The INEEL has been involved in researching techniques to non-intrusively/non-destructively characterize the contents of containers and objects for many years. Waste assay, nuclear reactor diagnostic equipment, spent fuel characterization are just a few applications the INEEL has pursued. Two examples of ongoing research programs focused on national security applications are the Portable Isotopic Neutron Spectroscopy (PINS) and the Nuclear Materials Detection in Cargo Containers. Both of these systems were originally developed for nonproliferation/treaty verification applications.

Portable Isotopic Neutron Spectroscopy Systems (PINS)

PINS is a non-intrusive/non-destructive evaluation system that can identify chemical warfare agents and other chemicals inside containers:

- PINS operates on the principle of prompt gamma-ray neutron activation analysis.
- Neutrons from an isotopic source (i.e. Cf252) penetrate into the inspected object.
- Neutrons excite the nucleus and induce the emission of characteristic gamma-rays from material inside the object.
- The energy of the gamma-rays is unique to the elements inside the object. The chemical inside the container can be deduced from this information.
- The type of material inside the container is identified using an automated gamma spectral analysis system.

The original research, which resulted in an R&D 100 award, was sponsored by NNSA's Defense Nuclear Nonproliferation program as a verification tool for the Chemical Weapons Convention. Subsequently, the Defense Threat Reduction Agency and the Army's Chemical Demilitarization Programs has sponsored significant development and optimization of the technology.

The system has been used for a number of applications throughout the world. The system has assessed hundreds of munitions at chemical agent depots throughout the US (such as Pine Bluff Arsenal) and continues to be used by the Army's Technical Escort Unit to identify the contents of munitions that continue to turn up. PINS is a component of the Mobile Munitions Assessment System you will be hearing about later.

PINS has been deployed to support the latest Olympic Games and is currently being used in Iraq to characterize suspect munitions and containers.

The INEEL supports an ongoing training program for Technical Escort, Onsite Inspection Agency and others who use PINS. INEEL also supports a reach back capability where government agencies that use PINS can contact INEEL scientists for technical support.

PINS has been licensed and is commercially available from ORTEC.

Ongoing research includes continued miniaturization and optimization of the system, exploring use of a neutron generator as the neutron source, developing a system for explosives detection and continual expansion of the library of chemicals the system will automatically identify.

Nuclear Material Detection in Cargo Containers – Pulsed Photonuclear Assessment Technique (PPNA)

One of the most challenging problems facing our national security is the ability to screen the enormous number of cargo containers that enter the US every day for weapons of mass destruction and other contraband. The INEEL is developing one of the more promising techniques to help detect nuclear materials and in particular highly enriched uranium.

The PPNA system is a flexible, non-intrusive/non-destructive evaluation system to detect nuclear material in large cargo containers:

- A pulsed electron accelerator is used to accelerate electrons, which in turn interact with a high atomic number material (i.e., tungsten) to produce photons (from bremsstrahlung).
- The maximum photon energy corresponds to the maximum electron beam energy. Relevant energies are between 6 and 10 MeV for this application.
- Energetic photons can effectively penetrate into inspected objects.
- Photons induce fission in nuclear materials such as uranium or plutonium.
- Only fissile materials will fission to produce both prompt and delayed neutrons.
- Delayed neutrons detected between accelerator pulses indicate the presence of nuclear material.

This technology was originally developed as a verification tool for the Strategic Arms Reduction Treaty; however, unlike PINS, which is being used for its original application and many others, this technology was not an acceptable approach for START applications. Fortunately it was recognized that this technology has significant promise for nuclear smuggling applications; hence, NNSA's Defense Nuclear Nonproliferation continued to sponsor the project. The development of this technology has now transitioned to the Department of Homeland Security.

Why is this approach so promising?

- Energetic photons are very penetrating. Intense beams (pulses) can be produced using relatively small, transportable linear accelerators.
- The technique can be integrated with high-energy x-ray systems used for imaging the contents of cargo containers.

The INEEL has demonstrated the ability to quickly detect significant quantities of fissile material in cargo containers hidden in various shielding configurations.

The INEEL has demonstrated the ability to distinguish between different kinds of nuclear material using measurements from different incident photon energies.

The INEEL has a CRADA with ARACOR focused on integrating the system with ARACOR's Eagle cargo container x-ray system. Other companies have also expressed interest in licensing the technology.

Most of the development of this technology has taken place at the Idaho Accelerator Center at Idaho State University through a very strong collaborative effort. Recently the INEEL has established the capability to operate linear accelerators up to 10 MeV onsite. This will allow realistic testing using highly enriched uranium and other nuclear materials. The remoteness of

the site will also allow the INEEL to prototype very large systems and safely operate the system outdoors. This work is taking place at the Critical Infrastructure Test Range Complex, which is being established at the former WROC (Waste Reduction Operations Center) facilities on the INEEL. INEEL is now taking the required steps to operate 160 MeV accelerators onsite. These higher energy systems will be required for stand off detection of materials.

Ongoing development is focused on working with industry to deploy the technology, developing "Cabinet Safe" accelerators for transportable and roadside applications, moving to higher energy systems for standoff detection and establishing the capability to detect other contraband such as explosives.