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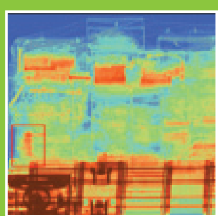

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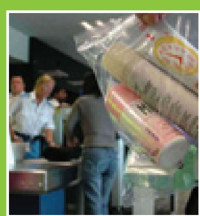

CARGO SCREENING: ANY IMPROVEMENT?

Cargo inspection (Credit: Eagle Security Services, USA)

The attempted bombing of cargo aircraft, with improvised explosive devices (IEDs) concealed in printer cartridges, in 2010, once again demonstrated that terrorists continue to have an uncanny understanding of our critical weaknesses and grow more sophisticated in their attempts to smuggle IEDs on board commercial aircraft using different vectors. ***Steve Wolff*** *looks at current and emerging technologies and explores where we are in countering the ever-evolving threats through screening.*

Air cargo is an ideal terrorist target for several strategic reasons. Firstly, it leverages the fact that successful aircraft attacks have a significant impact well beyond the immediate loss of life. For example, many more people die per year from e.g. shootings in the US than were killed on 9/11, yet these individual tragedies don't disrupt the economy, influence infrastructure spending or affect the national psyche in the same way. Secondly, for cargo, a successful attack, and especially our response to it, has the potential to severely impact the flow of commerce and hence the global economy, given that airfreight is crucial for rapid movement of goods and components in our 'just in time' (often 'just in the nick of time') economy. As economic disruption of the West is one of al-Qaeda's key goals, a successful attack against air cargo (or attacks against mass transportation if they led to draconian screening methods that impacted commerce) would have a more substantial economic impact than an attack via other threat vectors, such as passengers or baggage.

Where We Are

Regulators worldwide have cooperated extensively to develop internationally recognised air cargo security strategies, including initiatives such as improving the supply chain process. Trials of SecureFreight – where shippers are 'known' and cargo has been validated and secured upstream and maintained throughout the supply chain - are underway. IATA has been advancing its Air Cargo Advanced Screening Programme (ACAS) with the goal of global harmonisation and increased use of electronic waybills and e-cargo security declarations. This approach, which loosely amounts to 'profiling' cargo, is another example of risk-based screening. Centralised screening facilities (CCSFs in the US), run by the private sector, provide screening to international (or regional) standards. However, there is a critical problem in dealing with 'unknown' cargo: screening technology for cargo lags about 20 years behind systems that are available for baggage. Fortunately, this may be about to change.

Current Technologies

Today's technological workhorses for cargo inspection have been X-ray (often just single view, low penetration systems) and trace detection. Most of the major X-ray manufacturers sell pallet-capable dual energy X-ray systems with either single or dual views as well as larger systems. Where needed, due to the inability to see inside dense objects, these have been supplemented with physical search, explosives trace detectors (ETDs) and, in some countries, the use of dogs, either via an innovative sampling, remote K9 inspection process called REST (formerly RasCargo) or using Free Range Explosive Detection Dog teams (FREDD). For certain types of non-metallic cargo containers, metal detection technologies have been considered, but obviously would be of questionable use if non-metallic chemical timer/triggering mechanisms were used as they have been by terrorists inside the aircraft cabin. The Transportation Security Administration (TSA) and others have explored – and permit – the use of Certified Explosives Detection Systems (EDS) but the small apertures of current EDS systems create an operational problem as cargo pallets need to be broken down for screening and reassembled afterwards, increasing processing time, cost and the potential for damage and theft.

Other technologies that have been tried over the past 20 years include thermal neutron and fast neutron inspection systems. In the 1980s, SAIC (Science Applications International Corporation) developed Thermal Neutron Activation (TNA) for hold baggage screening (the author's first foray into explosive detection technology). Rapiscan, which purchased the SAIC division responsible for TNA development, developed a hybrid X-ray + TNA cargo screening system and sold a couple of systems for use in Asia. However, TNA detects nitrogen and chlorine, and many of the explosives used by today's terrorists (especially homemade explosives) contain little or no nitrogen, rendering it significantly less effective against the broad threat. A related technique with more capability, though with its own problems, is Fast Neutron Activation (FNA) and its relatives, Pulsed Fast Neutron Activation (PFNA) and associated alpha particle fast neutron inspection. While these techniques can detect a wider array of elements (and have the potential to discriminate based on isotope ratios), they suffer from other drawbacks: cost, size, complexity, poor image resolution, the inability to penetrate high hydrogen content cargo and, last but not least, the unfortunate ability to render some metallic items mildly radioactive.

Credit: Alitalia

Emerging Technologies

1) The Big Guns

Ideally, cargo would be inspected automatically with high detection probability as rapidly as possible while still palletised. The cost, in terms of time and potential damage from stripping down such containers in the event of a reject means that the false alarm / nuisance alarm rates need to be extremely low. This places a huge burden on technology developers in addition to those of cost, processing speed, size, resolution, image quality and penetration ability, but a couple of approaches are nearing prototype completion and are worth mentioning.

> "…screening technology for cargo lags about 20 years behind systems that are available for baggage…"

First is a technique called Nuclear Resonance Fluoroscopy Imaging (NRFI). While it might sound ominous, it merely uses X-rays with energies similar to truck inspection X-rays. With NRFI, when an object is irradiated with a continuous spectrum X-ray beam, the nucleus of each element absorbs and then re-emits characteristic resonance energy gammas. NRFI identifies a material's elemental composition in addition to the shape and density of an object based on 'gaps' in the transmission spectrum, which can be detected by specially configured detector filters and detectors opposite the beam. This results in a high-resolution image that can be coloured according to isotope ratios. In addition, detectors to the side or adjacent to the beam measure the re-emitted gammas, allowing 3D positioning of threat materials. The technique is undergoing testing in the US by DNDO at Massport in Boston. However, the system is large and extremely expensive, so is unlikely to see widespread deployment for air cargo screening, even if it meets the performance requirements.

Another technique being considered (primarily for detecting nuclear weapons) uses muons, naturally occurring highly penetrating subatomic particles that are part of cosmic radiation with a rate of 10,000 muons per m2 per min. When these negatively charged particles pass close to a nucleus they are deflected slightly. By measuring the incident and scattering angles using detector arrays on top and underneath the container, denser materials, which cause more deflection, can be detected by tracking the muons on both sides of the container. The technique is being supplemented with cosmic electron detection, which aims to help with low-density material (such as explosives) discrimination. Electrons that don't make it through the container help pinpoint materials and the stopping power vs. scattering angle is being explored for differentiating explosives from other organics. If it works, a key advantage is that the technique does not require a radiation source.

Several companies (including CSIRO, SAIC and several companies in Russia) are working on improved neutron techniques. Neutrons complement X-ray in that they penetrate materials that X-rays cannot and vice versa. They also can provide better material discrimination than X-ray alone. However, these systems come with increased cost, size, safety and installation complexity along with that aforementioned radioactivity issue.

2) The Little Guns

More conventionally, several companies are looking at static CT or 'many-view' X-ray systems to potentially replace conventional X-ray without requiring more exotic inspection techniques for bulk cargo. The author knows from personal experience the challenges in increasing the gantry size of rotating CT systems; for cargo, the approach is to either use a static X-ray source / detector array and rotate the cargo container, or use multiple X-ray tubes and detectors that inspect the container from different angles. A combined approach is being pursued by Astrophysics, while companies like SureScan and L3 have opted for different variants of the latter

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method and there is a strong interest in using a new generation of scanning X-ray tubes, simpler detector hardware coupled with sparse-data reconstruction methods (so-called 'Compressive Sensing') developed by, among others, Duke University in the US. These systems have not yet been deployed, but should lead to improvements in imaging capability for many types of cargo containers and potentially automatic inspection algorithms, albeit at a greater cost than existing X-ray systems. However, X-ray-only techniques by themselves will still be unsuitable for high-density cargo; we're still constrained by the laws of physics.

At the opposite end of the technology spectrum are ongoing attempts to improve detection of lower vapour concentrations of targeted materials. Driven by regulators' discomfort with the security implications of combining poorly understood human factors variables with even less well understood 'canine factors', the Department for Homeland Security has funded the development of more sensitive 'electronic dogs' noses' to seek more repeatable – and identifiable – methods for sniffing explosive vapours that might supplement, or potentially replace our furry friends and their handlers for routine cargo inspection.

There are two basic approaches. The first pursues scaled-down table-top versions of highly sensitive forensic technologies, such as Mass Spectrometry (considered the gold standard of forensic analysis) being pioneered by MSA Analytics in the UK and Implant Sciences, Smiths and Morpho Detection, Inc. in the US. Challenges remain for field deployable systems, as these more sensitive instruments have historically been delicate, sparingly used, lab-based devices operated by highly trained scientists. Their ability to survive continuous often harsh cargo screening operating environments remains to be seen.

The second approach uses chip-based sensors and an assortment (depending on the company) of chemical absorbers and inspection methods to identify the minute quantities of the target materials that are captured from sampled air. One technique, from SpectraFluidics, Inc., uses a method analogous to the way in which our noses work, by mimicking the function of mucus - which absorbs the vapour - using a minute 'micro-river' of liquid flowing along a channel on the chip's surface. The absorbed molecules attach to colloids in the liquid; a laser technique known as Surface Enhanced Raman Spectroscopy (SERS) identifies the material. Other approaches, from FLIR, Nevada Nanotech and others use counterbalance techniques, antibody absorbers and other methods aimed at separating and detecting target molecules in air obtained from inside the container.

A challenge for these techniques is to develop reliable testing standards and methods. As these devices are capable of detecting target materials in the 1 part per trillion to 1 part per quadrillion levels, the ability to reliably prepare testing samples and avoid cross contamination becomes more complicated.

"...these devices are capable of detecting target materials in the 1 part per trillion to 1 part per quadrillion levels..."

Over the next few years, one or more of these techniques is likely to reach a level of maturity for application to cargo screening or alternatively, to allow regulators to better understand how and when to use K9 teams.

A Possible Path Forward

Cargo represents a significant challenge that will require the industry to evolve further towards a Risk Based Screening approach. This could mimic the general strategy that IATA is pursuing for passenger screening or sort the stream of commerce according to risk and screen it according to the best method/combination of technologies needed for the type of cargo and the risk it presents. Fortunately, SecureFreight and ACAS can serve as the front end of the process; sorting the cargo into risk categories poses no privacy or data sharing issues that are of concern with passengers.

For screening, instead of using technology or processes based solely on the type of cargo content, a better approach for higher risk cargo would be to use an assorted suite of complementary technologies so that different techniques mitigate the weaknesses of other systems in a layered screening approach. This mirrors the Checkpoint of the Future strategy. For low-risk cargo, critical attributes are rapid screening at an extremely low end-to-end false alarm rate. More time would be spent screening elevated risk cargo to higher detection requirements. The unknown shippers would pay the higher cost for this slow, more scrupulous inspection of a small subset of the total air cargo stream.

Unlike passenger screening, there may be advantages to physically separating the different screening regimens including handling them at different facilities. This could lead to different levels of certification for each type of screening facility. Chain of custody, perimeter security, screening technologies and manpower expertise would then be customised for the facility based on the risk level that it serves.

Elevated risk cargo: Fewer Elevated Risk screening facilities would spend more on technology and personnel. A

Credit: El Al Israel Airlines

combination of advanced technologies would be configured orthogonally (i.e. using 'OR Logic') where a reject from any initial screening component results in a secondary search with sophisticated but slower technologies potentially including e.g. NRFI and/or neutron-based techniques to minimise and better target physical search.

Low risk cargo: Here, the emphasis would be on auditing measures to assure that the cargo declaration / risk assessment / manifest is accurate, supplemented with high speed, lower cost and with less intensive screening methods aimed at verifying the manifest.

As the additional cost of screening elevated risk cargo would be borne by the shipper/originator, this strategy provides an added incentive (on top of processing speed) for unknown shippers to enrol

> "…the 2010 printer bomb attempt showed that, even with excellent intelligence right down to the specific cargo item, the existing processes were challenged in finding the threat…"

in e.g. SecureFreight, ACAS or another internationally recognised programme.

In summary, given the effect a successful attempt would likely have on the world economy, air cargo is a prime target for terrorists. The 2010 printer bomb attempt showed that, even with excellent intelligence right down to the specific cargo item, the existing processes were challenged in finding the threat and, if no such intelligence existed, would not have identified the device.

New technologies, for both bulk and vapour/trace detection are being developed and are likely to be available within the next few years. Some of these will be large and expensive. Accordingly, an end-to-end security process, analogous to IATA's Checkpoint of the Future initiative that effectively integrates multiple less-than-perfect technologies to counter each one's deficiencies should be applied to cargo screening. Such a process would allow cargo of different risk levels to be screened appropriately (including potentially at different facilities), so that more expensive, highly capable technology and invasive processes can be applied to a smaller percentage of higher risk cargo. The advantage for Preferred Shippers is that their commodities would move rapidly – and less expensively – through a simpler screening process, while unknown or elevated risk cargo shippers pay more for thorough screening. This incentivises Unknown Shippers to become Preferred Shippers.

From a technology developer's perspective, this would provide a smaller initial market for high detection performance systems where new, advanced technologies can be proven, refined and cost reduced. Once this occurs, regulators could consider expanding their use to lower-risk screening facilities and rolling in newer advanced technologies into the higher risk screening facilities via a 'Spiral Deployment' process.

This strategy is likely the best method for thwarting one of the terrorists' goals – disrupting the world's economic activities – by maximising the likelihood that the next cargo bomb, if not intercepted by intelligence, has a good chance of being detected before ending up on a plane without countries running out of funds trying to deploy and maintain a consistent screening process across the entire industry.

Steve Wolff has 28 years' experience developing and marketing advanced detection solutions based on a wide range of inspection technologies including the successful CTX-5000. He was a cofounder of - and V.P., Marketing & Engineering for - InVision Technologies (now Morpho Detection). His 10-year-old consultancy helps companies develop technologies and engage industry stakeholders. He co-authored IATA's Checkpoint of the Future vision, has been an expert witness and is Vice Chair of the 2015 Gordon Research Conference on Illicit Substance Detection.