Combined Technology for Cargo Security

Douglas R. Brown, Ph.D.
Senior Vice President
Ancore Corporation, an OSI Systems Company
Technical Marketing, OSI Systems Cargo Group

Introduction

Terrorists who launch attacks against modern societies attack more than our way of life. They also threaten our economy that is closely tied to the free and open movement of commerce. Nowhere is this more apparent than at seaports. It often has been noted that the sheer size and number of marine containers arriving at seaports around the world make them a likely vector of terrorist attacks. Many tons of conventional explosives, chemical weapons or other weapons of mass destruction can potentially be packaged in containers and shipped to a target location. In response to this threat the Cargo Security Initiative (CSI) aims to increase security using modern techniques available from the information technology sector, such as advanced manifest review and known shipper. The CSI also requires the inspection of identified suspect cargoes. Much of this inspection will eventually happen in the country of origin allowing for faster entry at the destination country.

Addressing the magnitude of this required inspection task is only possible with newly developed non-intrusive inspection (NII) technologies. This paper discusses the need for combined NII systems to ensure effective inspection of marine containers.

Non-Intrusive Inspection Technologies

In response to the growing use of sea containers for smuggling drugs and illegal contraband, NII technologies were developed during the 1990s to inspect cargoes both at seaports and land border crossings. NII systems include gamma-ray radiography systems, low and high energy x-ray radiography systems, and low and high energy neutron inspection systems. Gamma-ray radiography systems and x-ray systems present an image of the container and its cargo contents and task a human screener with finding smuggled items or suspect anomalies. Neutron scanning systems detect contraband and threats by material specific signatures, then automatically alert screeners to suspect materials in the container. As discussed below, each of these systems has specific strengths and weaknesses. Only by combining these technologies can the requirements for rapid and effective inspection of marine containers be met.

Gamma-ray Radiography Inspection Systems

Gamma-ray radiography systems have been widely adopted because they are relatively low in cost. They can readily confirm empty cargo containers, image the general shape of cargoes, and show anomalies in lightly loaded containers. Two such systems, Mobile GaRDS and Portal GaRDS, are shown in Figure 1.

Figure 1. Mobile Gamma Radiography Detection System (GaRDS) inspecting a truck (left), and Portal GaRDS at a border crossing inspecting trucks in drive-by mode (right).

A Mobile GaRDS can be driven around ports to inspect incoming cargo containers as they are unloaded. A Portal GaRDS can inspect containers as they are driven through the inspection portal at the rate of 60 or more containers per hour. The system's unique L-shaped array allows the source to be positioned close to the inspected truck, eliminating any corner cut-off in the resultant image. The resolution of the gamma-ray radiography system is sufficient to identify weapons and other anomalies. Included on the mobile truck is a compact radiological threat identification system (RTIS) to allow positive isotopic identification of radiological dispersal devices (RDDs) and neutrons from fissile material that may be concealed in containers. The RTIS can also be combined with other inspection systems described below.

Figure 2. Radiological Threat Identification System (RTIS) on a Mobile GaRDS truck.

X-ray Inspection Systems

Both fixed-site and mobile x-ray inspection systems are commercially available. High energy fixed-site x-ray inspection systems have undergone a rapid evolution in the last few years. With space at a premium in ports, systems must have a minimal footprint. The Rapiscan 2000 Relocatable X-ray inspection system is a pre-fabricated, relocatable design that has been developed to meet this requirement. The x-ray system and inspection tunnel are built in pre-fabricated modules that can be assembled on an appropriate cement slab. The overall system dimensions are around 20 m by 34 m and the system can be redeployed within several weeks, leveraging its usefulness.

Figure 2 shows a truck during inspection by a Rapiscan Series 2000 high energy x-ray inspection tunnel. When conveyed through the tunnel, the x-ray image of the truck and container contents is displayed on the screener station (Figure 3). Image manipulation tools allow the operator to increase the contrast and magnify suspect areas within the cargo.

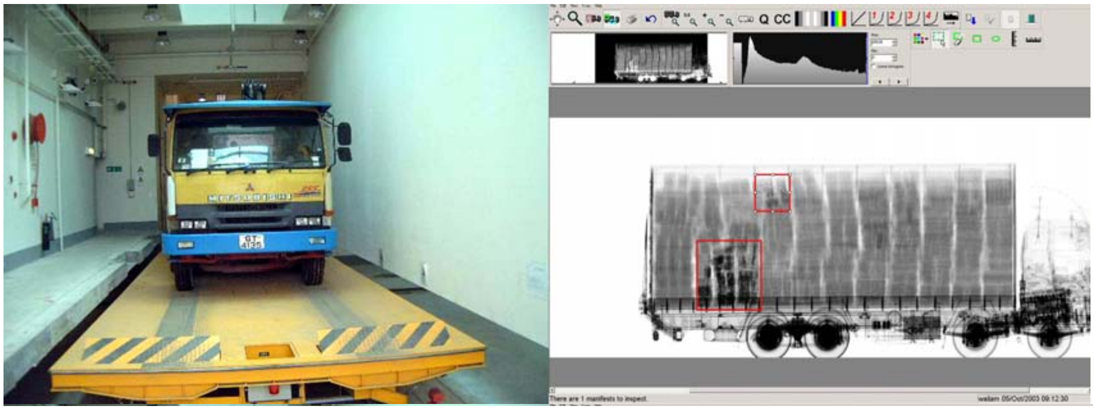

Figure 3. Rapiscan Series 2000 high energy x-ray inspection shows a truck moving through the inspection tunnel. Smuggled contraband is shown among legitimate cargo.

The throughput of the high energy x-ray inspection system is between 20-30 vehicles or containers per hour; the actual x-ray scan takes only a small fraction of the time. Thereafter, it takes several minutes for a screener to examine an x-ray image of a container or truck. The high resolution aids in finding suspect anomalies or concealed smuggled goods. High throughput is achieved through multiple operator screening stations.

X-ray systems can also be deployed on mobile and relocatable platforms. The Rapiscan MXRVS shown in Figure 4 below is a 2-4 MeV x-ray inspection system integrated on a commercial truck chassis. This highly mobile unit can be deployed in less than 2 minutes. Its integrated x-ray collimation and L-shaped detector array are deployed on a single boom to assure alignment and high resolution.

Figure 4. Highly mobile MXRVS 2-4 MeV x-ray inspection truck.

The Aracor Eagle® was designed to meet the requirements of the US Customs Service for a high penetration x-ray inspection system with low external radiation levels to be used within the tight confines of seaports. The Eagle® shown in Figure 5 was realized by incorporating the highly collimated 6 MeV x-ray system on a commercial straddle carrier.

Figure 5. Aracor Eagle® relocatable x-ray inspection system inspecting a fully loaded truck.

With its unique steering, the Eagle® can be driven in either direction and is highly maneuverable in a crowded port environment. The radiation-safe inspection station is located in the compartment above the driver's cabin. The Eagle® can be relocated to different inspection sites in a matter of days. In practice, the Eagle® is often used in combination with lower-cost gamma-ray systems to inspect trucks. This combination ensures the highest inspection throughput.

Automated, Material Specific Neutron Inspection

As part of the NII technology development in the 1990s, the US Government worked in partnership with private industry to develop a family of neutron-based cargo inspection devices. These systems were developed to overcome the limitation of imaging systems in detecting drugs, explosives and other threats which have no definitive shapes. Plastic explosives can be molded into different shapes and terrorists often use simple plastic drums for homemade ammonium-nitrate and fuel-oil bombs. X-ray systems cannot distinguish a full barrel of explosives from one with legitimate fruit puree or industrial chemical; likewise, drugs can be molded to look like legitimate cargo.

Neutron inspection systems use neutrons to stimulate *material specific* signals from the inspected object. These signals, which are characteristic of the cargo's elemental composition, are examined by a computer and compared to a library database of threats. If there is a match, the system alarms. Thus the detection is automatic and does not rely on the vigilance of a human operator. This is an important point when it comes to port security as the actual probability of a terrorist threat in a cargo container is very low and humans are poorly suited for finding such low probability occurrences.

The most advanced neutron scanning technology is Ancore's Pulsed Fast Neutron Analysis (PFNA®). The PFNA® system was designed to detect threats and contraband concealed in fully- loaded cargo containers and trucks. Figure 6 shows the PFNA® system inspecting a fully- loaded cargo container. The PFNA system forms a 3-dimensional map of the materials in the cargo container. This map is compared to a database of known threats. The operator is alerted only if there is a match. There is no human involvement with screening legitimate cargos.

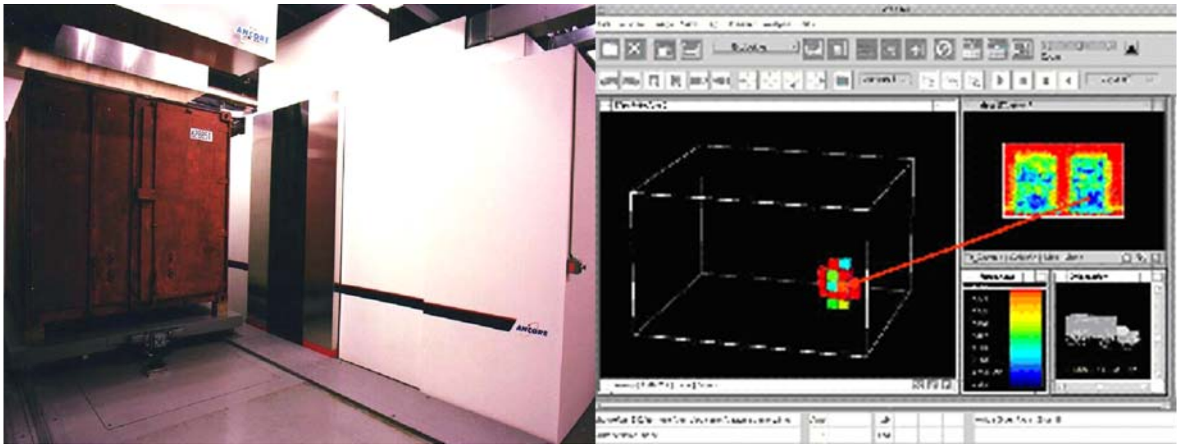

Figure 6. PFNA inspects a fully loaded cargo container (left). The PFNA automatic detection screen on the right shows the 3-D position of an explosive concealed within a container of industrial goods.

Importantly, the PFNA® system threat library can be updated to track shifting and new threats. The first PFNA® system is being installed at the US-Mexican border as a joint US DOD-TSA-CBP project and is a fixed site system.

A small neutron inspection system, based on low energy thermal neutron analysis (TNA®), has also been developed for cargo scanning. The TNA® technology is embedded in a product called the Ancore Vehicular Explosive Detection System (VEDS™). VEDS™ is designed to detect large bombs that terrorists use to attack facilities. Its compact sensor can be configured on a mobile or portal platform.

The Portal VEDS™ moves up and down as it scans a truck or container – see Figure 7. Trucks or containers are quickly cleared; if there is a signal that indicates the potential presence of explosive, it is clearly indicated on the operator screen. The VEDS™ can also be deployed on a forklift and taken to a port container yard for scanning stacks of containers.

Figure 7. Portal VEDS™ scanning a truck for terrorist threats.

Combining Technology

The primary function for NII cargo inspection in ports is to *quickly clear* the overwhelming number of legitimate containers while maintaining a high level of performance to stop a terrorist threat. Combining the strengths of radiography with those of neutron scanning in a complementary way offers the highest performance NII system available today. As discussed above, the x-ray and gamma-ray radiographic imaging systems work well where the search target has a recognizable shape. These systems are suitable when the targets are weapons or contraband. They can quickly clear homogenous cargoes when no anomalies are detected.

However, there are potential threat anomalies that cannot be cleared by looking at an image. These threats include explosives, chemical weapons and other terrorist threats. These materials can easily be mistaken for or concealed as legitimate cargo. Radiographic images alone lack the information necessary for a screener to come to a reasonable conclusion of a threat. The addition of automatic neutron scanning will overcome this shortcoming. In the past year such combined systems have become a reality. Figure 8 shows the Rapiscan MXRVS-450 combined with a VEDS™ (the VEDS™ sensor is the white box located on the left hand side of the truck behind the x-ray). In this system, suspicious anomalies spotted in the x-ray image are tagged and the truck is automatically repositioned for scanning by the VEDS™.

Figure 8. Mobile X-ray - VEDS™ combination.

Another combined technology system has been used at an Asian airport for over a year to inspect incoming air cargo containers for smuggled goods, drugs and explosives. This system combines a 3-MeV Rapiscan Series 2000 fixed-site x-ray inspection system with an Ancore VEDS™ neutron inspection system. Figure 9 below shows an example of an air cargo container screened by a combined technology system. The x-ray screener easily identifies the main components of the cargo which allows clearance of most cargoes. In this case, a concealed gun was identified. However, the questionable large, dark objects in the upper right and left of the screen had no identifiable shape. The screener tagged them on the x-ray image and the conveyor system moved the container to the VEDS™ neutron scanner where signatures indicated the presence of explosives and drugs.

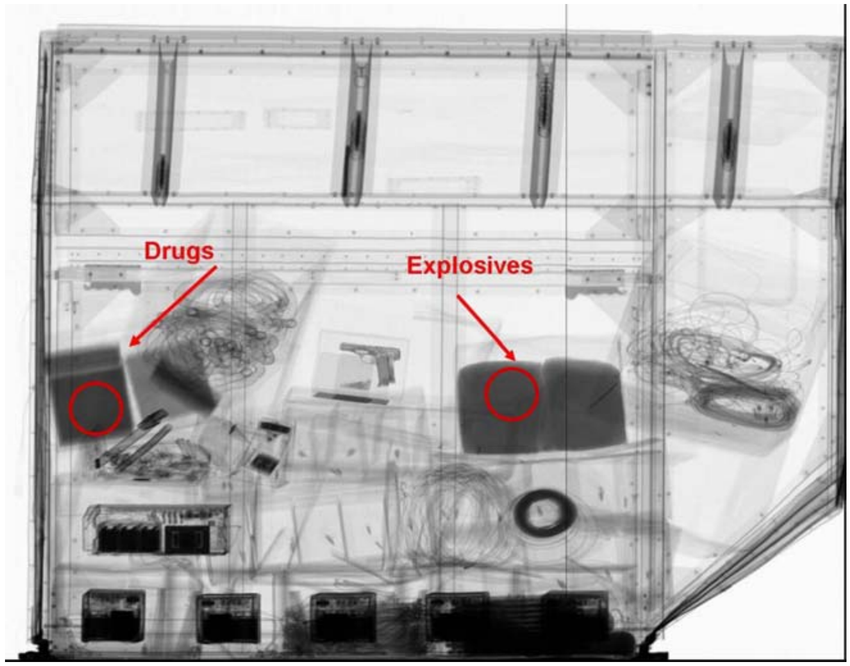

Figure 9. X-ray and VEDS™ scan of an air cargo container detect weapons, drugs and explosives.

Conclusion

Cargo inspection in ports requires high throughput and surety. A high performance technology system which combines the strengths of a radiography system and automatic neutron scanning of unidentifiable anomalies can fulfill present cargo security requirements.