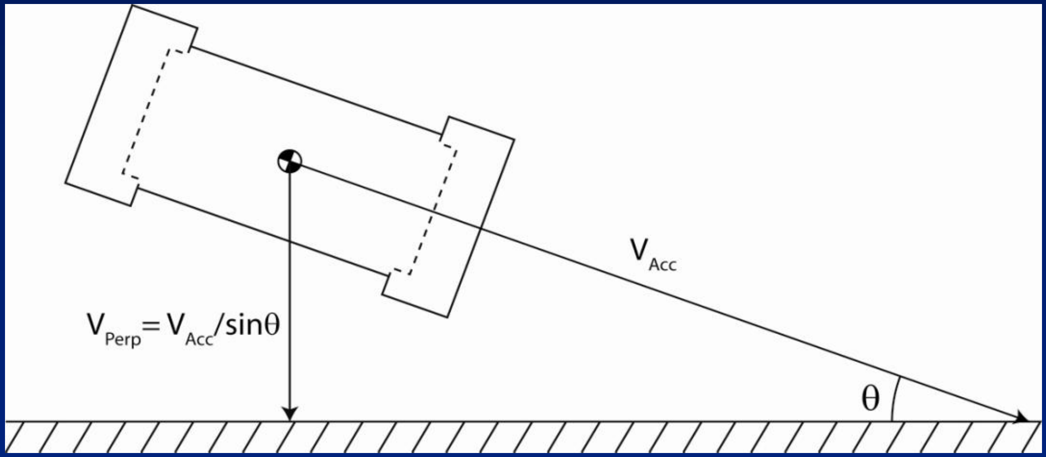
Rail-lead cask impact analysis

- **Side orientation 90 mph impact onto a rigid target**
- **Only cask and orientation resulting in a leak-path**
  - no leak-path if fuel is loaded in an inner welded canister

- **Side orientation 60 mph impact onto a rigid target**
  - No leak path, but
  - The risk assessment assumes impacts into hard rock (5%) above 50 mph result in a leak-path
- **Side orientation impacts at any recorded accident velocity onto targets softer than hard rock do not result in a leak-path**

Affect of impact angle

Angle	V_{Acc} so V_{perp} = 97 kph (60 mph)	Probability
0 - 10	556 (345)	0.2000
10 - 20	282 (175)	0.1778
20 - 30	193 (120)	0.1556
30 - 40	150 (93)	0.1333
40 - 50	126 (78)	0.1111
50 - 60	111 (69)	0.0889
60 - 70	103 (64)	0.0667
70 - 80	98 (61)	0.0444
80 - 90	97 (60)	0.0222



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Impact accident summary

- Only 1 in 2000 accidents is more severe than the regulatory hypothetical accident.
- Due to conservatisms in cask design, only 1 in a billion accidents is severe enough to cause release or loss of gamma shielding.
- A rail cask with an inner welded canister results in no release.
- An impact speed onto a rigid target greater than 60 mph is required to cause seal failure in a rail cask.

Impact accident summary (continued)

- A 60 mph side impact onto a rigid target
  - produces a force of 45 million pounds
  - is equivalent to a 115 mph impact onto a concrete roadway or abutment
  - is equivalent to a 153 mph impact onto hard soil

- For impacts onto rock that is hard enough to be able to resist these large forces, impacts at angles less than 30 degrees require a speed of more than 120 mph to be equivalent.

Response to regulatory fires

- Casks are required to withstand a fully-engulfing hydrocarbon fuel fire for 30 minutes.
- Generally demonstrated by analysis using a prescribed boundary condition of 800°C.
- Real fires have temperatures that vary with both time and location – but the average heating is similar to that from the uniform thermal boundary condition.
- Regulatory review requires seal temperatures and fuel temperatures stay below their failure thresholds.

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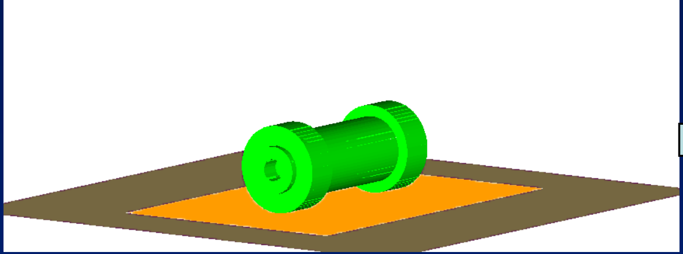
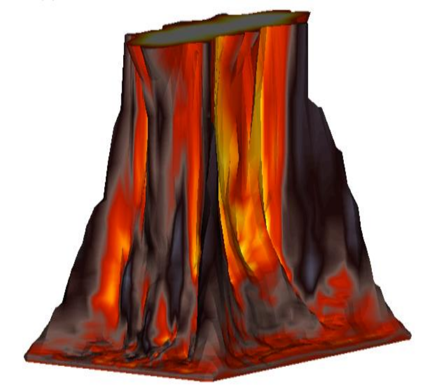
Fire cases analyzed for rail casks

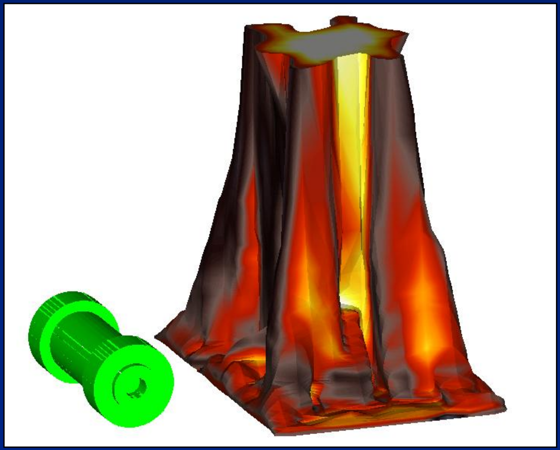
All pools are 46 ft x 29.5 ft and burn for 3 hours



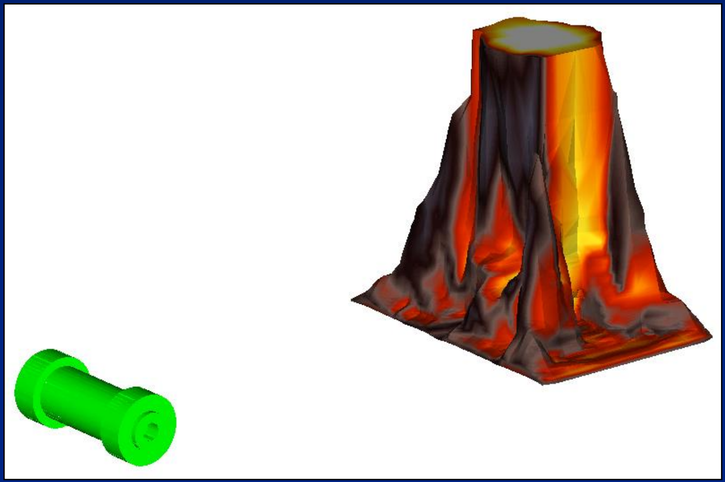
Cask in the middle of flammable liquid fuel pool region (shown in orange) before the fire starts



Fire engulfing the cask

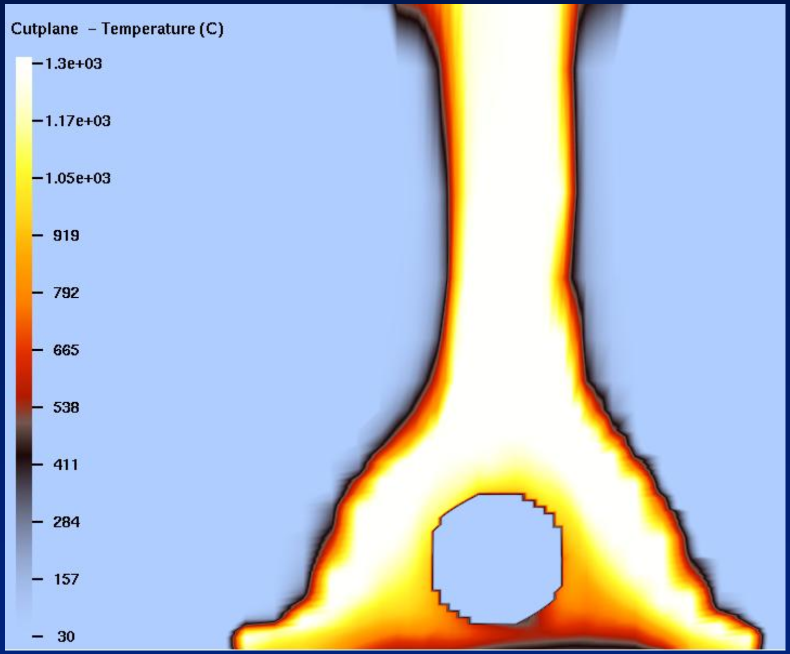


Cask offset from the flammable liquid fuel pool by 3 meters (10 feet)



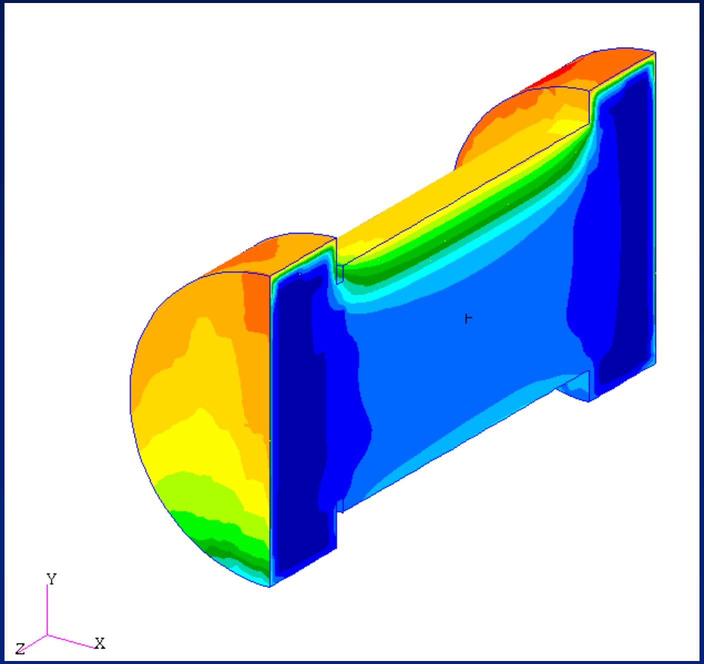
Cask offset from the flammable liquid fuel pool by 18 meters (60 feet)

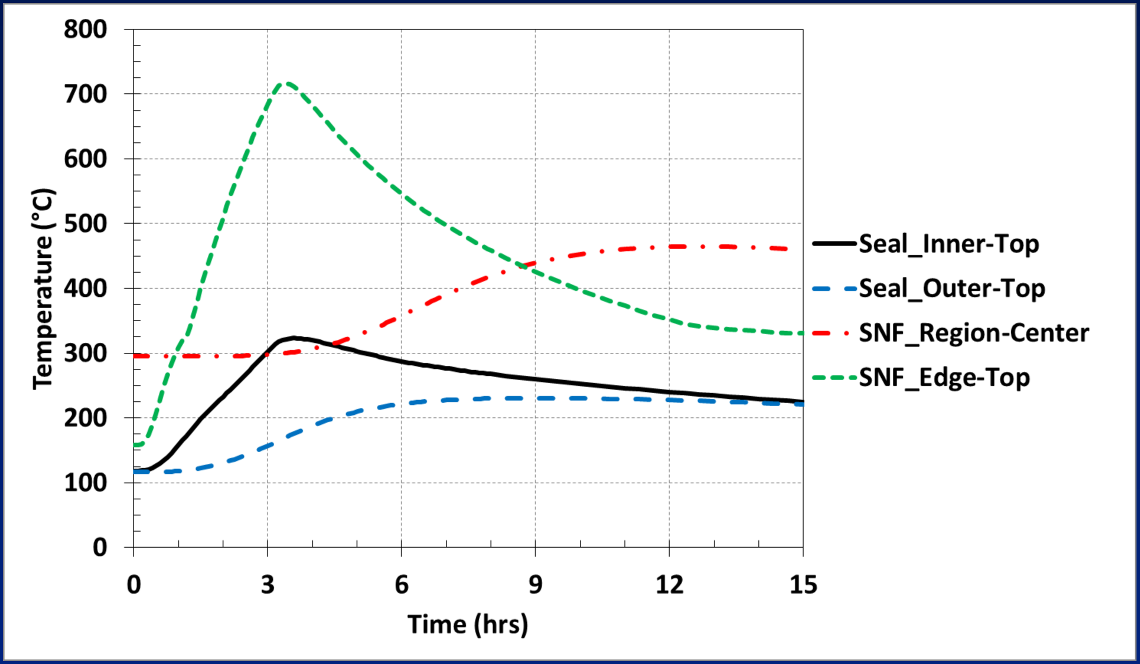
Flame temperatures



Fully engulfing pool fires have temperature variations both spatially and temporally.

Rail-lead cask fire accident
After 3-hour concentric fire:





- Seal temperature is below its failure temperature of 350°C.
- Spent fuel temperature is below the rod-burst temperature of 750°C.

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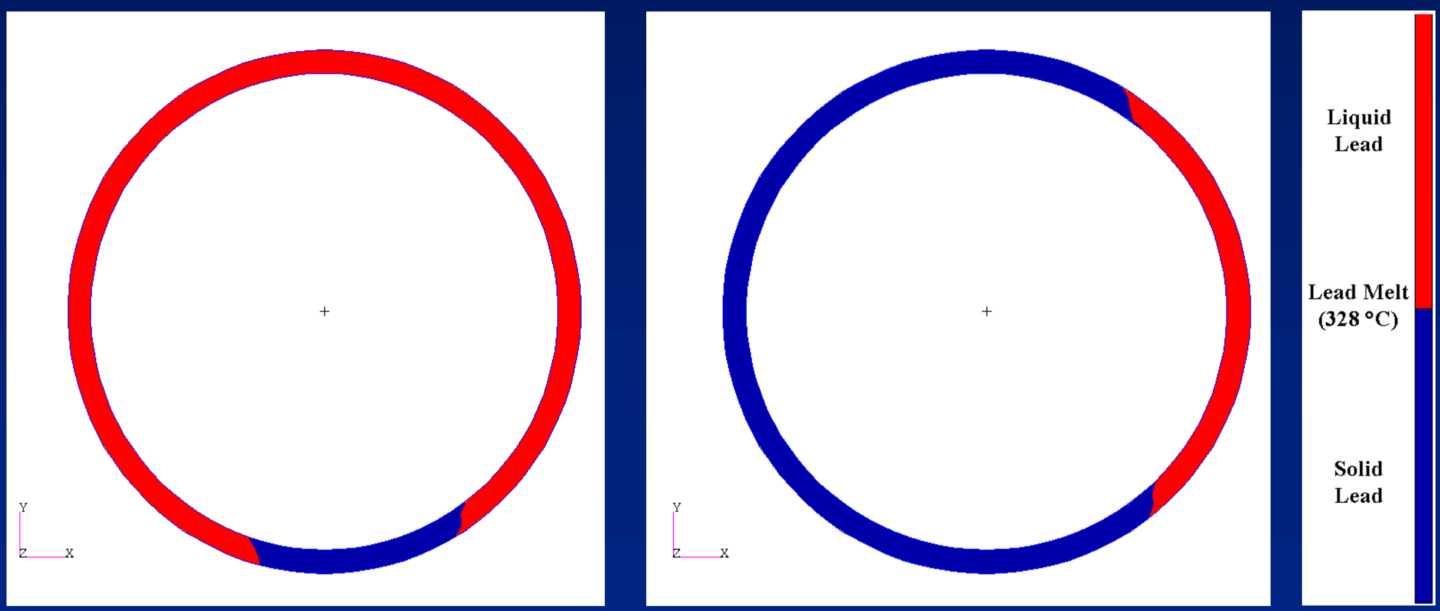
Lead melt

When lead melts it expands and deforms the lead cavity. When it solidifies, it shrinks, leaving a gap.



Concentric fire

3m offset fire

Fire accident summary

- No cask loses containment in the fires analyzed.
- The fuel rods do not fail in the fires analyzed.
- Reduction in neutron shielding is likely for many fires (this is assumed in the certification of the casks).
- Reduction in gamma shielding is possible for very severe fires with lead shielded casks.
  - exposure to a concentric fire that burns longer than 65 minutes
  - exposure to a fire offset by 10 feet that burns longer than 2.25 hours
- Confined fires, such as tunnel fires or fires under overpasses, were not analyzed because other NRC studies have evaluated these environments.

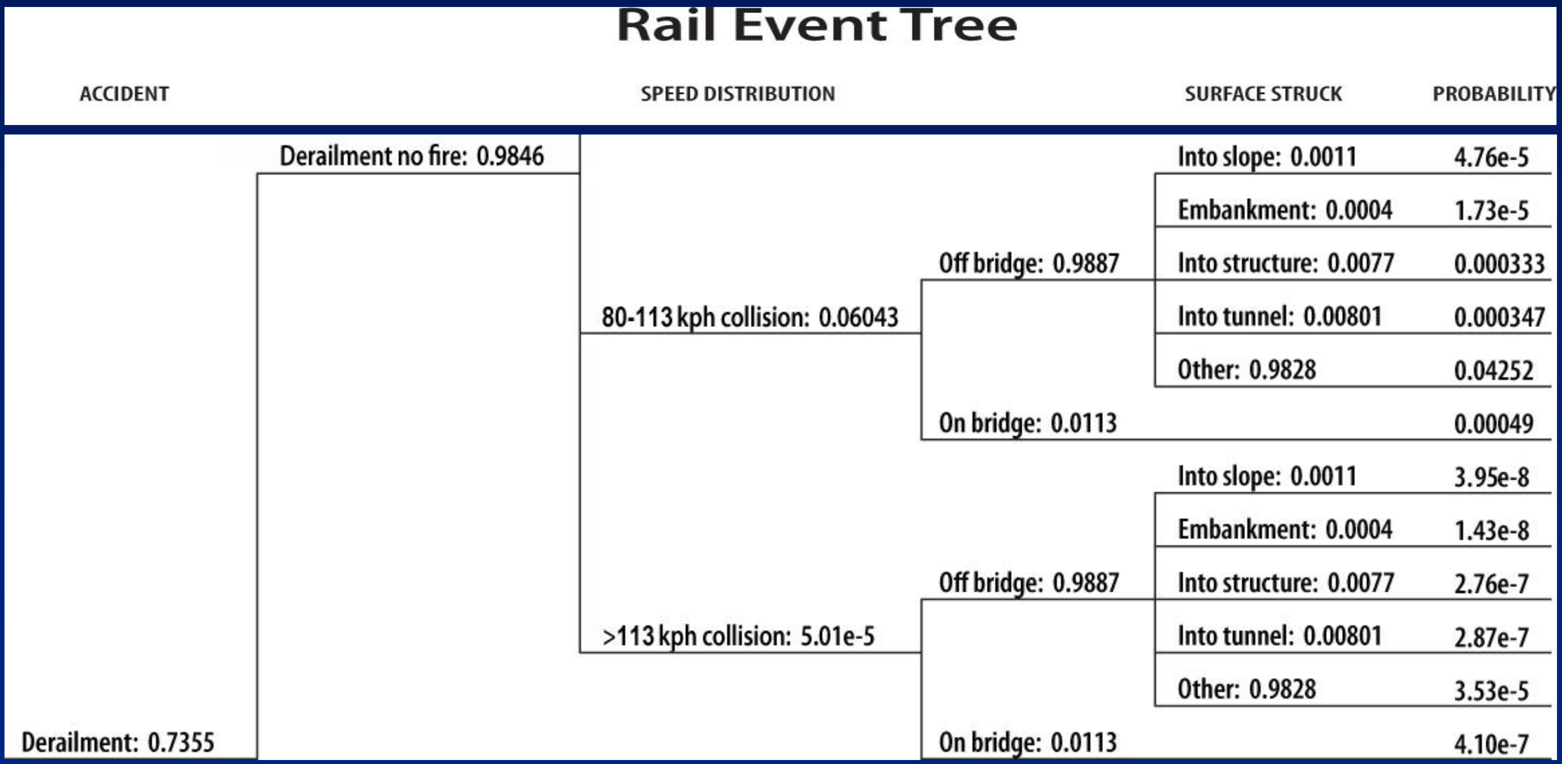
Types of accidents and incidents

- Accidents in which the spent fuel cask is not damaged or affected, but the shipment is delayed
- Accidents in which the spent fuel cask is affected
  - Accidents resulting in loss of neutron or gamma shielding, but no release of radioactive material
  - Accidents resulting in release of radioactive material

Probabilities of all accident types

- Highway and railroad accident statistics are maintained by DOT's Bureau of Transportation Statistics.
- The average probability of an accident is
  - 1.9×10^{-6} per km for heavy trucks (3.1×10^{-6} per mi)
  - 1.1×10^{-7} per km for railcars (1.8×10^{-7} per mi)
- Accident severities are categorized using an event tree with conditional probabilities.
  - For trucks, the event tree was developed at Sandia National Laboratories.
  - For rail, the event tree was developed at the Volpe National Transportation Systems Center.

Accident Conditions: U.S. DOT Rail Accident Event Tree Segment



Additional probabilities included in analyses

- The rail event tree does not include target hardness, so the distribution from the truck event tree was used.
- Neither event tree includes impact angle or orientation, so conservative engineering judgments of angle and orientation distributions were assumed.
- The truck event tree does not include impact velocity, but since impacts at even the highest velocity analyzed did not result in release, this was not needed.
- The rail event tree does not divide accident speeds greater than 113 kph (70 mph), so it is assumed that 95% of them are between 113 and 145 kph (90 mph), and 5% are above 145 kph (needed for lead slump dose risk calculations).

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Accidents without loss of shielding or release

- Almost all accidents will fall into this category.
- Dose depends on the external dose rate of the cask.
- A 10-hour stop time is assumed for all accidents of this type.
- Collective doses are calculated using the average rural, suburban, and urban population densities for each route.
- 10 hour dose to an emergency responder at a 2 meter distance from the cask is ~0.001 Sv (100 mrem).
- Collective population dose risk to nearby residents is ~7 x 10^{-5} person-Sv (7 x 10^{-3} person-rem).

Accidents with loss of gamma shielding but no release

- Less than one in a billion impact accidents is severe enough to cause a loss of lead gamma shielding resulting in a dose rate greater than the regulatory post-accident dose rate.
- Because these accidents are so rare, the collective dose risk is much smaller than that from the no loss of shielding case, about 10^{-13} person-Sv (10^{-11} person-rem).

Accidents with release

- Only rail casks without an inner welded canister have release.
- Dose depends on
  - the inventory (quantity and physical form), assumed in this study to be the maximum the casks are certified to transport (9-year cooled 45 GWD/MTU burn-up).
  - the exposure pathway, which includes rod-to-cask release fraction, cask-to-environment release fraction, and dispersion

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Release fractions

	Cask Orientation	Side	Side
	Rigid Target Impact Speed, kph (mph)	193 (120)	145 (90)
	Seal	elastomer	elastomer
Cask to Environment Release Fraction	Gas	0.80	0.80
	Particles	0.70	0.70
	Volatiles	0.50	0.50
	CRUD	0.001	0.001
Rod to Cask Release Fraction	Gas	0.12	0.12
	Particles	4.8×10^{-6}	4.8×10^{-6}
	Volatiles	3.0×10^{-5}	3.0×10^{-5}
	CRUD	1.0	1.0
	Conditional Probability	1.79×10^{-11}	3.40×10^{-10}

Doses from release

- Dominated by inhalation
- Includes resuspension, cloudshine, groundshine, and ingestion
- Because of thermal loft due to the elevated temperature of the cask interior, the maximum dose occurs 21 meters downwind from the accident.
- Maximum individual dose to a hypothetical person at this location is 1.6 Sv (160 mrem).
- Collective dose risk is 10^{-12} person-Sv (10^{-10} person-rem).

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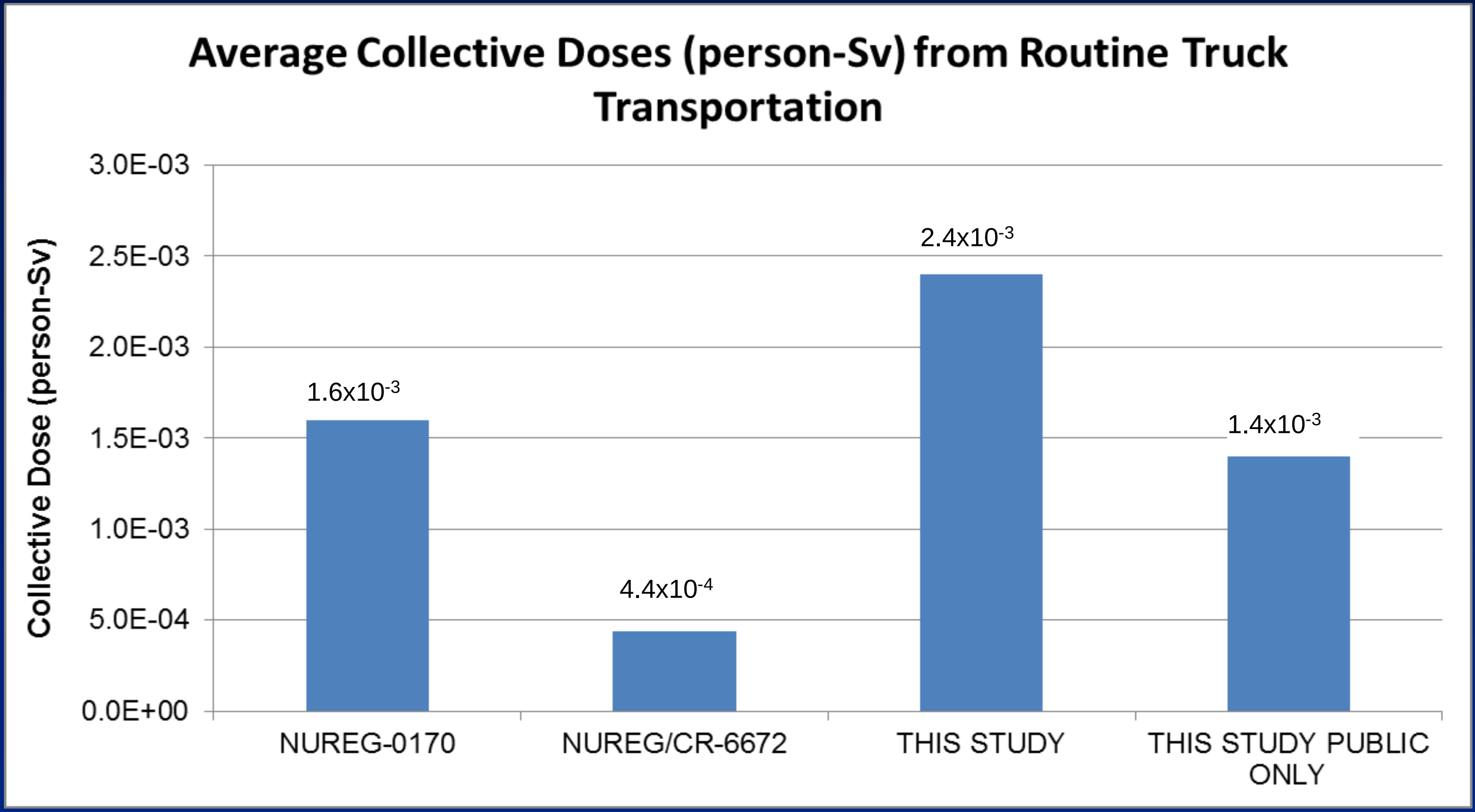
Accident risk summary

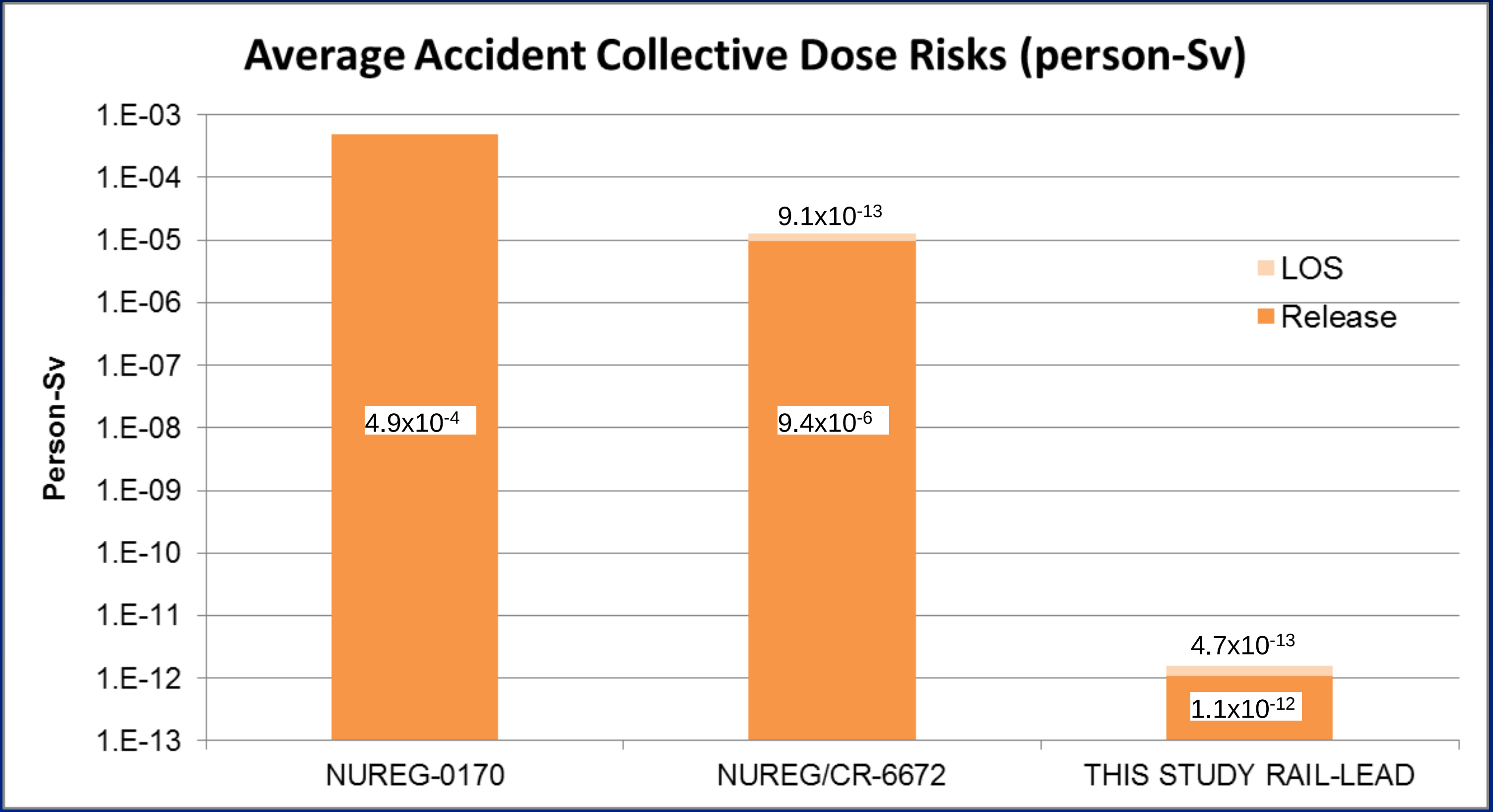
- The overall collective dose risks are very small.
- The collective dose risks for the two types of extra-regulatory accidents (accidents involving a release of radioactive material and loss-of-lead-shielding accidents) are negligible compared to the risk from a no-release, no-loss-of-shielding accident.
- There is no expectation of release from spent fuel shipped in inner welded canisters from any impact or fire accident analyzed.
- The collective dose risk from loss of lead shielding is comparable to the collective dose risk from a release, both are very small.
- These accidents occur with extremely low probability (less than one in a billion accidents).

Routine Transportation Results Comparison:



Accident Results Comparison:

Accident collective dose risks from release and loss of gamma shielding (LOS) accidents. The LOS bars are not to scale.



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SFTRA Findings

- The collective dose risks from routine transportation are very small. These doses are about four to five orders of magnitude less than collective background radiation dose over the same time period and exposed population as the shipment.
- There was little variation in the risks per kilometer over the routes analyzed.
- Radioactive material would not be released in an accident if the fuel is contained in an inner welded canister inside the cask.
- Only rail casks without inner welded canisters would release radioactive material, and only then in exceptionally severe accidents.
  - If there were an accident during a spent fuel shipment, there is less than one in a billion chance the accident would result in a release of radioactive material.
  - If there were a release of radioactive material in a spent fuel shipment accident, the dose to the maximum exposed individual would be non-fatal.

SFTRA Conclusions

- This study reconfirms that estimated radiological risks from spent fuel transportation *conducted in compliance* with NRC regulations are low, in fact generally less than previous estimates, which were already low.

- Accordingly, for spent fuel transportation, the regulations for transportation of radioactive material are adequate to protect public health and safety.

- No changes are needed to the regulations for spent fuel transportation.

Draft NUREG-2125 published for comment

- Federal Register Notice**: 77 FR 28406**, May 14, 2012
- ADAMS Accession Number for Draft NUREG-2125 : **ML12125A218**
- Public comment period closed on July 15, 2012
- Comments received from
  - The State of Nevada
  - The State of Oregon
  - Western Interstate Energy Board
  - Nuclear Energy Institute

Comment: 60 day comment period is inadequate/extension request

- Draft response
  - Given the nature of the subject, the staff considered granting the extension request. However, in considering various factors, including contract expiration date, the staff felt that the comment period could not be extended. Furthermore, the Federal Register notice states that comments received after 60 days will be considered if it is practical to do so.
- No changes to Draft NUREG-2125

Comment: Accident scenarios underestimate potential fire durations and temperatures

- Draft response
  - The probability, given an accident, of the most severe fire considered in DRAFT NUREG-2125 is 10^{-14} as explained in Section E.3.1.2. While it is possible to envision a more severe fire accident; such events would have an even lower probability and would not affect the overall risk of spent fuel transportation unless they had a release of more than 10,000 A_2, which is not feasible.
- Changes to Draft NUREG-2125
  - Add discussion on Caldecott and Baltimore Tunnel Fires and MacArthur Maze Fire, including their probabilities, and show it does not change the risk results.

Comment: Calibration of finite element models

- Draft response
  - The report provides an example of a comparison between finite element analysis and test results for a large fire test in Appendix D. Similar comparisons have been made for regulatory and extra-regulatory impact analyses. There have been many physical tests on casks and cask components that have been compared to finite element predictions of the tests. Many spent fuel casks are certified by a combination of testing and analysis, where the testing is used to validate the finite element analysis.
- Changes to Draft NUREG-2125
  - References on comparison between test and analyses for impact analyses will be added to the report.

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Hanford should not be an example destination

- Draft response
  - Transportation risk assessments require designation of shipment points of origination and destinations. Currently, there are no planned spent fuel shipping campaigns. DRAFT NUREG-2125's shipment points of origination and destination were selected to illustrate long-haul geographic diversity. We believe the disclaimer "The routes shown are for illustrative purposes only, and no SNF shipments are planned from any of these points of origination to any of these destinations" makes this clear. While other origination/destination pairs are possible, the DRAFT NUREG-2125 pairs are adequate for the stated purposes of the study. Also, the report makes clear that DRAFT NUREG-2125 is a generic spent fuel transportation risk assessment, and is not intended as a facility- or site-specific environmental assessment.
- Changes to Draft NUREG-2125
  - Repeat existing DRAFT NUREG-2125 disclaimer at least once in chapter 2, chapter 5, chapter 6, appendices B, E, and F

Comment: Results should be used to risk inform 10 CFR Part 71

- Draft response
  - NUREG-2125 will be available for consideration in NRC's risk management activities.
- No changes to Draft NUREG-2125

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Back-up Slides

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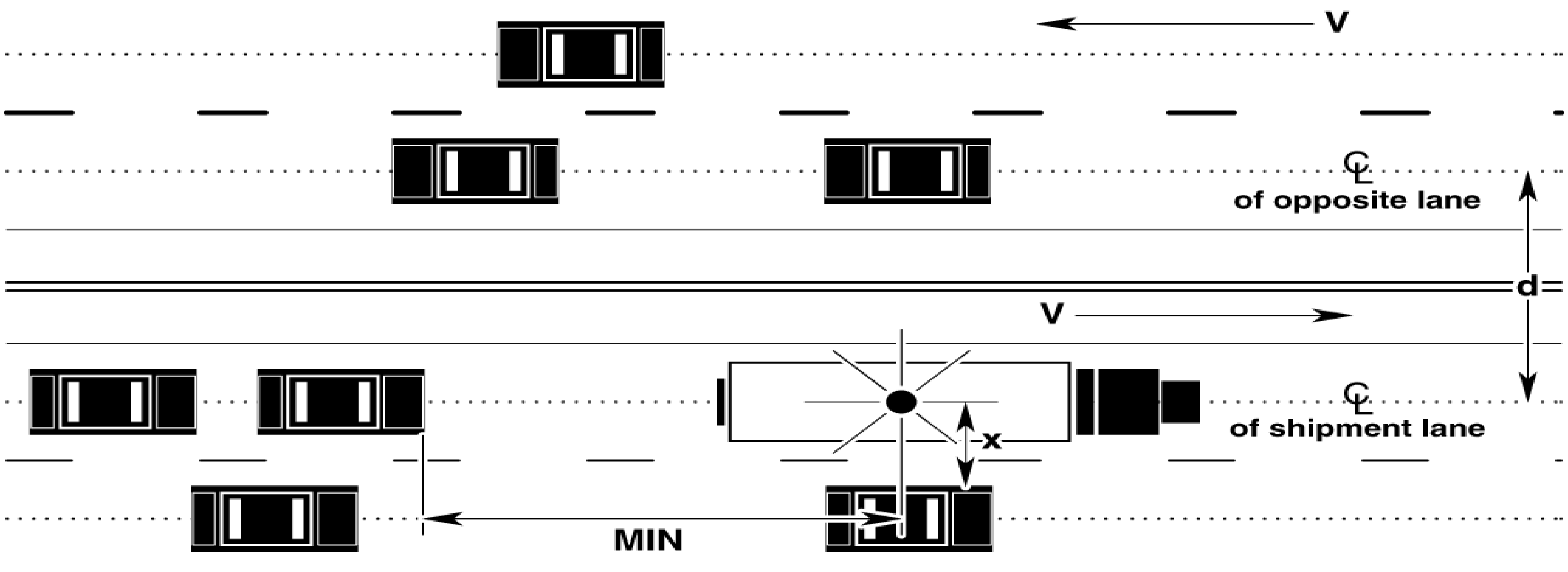
RADTRAN model for occupants of other vehicles

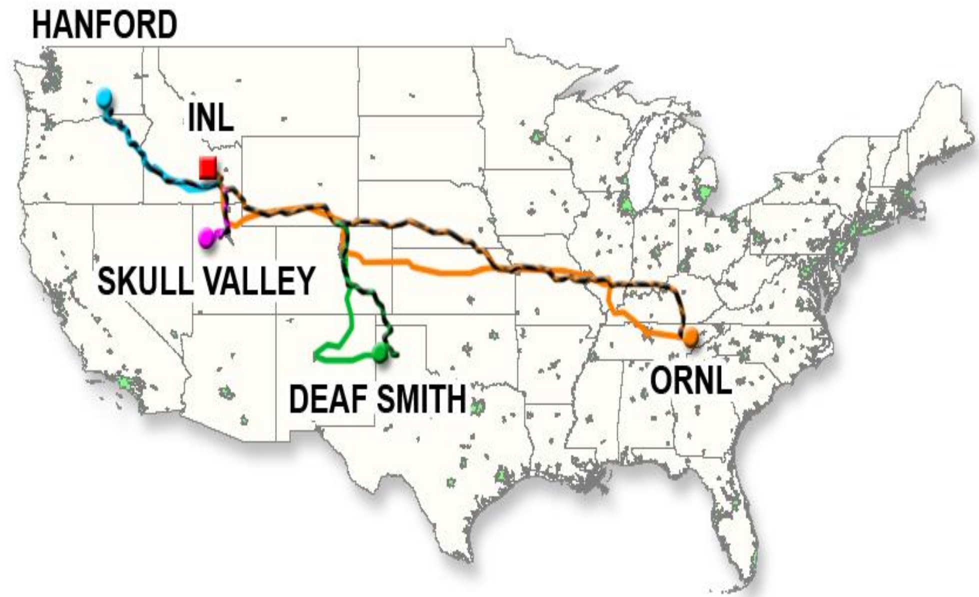


Legend

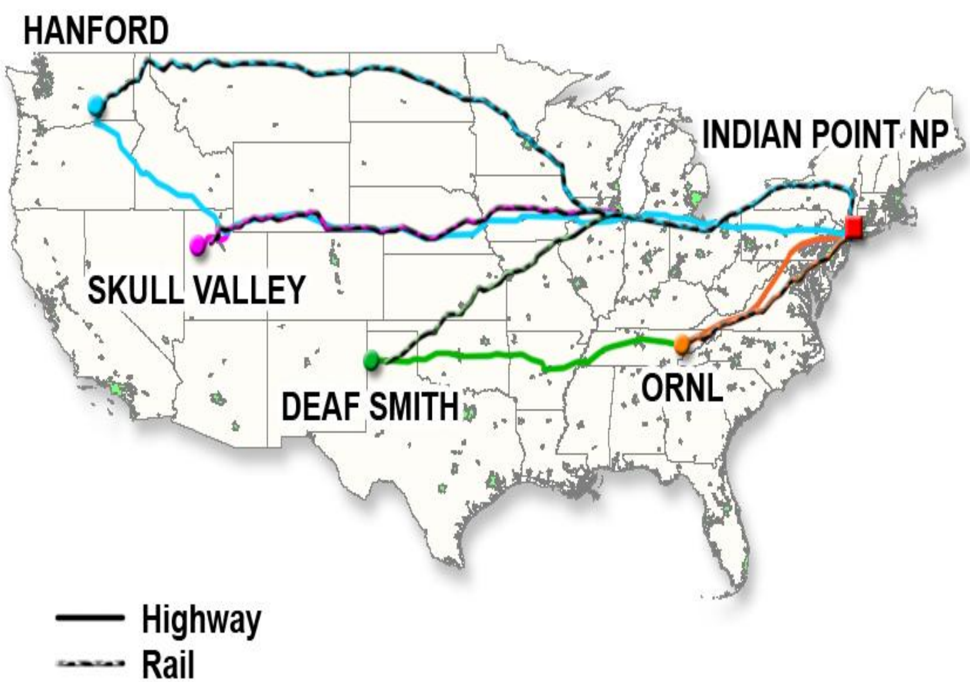
- **V** - Traffic velocity
- **d** - Distance fromRAM vehicle to traffic in opposite direction
- **x** - Distance from RAM vehicle to passing vehicle
- **MIN** - Minimum following distance

Example Routes (continued)

Idaho National Laboratory Routes



Indian Point NP Routes



- INL included as an origin because spent fuel is stored there.