The increased terror threat level has led many countries to re-evaluate how they screen large cargo passing through their borders. Richard Mastronardi weighs the various screening and inspection technologies available

INSIDE CARGO

With increased activity and renewed commitments by terrorist groups to undermine the values of developed nations, implementing a comprehensive security strategy is the top priority for many security professionals. Terrorist efforts to disrupt the supply chain and global economy is contingent on their ability to transport and deploy weapons, explosives and other hazardous materials – and when cargo crosses a land or sea border, it presents an opportunity to inspect containers, trucks, cars, and other conveyances. But what inspection technologies and tools are effective, easy to use, safe for operators and drivers and well-suited for the mission?

Various forms of security screening and inspection tools have been deployed at ports, border crossings and entrances to important facilities. Traditionally, the most widely deployed methods include hand inspection, canines for identifying explosives or drugs, radiation monitoring systems for finding nuclear materials and devices, and X-ray imaging systems for detecting a wide variety of contraband. More recently, emerging technologies and products have provided increased throughput, greater material specificity regarding the targeted threats, operational flexibility and products that incorporate complementary inspection modalities to increase the likelihood of detection.

For cargo and vehicle inspection, there are several factors that should be considered when developing a security screening strategy. Firstly, what are the types of threats and/or contraband that are most critical for the mission? Each inspection modality has its strengths and weaknesses, so identifying the priority of threats and contraband potentially concealed in cargo and vehicles can assist when selecting detection technology. For example, systems that are good at detecting weapons may not be optimal for finding explosives – and vice versa.

Next, what is the volume of cargo and/or vehicles to be inspected over a period of time? Will all cargo and/or vehicles be inspected at a specific site or selected at random locations? Will subjects for inspection be selected on the basis of gathered intelligence or other information profiles? Throughput requirements may require a tradeoff of inspection quality for speed of operation.

Finally, what is the concept of operations (conops)? Does the inspection system need to be flexible or mobile to accommodate changes in traffic flow or can traffic be consistently routed to a permanently located inspection facility? How much penetration into cargo is desired? Higher energy X-ray imaging systems, which provide deeper inspection penetration into cargo, require significant X-ray shielding for radiation safety. The weight and complexity of the shielding is a driving factor for system flexibility and mobility.


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Portal and gantry-mounted screening systems can utilise a range of detectors, including dual-source X-ray and backscatter

Of course, cost is also often an important factor. Cost includes the purchase of the equipment, installation, and life-cycle cost of operations and maintenance. The value judgment is a tradeoff of these costs against the critical nature of the mission. Inspection quality, including thoroughness, can be directly related to cost (better systems naturally often cost more money).

For inspection of cargo containers, large trucks, and cars, most of the deployed equipment consists of medium (3-4 MeV) or high-energy (6 MeV) X-ray transmission mobile and gantry systems. Over the last few years, new technology in the security market has provided increased throughput, more specific information regarding detected materials and the ability to detect a broader range of threats and contraband in cargo and vehicles. The most notable of these are: drive-through X-ray portals; high-energy dual-energy material discrimination; backscatter X-ray imaging.

Let's first discuss transmission X-ray gantry systems. This technology is designed to scan stationary vehicles with cargo located in a container on a trailer or inside a fixed body truck. The X-ray inspection system consists of a high-energy X-ray source (such as a linear accelerator) and a detector array located on the opposite side of the vehicle relative to the X-ray source. Both the source and detector array are mounted on a set of rails and propelled down the rails to scan one or more vehicles at a relatively slow speed of about 0.2 to 0.4 meters per second. Transmission X-ray gantry systems are typically designed for maximum penetration of cargo and trucks and

therefore use high-energy linear accelerators which emit significant amounts of radiation. Drivers and passengers must exit their vehicles and the scan tunnel prior to the scan to avoid exposure to excessive doses of radiation. The nature of gantry systems favours penetration and imaging performance over throughput.

Several types of portal systems have entered the market over the last few years. Drive-through portal systems offer a significant increase in throughput with some diminishment in imaging performance, including reduction in X-ray penetration and image resolution. Some systems also limit the inspection to areas of the vehicle where there is no driver or passenger. Typically, Portal systems favour throughput over penetration and imaging performance.

For X-ray transmission systems, information about a scanned object's specific material can be gathered by scanning with two spectrums of energy. Dual-energy scanning provides insight into the atomic number of the materials as well as their X-ray absorption density characteristics. The result is a colourised image that can indicate which materials are likely to be plastic, steel or something in between. Although not a perfect indicator of specific materials due to clutter in complex cargos and other factors, dual-energy technology provides a helpful tool for evaluating potential threats and contraband.

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Scanning on the move: the latest screening technologies can uncover a wide array of contraband and dangerous materials

Dual-energy is available for both gantry and portal X-ray transmission systems.

When X-rays interact with materials, they can either pass right through the material, be absorbed, or be scatter off molecules in all directions. When X-rays scatter, it is referred to it as "Compton scattering". The method for creating an X-ray image from Compton scattered X-rays in a backward direction (backscatter) was first developed and commercialised in the late 1980s. A very useful characteristic of backscatter is that it emanates primarily from lower atomic number materials (such as organics) but not from higher atomic number materials such as metal. As a result, backscatter enables material discrimination into general categories of organics and non-organics, and backscatter images highlight organic threats and contraband such as explosives, plastic weapons and drugs.

Backscattered X-rays tend to be lower energy than the X-rays that were initially directed at the inspection target. This limits the depth in the cargo from which backscattered X-rays can reemit to imaging detectors. At first this was viewed as a weakness when compared to transmission X-ray imaging; however, users of backscatter imaging systems have found that backscatter's unique ability to highlight organic materials and the lack of superimposed objects in the image (a characteristic of transmission systems) provide a powerful tool for detecting threats and contraband. Backscatter has proven very effective in applications where the detection of organic materials (such as explosives and drugs in passenger vehicles, trucks and cargo) is the primary inspection objective.

When used as a complement to transmission X-rays, backscatter X-ray imaging increases detection capabilities. Some threats are more visible in transmission X-ray images (such as weapons and other metallic objects), while others are more apparent in backscatter X-ray images (such as explosives or drugs). In one particular case, blocks of heroin were hidden in boxes of Durian fruit. The transmission X-ray image was too complex to allow for identification of the heroin blocks, while the strong smell of the fruit prevented canine detection. Backscatter imaging, however, was able to highlight the drugs clearly.

Backscatter X-ray inspection systems have been commercially available for years, both on mobile platforms and as standalone drive-through portal systems. Backscatter portal systems provide high throughput inspection of cars and trucks, with up to three views simultaneously (left side, right side, and top-down). The radiation exposure to drivers and passengers is very low and well within the limits of personnel X-ray standards, such as ANSI 43.17.

Combination systems that include both transmission X-rays and backscatter are also commercially available, deployed on gantry rails or as drive-through portal systems. Both types of system take advantage of the dual technologies to provide comprehensive inspections featuring high-energy transmission X-rays with dual-energy imaging as well as three-sided backscatter imaging.

By deploying X-ray scanning systems that feature high-energy transmission, dual-energy and backscatter technologies, security inspection operations are therefore significantly enhanced and the capability to identify threats and contraband is greatly increased. The combination of technologies provides the most comprehensive inspection solution for vehicles and cargo.

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