Testimony of

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Hearing on the

Safety and Security of Spent Nuclear Fuel Transportation

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Good afternoon Chairman Inouye and members of the committee. My name is Kevin Crowley, and I am the director of the National Research Council's Nuclear and Radiation Studies Board.[1] I also directed two National Research Council studies that are relevant to this hearing on the safety and security of spent nuclear fuel transportation:

- Going the Distance? The Safe Transport of Spent Nuclear Fuel and High-Level Radioactive Waste in the United States[2]
- Safety and Security of Commercial Spent Nuclear Fuel Storage[3]

Both of these reports were published in 2006. The latter report, which has classified and unclassified versions, was the product of a congressionally mandated study. That study examined the safety and security of dry storage of spent nuclear fuel at civilian nuclear power plants. Some of the results of that study have informed my comments on transportation security.

My testimony is provided in three parts: transportation safety challenges, transportation security challenges, and the challenges associated with transportation of spent fuel to the proposed repository at Yucca Mountain, Nevada.

Transportation Safety Challenges

My comments on the safety[4] challenges associated with transporting nuclear waste will focus specifically on the transportation of spent nuclear fuel generated by civilian nuclear power plants. Spent fuel is highly radioactive and can cause severe harm to humans and the environment, if not properly managed. Immediately after its discharge from a power reactor, for example, the radiation emitted from a single spent fuel assembly would be lethal to a nearby

[1] The National Research Council is the operating arm of the National Academy of Sciences, National Academy of Engineering, and the Institute of Medicine of the National Academies, chartered by Congress in 1863 to advise the government on matters of science and technology. The Nuclear and Radiation Studies Board is responsible for oversight of National Research Council studies on safety and security of nuclear materials and waste.
[2] This report is available online at http://www.nap.edu/catalog.php?record_id=11538.
[3] The unclassified report is available online at http://www.nap.edu/catalog.php?record_id=11263.
[4] Safety refers to measures taken to protect spent fuel and high-level waste during transport operations from failure, damage, human error, and other inadvertent acts.

unshielded person for exposure periods on the order of minutes. Spent fuel becomes less radioactive with time, but even after several years of storage it is still highly radioactive and can cause both immediate (i.e., radiation sickness and death) and delayed (e.g., cancer) effects in exposed populations if not properly managed.

There are at least three factors that promote the safety of spent fuel transportation in the United States:

- Storage before shipping: Civilian spent fuel must be stored for at least a year before it can be transported, and current industry practice is to store this fuel for at least five years before transporting it. This provides time for radioactive decay in the spent fuel, which helps to reduce its hazard.
- Transport packages: Spent fuel is transported in *packages* (also referred to as *shipping casks*) that are designed to shield the radiation that is emitted by the fuel and also to prevent the release of radioactive material, even in severe accidents.
- Conduct of transport operations: There are strict regulatory requirements for selection of shipping routes, advance notification of state authorities before shipments are made, and for shipping operations.

The National Research Council's *Going the Distance* report provides a detailed discussion and analysis of the safety of spent fuel transportation, focusing on the design and testing of packages used to transport spent fuel and on the historical record of spent fuel shipments. Based on this analysis, the expert committee[5] that conducted this study found that it

> "… could identify no fundamental technical barriers to the safe transport of spent nuclear fuel and high-level radioactive waste in the United States. Transport by

[5] Committee on Transportation of Radioactive Waste. Dr. Neal Lane, a physicist at Rice University and former director of the National Science Foundation and presidential science advisor, chaired this study.

> highway (for small-quantity shipments[6]) and by rail (for large-quantity shipments) is, from a technical viewpoint, a low-radiological-risk activity with manageable safety, health, and environmental consequences when conducted in strict adherence to existing regulations. However, there are a number of social and institutional challenges to the successful initial implementation of large-quantity shipping programs that will require expeditious resolution …. Moreover, the challenges of sustained implementation should not be underestimated."

I want to emphasize that this finding focused on the technical aspects of spent fuel and high-level waste transportation—for example, the design, fabrication, and maintenance of the packages and conveyances used for transporting spent fuel and the conduct of transportation operations. This finding is predicated on the assumption that these technical tasks are being carried out with a high degree of care and in strict adherence to regulations. The finding also is based on an assessment of past and present transportation programs and would apply to future programs only to the extent that they continue to exercise appropriate care and adherence to applicable regulations. Continued vigilance by all parties involved in these transportation programs, including planners, shippers, and regulators, will be required to ensure that transportation operations in the United States continue to be conducted in a safe manner, especially if and when the large-quantity shipping program to Yucca Mountain is initiated.

The packages that are used to transport spent fuel play a crucial role in transportation safety by providing a robust barrier to the release of radiation and radioactive material. In fact, the robust design of these packages helps to minimize the impacts of human error on transport safety. The committee that conducted the *Going the Distance* study found that current

[6] The *Going the Distance* report identified two general types of transportation programs, small-quantity shipping programs and large-quantity shipping programs. The former involve shipment on the order of tens of metric tons of spent fuel or high-level waste, while the latter involve shipment on the order of hundreds to thousands of metric tons. The program to transport spent fuel to the proposed repository at Yucca Mountain would be an example of a large-quantity shipping program.

international standards and U.S. regulations are adequate to ensure package containment effectiveness[7] during both routine transport and in severe accidents. However, the study committee noted that recently published work suggests that there may be a very small number of extreme accident conditions involving very long duration fires[8] that could compromise package containment effectiveness. The study committee recommended that the U.S. Nuclear Regulatory Commission (USNRC) undertake additional analyses of very long duration fire scenarios that bound expected real-world accident conditions. Based on the results of these investigations, the study committee also recommended that the USNRC implement operational controls and restrictions on spent fuel and high-level waste shipments as necessary to reduce the chances that such conditions might be encountered in service. The study committee further recommended that transportation planners and managers undertake detailed surveys of transportation routes to identify and mitigate the potential hazards that could lead to or exacerbate extreme accidents involving such fires.

Transportation Security Challenges

Let me now turn to the security[9] of spent fuel transportation. Many of the regulatory requirements that are in place to promote the safety of spent fuel transport also help to promote security. For example, the robust shipping packages that are used to protect spent fuel in the event of a severe accident would also help to protect spent fuel against some types of sabotage and terrorist attacks. There are additional regulatory requirements that also help to promote security of spent fuel shipments: for example, the USNRC conducts route inspections to identify potential security vulnerabilities as part of its route approval process; it has established requirements for armed escorts when shipments pass through highly populated regions; and it

[7] That is, the ability of a transportation package to contain its radioactive contents and maintain its radiation shielding effectiveness during routine use and under severe accident conditions.
[8] The USNRC requires that packages be designed to maintain containment effectiveness in a 30-minute fire that is fully engulfing. A very long duration fire is a fire that burns for much longer periods, for example, hours to days.
[9] Security involves measures taken to protect spent fuel and high-level waste against sabotage, attacks, and theft while it is in transport.

has established other requirements for equipment security and communications. Some of these regulatory requirements were revised after the September 11, 2001, terrorist attacks, and some specific requirements have not been disclosed to the public to protect national security.

However, transportation security differs from transportation safety in at least one important respect: safety problems arise from human error and equipment malfunctions that are amenable to quantitative analysis, whereas security problems arise from intentional malevolent acts that generally do not lend themselves to such analysis. Transportation safety analyses, for example, rely heavily on the historical record for shipping other types of hazardous materials. This record allows analysts to identify severe accident scenarios that might be a concern for spent fuel transport—for example, train collisions or derailments that expose shipping packages to large impact forces or severe fires—and also provides analysts with reliable data on the frequency of occurrence of such accidents. These accident scenario and accident frequency data can be used to quantitatively model the safety consequences of severe accidents involving spent fuel.

There is no comparable historical record that can be used to develop quantitative estimates of sabotage or attack scenarios or their frequency of occurrence. Instead, analysts must rely on expert judgments about the threat environment and terrorists' access to technical means and opportunity for attacking or sabotaging spent fuel shipments. I should note that this security challenge is not unique to spent fuel transportation, but is also faced by owners and operators of other critical infrastructure.

A great deal of work has been carried out in the United States and in some other countries to understand the potential consequences of sabotage and terrorist attacks on spent fuel shipments. Most of this work is classified or otherwise restricted from public release. The National Research Council study on *Safety and Security of Commercial Spent Nuclear Fuel Storage* examined some of the relevant work that has been carried out by Sandia National Laboratories and others to estimate the consequences of sabotage or terrorist attacks on spent

fuel being stored at civilian nuclear plants.[10] This work is relevant to spent fuel transport security because some of the packages that are used to store spent fuel at civilian nuclear plants can also be used for transportation. The study committee's[11] detailed analyses of the consequences of various terrorist attack scenarios are classified; however, the study committee's unclassified report notes that all storage cask designs are vulnerable to some types of terrorist attacks for which releases of radioactive material would be possible, although the magnitudes of such releases are predicted to be small. However, it is important to recognize that storage casks at fixed sites such as nuclear plants are in principle easier to protect from certain kinds of terrorist attacks than spent fuel packages in transport on the nation's highways and railways.

The National Research Council's *Going the Distance* study was organized before the September 11, 2001, terrorist attacks on the United States. It was focused primarily on the safety of spent fuel and high-level waste transport because this issue was receiving the most public attention when the study was organized. Once the study was begun, however, it soon became clear that transportation security had established itself in the public's consciousness as a top concern along with transportation safety. The study committee was not able to conduct an in-depth review of transportation security because of information access constraints. However, the study committee found that "malevolent acts against spent fuel and high-level waste shipments are a major technical and societal concern, especially following the September 11, 2001, terrorist attacks on the United States." The study committee also recommended that

> "An independent examination of the security of spent fuel and high-level waste transportation should be carried out prior to the commencement of large-quantity shipments to a federal repository or to interim storage. This examination should provide an integrated evaluation of the threat environment, the response of

[10] This study examined both wet storage of spent fuel in pools and dry storage in casks. My comments in this testimony are focused only on dry storage.
[11] Committee on Safety and Security of Commercial Spent Nuclear Fuel Storage. The committee was chaired by Dr. Louis Lanzerotti, a geophysicist and member of the National Academy of Engineering.

> packages to credible malevolent acts, and operational security requirements for protecting spent fuel and high-level waste while in transport. This examination should be carried out by a technically knowledgeable group that is independent of the government and free from institutional and financial conflicts of interest. This group should be given full access to the necessary classified documents and Safeguards Information to carry out this task. The findings and recommendations from this examination should be made available to the public to the fullest extent possible."

I want to emphasize that this recommendation was not made because the study committee had specific knowledge of vulnerabilities of spent fuel shipments to sabotage or terrorist attacks. Instead, it was motivated primarily by concerns that were expressed to the study committee about whether such shipments could be made in a secure fashion in spite of reassurances from federal agencies. The study committee recognized that the federal agencies were in a difficult position on this issue because as much as they might like to share security-related information that might help to inform the public, there were legitimate national security reasons for not doing so. The study committee judged that an independent review would help to improve the technical soundness of the agencies' security programs for spent fuel transportation and also help to reassure the public that the agencies' programs were proceeding on a sound technical basis.

Transportation Challenges for Yucca Mountain

The primary challenges for the Yucca Mountain transportation program arise from at least three factors: the large number of shipments that are planned; the two-decade-plus-time period over which the transportation program must be operated in a safe and secure manner; and the long lead times and large expenditures that will be required to put the necessary transportation infrastructure in place. The National Research Council's *Going the Distance*

report noted that the planned number of rail shipments to a repository at Yucca Mountain under the Department of Energy's (DOE's) "mostly rail" scenario is approximately 18 times the number of rail shipments that have occurred in the United States between 1964 and 2004.[12] In other words, previous spent fuel transport experience in the United States is small compared with the numbers of shipments that will be needed to move spent fuel and high-level waste to a Yucca Mountain repository.

The National Research Council committee that authored the *Going the Distance* report provided several findings and recommendations for improving the Yucca Mountain transportation program; these are summarized below:

- The study committee strongly endorsed DOE's decisions to ship spent fuel and high-level waste to the federal repository by "mostly rail" using dedicated trains. This approach would reduce routine radiological exposures; provide for greater physical separation from other vehicular traffic and reduced interactions with people along transportation routes; and simplify operational logistics. It is also the approach that is preferred by the public. The study committee recommended that DOE fully implement this approach by completing construction of the Nevada rail spur and making other necessary arrangements before commencing large-quantity shipments to the repository. The study committee also recommended that DOE examine the feasibility of further reducing its needs for cross-country truck shipments[13] of spent fuel.
- DOE should identify and make public its suite of preferred highway and rail routes for transporting spent fuel and high-level waste to a federal repository as soon as

[12] The Yucca Mountain EIS noted that DOE plans to make up to 9600 rail shipments of spent fuel and high-level waste to the repository. The *Going the Distance* study estimates that about 540 rail shipments of spent fuel were made in the United States between 1964 and 2004. The actual number of rail shipments to Yucca Mountain would depend on how DOE conducts its transport operations.
[13] Even under the "mostly rail" scenario, DOE estimated in its Yucca Mountain EIS that about 1100 truck shipments would be made to the repository.

practicable to support state, tribal, and local planning, especially for emergency responder preparedness. DOE should follow the practices of its foreign research reactor spent fuel transport program of involving states and tribes in these route selections.[14]

- DOE should negotiate with commercial spent fuel owners to ship older fuel first to a federal repository or to federal interim storage.[15] Should these negotiations prove to be ineffective, Congress should consider legislative remedies. Within the context of its current contracts with commercial spent fuel owners, DOE should initiate transport to the federal repository through a pilot program involving relatively short, logistically simple movements of older fuel from closed reactors to demonstrate its ability to carry out its responsibilities in a safe and operationally effective manner.
- DOE should begin immediately to execute its emergency responder preparedness responsibilities defined in Section 180(c) of the Nuclear Waste Policy Act. The study committee recommended several approaches for carrying out this recommendation.
- DOE, the Department of Homeland Security, Department of Transportation, and USNRC should promptly complete the job of developing, applying, and disclosing consistent, reasonable, and understandable criteria for protecting sensitive information about spent fuel and high-level waste shipments. They should also commit to the open sharing of information that does not require such protection and should facilitate timely access to such information, for example, by posting it on readily accessible Web sites.

[14] The *Going the Distance* report contains a detailed discussion of routing regulations for spent fuel shipments.
[15] Shipping older fuel first would help to reduce transportation worker exposures to radiation from the spent fuel and high-level waste shipments.

- DOE should take early and proactive steps to establish formal mechanisms for gathering high-quality and diverse advice about social risks[16] and their management on an ongoing basis.
- The Secretary of Energy and the U.S. Congress should examine options for changing the organizational structure of DOE's program for transporting spent fuel and high-level waste to a federal repository to increase its chances for success. The following three alternative organizational structures, which are representative of progressively greater organizational change, should be examined: (1) a quasi-independent DOE office reporting directly to upper-level DOE management; (2) a quasi-government corporation; or (3) a fully private organization operated by the commercial nuclear industry.

The study committee found that successful execution of DOE's program to transport spent fuel and high-level waste to a federal repository will be difficult given the organizational structure in which it is embedded, despite the high quality of many program staff. As currently structured, the program has limited flexibility over commercial spent fuel acceptance order; it also has limited control over its budget and is subject to the annual federal appropriations process, both of which affect the program's ability to plan for, procure, and construct the needed transportation infrastructure. Moreover, the current program may have difficulty supporting what appears to be an expanding future mission to transport commercial spent nuclear fuel for interim storage or reprocessing. In the study committee's judgment, changing the organizational structure of this program would improve its chances for success.

[16] Social risks arise from social processes and human perceptions. Social processes shape the communities in which people live by, for example, influencing choices about where to purchase or rent a home, where to work, and where to send children to school. Social perceptions can have a strong influence on peoples' behavior, whether or not such perceptions are an accurate picture of reality.

This concludes my testimony to the committee. Thank you for the opportunity to testify on these important issues. I would be happy to elaborate on any of my comments during the question and answer period.