STORING NUCLEAR WASTE

The United States' Nuclear Waste Policy Act of 1982 [1] established a national program for the safe, permanent disposal of highly radioactive wastes in underground storage locations. The availability of storage for spent fuel rods from fission-based reactors is critical due to the extremely long half-lives of the waste. For instance, strontium-90 and cesium-137 have half-lives of about 30 years, but plutonium-239 has a half-life of 24,000 years [2]. One proposed storage location was in Yucca Mountain, located in Nevada. After investing $15.4 billion, however, the Obama administration cut funding for the site and it has since sat empty [3].

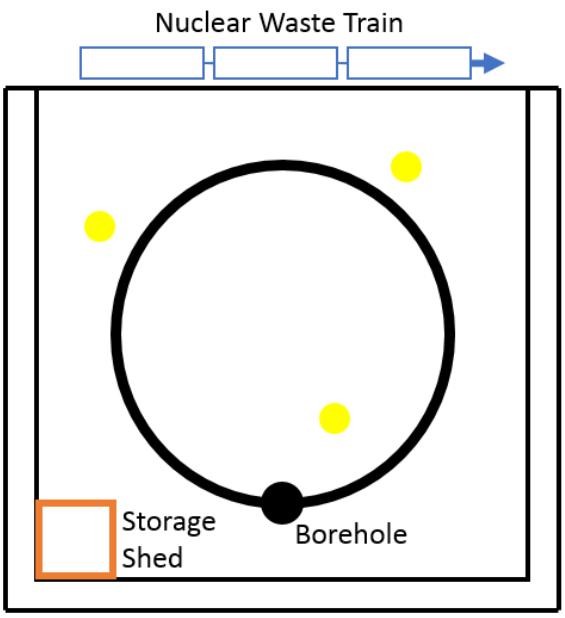
Deep borehole disposal is a promising alternative for nuclear waste disposal [4]. In this method, a 2-5 km deep borehole is drilled deep into the earth. Then spent nuclear fuel and high-level radioactive waste are lowered into the borehole. Drilling of this depth has been previously demonstrated in Nevada [5] and Russia [6]. To aid in collection of the nuclear waste, the federal government is investigating the use of a specialized train for transportation of the waste to a storage location [7].

You are submitting a bid to design and build an autonomous robot capable of retrieving sealed containers of nuclear waste from a specialized train, then transporting them to the borehole for disposal. You will eventually prepare a working prototype for a small-scale demonstration. Your demonstration robot is to retrieve and dump all dummy nuclear containers located within a small testing area. To facilitate storage, your robot must fit within the provided storage shed. Based on prototype demonstrations and technical presentation, the winning concept may be selected for a construction of a full-scale prototype.

To encourage early testing of the concept, waste material will be delivered in spherical containers, rather than cylinders. The spherical containers will be rolled off of the transport train, and onto a flat concrete surface. A circular black line will be painted on the concrete surface, to aid in robot navigation. You should assume the containers (shown as yellow circles in the figure below) are randomly located in the dropoff area. Your vehicle will start from the storage shed, scan the concrete surface for spherical containers, pick up the containers, and drop them into the borehole. To minimize vehicle emissions, assume the robot is electrically powered.

Requirements

- The robot must be autonomous: no human intervention and no tethers.
- The demonstration robot must fit in a shed for deployment.
- The demonstration robot must deploy from its shed autonomously.
- There is no weight limit for the robot.
- The robot should be able to complete a demonstration of depositing multiple containers into the borehole in less than 1 minute.
- The robot will be allowed three attempts to complete its demonstration phase.



Assignment

Prepare a 3-page proposal that presents your best concept for transporting the randomly positioned containers into the borehole. Please define what you believe to be appropriate sizes and weights for the waste containers, as well as appropriate sizes for the borehole and dropoff area. You may wish to discuss how your vehicle will achieve locomotion, and how it will locate the spheres. Explain how the containers will be dropped into the borehole. Evaluations of the strengths and weaknesses associated with your proposed power, sensor, navigation, and control subsystems are also appreciated.

Your proposal should be electronically submitted to the course instructor no later than 5 pm on Monday, 16 February 2015.

[1] "Summary of the Nuclear Waste Policy Act"
URL: http://www2.epa.gov/laws-regulations/summary-nuclear-waste-policy-act

[2] "Backgrounder on Radioactive Waste."
URL: http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/radwaste.html

[3] "Nuclear Waste: Yucca Mountain Gets Reprieve as Storage Site."
URL: http://abcnews.go.com/Business/yucca-mountain-reprieve-nuclear-waste-storage-site/story?id=19961367

[4] "Deep borehole disposal of spent nuclear fuel and high-level waste."
URL: http://www.nwtrb.gov/facts/BoreholeFactSheet.pdf

[5] "Petrophysical properties, minerology, fractures, and flow tests in 25 deep boreholes at Yucca Mountain, Nevada."
URL: http://pubs.usgs.gov/of/2014/1023/pdf/ofr2014-1023.pdf

[6] "Beneath this Metal Cap is the World's Deepest Hole."
URL: http://www.slate.com/blogs/atlas_obscura/2014/05/08/kola_superdeep_borehole_is_the_world_s_deepest_hole.html

[7] "Feds Want Nuclear Waste Train, but Nowhere to Go."
URL: http://abcnews.go.com/US/wireStory/feds-nuclear-waste-train-25195896