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Vehicle and Cargo Scanning for Contraband

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Abstract

There is a need to inspect vehicles and their contents for Special Nuclear Material (SNM) and general contraband. The most widely used technology for scanning vehicles, ranging from vans and trucks to railcars, is gamma-ray and X-ray radiography. New technologies are required for higher penetration to reduce insufficient penetration alarms, for improved image quality and material discrimination to increase detection at high throughput and to enable scanning fast-moving trains. In most cases, the scanning footprint, which includes the radiation exclusion zone, must be small due to the limited space available at the inspection sites. Some of these conflicting requirements have been addressed by employing adaptive intensity and/or energy modulation of the X-ray source. Any alarms produced by these primary systems need to be cleared or confirmed to eliminate labor-intensive manual inspection. Various technologies have been proposed and used for secondary inspection, mainly based on the detection of fission signatures. Such systems would preferentially require minimal infrastructure and cost would be kept reasonably commensurate with the performance improvements to allow for wide deployment. The Domestic Nuclear Detection Office (DNDO) has performed tests of some of these systems to determine the envelope of the various technologies. Selected results with primary systems, and examples of potential system improvements are presented.

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Keywords: Radiography; Special nuclear material (SNM); Contraband detection; Active interrogation; Intensity modulation; Muon detection system.

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1. Introduction

Cargo containers and rail cargo have been identified as a probable mechanism to smuggle nuclear material into the United States (U.S.). Approximately 32,000 cargo containers arrive in the U.S. ports and 5,400 railcars cross the U.S. borders daily. These numbers are expected to rise with the increase in commerce.

In 2007, Congress passed a mandate requiring that cargo must be scanned using imaging scanners before arriving to the U.S. by 2012. Due to the complexity of the procurement and operational logistics and, to some extent, due to the lack of viable technologies, an extension through 2018 was approved. It has been estimated that it would cost approximately $20 billion to meet the mandate for the 700 foreign ports that ship cargo to the U.S. (Espie, 2016). Therefore, innovative and cost effective approaches are required to ensure container and rail-cargo security.

The U.S. Department of Homeland Security (DHS) Domestic Nuclear Detection Office (DNDO) was tasked by the National and Homeland Security Directives to protect against radiological and nuclear ("RadNuc") threats directed against the U.S. DNDO has been seeking to identify commercially available equipment to meet the requirements to detect threats, regardless of the amount of shielding or the complexity of cargo with minimal impact to the flow of commerce before eventual deployment. As part of the nuclear detection effort, DNDO has funded a number of Advanced Technology Demonstration (ATD) campaigns, including Cargo Advanced Automated Radiographic System (CAARS), Shielded Nuclear Alarm Resolution (SNAR) and Nuclear and Radiological Imaging Platform (NRIP). DNDO has also funded other Exploratory Research Programs (ERPs) for development general aviation and advanced rail- cargo scanners, portable systems, system components and other areas.

Customs and Border Protection (CBP) currently performs inspections for general contraband and radiological materials. CBP employs a protocol called Automated Targeting System (ATS) to identify a percentage of cargo for inspection with imaging scanners (CBP, 2017). Currently, all containers arriving in U.S. ports and border crossings are screened by Radiation Portal Monitors (RPMs), and when an alert surfaces the container is also subject to secondary screening. In light of this, improvements in general contraband and radiological detection are sought for imaging cargo scanners.

2. DNDO Advanced Technology Demonstrations

2.1. Basic Concept of Operations

The basic approach is to use a primary system to inspect cargo at high throughput to identify suspect objects and employ a secondary system to clear or confirm the alarms. It is preferred to employ a single system to detect also nuclear materials. However, material-specific technologies would be required to result in very low alarm rates (<<1%). These techniques are inherently slow or require very high-power sources that would increase exclusion zone, or most probably would require a shielded facility.

A secondary system could be collocated, placed at a distance, or it could be integrated into the primary system, operated in a different mode for the second scan. For low-throughput operations, collocation and using the same system would probably work. However, for high throughput, the secondary system would be placed elsewhere to prevent reducing the throughput of the primary system during the longer scanning time of the secondary inspection.

RPMs are required for the detection of radiological sources, and complement X-ray scanners which cannot directly detect these sources. RPMs are very sensitive and can also be triggered by nearby X-ray scanners. Typically, the RPMs are therefore inhibited during the intense radiation pulse of the linac source used by most cargo scanners. Depending on the system configuration, energy and power, RPMs need to be placed at a safe distance. In any case, the data from the RPM and primary system should be fused to improve detection.

2.2. DNDO-Funded Programs

As mentioned, as part of the nuclear detection effort to develop technologies to protect the U.S. against RadNuc threats, DNDO has funded a number of ATD projects including CAARS, SNAR, and NRIP.

The CAARS program dealt with only radiographic (primary) systems. The SNAR program supported two approaches: Integrated (I-) SNAR and Relocatable (R-) SNAR. The I-SNAR concept consisted of a single integrated

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