METAL DETECTION TECHNOLOGY:

WALK-THROUGH, HAND-HELD, HAND-WORN, STEPPED UPON AND SAT ON

Civil aviation remains a prominent target for terrorism and other criminal activity. As such, there is a need to continuously evolve and update security procedures, techniques and, of course, technology. The industry must remain open to new technologies such as advanced imaging technologies (also known as full-body scanners). We must also ensure the continued research and development of the ways in which technologies currently deployed can be updated, remain relevant, and be effective tools in the aviation security arsenal. An important consideration is also the time factor – passengers should be moved through checkpoints as quickly and smoothly as possible so not to create bottlenecks and large queues, which are themselves a target. **Lucy Rawlings** looks into some of the latest developments in the metal detection technologies available to the security sector and discusses their ongoing relevance in a world in which many prominent security threats contain zero metal content.

The physical screening of airline passengers began in the early 1970s with the widespread deployment of metal detection technologies since the vast majority of terrorist attacks and hijackings carried out at this time were perpetrated by individuals carrying metallic weapons. It was a Finnish company, Outokumpu, who first adapted mining metal detectors to make a commercial walk-through security detector. Following this, the development of these systems was continued by a spin-off company, and systems branded as Metor Metal Detectors (by Rapiscan Systems) evolved in the form of the rectangular gantry now standard in airports.

"…although magnetic fields are a form of radiation, it is 'non-ionising' in nature…"

Both walk-through metal detectors (WTMDs) and hand-held metal detectors (HHMDs) started to be used and proved to be highly effective, speeding up procedures and complementing pat-down searches. Early WTMDs were considerably more basic than today, only capable of alerting screeners to the mere presence of a metallic object and often affected by changes in climate or giving false alarms when sensing metal in close proximity to them. Temperamental and somewhat unreliable, they were nowhere near as

A woman walking through a metal detector at San Francisco International Airport in 1973 (Credit: Bill Young)

Elpam Electronics Hand Held Metal Detector

sensitive and sophisticated as the metal detectors you find at busy airports today. It wasn't until 1995 that detectors had the ability to indicate the approximate height of the metal object above the ground, enabling security personnel to more rapidly locate the source of the signal. Metal detection remains the most widely deployed people screening technology in aviation both for passengers and staff, with varying sensitivities and types of detectors able to be used.

Different kinds of metal detectors work in various ways, however, they are all electromagnetic in nature. The simplest form of metal detectors are based on pulse induction and contain a coil of wire (transmitter coil) through which short, powerful bursts of electric current are sent. When the current flows through the coil it produces a magnetic field. As a metal object passes through the detector's magnetic field, the atoms inside the object are affected and it changes the way the electrons move. Simply put, the metal detector induces electrical activity in the metal causing a change in the detector's magnetic field due to the presence of another, opposite, field. It is this second magnetic field around the metal object that the detector picks up. The closer you move the transmitter coil to a piece of metal the stronger the magnetic field the transmitter coil creates in it.

Although the basic principle of metal detection technology has not really changed over the years, vital changes have occurred, which have enhanced reliability, operational features, and the overall detection performance and reliability of the devices. Modern technologies are additionally far more capable of dealing with shifts in temperature, humidity, and environmental interference as well as capable of detecting much smaller objects than technologies available as little as a decade ago.

HEALTH CONCERNS

People are often concerned about the safety of metal detectors with regard to pacemakers, pregnancy, or surgical metal implants and plates. However, countless studies over the years have concluded that passing through a metal detector will have no adverse effect on the person, a pacemaker, or an unborn child. Pacemakers and metal implants may set off the detector alarms but no harm will be caused and it is often advised that individuals with pacemakers should carry their device identification card for the purpose of a smooth transition through security.

Frequent flyers have additionally expressed concern about repeated exposure to radiation at the security checkpoint, but it is important to note that although magnetic fields are a form of radiation, it is 'non-ionising' in nature which means that the magnetic fields do not generate additional, damaging radiation the way that ionising radiation (such as X-rays) does. Magnetic fields below a certain intensity (including all those used in security screening procedures) are considered to be safe and will not cause any biological damage.

HAND WORN METAL DETECTORS

Travellers will now be very familiar with the traditional WTMDs and HHMDs (typically in the form of wands), however, some of the latest technologies to be deployed now include metal detection gloves. Adams Electronics Inc. has specialised in the design and manufacturing of portable metal detectors since 1965 and is one company that provides this new technology. Speaking with Robert Adams, he told us that Adams Electronics continually focuses on developing new super-high sensitivity metal detection technology that is reliable and user-friendly, explaining that, "The main reason for the continual development in this field, from an aviation security applications perspective, is with greater sensitivity the operator has a greater detection range and depth penetration for accurately detecting potential threat items that could be concealed deep within loose fitting clothing." With regard to their HHMD devices, it was explained that a high-performance level technology is also a distinct advantage to security staff and passengers as it allows the screening procedure to be less intrusive: "By having the advantage of a far higher sensitivity range, the security staff are able to search for items without having to physically touch the individual, even if they might have secreted threat objects between the legs or within the body cavities".

Adams Electronics MIT hand-worn metal detection gloves

"...technology that allows the operator the ability to search for metal objects while feeling for non-metallic objects simultaneously..."

Adams produces hand worn metal detectors (HWMD), the MODEL MIT and MODEL HF-1 e-gloves, which use a different technology to HHMDs as the sensor heads are very small and have to be fully flexible so that they may be moved while being used and additionally withstand the force of constantly being squeezed in the palm of the operator's hand without giving false positive readings. The aim of the gloves is to give the operator a 'sixth sense' - the ability to use the sense of touch, as in a standard pat-down procedure, together with an advanced metal detection technology that allows the operator the ability to search for metal objects while feeling for non-metallic objects simultaneously.

The search head area of the HWMD is much smaller than a standard HHMD, the diameter being approximately 30mm as opposed to 120mm or more. This means that the MIT can precisely pinpoint the exact location of a concealed object with supreme accuracy, speed and reliability, and gives off a discrete vibration alert against the wrist of the operator when something metallic is detected. At present, these types of devices are more frequently used within prisons or for door security, however, they are starting to become more popular in the world of aviation security.

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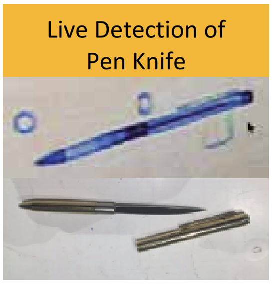

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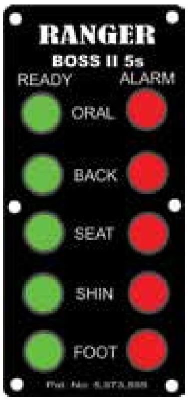
BODY ORIFICE SCANNERS

Another technology that is more commonly used within the prison sector is the Body Orifice Security Scanner (B.O.S.S.). Manufactured by RSD Security Scanners and available from Xeku Corp., the B.O.S.S. offers non-intrusive scanning designed to detect small weapons or contraband metal objects concealed in the abdomen, rectal or vaginal cavity, and nasal and oral cavities. With contraband becoming smaller and IEDs and detonators often containing very low metallic content, perhaps only in very fine wires, they become very difficult to detect and locate. Isac Salido from RSD explained that the B.O.S.S. chair is highly sensitive and capable of detecting and locating something as small as a paper clip concealed within a body cavity. The chair works through continuous wave electromagnetism with high precision, non-contact measurement sensors contained within a frame of birch wood that is coated in radio frequency resistant paint for improved electromagnetic interference rejection. The sensors provide instantaneous, high sensitivity detection capable of detecting most ferrous and non-ferrous metals or alloys. As with other metal detectors, the process is quick and safe and offers the ability to pinpoint internally concealed weapons, which may be picked up initially by WTMDs and HHMDs but cannot be found on the person externally.

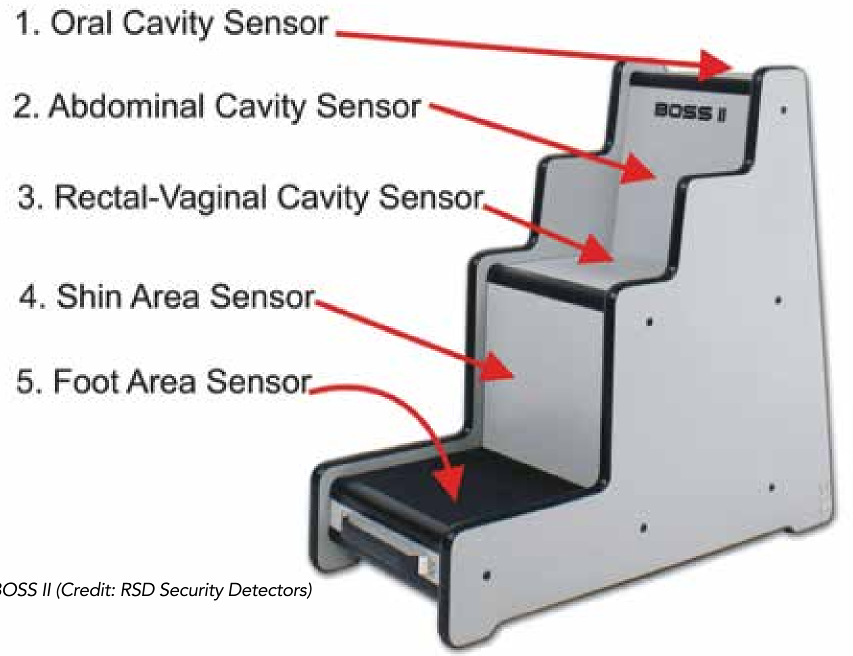


BOSS II 5s alarm panel (RSD Security Detectors)

SHOE SCANNERS

Footwear often poses a challenge at checkpoints. Some airports require all footwear to be removed and X-rayed, others may only ask that certain types of footwear be removed and checked, while some do not require footwear to be removed at all. With the high security standards required today for WTMDs, a number of shoes containing small amounts of metal can set off the alarms, often resulting in further scanning and screening of the shoes. CEIA S.p.A. have developed the 'SAMD Shoe Metal Detector', which allows passengers' shoes to be checked for metallic content without the need to remove them. As with other metal detectors used in the security process, the technology employs low-frequency electromagnetic fields, which are non-ionizing and completely harmless. The purpose of the 'Shoe Analyzer' is to be an extension of the WTMD, which complies with the most recent, stringent security requirements and, CEIA claims, reduces by up to 10 times or more the number of shoes that must be examined manually because of metal alarms. The CEIA SAMD also provides a programmable random alarm function for supplementary inspection requirements.

> "...the chair works through continuous wave electromagnetism with high precision, non-contact measurement sensors contained within a frame of birch wood that is coated in radio frequency resistant paint..."



BOSS II (Credit: RSD Security Detectors)

SAMD Shoe Scanner 2 (Credit: CEIA)

In addition to the arrival of these new metal detection technologies, there are a number of ways the traditional WTMDs have been enhanced to increase their accuracy and effectiveness. Garrett Electronics Inc. are one of the global leaders in WTMD technology. Some of their products boast impressive modern features and developments, including dual-sided detection – a bilateral technology with transmitters and receivers in each side panel to allow scanning from both sides, resulting in uniform detection throughout the archway – and highly accurate pinpointing of objects with independent zone indicator lights on both side panels which identify not only the height of the object but also left, centre and right locations for one or more objects passing through the archway.

ACADEMIC RESEARCH

The advancements in the technology over the years have been impressive and are vital in ensuring that security procedures remain effective, efficient and unpredictable for criminals. Some of the latest research into metal detection is taking it to the next level. In the UK's new Engineering and Physical Sciences Research Council funded project (*Reducing the Threat to Public Safety: Improved Metallic Object Characterisation, Location and Detection, 2018 – 2021*), which began earlier this year, a team of UK researchers led by Dr Paul Ledger, Associate Professor in the College of Engineering at Swansea University, are developing new techniques to improve metal detection technology. In

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"…a team of UK researchers led by Dr Paul Ledger, Associate Professor in the College of Engineering at Swansea University, are developing new techniques to improve metal detection technology…"

an interview with *The Engineer*, Ledger explained that, "with current metal detection technology it can be hard to distinguish between objects that are located close to the surface, and other objects buried deeper, so trying to distinguish between the different shapes and the different material properties of these objects is quite difficult".

To tackle this problem, the team, which also includes researchers from Manchester University and University College London, are working to develop a technique based on the idea that different metallic objects can be identified by measuring how electromagnetic fields behave at different distances away from them, across a range of frequencies. In this way, different objects can be classified using a mathematical construction called a polarizability tensor. Once the objects have been classified, algorithms can be used to detect the hidden targets through measurements of the electromagnetic field.

"We're looking at a way to mathematically characterise the shape and material properties of different objects, and use this characterisation to better understand and, then, detect different objects" said Ledger. The team has already made progress in understanding the changes to the magnetic field surrounding different objects and now hope to build on their theory in order to better understand how to characterise different shapes and material properties. "We are trying to improve metal detection across a complete spectrum of applications," explains Ledger, "so we want to look at better location, better discrimination of multiple objects, and try to reduce the number of false positives". If successful this exciting research could mean that future metal detection technologies would be able to distinguish between different metallic objects, leaving security personnel to only investigate further the objects with which they are particularly concerned.

Metal detectors are highly efficient operationally, analysing people on the move and alerting security staff to potential threats without the reliance on initial human identification of objects, such as in X-ray baggage screening or with the new full-body scanners. They can be portable, are easy to use, and the cost of WTMDs and HHMDs is generally considered low in comparison to other technologies. However, many of the threats facing aviation today contain zero metal content and those planning attacks are continuously trying to stay one step ahead by developing threats to go undetected by screeners and screening technologies currently deployed at airports. Internally concealed weapons and devices pose an additional challenge within aviation security as they often have no metallic content and, as contained internally, cannot be detected by either millimetre wave scanners or backscatter X-ray machines (used as body scanners) as they are designed only to detect items under the clothes and cannot penetrate the body.

With the arrival of millimetre wave imaging devices, which can detect threat objects concealed beneath the clothing, whether they be metallic or non-metallic, it was speculated that the necessity for metal detectors may have come to an end. However, this is not the case. Robert Adams explained that the presence of WTMDs still provides an important and a relatively inexpensive solution for screening people quickly and en masse. They additionally add yet another important layer of security in the already comprehensive screening process and, in addition to the millimetre wave equipment installation, give passengers confidence that everything is being done to safeguard their security. The presence of the HHMD, which is normally used as a back-up to the millimetre wave and archway metal detectors, provides the security checkpoint with a very portable, inexpensive, easy-to-use solution which, again, adds a further layer of security to the process and offers security staff the ability to screen a passenger in much more detail as well as provide an additional opportunity for passenger observation and behavioural analysis to be applied to the procedure.

CONCLUSION

Despite the fact that many weapons that might be used in an attack against aviation contain no metallic elements, it is clear that metal detection technologies still have a key role to play in aviation security screening as part of a thorough, 'layered' security approach. We are well aware that no single security measure is sufficient alone and metal detectors should be combined with screening for prohibited non-metallic items (both in bags and on the individual) as well as the implementation of behavioural analysis. Of vital importance is ensuring that those who operate metal detectors and screening equipment are vigilant and not solely reliant on machinery to alert them to potential hazards, nor to allow them to develop 'tunnel vision' by solely seeking metallic objects alone. The key to success lies in the application of human security, behavioural analysis and questioning of individuals, combined with the thorough use of technology. The aim is for people to be able to move smoothly and swiftly through checkpoints – avoiding bottlenecks and preventing queues from becoming targets. To do this, a layered, common-sense approach to security is pivotal.

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