Australian Government
Australian Customs Service

Review of Emerging Counter-Terrorism Technologies for Air Cargo

Executive Summary

Introduction

In response to the Wheeler Review on Aviation Security, the Australian Government announced a number of measures to improve the security of air cargo. As part of these measures, it was agreed that Customs would undertake a review of emerging technologies that might contribute to improved border protection and security for air cargo in the short and medium term.

Technology is a tool to help achieve required business outcomes. As such, the use of technology must sit within a clear policy and process framework. The Government's counter-terrorism and security policy framework provides a clear direction for technology evaluation and deployment. It is also acknowledged that approaches to counter terrorism and security must be achieved without significant impact on legitimate trade.

For airport operations, timeliness is critical because it affects Australian industries' efficiency and competitiveness. Therefore, the particular requirement in the air cargo environment is for technologies that can process cargo rapidly and reliably.

The interface with industry is critical, particularly as there are many parties involved in air cargo operations: The Australian Customs Service (Customs), the Department of Transport and Regional Services (DOTARS) and various industries with some of the larger companies having invested in security screening equipment for export cargo. Where appropriate, there should be a move towards the standardisation of technologies for economies of scale, good and uniform practice, quality assurance and simplification of training, but at the very least there must be coordination between the parties.

It must also be remembered that there is no "silver bullet", that is, no single technology can provide a defence against all the options open to terrorists. Terrorist threats include a variety of explosives, chemical and biological agents and radioactive materials; each has characteristic properties, some of which can be exploited for detection.

This means that there needs to be a breadth and depth in the technology deployment: geographically, to cover entry and exit points, and with different systems to counter every likely attack. With constraints on cost and processing time, one successful tactic is to deploy numerous instruments of lesser capability, and to confirm any detections with a more powerful instrument operated by more highly trained staff.

The following provides summary information on current and emerging technologies for scanning cargo, detecting traces of explosives and chemicals, and monitoring of freight handling and movement. They range from products already available commercially, products soon to be available commercially, items under research or undergoing engineering development to new concepts that have yet to be proven feasible.

Bulk Detection

Bulk detection relies on imaging or material identification, or both. Over the next few years, the intense research and development efforts in many countries on counter-terrorism should yield at least evolutionary advances in bulk detection and, quite likely, significant improvements.

X-ray and gamma-ray radiography is mature. Devices are available for scanning objects ranging in size from luggage to sea containers and now cover:

- High power (for better penetration);
- High resolution (for better images);
- Dual views (from the side and top);
- Dual energies (to provide some discrimination between different materials); and
- Diffraction to identify materials by analysing crystal structure.

Current developments include:

- Multiple energies which are designed to give better discrimination between materials, eg organics and inorganics;
- Multiple views where a 3-D computer tomographic reconstruction of the object; and
- Combination of X-rays with other technologies.

Future advances in X-rays are likely to be incremental, with attendant cost and other implications.

Raman spectroscopy is used by Customs to identify suspect materials found or to detect target substances among the constituents of the materials.

Neutron radiography can be based on transmission (for imaging, like with X-rays) or on neutron activation analysis (for identifying materials). The neutron transmission scanner, developed for air cargo examination by Commonwealth Scientific and Industrial Research Organisation (CSIRO) in collaboration with Customs has the potential to reveal shape, density and composition. If the commercial prototype can deliver on the promises of the laboratory prototype, it will represent a breakthrough in bulk detection. Customs is in the process of field testing the commercial prototype.

Nuclear Quadrupole Resonance (NQR) can distinguish materials (such as "conventional" explosives and drugs) that contain nitrogen.

Radiation monitoring is a mature technology and a variety of detectors − ranging from portals that scan entire trucks to hand-held devices − are available.

Millimetre Waves (MM-Waves) and Terahertz-Rays are short-wavelength electromagnetic waves that may contribute to air cargo security in the long-term future. Currently, the technology looks promising, however much more research and development is required before it will be of practical use for aviation security.

Although many of the bulk detection technologies are mature, there are prospects of useful advances − in a relatively short time and cost − through the combination of technologies with complementary capabilities.

Trace Detection

Trace detection exploits chemical and physical characteristics of threat substances. Analysis can be performed on air samples, swabs, or by using remote sensing. Existing laboratory analytical instruments are very sensitive and capable of excellent discrimination between different materials but usually require highly trained staff and are often expensive and slow.

Gas Chromatography - Mass Spectrometry (GC-MS) is one of these well-established laboratory analytical tools; it is very sensitive and gives very good discrimination between materials but is slow and requires skilled operators.

Ion Mobility Spectrometry(IMS) is a mature technology that is widely deployed in airports and cargo depots to detect drugs and explosives. It is compact, relatively inexpensive, rapid and requires little training. It can have a high rate of false positives (false alarms), and it is recommended that complementary verification technology be used to confirm findings. The interpretive skill of the operator is also critical in reducing the false alarm rate and robust training and accreditation programs are critical for optimum use. Incremental improvements can be expected in its performance over time.

Selected Ion Flow Tube - Mass Spectrometry (SIFT-MS) is a well-known technique for trace gas analysis. Customs uses these units in the examination of sea cargo. At this stage, these units are not easily portable. They can be programmed to detect a wide range of substances such as chemical warfare agents, explosive vapours (such as marking agents for plastic explosives) and fumigants.

A recent promising innovation adapts *medical antibody technology* to the detection of illicit substances including explosives. It discriminates very well between different substances; performance improvements could be substantial. Customs uses a number of these units as a verification tool.

'*Lab-on-a-chip' devices* use electronic microchip technology to miniaturise chemical and biological laboratory analysis and processing. Rapid advances can be expected

over the next few years, leading to a variety of devices that are portable, robust, simple to use and relatively inexpensive. Changes here could be revolutionary.

Some commercial products pump air through concentrators that extract the wanted substance while suppressing undesirable ones. There is the possibility of extending their use to process, over a relatively long period of time, the air in cargo areas to enhance the detection of explosive vapours.

Container Tracking and Monitoring

Improvements are possible to efficiency and security in air cargo handling and management, through advances in video processing of closed-circuit television (CCTV) and radiofrequency identification (RFID).

CCTV

Large numbers of CCTV cameras are deployed in all airports and more installations are planned. They play a vital part in security, including that of air cargo but to be effective require continual monitoring and recording capability.

There are a number of academic, research and corporate organisations working on CCTV enhancements, with the development of new software packages that can be added to existing systems. These improvements, such as automatic tracking and detection of anomalous movement, still need to be evaluated within operational settings to test their usefulness.

RFID

It can be expected that RFID devices (not unlike an electronic version of the familiar barcode) will be widely deployed for the detection and tracking of items over the next few years. They may have applications in airports for baggage handling and security, but there are practical as well as cost issues that will need to be resolved.

Conclusion

The major conclusion of this report is that X-ray and IMS are the currently available and operationally proven technologies. They are mature technologies and it is expected that incremental improvements will continue.

In the short-term, increasing use of antibody based technology and Raman Spectroscopy will provide much needed verification capability to IMS technology.

In the medium term, there are prospects of revolutionary improvements in neutron radiography, Lab-on-a-chip devices and CCTV monitoring technology but these require more research, development and operational testing over the next few years.

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