Nuclear Waste: Transportation Across U.S. and the Globe

HIRES Interns: Derek Chen, Chloe Wu, Valerie Tang, Josiah Cox
Mentors: Emely M. Núñez Rodriguez, Ana M. Mejía Manrique, Eromosele E. Osuide, Liam H. Forsythe
Faculty Advisors/Researchers: Dr. Liubov Kreminska,
Address/Affiliation - CUNY CREST High School Initiative in Remote Sensing of Earth System Engineering and Sciences (HIRES)
The City College of New York, NY 10031

Background:

- Nuclear waste is becoming increasingly relevant across countries. The U.S., China, Russia and France have all started to use nuclear energy.
- People have concerns and are scared of nuclear energy overall due to incidents like Chernobyl, Fukushima, and Three Mile Island and we want to see if these concerns are valid and if the nuclear waste transport industry needs immediate attention.
- While expensive, nuclear energy is immensely better than for the environment than fossil fuels. If it is safe to transport nuclear waste, there should be no reason for communities to worry about it and the U.S. should progress with nuclear energy.

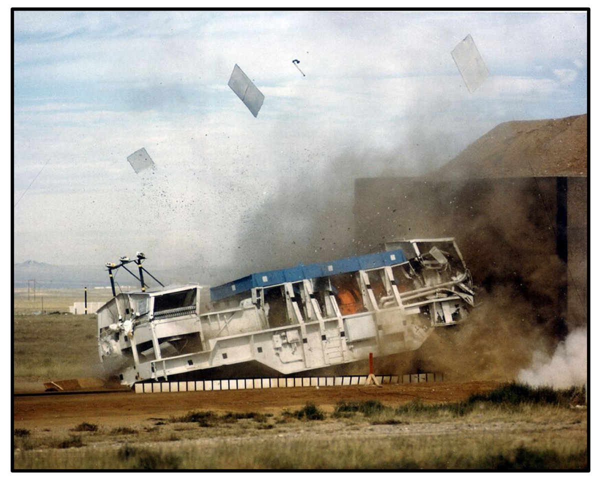

Fig.1. Spent Nuclear Fuel cask testing by Sandia Laboratories (cask was propelled into wall at 81 mph and remained intact)

Motivation:

Nuclear energy has become increasingly more popular not only in the eye of the public, but in the eyes of government officials as a newer source of clean energy. However, since the dawn of nuclear weapons during the World War II era, people in America have retaliated against the push towards nuclear energy. Our motivation is to help people come to realize the benefits of nuclear energy as well as how safe it is compared to even other clean energy sources.

Methods:

First, we clarified our research focus by creating questions, an outline and assigning subtopics. We looked through online databases like ScienceDirect, government websites, and JSTOR for literature review. Additionally, we also printed out articles in order to highlight and note important details. Through CUNY HIRES, we also took a course on GIS and the many functions of ArcGIS Pro to create maps that represent real life data.

Study Area:

Fig.2. WIPP Nuclear Waste Transportation Routes in the U.S.A.*

Legend: Pinpoint= Major Laboratory centers, star=Waste Isolation Pilot Plant, Triangle = Nuclear Reactors, Blue lines= U.S. Highway(Open), Red lines= Route closed, Green lines = State Highway(open), Yellow lines= Route Not Open, Blue area=land

In our GIS map, we focus on the U.S. for the current route that the Waste Isolation Pilot Plant (WIPP) has been using since 1950s to transport transuranic nuclear waste from World War II. Military waste is generated from the development and testing of nuclear weapons, which was more prominent back then in the United States. On the other hand, industrial waste refers to the radioactive materials from industries, which is more prevalent today, as nuclear energy is still being used to generate power.

* Routes in the map are not entirely accurate

Results and Findings:

Containers:

Containment Process

1. Put in pool of water for 5-7 years
2. Put into rods and into internal canister
3. Put neutron shielding
4. Cover in concrete
5. Put shock absorbers
6. Put internal canister into storage casks

Container Materials:

- *Stainless/steel:* general structure and basic protection
- *Concrete:* shielding radiation
- *Lead:* Shield gamma radiation
- *Polyethylene:* Neutron shield
- *Shock absorbers:* Aluminum honeycomb, certain foams and/or wood inserts in steel jackets, etc.

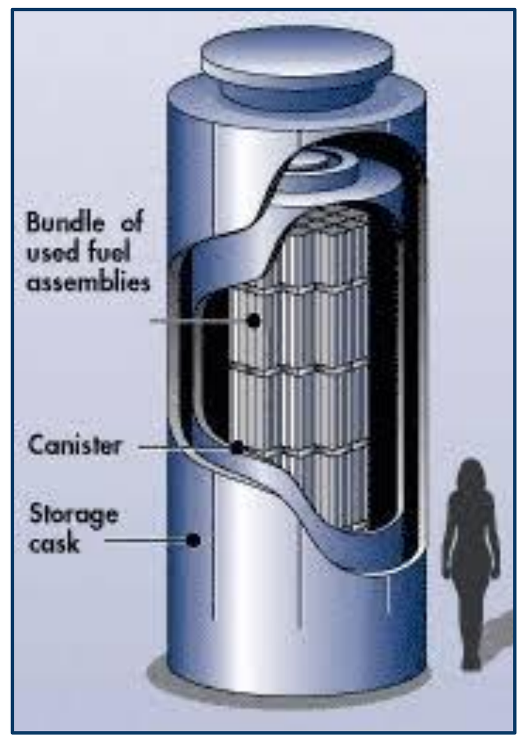

Fig.3. Basic Dry Cask

Cask Classification

- Accepted: Acceptable strength, weakest cask (steel, lead and copper)
  - Postal packages for radiopharmaceuticals
- Industrial: Barely stronger than Accepted casks (concrete)
  - Hospital waste & surface contaminated mats
- Type A: Relatively small, significant quantities of radioactive materials
  - Medical or industrial radioisotopes
- Type B: Materials w/ high activity (In some cases polyurethane foam)
- Type C: Strongest shield protection and general durability

Fig.4.TN RAM

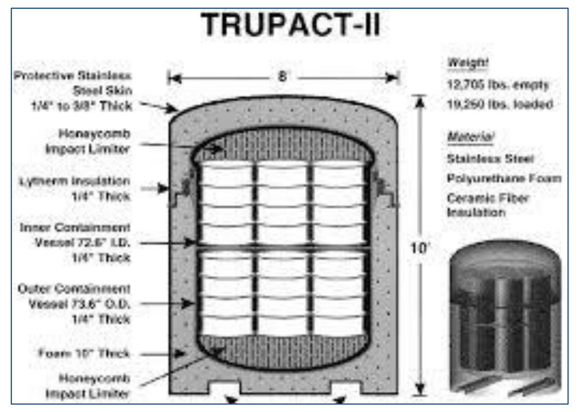

Fig.5.TRansUranic PACkage Transporter cask

Transport routes and vehicles

- Rail and truck are the dominant modes of transportation:
- Routes are selected based on safety, population, and remoteness to nuclear facilities
- Routing in the U.S. follow the Department of Transportation (DOT) and the Nuclear Regulatory Commission (NRC)
- Past studies highlight strong use of national highways and Class I railways in the U.S.
- France and other parts of Western Europe build rail around centralized reprocessing centers such as the La Hague
- Type B container designs withstand all accidents and all countries follow the International Atomic Energy Agency's guidelines for B containers
- Risk assessments model accident scenarios, route hazards, and emergency accessibility responses.
- GIS- route modeling is increasingly used to optimize safety and efficacy.
- Recent trends show a focus on developing interim storage instead of relying on long-haul transportation
- Rising attention to climate resilience such as flooding risks on routes

Additional information:

Standing 10 cm from a nuclear waste cask results in receiving about 10 millisieverts per hour. This is about the same amount of radiation of a chest x-ray. If you eat 1,000 bananas, it is roughly equal to a chest x-ray too due to the potassium-40.

Community Impact

- Urban areas are more negatively affected than rural areas in terms of housing prices (Charleston vs Berkeley)

Yucca Mountain

- Capacity of 77,000 metric tons
- Treaty of Ruby Valley
- Western Shoshone tribes would have their land taken away
- Union pacific is the proposed route and it would affect 106 million people in 703 counties
- Four casks have 2 million curies (more cesium-137 than Chernobyl)

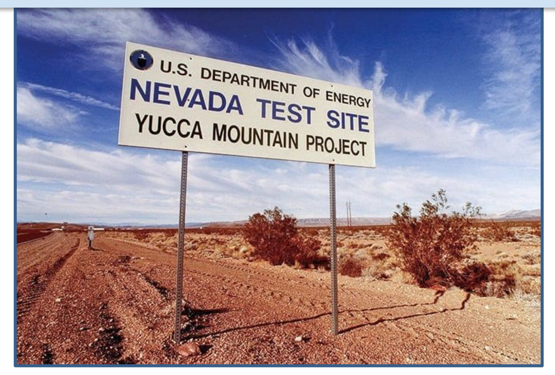

Fig.6. Yucca Mountain Nevada Test site (not currently in use)

Findings (Continued):

Fig.7. Atlas Railcar

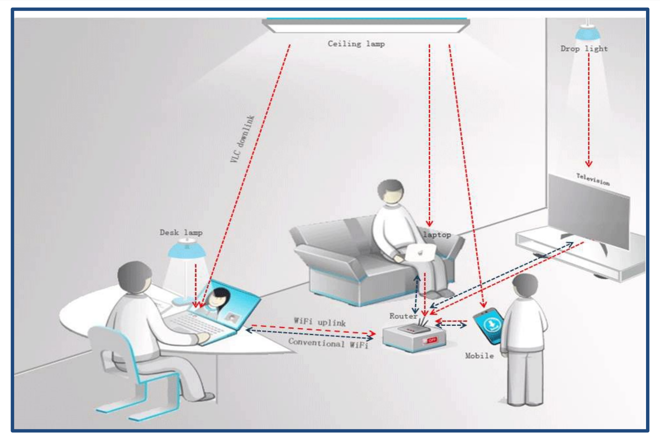

Fig.8. How Visible Light Works

Currently, the Atlas Railcar is the most prominent means of nuclear waste transportation in the U.S., but visible light communication technology has been proven as a viable improvement, to be potentially integrated into systems in the future. Scientists have tested and validated using VLC.

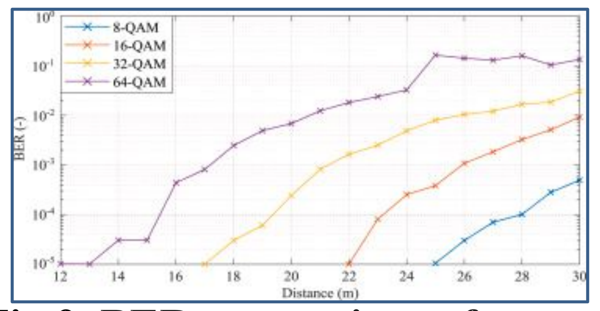

Fig.9. BER comparison of maximal reachable distance.

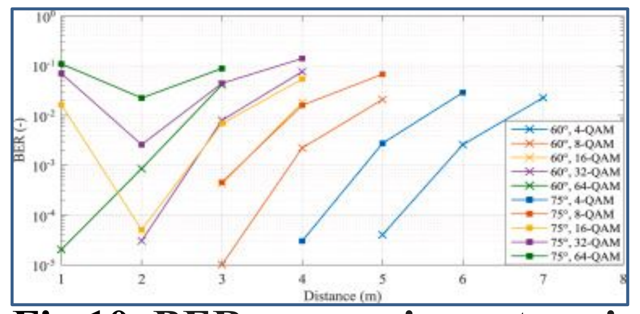

Fig.10. BER comparison at various measured angles and distances

Discussions:

The common perception that people have of nuclear energy is misguided from exaggerated media sources. Currently, the truth about nuclear waste transport is that it is safely regulated and containers are tested for accidents. Current nuclear waste transportation does not require any means of action and in the case of potential future accidents, VLC can be potentially integrated into vehicles to improve the designs. While the chances of transport accidents are low, this does not allow governments to place nuclear waste sites wherever they want. Governments should involve local governments to represent communities' voices around the routes and better regulate transport processes.

Conclusions:

Overall, nuclear waste transportation is a highly regulated process that does not raise immediate concerns at the moment. Strict policies are in practice, and the materials used for transport are able to withstand the waste, therefore reducing the chances of accidents along the routes. The general public must also be aware that current nuclear energy practices stem from industries, rather than military uses. With all of this in mind, people can be more tolerant of the push towards nuclear energy for power and mindful of waste transportation.

References:

ASN – Autorité de sûreté nucléaire (2023). Nuclear transport oversight in France.
Pacific Nuclear Transport Ltd. (2023) MOX maritime shipments.
Gawande, K., & Jenkins-Smith, H. (2000, October 24). Nuclear Waste Transport and Residential Property Values: Estimating the Effects of Perceived Risks. *Journal of Environmental Economics and Management*, *42*(2), 27. ScienceDirect. 10.1006 https://www.sciencedirect.com/science/article/pii/S0095069600911550?ref=pdf_download&fr=RR-2&rr=963d4cdedc155017
George, P., & Russ, A. (n.d.). *Nuclear Testing and Native Peoples*. Reimagine. Retrieved July 22, 2025, from https://reimaginerpe.org/node/165#:~:text=Some%20elders%20remembered%20visible%20radiation,each%20week%2C%20including%20the%20thyroids
Halstead, B. (2003, March 16). Yucca Mountain Transportation Issues. https://www.nrc.gov/docs/ML0403/ML040300315.pdf
International Atomic Energy Agency (2023). Regulations for the safe transport of radioactive, https://doi.org/10.61092/iaea.ur52-my9o material (SSR-6).
Ionizing radiation and health effects. (2023, July 27). World Health Organization (WHO). Retrieved July 22, 2025, from https://www.who.int/news-room/fact-sheets/detail/ionizing-radiation-and-health-effects
Khan, L. U. (2017, May 2). Visible light communication: Applications, architecture, standardization and research challenges. https://www.sciencedirect.com/science/article/pii/S2352864816300335#s0060
Radiation Health Effects | US EPA. (n.d.). Environmental Protection Agency (EPA). Retrieved July 22, 2025, from https://www.epa.gov/radiation/radiation-health-effects
Slanina, Z., Danys, L., Jaros, R., Krupa, F., Dratnal, M., Polak, D., & Martinek, R. (Eds.). (n.d.). VLC-enhanced autonomous rail vehicle for nuclear waste disposal. https://www.sciencedirect.com/science/article/pii/S1738573325001111
A document containing all of our reference sources can be accessed by scanning the provided QR code.

Acknowledgement

This summer research project was supported by American Nuclear Society (ANS) and the HIRES Summer Program.
The statements contained within the poster are not the opinions of the funding agency or the U.S. government but reflect the author's opinions.