Nuclear Ambulatory Reactor Protection (N.A.R.P) Corps

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Objective

To design a system capable of protecting a small modular reactor against assault and proliferation both while in transportation and once docked at a Forward Operating Base (F.O.B).

Forward Operating Bases rely on convoy operations to transport food, water, and large amounts of fuel for diesel generators, which is very dangerous. ⅛ of casualties came from fuel convoys from 2003-2007.

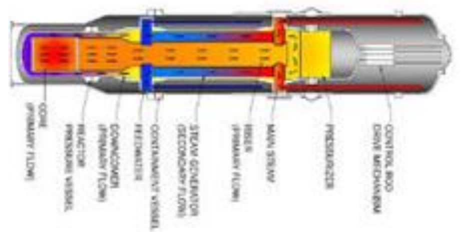
Weight	40 tons
Size	20-40' 8'x8' CONNEX Container
Protection Level	Small arms fire
Access Delay	45 minutes

Photo [left] of M1070 Oshkosh Truck with M1000 Series Semi-Trailer, capable transporting a heavy reactor container on the ground.

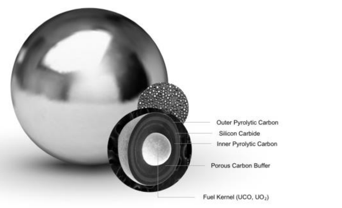
Table [right] of Project Pele design considerations, which serve as the primary limitations for this project.

Small Modular Reactors

Teams at Holosgen, NuScale, X-Energy, and Combat Ready Reactor [USNA] have made viable contributions to creating a reactor that will be protected.



Both NuScale (Left) and Holosgen (Right) have developed pressurized light water reactors that are cheaper and more mobile than ever before, but not suitable for military use.



X-Energy utilizes TRISO fuel pebbles (Left) to power their reactors in a much safer way as part of project Pele. Combat Ready Reactor (Right) intends to apply these principles in developing their own reactor.

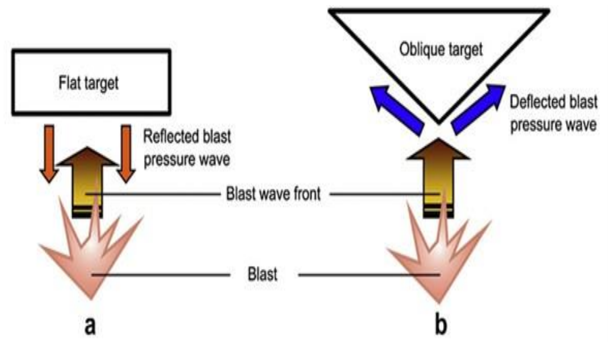
Adversary Tool and Capabilities

If an adversary were to attempt to infiltrate this containment system, it is believed that they would use commonly available tools such as angle grinders, circular saws, sledgehammers, small arms, and IEDs/small explosive systems. The enemy should not be able to gain access to the material with a single tool.

Safety Implementations

V-Shaped Hull

This system protects again IED explosives in the path of the reactor by distributing the impact away from the undercarriage of the vehicle.



Stationary Defenses

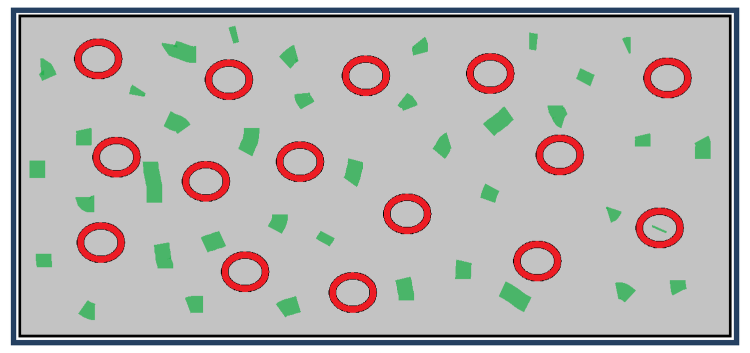
Once the reactor has completed its transit, it is imperative that stationary defenses are in place that are unbound by weight constraints. Examples include dirt and concrete magazines as seen to the left, or additional lead shielding if necessary.

Composite Design

Outer Layer: Abrasion Resistant Steel

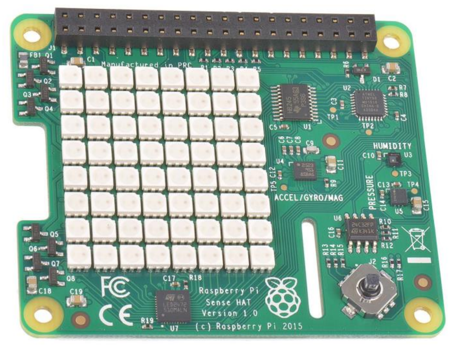
Abrasion resistant steel used on the outside to add resistance to cutting and better bulletproofing than traditional steel at the same mass. Testing is delayed due to lack of materials currently.

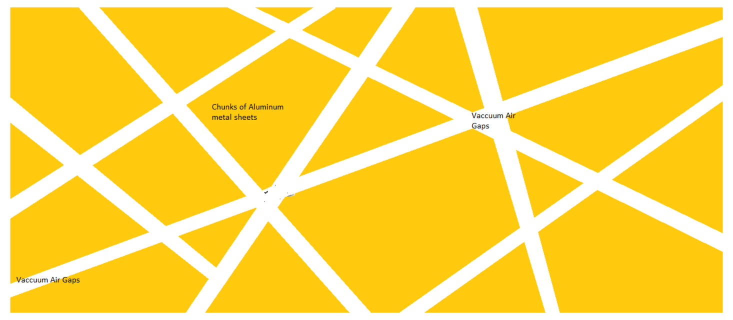
Second Layer: Concrete Solution



A cross section of the team's concrete layer is seen on the right. The grey is high strength concrete. The red is steel tubes to provide structural support and prevent the adversary from easily using a sledgehammer to remove large chunks. The green represents tungsten carbide nuggets, which cannot be cut through with a saw or angle grinder. This system is believed to provide the greatest protection for its weight.

Third Layer: Aluminum & Electronic Suite

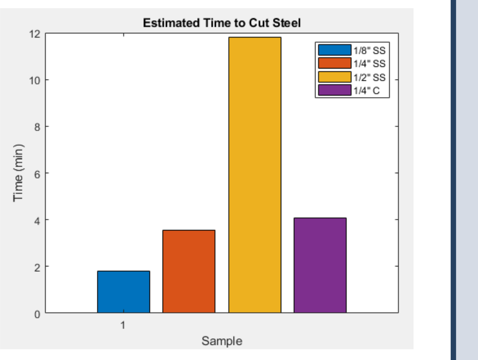




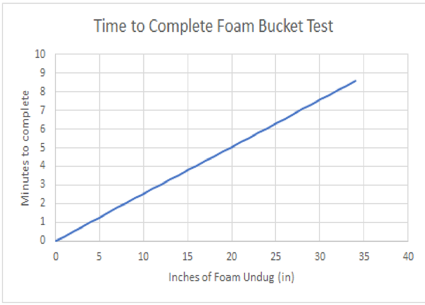
Aluminum was used in this layer, as it requires special grinding wheels to cut through, and attempting to cut without them will damage the tools and possibly the adversary. Within this layer is a vacuum web, which will rapidly gain pressure if compromised. The electronic suite can be run by one or more sensors capable of reading orientation, acceleration, pressure, and temperature. This is closed loop to prevent cyber attacks.

Fourth Layer: Stainless Steel

Stainless steel is the final solid layer, as it cannot be cut through with a torch. Testing was done to determine the thickness of steel necessary to provide sufficient time for the foam to solidify behind it.



Final Layer: Rigid Foam



An emergency deployable foam was added to the design to add several minutes of defense to the vessel until support is available.

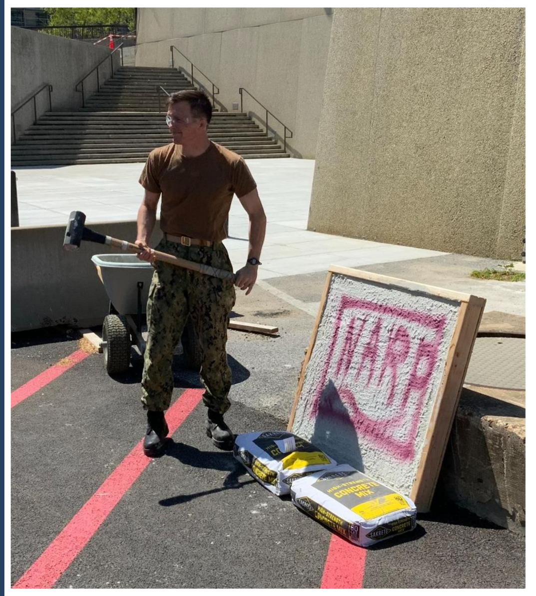
Testing/Model Building

Each layer was individually tested to ensure that the materials performed as expected and to give a rough estimate of the access control time resulting from the composite structure. Most testing and model development was done with the assistance of the USNA machine shop.

USNA shop working performing a steel cutting test with an angle grinder alongside MIDN Travis

MIDN Travis using a table saw to cut steel pipe for use in the final prototype of the concrete solution

MIDN Budan performing a rigid foam dig test, where a midshipman is timed to see how long it takes to unscrew a rod from a bucket covered a certain amount of foam.



MIDN Cobb, along with the rest of the N.A.R.P. Corps team conducting an iteration of concrete destruction testing with a variety of tools including sledgehammers.

Access Control

Besides the composite structure, the CONNEX Container will contain a complex locking system made up of multiple mechanical locks and an electronic lock. The crew will have all pass codes but the enemy will have to take a considerable amount of time to break the codes. As a last ditch effort to protect the reactor, canisters of rigid, fast curing urethane foam will be deployed to encase the reactor vessel to slow the enemy down considerably. The decision to deploy the foam will come from the electronic suit that will constantly monitor for any breaches to the container.