LA-UR-16-26780

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Title: Safeguards by Design Challenge

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Intended for: University Engagement- U RI

Issued: 2016-09-06

Safeguards by Design Challenge

Presented to University of Rhode Island Department of Mechanical, Industrial, and Systems Engineering

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September 13, 2016

Safeguards by Design Challenge

Introduction

- The International Atomic Energy Agency (IAEA) defines Safeguards as a system of inspection and verification of the peaceful uses of nuclear materials as part of the Nuclear Nonproliferation Treaty.
- IAEA oversees safeguards worldwide.
- Safeguards by Design (SBD) involves incorporation of safeguards technologies, techniques, and instrumentation during the design phase of a facility, rather that after the fact.

Safeguards by Design Challenge

Design Challenge Goals

Design a system of safeguards technologies, techniques, and instrumentation for inspection and verification of the peaceful uses of nuclear materials.

- **Cost should be minimized to work with the IAEA's limited budget.**
- **Dose to workers should always be as low are reasonably achievable (ALARA).**
- **Time is of the essence in operating facilities and flow of material should not be interrupted significantly.**
- **Proprietary process information in facilities may need to be protected, thus the amount of information obtained by inspectors should be the minimum required to achieve the measurement goal.**

Los Alamos
NATIONAL LABORATORY
EST. 1943

Design Challenge #1- Plutonium Waste Item Measurement System

- **Waste items from glovebox lines are placed into 55-gallon drums for waste disposal**
- **The waste items come from:**
  - contaminated materials and consumables such as glovebox gloves,
  - used process equipment in which a holdup of process materials occurs.
- **The waste items are bulky and do not fit within the current nondestructive assay (NDA) Instruments**

Design a method for determining the nuclear material content of waste items before they are placed into a drum and moved to the NDA lab

Design Challenge #1- Plutonium Waste Item Measurement System

- If the drum limits are exceeded, the operators must declare a process deviation, pause the work, and eventually conduct a more hazardous job to open the drum while suited out in respirator and split the contents into two or more drums.

- The result of drums that are over the limit has repercussions with respect to: worker dose [ALARA], contamination control, criticality safety, and waste minimization.

- The design challenge includes technical aspects – how to properly characterize the material and develop a technique to measure various material forms.

- The waste in the gloveboxes can range from contaminated metal to hydrogenous nuclear materials.

Design a method for determining the nuclear material content of waste items before they are placed into a drum and moved to the NDA lab

Design Challenge #1- Plutonium Waste Item Measurement System

- The design challenge includes technical aspects – how to properly characterize the material and then develop a technique that can measure various material forms.

- The waste in the gloveboxes range from contaminated metal items to hydrogenous nuclear materials.

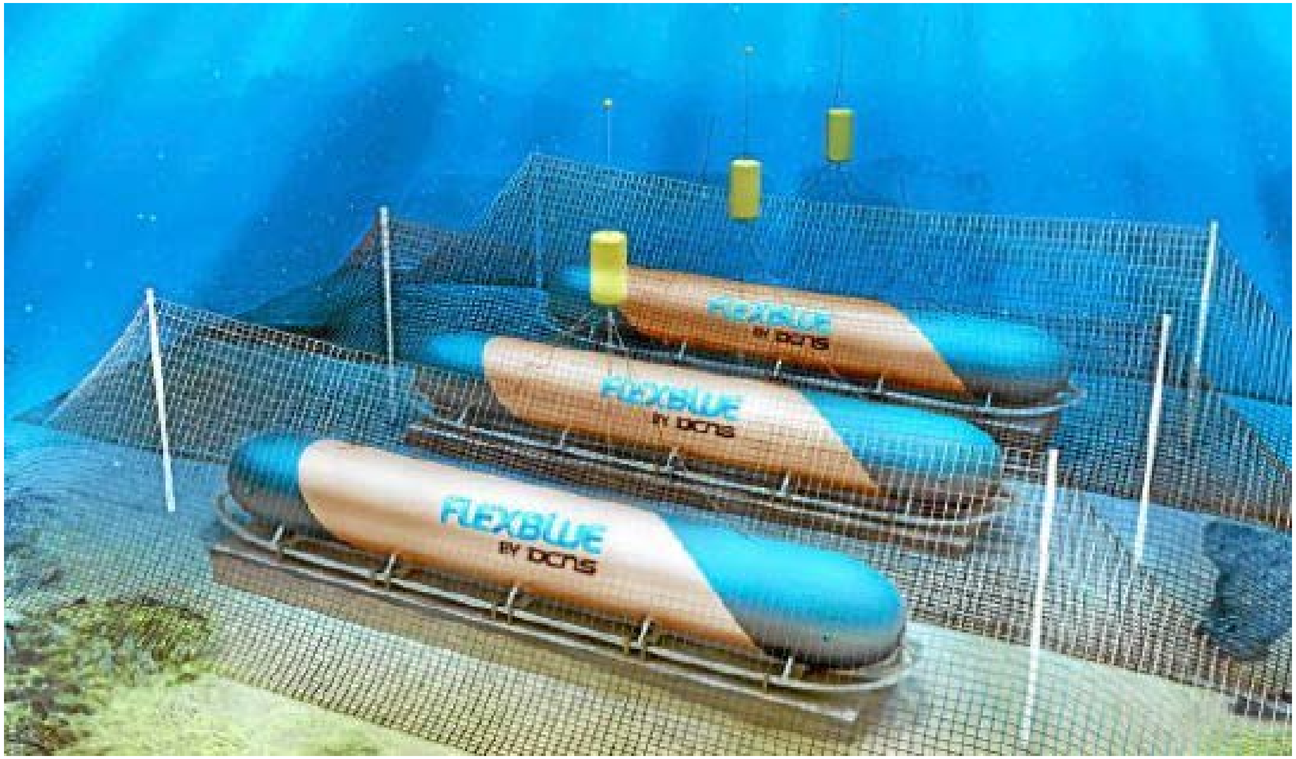
- Potentially novel approaches could be developed using methods to measure items through gloves, windows, or ports; applying novel technology; or developing a unique application for an already existing technology.

Design a method for determining the nuclear material content of waste items before they are placed into a drum and moved to the NDA lab

Design Challenge #2- Marine-based Modular Reactor

- **Direction of Construction of Naval and Submarines (DCNS) in France is pursuing development of the Flexblue, a small marine based modular designed reactor.**

- **160 MWe operated on sea floor**
- **Water cooled reactor**

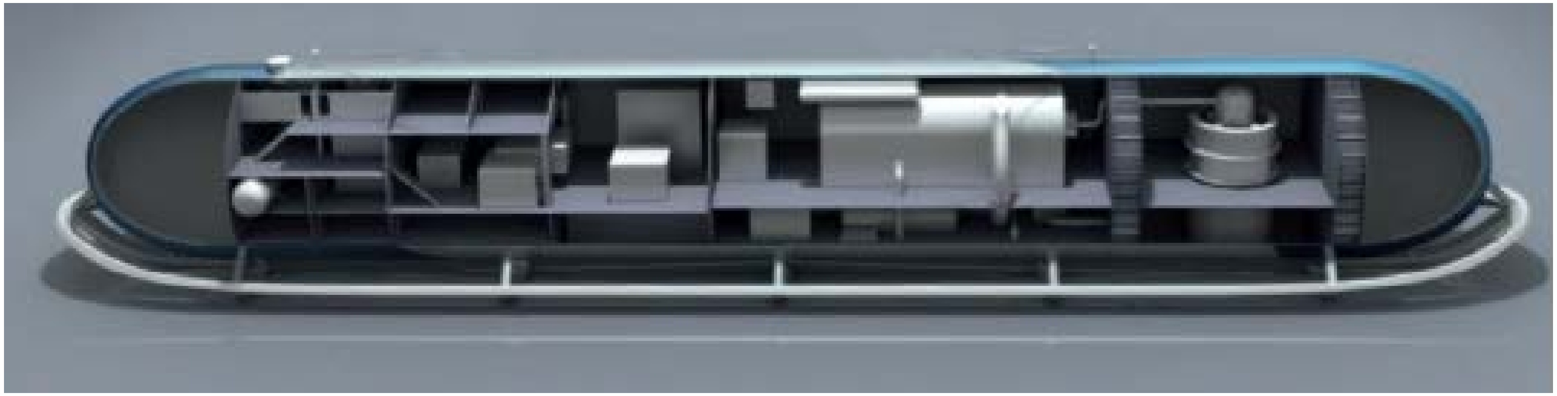


Flexblue marine based nuclear power plant.[1,2,3]

Design marine-based modular reactor safeguards considering physical security, material control and accountability , nuclear security infrastructure, & IAEA inspections

Design Challenge #2- Marine-based Modular Reactor

- **The water cooled reactor uses navel offshore and passive nuclear technologies to take advantage of the sea's infinite and permanently available heat sink for cooling.[1,2,3]**



Inside of Flexblue marine based nuclear power plant.[1,2,3]

1. **"Nuclear Technology Review," Fifty-eighth regular session of the General Conference, International Atomic Energy Agency (IAEA), GC(58)/INF/4,17 July 2014, Paragraph 150 https://www.rt.com/news/floating-nuclear-plant-Russia-759/, July 9 2013 (accessed Oct 5, 2015)**
2. **"France's DCNS, AREVA, EDF, CEAR Plan Underwater Nuclear Plant (US)," France-Metallurgie, 24 January 2011, available at" http://www.france-metallurgie.com/index.php/category/recherché-developpement/page/10/#sthash.qFg0nvax.dpbs (accessed October 2015).**
3. **"France's Underwater Nuclear Reactor," available at: http://large.Stanford/edu/courses/2011/ph241/nazir1/ (accessed October 2015).**

Design marine-based modular reactor safeguards considering physical security, material control and accountability , nuclear security infrastructure, & IAEA inspections

Design Challenge #3- Floating Nuclear Power Plant (FNPP)

- There is recent increased interest in small modular reactors (SMR), one of which is the floating nuclear power plant (FNPP).

- FNPPs are built by countries with extensive knowledge of nuclear energy (Russia, France, China, US)

- FNPPs are sent to countries in need of power and/or seawater desalination.

Russia's floating nuclear power plant.[1]

15 countries have expressed interest including China, Indonesia, Malaysia, Algeria, Namibia, Cape Verde and Argentina[1].

1. "World's first floating nuclear power plant to begin operating in Russia in 2016," https://www.rt.com/news/floating-nuclear-plant-Russia-759/, July 9 2013 (accessed Oct 5, 2015)

Design FNPP safeguards considering physical security, material control and accountability , nuclear security infrastructure, & IAEA inspections

Design Challenge #3- Floating Nuclear Power Plant (FNPP)

"Afrikantov OKBM" to design, manufacture, supply FNPPs in Russia, design is based on Russia's KLT-40S, used in icebreakers, smaller version, the KLT-20, for FNPPs.

Russia's FNPP design.[2]

- **LEU aluminum silicide fuel**
- **<20% enriched with ^{235}U**
- **150 MWt**
- **35 Mwe**
- **35 MW of heat for desalination or district heating**
- **3-4 years before refueling**
- **onboard refueling capability**
- **includes storage for used fuel**
- **two reactors per barge**

2. http://www.okbm.nnov.ru

Design FNPP safeguards considering physical security, material control and accountability , nuclear security infrastructure, & IAEA inspections

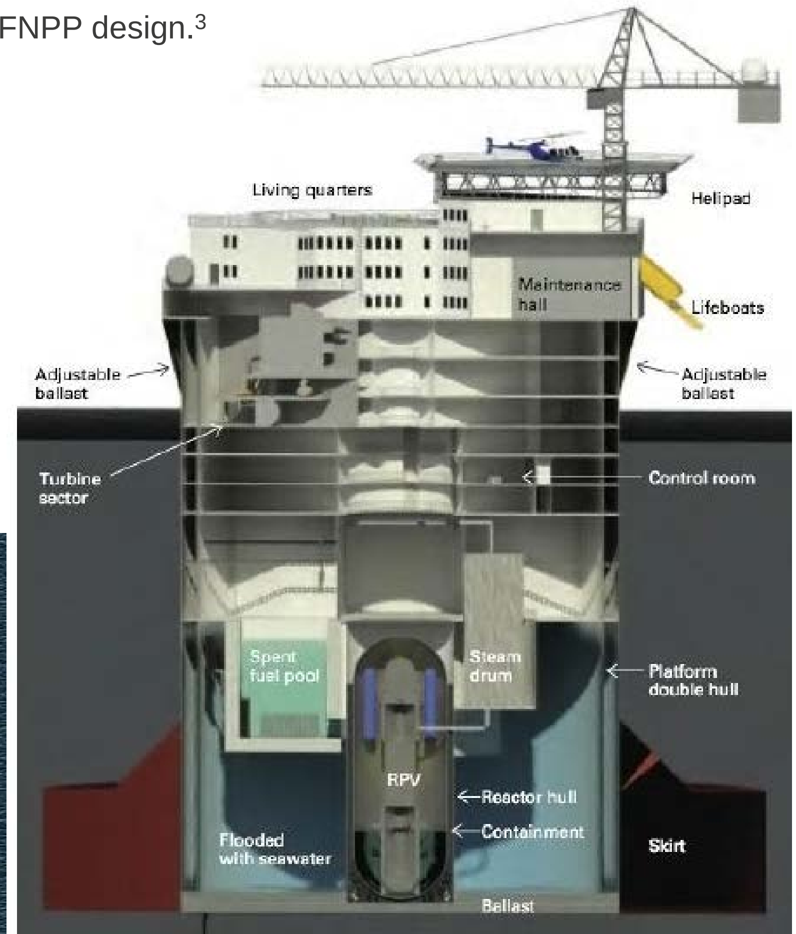
Design Challenge #3- Floating Nuclear Power Plant (FNPP)

US FNPP design by MIT

- **Use oil platform technology**
- **Ocean for natural cooling**
- **Designed to withstand Tsunamis & earthquakes if far from shore**
- **Located well away from population**
- **Linked by underwater transmission lines**
- **45 m diameter**
- **300 Mwe**
- **alternate design 1,100 MWe (75 m dia.)**

US FNPP design.[3]

US FNPP design.[3]



3. Floating Nuclear Power Plant that is Safer and Cheaper," in TechDaily, June 25, 2015, available at http://scitechdaily.com/floating_nuclear_power_plant_safer_cheaper/ (accessed 5 October 2015).

Design FNPP safeguards considering physical security, material control and accountability , nuclear security infrastructure, & IAEA inspections