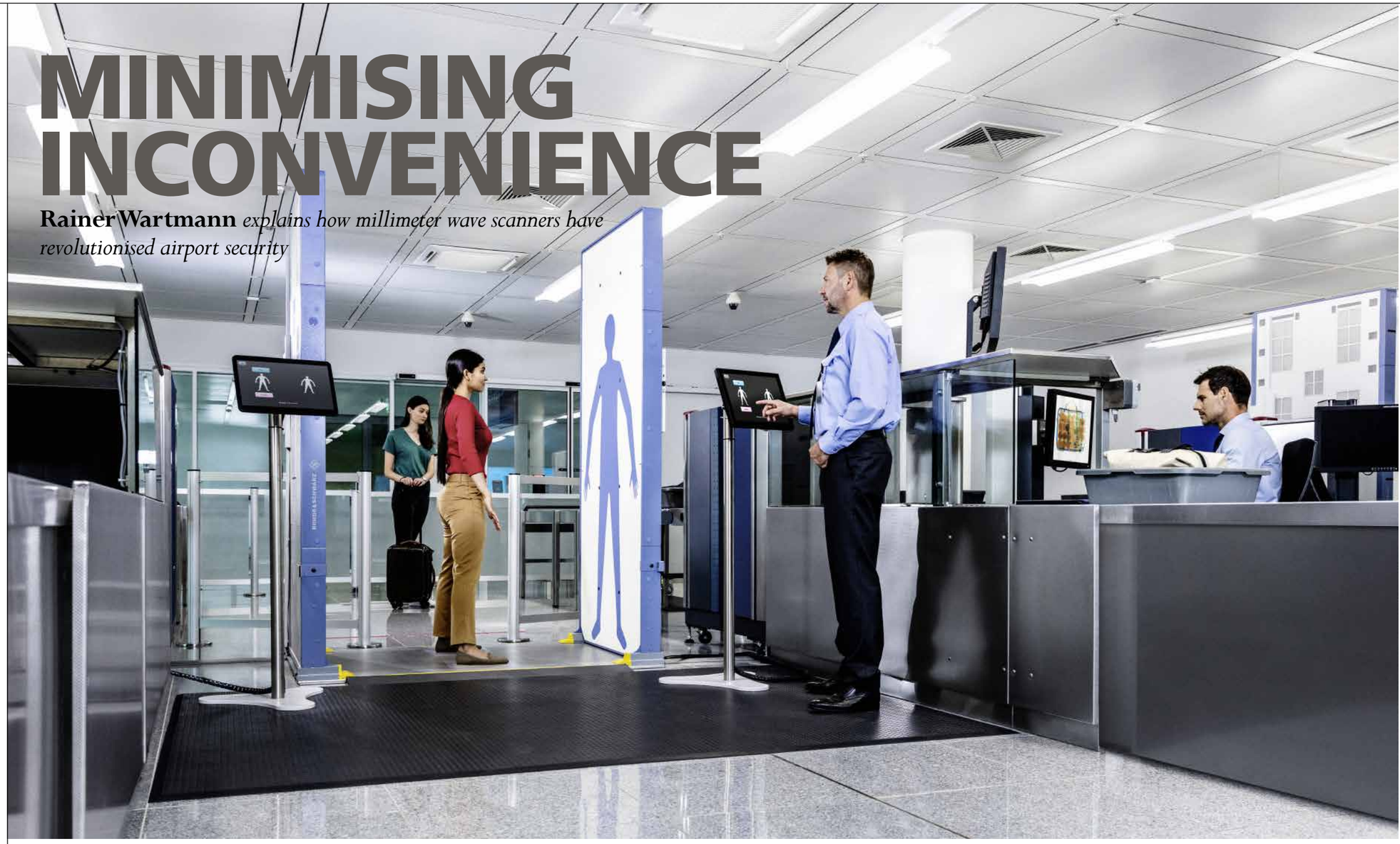
# MINIMISING INCONVENIENCE

**Rainer Wartmann** *explains how millimeter wave scanners have revolutionised airport security*



Picture credit: Rohde & Schwarz

**A new range of security scanners introduced in 2014 helped millimeter wave technology achieve a breakthrough in aviation safety. The benefits, including significantly quicker security screening, have created a more comfortable world – even beyond airports.**

The history of aviation safety, at least in terms of preventing attacks, is linked directly to a series of key events and the responses to those events. In many ways, the 9/11 attacks of 2001 were "zero hour" in terms of security policies. As a result of those attacks, the US created the Transportation Security Administration or TSA for short.

Until the turn of the century, protecting people in buildings, on ships, planes and more recently at large events relied on just two technologies: X-ray scanners and metal detectors. X-ray equipment was used to check baggage, allowing personnel to screen suitcases and bags, identify weapons based on their outline, and detect explosives based on their materials. Large walk-through metal detectors were used to spot anyone carrying traditional metal weapons like pistols and knives.

Other methods, including pat-down screenings carried out by security personnel, can prove difficult for a variety of reasons, including gender, culture and religion - not to mention high personnel costs. Respect for privacy is also an important aspect, and since the COVID-19 pandemic people have become even more reserved when it comes to physical contact. Moreover, pat-down procedures always carry the risk that certain areas, where objects could be hidden, might not be checked. What's more, the level of security provided by pat-down screening largely depends on the motivation and quality of security personnel.

**As recently as 2019, airports had no reliable way to detect whether a person was hiding dangerous, prohibited items underneath their clothing**

Lacking appropriate technical options, security providers had to settle for this status quo and accept the risk that terrorists might threaten people with explosives, ceramic knives and 3D-printed guns. Deterrents, including random searches, provided a certain level of protection. However, on Christmas 2009, the creativity of attackers extended even to underwear when a passenger tried to ignite explosives hidden in his underwear shortly before landing in Detroit, often referred to as the 'Underwear Bomber'.

Some manufacturers tried to address shortcomings in detection with backscatter technology, which uses ionizing X-rays. Although it worked with extremely low radiation power, the technology failed to catch on, primarily down to safety concerns and the fact that detailed images of nude bodies were displayed on a screen for analysis.

As understandable as the concerns are, the situation was just as unsatisfactory for security personnel. As recently as 2019, airports had no reliable way to detect whether a person was hiding dangerous, prohibited items under their clothing while also ensuring the safety of personnel and adequately protecting the privacy of passengers. The solution to the problem appeared to lie in sampling specific frequency ranges to penetrate clothing and generate as accurate and high-resolution images of the body as possible. Clothing is irrelevant, and the system must be able to detect all object-related anomalies on a person. Millimeter waves offer the perfect answer thanks to their unique characteristics. The spectrum between 70GHz and 80GHz yields accurate images even through clothing.

## ARTIFICIAL INTELLIGENCE IS CRUCIAL TO HELPING IMPROVE DETECTION AND REDUCE FALSE POSITIVES

Millimeter waves pose no health problems for humans as they are almost completely reflected by the skin. What's more, the power levels used by millimeter wave security scanners are much lower than even that of standard wi-fi routers, Bluetooth devices and cell phones. Millimeter wave radiation is non-ionizing and has an extremely low power density compared to ionizing radiation, eg X-rays, which can travel through the human body and cause cell damage. Millimeter waves, on the other hand, are safe for everyone, including pregnant women, anyone with medical equipment normally hidden, and operating personnel.

At the end of the 2010s, the first millimeter wave scanners – working in different frequency ranges – gradually began to appear in airports. They used a mechanical system with a heavy arm to scan passengers all around. With approximately 100kg of steel moving around them loudly inside a small booth, many people found the experience unpleasant. On top of that, the scanners required them to stand with their hands up, which is not only a difficult position for many people to assume but also has negative associations (eg it is the position you must assume when being arrested in many cultures) and brings up other ethical concerns.

Another scanner on the market even required passengers to rotate 360° while keeping their hands raised. Even if the metal arm were less intimidating, many customers and passengers disliked the concept as not everyone was able to, or wanted to, turn in the right way at the right speed. The system proved similarly unpopular with users as it required a lot of effort from staff to explain to passengers exactly what they needed to do. This scanner was eventually pulled from the market.

Negative experiences with failed backscatter scanners brought new challenges, as protecting people's privacy became the top priority. Displaying any kind of likeness of a person was banned, which is why modern millimeter wave scanners rely on AI-powered automatic detection and target recognition

(ATR) of objects depicted on a unisex avatar, ie a generic figure on a monitor.

Rohde & Schwarz began developing a security scanner with an open design, steady-state sampling, easy and ethically indiscriminate posture, quick scanning process, low false-positive rate, and high detection rate. The result ushered in a new age of comfort for both passengers and operating personnel.

## MILLIMETER WAVES POSE NO HEALTH PROBLEMS FOR HUMANS AS THEY ARE REFLECTED BY THE SKIN

Artificial intelligence is crucial to evaluating scans, helping both further improve detection and reduce false positives. Before AI-powered automated detection algorithms were used in image-producing systems, the ability to detect anomalies and recognise threats ultimately came down to human eyes. More recent developments in the field of AI and deep learning, however, have led to even more effective and targeted algorithms that offer unprecedented performance with some of the lowest false-positive rates seen.

The AI software uses neural networks, which are complex mathematical models that emulate the human brain. This means that the software can learn, and therefore be trained, how to detect objects. The software is trained in a lab both with and without objects. Tags are used to show where a target is in a given image. This helps the neural network learn what items that have triggered an alarm look like and what the scanner needs to concentrate on. As soon as the neural network has been fully trained, the detection algorithm is frozen, combined with other scanner software, and readied for use in the field.

Although that might sound simple, in reality, it's a significant challenge because security scanners need to be able to detect almost anything. For example, they need to be able to detect metallic and non-metallic weapons. They need to be able to detect every type of explosive – in every shape and size. They also need to be able to detect things that are currently unknown to prepare for any threats and detection challenges the future may bring. Fortunately, it's precisely these capabilities that make AI-powered millimeter wave scanners so versatile and future-proof.

AI-powered millimeter wave scanners are not only ideal for security, but also for preventing theft and protecting property rights. Their incredible performance combined with the fact they can be optimised for different applications using AI makes them perfect for all kinds of applications – from prisons and customs to production facilities, logistics, and large events like the Munich Security Conference.

A security scanner you can walk through without stopping was a visionary idea for exactly these types of VIP security checks with lots of people. But this vision became a reality with the R&S QPS Walk2000 walk-through millimeter wave security scanner.

Unlike its sister model, this security scanner uses ultra-wideband technology (UWB) between 3GHz and 10GHz, which allows it to penetrate multiple layers of clothing. This means there is no need to take off any outer clothing or headwear, setting new standards for both efficiency and comfort when it comes to security screening.

Passengers can look forward to walk-through security screening at airports in the near future. Well-established millimeter wave security scanners are now continuously being improved, with new algorithms boasting extremely low false-positive rates and semi-automated screening solutions driving huge improvements in both efficiency and comfort. Together with CT baggage scanners and intelligent baggage conveyor solutions, these scanners are helping solve the widespread problem of security personnel shortages as well as providing passengers with a quick, comfortable, and safe start to their flight ●

**Rainer Wartmann**, Director Product Management Microwave Imaging, has been at Rohde & Schwarz for 26 years. Having studied electrical engineering at the University of the German Armed Forces in Munich and following National Service for the German Air Force he joined R&S in 1990. He managed a wide variety of projects for secure communication products, until taking on product management for QPS in 2014.

**Modern millimeter wave scanners rely on AI-powered automatic detection and target recognition (ATR) of objects depicted on a unisex avatar**

Picture credit: Rohde & Schwarz