SCIENCE & SECURITY Issue 22

CASRA NEWSLETTER

Autumn is in the air and it is time for our second newsletter in 2019.

In this 22nd issue, the section "Research Put Across" explains what should be considered for effective training of screeners working with single-view, multi-view and 3D imaging for cabin baggage screening. In the "Security in Practice" section, we conducted an interview with Securitas Transport Aviation Services on challenges and solutions in aviation security screening and on the trial they conducted with our new training system X-Ray Tutor version 4 (XRT4).

We are looking forward to receiving any feedback you might have as well as your input on topics you would like us to address in upcoming newsletters. We hope you continue to enjoy reading our articles.

Dr. Diana Hardmeier
Director

Prof. Dr. Adrian Schwaninger
Chairman

RESEARCH PUT ACROSS

SINGLE-VIEW, MULTI-VIEW AND 3D IMAGING FOR BAGGAGE SCREENING: WHAT SHOULD BE CONSIDERED FOR EFFECTIVE TRAINING?

X-ray screening of passenger baggage is conducted at airports worldwide to prevent terrorist attacks and other acts of unlawful interference against civil aviation. The best equipment is of limited value if the humans who operate it are not trained appropriately. But what should be considered for effective training when single-view, multi-view or 3D imaging is used for cabin baggage screening? This article provides recommendations based on scientific studies conducted with screeners over the last 15 years.

SECURITY IN PRACTICE

INTERVIEW WITH SECURITAS TRANSPORT AVIATION SERVICES

Securitas is a global leader in security. In our interview, Marcia Awouters and Kim Marnef from Securitas Transport Aviation Services answer questions on challenges in airport security screening and how Securitas meets these challenges. They tell us about their experience in a trial of our new training system X-Ray Tutor version 4 (XRT4) with 300+ screeners in seven countries, what they expect from a training software and how XRT4 meets these expectations.

SINGLE-VIEW, MULTI-VIEW AND 3D IMAGING FOR BAGGAGE SCREENING: WHAT SHOULD BE CONSIDERED FOR EFFECTIVE TRAINING?

Text: Sarah Merks, Adrian Schwaninger

X-ray screening of passenger baggage is conducted at airports worldwide to prevent terrorist attacks and other acts of unlawful interference against civil aviation. Whether or not prohibited items are detected under X-ray examination depends both on the technology deployed and on human factors. While single-view imaging has been used for decades to screen passenger baggage, newer technology is based on multi-view and 3D imaging with automated explosives detection. However, the best equipment is of limited value if the humans who operate it are not trained appropriately [1]. But what should be considered for effective training when single-view, multi-view or 3D imaging is used for passenger baggage screening? This article provides recommendations for cabin baggage screening training based on scientific studies conducted with screeners over the last 15 years. An extended version of this article including recommendations for training of hold baggage screeners has been published in Aviation Security International in February 2019 [2].

Cabin baggage screening (CBS) refers to screening of bags and other belongings that passengers carry with them when going through airport security checkpoints. The main categories of prohibited articles are guns, knives, improvised explosive devices (IEDs) and other prohibited items such as a taser or an irritant spray device [3, 4]. Conventional CBS technology is based on **single-view imaging**, which displays cabin baggage from a single viewpoint (Figure 1). The task of X-ray screeners is to visually inspect the X-ray images by searching for prohibited articles and deciding whether the bag is harmless or needs further inspection [5] using explosives trace detection technology and physical search of the bag [6].

Newer CBS technology is based on **multi-view imaging**. It shows cabin baggage from two viewpoints, usually a main view and a side view (Figure 2). Furthermore, multi-view imaging technology features explosives detection systems for cabin baggage (EDSCB). EDSCB highlights areas that might contain explosive material by colored frames (Figure 2). The task of screeners is the same as when using single-view imaging, i.e. searching for prohibited items and deciding whether the bag is harmless or not [5]. However, there are different procedures on how to handle

Abbreviations:

CBS:	Cabin baggage screening
CBT:	Computer-based training
CT:	Computer tomography
EDS:	Explosive detection system (for hold baggage screening)
EDSCB:	Explosive detection system for cabin baggage screening
HBS:	Hold baggage screening
IED:	Improvised explosive device (bomb)
VR:	Virtual reality

EDSCB alarms: In some countries, screeners conduct on-screen alarm resolution, i.e. they decide whether the areas which are highlighted by the EDSCB are harmless or whether they might contain explosive material or an IED and hence need to be sent to secondary search. In other countries, bags with EDSCB alarms are automatically sent to secondary search [8].

The newest CBS technology features **3D imaging** that is based on computer tomography (CT). Such systems have better explosives detection (EDSCB) than multi-view imaging systems. Further, with 3D imaging, cabin baggage is displayed as 3D rotatable images (Figure 3a). Most systems also provide cross-sectional images (also called slice or slab images, see Figure 3b for an example). Material that could be explosive

Figure 1: Conventional single-view X-ray image of a cabin bag (from [6]).

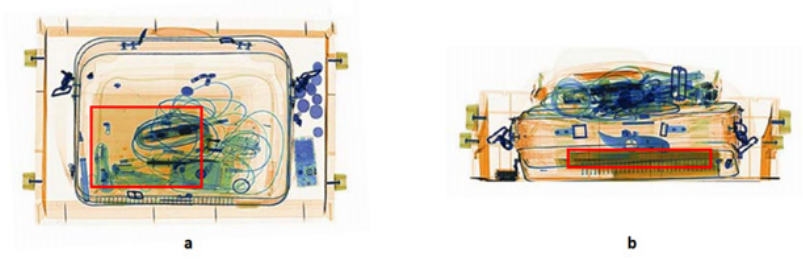


Figure 2: The bag of Figure 1 scanned with a multi-view imaging system with automated explosives detection (EDSCB). a) Main view b) Side view. Red frames indicate areas in the bag that might contain explosive material.

is highlighted by color (red areas in Figure 3a and Figure 3b). The task of X-ray screeners is the same as when using multi-view imaging.

GENERAL TRAINING RECOMMENDATIONS FOR CBS

In CBS, screeners have to detect a large variety of prohibited articles that could pose a threat during a flight. Recognizing prohibited articles in X-ray images can be difficult for several reasons: 1) screeners may not be familiar with certain objects, 2) many objects look very different in X-ray images, 3) some prohibited items resemble everyday objects, and 4) prohibited items can be difficult to recognize when depicted from unusual viewpoints [1]. Figure 4 illustrates these challenges.

Screeners must therefore not only learn which articles are prohibited, but also what they look like in X-ray images in different rotations and how they can be distinguished from harmless objects [1, 9]. To achieve and maintain good detection performance of screeners in CBS, computer-based training (CBT) has been shown to be very effective and efficient [5, 10, 11]. A study conducted with 5'717 screeners from over 70 airports showed that CBT results in large increases of detection performance following a logarithmic function [11]. After 50 hours of training, CBT is still relevant, but mainly for maintaining detection performance. However, not all CBT systems are effective. For instance, Koller et al. [10] showed that an individually adaptive CBT that uses a large image library with target items in different rotations was very effective whereas a CBT that was not individually adaptive with a smaller training library was not effective. Moreover, as terrorist threats evolve constantly, it is important to keep screeners up to date regarding new and emerging threats. Therefore, CBT libraries should be updated regularly based on systematic threat assessment [12].

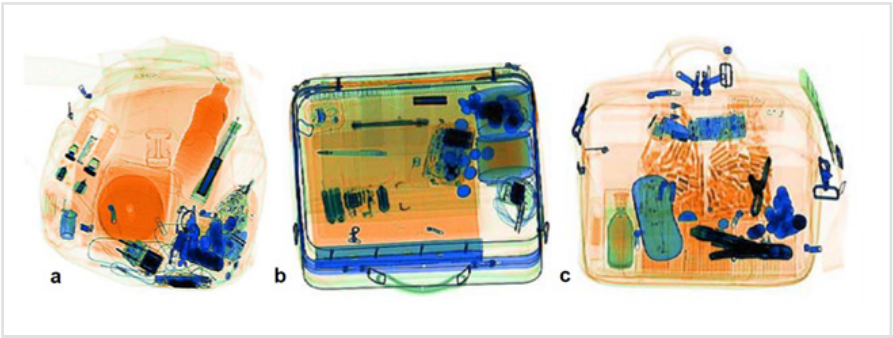


Figure 4: a) In addition to a bottle, which is easy to recognize, this bag also contains a self-defence gas spray and torch light with a shooting mechanism. b) This bag contains a prohibited item (taser) that looks very different in the X-ray image than in reality and a prohibited item that looks similar to a harmless object (a switchblade knife that looks like a pen). c) The gun and scissors in this X-ray image are difficult to recognize because they are depicted from unusual viewpoints. Images are from [1].

Figure 3: A bag scanned with a 3D imaging system for CBS. a) 3D rotatable image b) Cross-sectional image. Red color indicates areas in the bag that might contain explosives. Images are from a 3D training simulator for CBS (X-Ray Tutor Version 4 [XRT4]) provided by CASRA.

SPECIFIC TRAINING RECOMMENDATIONS FOR MULTI-VIEW CBS

As explained above, multi-view imaging for CBS displays cabin baggage from two different viewpoints (Figure 2). This can help screeners to detect prohibited items when depicted from unusual viewpoints or when superimposed by other items [7]. This is illustrated in Figure 2, where the knife is difficult to recognize in the main view (Figure 2a), but much easier to recognize in the side view (Figure 2b). Additionally, multi-view CBS features EDSCB. A recently published study has shown that EDSCB is useful for increasing the detection of explosives and IEDs, in particular for screeners with limited experience [8]. However, screeners also showed a tendency to ignore many EDSCB alarms and had sometimes difficulties in distinguishing bare explosives from harmless organic mass (see Figure 5).

In order to benefit from multi-view imaging for CBS, the following specific training recommendations can be made in addition to the general training recommendations. Screeners should learn how the side view of a bag relates to the main view and also be encouraged to use the side view, in particular if ob-

jects are depicted from difficult viewpoints and/or superimposed by other objects in the main view. If on-screen alarm resolution is used, screeners should receive training to increase their awareness that some explosives can be difficult to distinguish from harmless organic mass [8]. Secondary search using explosive trace detection and manual bag search is recommended using a risk-based approach when an EDSCB alarm cannot be resolved [6]. Finally, yet importantly, introducing new technology is an organisational change that can result in screeners reacting with concerns and resistance. Therefore, a phased approach allowing enough time for screeners to adapt to the new technology using a multi-view training simulator is recommended.

SPECIFIC TRAINING RECOMMENDATIONS FOR 3D CBS

As explained above, 3D CBS technology allows 3D rotation of a bag (see Figure 3a) and most systems also provide cross-sectional images (see Figure 3b). These features may be even more effective than multi-view imaging at helping screeners to detect prohibited items when depicted from unusual viewpoints or when superimposed by other items. The main training challenge of introducing 3D imaging for CBS is that screeners need to learn how to effectively and efficiently use image display functions (3D rotation, cross-sectional images, etc.). It has not yet been investigated whether it is difficult for screeners to distinguish explosives from harmless organic masses using 3D CBS, as has been shown for 2D imaging for CBS [8]. However, based on observations at airports that have introduced 3D imaging, it seems that this challenge exists for 3D CBS as well.

In order to meet these challenges, the following specific training recommendations can be made for 3D imaging in addition to the general CBS training recommendations. Screeners should learn how to use 3D rotation and other image display functions effectively and efficiently. If cross-sectional images are available, screeners should learn how they relate to the 3D rotatable view. Screeners should be encouraged to use 3D rotation, in particular if objects are depicted from difficult viewpoints and/or superimposed by other objects. Again, if on-screen alarm resolution is used, screeners should receive training to increase their awareness that certain explosives are difficult to distinguish from harmless organic masses and therefore use a risk-based approach when an EDSCB alarm cannot be resolved [6].

As mentioned already for multi-view imaging, introducing new technology is a big organisational change. This is particularly important when introducing 3D imaging for CBS as screeners have to learn new skills for operating the equipment (3D rotation of bags and using cross-sectional images if available). A phased approach allowing enough time for screeners to adapt to the new technology and learn the new skills needed for operating the equipment effectively and efficiently using a 3D simulator is highly recommended. This should consider differences between screeners' abilities to operate computers and include enough supportive supervision.

PLANNED STUDIES FOR 3D CBS

In January 2019, CASRA started with a four year project that will focus on the introduction and training of 3D CBS. On one hand, the project will investigate research questions in regard of the optimal implementation of new EDSCB standards. One work package will focus on requirements for the selection and training of 3D screeners. Furthermore, different concepts of operation for EDSCB C3 standard are evaluated. And, the relevance and optimal use of 3D CT functionalities, like rotation and slicing, are examined. On the other hand, the project will evaluate the potential of virtual reality (VR) technologies for interactive learning, training and competence measurement in the context of the transition from 2D X-ray to 3D CT machines for security checkpoints. This will include VR learning modules for the introduction of screeners to new

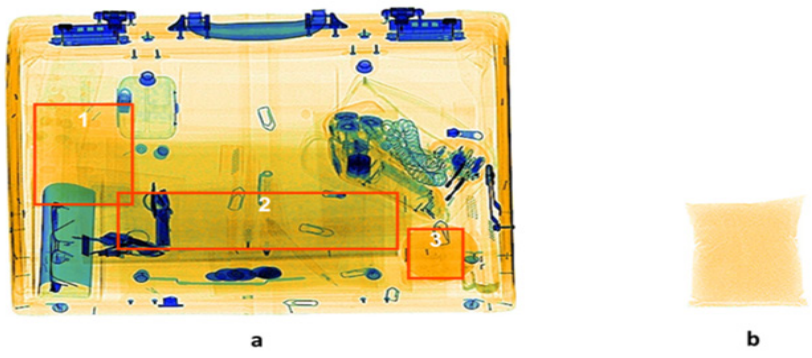


Figure 5: Explosive material can be difficult to distinguish from harmless organic mass. a) X-ray image of a cabin bag with three areas on which the EDSCB has raised alarms (one true detection in area 1 and two false alarms in areas 2 and 3). b) Explosive contained in the bag in area 1.

Figure 6: Illustration of the X-Ray Tutor version 4 (XRT4) 3D CT training simulator for HBS.

3D CT technologies and equipment; a VR object learning environment for 3D object recognition; and a VR simulated environment for checkpoint and remote screening for training and competence measurements of screeners. For the successful realisation of these studies, we are still looking for project partners, ideally airports or security service providers, who already have experience with 3D CT CBS. If you are interested in any of the above mentioned subjects, please do not hesitate to contact CASRA.

REFERENCES

[1] Schwaninger, A. (2005). Increasing efficiency in airport security screening. *WIT Transactions on the Built Environment, 82*, 407–416. [PDF]

[2] Schwaninger, A., & Merks, S. (2019). Single-View, Multi-View and 3D Imaging for Baggage Screening: what should be considered for effective training? *Aviation Security International, February/March*, 32-35. [PDF]

[3] Schwaninger, A., Hardmeier, D., & Hofer, F. (2005). Aviation security screeners visual abilities & visual knowledge measurement. *IEEE Aerospace and Electronic Systems, 20*(6), 29-35. [PDF]

[4] Koller, S., & Schwaninger, A. (2006). Assessing X-ray image interpretation competency of airport security screeners. *Proceedings of the 2nd International Conference on Research in Air Transportation, ICRAT 2006, Belgrade, Serbia and Montenegro, June 24-28, 2006*, 399-402. [PDF]

[5] Koller, S., Drury, C., & Schwaninger, A. (2009). Change of search time and non-search time in X-ray baggage screening due to training. *Ergonomics, 52*(6), 644–656. [PDF]

[6] Sterchi, Y., & Schwaninger, A. (2015). A first simulation on optimizing EDS for cabin baggage screening regarding throughput. *Proceedings of the 49th IEEE International Carnahan Confer-ence on Security Technology, Taipei, Taiwan, September 21-24, 2015*, 55-60. [PDF]

[7] von Bastian, C. C., Schwaninger, A., & Michel, S. (2008). Do multi-view X-ray systems improve X-ray image interpretation in airport security screening? *Zeitschrift für Arbeitswissenschaft, 3*, 166–173. [PDF]

[8] Hättenschwiler, N., Sterchi, S., Mendes, M., Schwaninger, A. (2018). Automation in airport security X-ray screening of cabin baggage: Examining benefits and possible implementations of automated explosives detection. *Applied Ergonomics, 72*, 58-68. [PDF]

[9] Schwaninger, A. (2004). Computer based training: the enhancement of human factors. A*viation Security International, 2004*(2), 31-36. [PDF]

[10] Koller, S., Hardmeier, D., Michel, S., & Schwaninger, A. (2008). Investigating training, transfer and viewpoint effects resulting from recurrent CBT of x-ray image interpretation. *Journal of Transportation Security, 1*(2), 81–106. [PDF]

[11] Halbherr, T., Schwaninger, A., Budgell, G. R., & Wales, A. W. J. (2013). Airport security screener competency: A cross-sectional and longitudinal analysis. *International Journal of Aviation Psychology, 23*(2), 113–129. [PDF]

[12] Schmid, F. (2015). Systematic Threat Assessment: how to adapt security measures based on the research on latest threats. *International Airport Review, 19*(4), 60-63. [PDF]

INTERVIEW WITH SECURITAS TRANSPORT AVIATION SERVICES

Securitas is a global leader in security. In our interview, Marcia Awouters and Kim Marnef from Securitas Transport Aviation Services answer questions on challenges in airport security screening and how Securitas meets these challenges. They tell us about their experience in a trial of our new training system X-Ray Tutor version 4 (XRT4) with 300+ screeners in seven countries, what they expect from a training software and how XRT4 meets these expectations.

What challenges are the screeners of Securitas Transport Aviation Services currently facing?

In recent years, new technologies, such as centralized image processing (CIP) and 3D computed tomography (CT), have begun emerging and are now increasingly being implemented in the aviation security industry. Although these new technologies bring advantages, they also bring along challenges for the screeners operating them.

Since good performance highly depends on the screeners and their interaction with the equipment, it is important to be able to familiarize and train our staff to operate these technologies in the best possible way. Therefore, it is crucial that screeners are confident in using the equipment and in making their image interpretation decisions while being away from the screening checkpoint.

Furthermore, not only technology is changing; as terrorist threats continue to rise, threat items are also evolving and inventive ways to conceal those items are being found. Screeners need to recognize threats in endless shapes and forms and therefore need to be trained on detecting deep concealments, using large libraries of possible threats, to make sure we stay one step ahead.

INFOBOX: SECURITAS

Securitas is a global knowledge leader in security.

From a broad range of specialized services, technology solutions and consulting, **Securitas Aviation** customizes offerings that are suited to the individual customer's needs, in order to deliver the most effective security solutions.

Everywhere from small to large airports, our 28'000 aviation specialists are making a difference.

What projects has Securitas Transport Aviation Services carried out to meet emerging challenges, such as new technologies and screening concepts?

Securitas Aviation strongly believes in the efficiencies these types of technologies can bring and we have therefore greatly invested in preparing our staff to work with these concepts early on.

In 2017, we invested in a 6-month trial, implementing CIP and an automated lane (ATRS – Automated Tray Return Systems) at Zagreb Airport, in order to familiarize our staff with the equipment and show the benefits the technology can offer. The successful completion of this trial has led to Securitas Aviation installing, maintaining and operating a full security checkpoint solution at Zagreb Airport. The solution consists of three automated lanes, including CIP and a comprehensive security management system, allowing for faster passenger processing, enhanced customer service and improved working conditions for our screeners.

Over the past years, we have been involved in various trials at airports around the world, from implementing automated lanes to the use of 3D CT for cabin and parcel (cargo) screening.

What motivated Securitas Transport Aviation Services to cooperate in the RCBS research project with CASRA?

As Securitas Aviation installed and implemented CIP at Zagreb Airport, we had an interest in investigating further possibilities and new ways of working with the technology. With

screeners stationed away from the screening checkpoint, in a separate CIP room, it might be less efficient having screeners rotate every 20 minutes. This raises the question of how long screeners should work consecutively and how frequently they should rotate to achieve optimal performance.

However, very little scientific research has been done about how CIP affects the human factor. So, when we learned CASRA was conducting a research project on remote cabin baggage screening (RCBS), it was of course of great benefit to us to be able to cooperate in this project. Together with CASRA, we are now investigating various CIP human factor aspects, amongst which, a possible change in rotation schedules with longer screening session durations. We are proud to participate in the RCBS research project, as we believe it will provide important insights on how CIP affects the human factor and screener performance, thereby allowing for scientifically based decisions to optimally implement it.

In order to meet the new challenges of initial and recurrent training, Securitas Transport Aviation Services has tested the new software solution, XRT4, with 300+ screeners in seven countries. What were the central topics in the run-up to this trial?

We are always searching for cutting edge technologies; therefore, it is also important that the training of our screeners remains cutting edge as well.

Securitas Aviation has a holistic approach towards its security services as a whole, meaning we will not only propose security officers of the highest standards, but also the very best technologies in the field of aviation security. This implies that it is very important for us to train and develop the competencies of our screeners to be able to optimally work with these technologies. CASRA allowing us to test the new XRT4 version, has enabled us to see the potential of the system as a comprehensive solution for the selection, training and assessment of screeners working with single view, dual view or 3D CT X-ray equipment.

What key functionalities do you expect from a training software and how does XRT4 fulfill these needs?

An important aspect of training screeners is to familiarize them with as much threat articles as possible. Therefore, a training software should include an extensive library of possible threats, which is updated on a continuous basis in line with emerging new threats.

The ability to train our screeners as close to reality as possible, e.g. having the same interface as the X-ray equipment on which they will be performing their task, is also a real added value. Whether it be for the screening of CBS, HBS, Supplies, Cargo, etc. with the use of single view, dual view or 3D CT equipment, the training software should be flexible enough to be able to provide training on these simulator types.

Furthermore, having an excellent reporting system in the training software will allow us to analyze our screeners' data, closely monitor their performance and remain fully compliant with regulations.

XRT4 does a great job at fulfilling all of these key functionalities we would expect from a training software.

What claims does Securitas Transport Aviation Services have for future versions of the training software?

As XRT4 is a very comprehensive system, which includes extensive functionalities that respond perfectly to our needs, there are currently not many extra features we would envision for future versions. If we would have to state one, it could be nice to be able to use XRT4 on tablet or mobile applications. Since the software is using the latest web technology HTML5, we are confident that is an option CASRA will be looking into.

In the view of Securitas Transport Aviation Services', what are the outstanding features of XRT4?

Some of the XRT4 features we consider to be excellent include the following, amongst others:

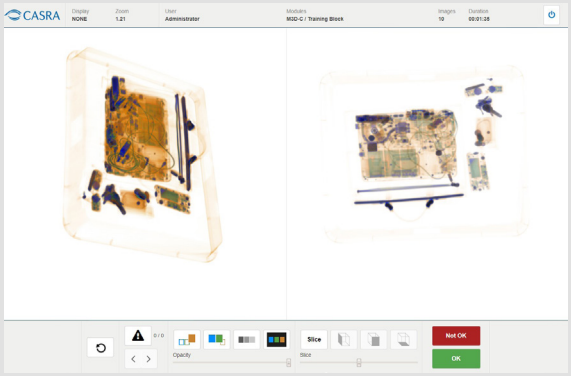
- XRT4 runs on most platforms and browsers without the need to install any additional plug-ins, making it a very user-friendly system.
- It covers dual-view and even 3D CT training, which better reflects the situation and equipment screeners are nowadays confronted with on the field.
- The system dashboard allowing screeners to track their own progress and statistics is a real added value and is keeping screeners motivated.
- The scientifically based, individually adaptive training algorithms present screeners with images tailored to their individual needs, taking into account their performance history.
- XRT4 offers a generic user interface as well as various manufacturer specific user interfaces, making the system realistic for screeners.
- The XRT4 training modules are highly customizable to meet specific needs and if required own image content can also be uploaded.
- The data warehouse with its extensive reporting system makes it easy to follow-up on screener performance and compliance with training regulations.

How does Securitas Transport Aviation Services assess the cooperation with CASRA?

We welcome CASRA and its team of highly professional experts as a partner and not just a provider. We feel that Securitas Aviation and CASRA share similar values and objectives, which helps in ensuring our screeners have the adequate tools to perform their tasks and thus maintain their high level of performance.

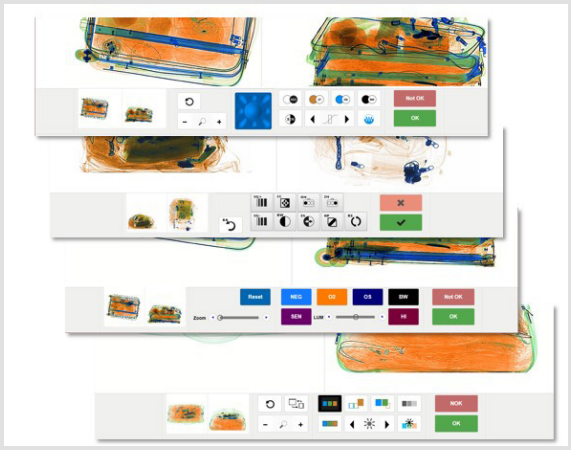
INFOBOX: XRT 4

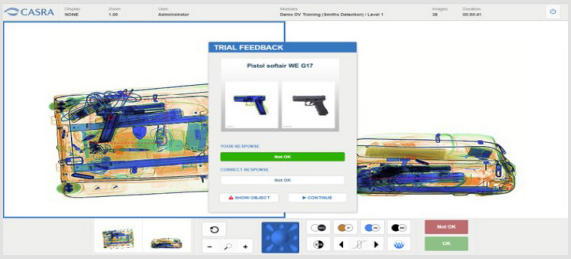
In the past few years, we have been working on our new **all-encompassing training and testing solution X-Ray Tutor 4 (XRT4)**. XRT4 is the designated successor of our current CASRA solution and will not only allow you to select, train and test X-ray security officers with single-view images, but will also support **dual-view and 3D computer tomography technology** – all in one solution!



We developed XRT4 on the latest technology and it runs without any plugin on various internet browsers. XRT4 is highly flexible and configurable and supports different user interfaces. Customers can also upload their own images and create customized training and testing courses.

Currently, XRT4 is in the beta-testing phase with chosen customers who are evaluating the solution from an administrator and user perspective. We are looking forward to first installations by the end of 2019.





Science & Security – CASRA Newsletter
ISSN 1664-5715

CASRA
Thurgauerstrasse 39
8050 Zurich, Switzerland

Phone +41 (0)43 336 01 01
Fax +41 (0)43 336 01 00
E-mail info@casra.ch
Web www.casra.ch