SCIENCE & SECURITY Issue 34
CASRA NEWSLETTER

Since 2012, we have been publishing newsletters in which we present results from our research, address trends, and provide information for security practitioners.

The first article of this issue describes the results of our study about explosives detection systems for cabin baggage (EDSCB). These systems flag potential threats in X-ray images but also generate false alarms and miscues. Our study with 112 screeners found that miscues reduced knife detection, highlighting the need for clear instructions to inspect the entire image whenever an EDSCB alarm occurs.

The second article covers an interview with two border security management clients who share how they are strengthening human–machine performance in X-ray screening.

We hope you enjoy reading these new articles and as always, 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.

With best wishes,

Dr. Diana Hardmeier
Director

Prof. Dr. Adrian Schwaninger
Chairman

TOPICS IN THIS ISSUE:

RESEARCH PUT ACROSS

EFFECTS OF FALSE ALARMS AND MISCUES OF EXPLOSIVE DETECTION SYSTEMS FOR CABIN BAGGAGE

Explosives detection systems for cabin baggage (EDSCB) highlight potential explosive areas in X-ray images during security screening but can trigger false alarms or miscues. In our study (Huegli et al., 2025), 112 trained screeners were tested under false alarm–prone, miscue–prone, and multiple failure conditions using realistic X-ray images. Miscues reduced knife detection when a false alarm occurred and a knife was elsewhere in the image. We recommend that screeners be instructed to inspect the entire X-ray image after an EDSCB alarm to ensure no prohibited items are missed.

SECURITY IN PRACTICE

INTERVIEW WITH BORDER SECURITY MANAGEMENT CLIENTS

Border security management involves protecting national borders by regulating the movement of people and goods while preventing illicit activities. Agencies increasingly rely on non-intrusive inspection systems like X-ray technology, but their effectiveness ultimately depends on skilled human operators. This interview shares how human–machine performance in X-ray screening are strengthened, with insights from: Cathy Hodge from DAFF (Australia) and Sandra Hormazabal Hernández from the Chilean Customs.

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EFFECTS OF FALSE ALARMS AND MISCUES OF EXPLOSIVE DETECTION SYSTEMS FOR CABIN BAGGAGE
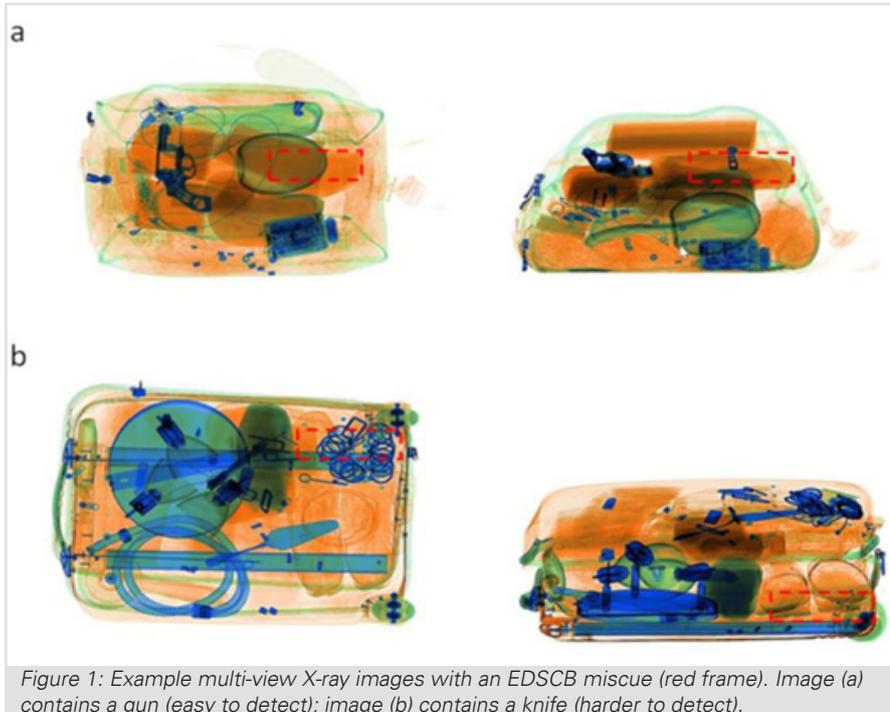
Text: David Hügli and Adrian Schwaninger

Figure 1: Example multi-view X-ray images with an EDSCB miscue (red frame). Image (a) contains a gun (easy to detect); image (b) contains a knife (harder to detect).

Explosives detection systems for cabin baggage (EDSCB) indicate areas that could contain explosives in X-ray images during airport security screening. However, these systems can produce false alarms (no threat present) and miscues (a prohibited article is elsewhere in the X-ray image). In our study [2], we tested 112 trained screeners under three conditions—false alarm-prone, miscue-prone, and multiple failures—using realistic X-ray images of IEDs, guns, and knives. Results showed that miscues reduced detection of knives when there was a false alarm of the EDSCB and there was a knife elsewhere in the X-ray image. We recommend that screeners should get clear instructions to visually inspect the whole X-ray image when there is an EDSCB alarm to ensure there is no prohibited article elsewhere in the baggage.

INTRODUCTION

Automated decision support systems such as EDSCB are increasingly being used at airports worldwide. By providing direct visual cues on X-ray images, these systems indicate areas in X-ray images that could contain explosives or improvised explosive devices (IEDs). Previous research has shown the benefits of such systems and identified important aspects of ergonomics, human factors and human-machine interaction [1]. EDSCB are not perfect, they also make false alarms, that is, they sometimes mark an area in an X-ray image by mistake. False alarms are miscues when there is a prohibited article such as a gun or a knife elsewhere in the X-ray image (see Figure 1). In this study, we investigated the impact of EDSCB on detecting its primary target (explosives, IEDs) and the effect of false alarms and miscues on detecting other targets (guns and knives).

METHOD

A total of 112 trained airport security screeners participated during their normal shifts. They were randomly assigned to one of three conditions:

› False alarm-prone: EDSCB alarms occurred on target-absent images (no other prohibited article in the X-ray image).
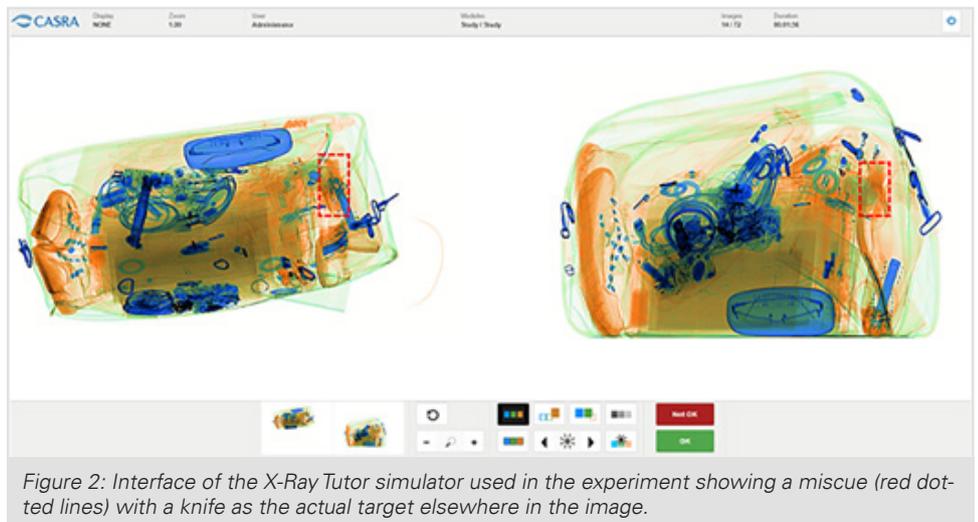

Figure 2: Interface of the X-Ray Tutor simulator used in the experiment showing a miscue (red dotted lines) with a knife as the actual target elsewhere in the image.
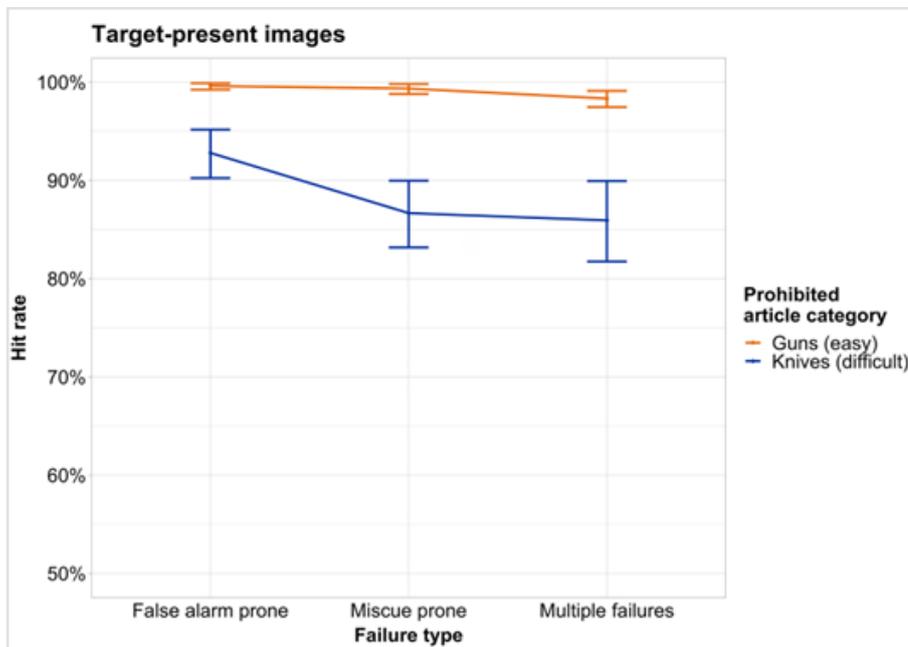
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Target-present images

Figure 3: Mean human–machine system hit rate by failure type condition and prohibited article category (guns vs. knives). Error bars show 95% confidence intervals.

› Miscue-prone: EDSCB alarms were false alarms and there was a gun or a knife elsewhere in the X-ray image.

› Multiple failures: both types of errors appeared equally often.

All screeners worked with highly realistic, color multi-view X-ray images that reflected operational conditions (Figure 2). Threat items included IEDs (12% of trials), guns (6%), and knives (6%). The EDSCB was configured with a 75% hit rate (percent detection) and 7% false alarm rate.

Screeners had 15 seconds per bag to decide whether it contained a prohibited article. They marked suspected items and rated confidence after each trial. Detection performance (hit and false alarm rates), response times, and trust in automation were measured.

RESULTS
Detection of guns and knives
Detection of guns and knives depended strongly on EDSCB's failure type.

Knives were significantly more likely to be missed in the miscue and multiple-failures conditions compared to the false alarm-prone condition. Guns were less affected, likely due to their larger size and more consistent shapes (Figure 3).

Interestingly, response times did not differ significantly across conditions whereas guns were detected faster than knives (Figure 4).

Detection of explosives (IEDs)
IED detection remained consistently high across all conditions, with hit rates above 90% and no significant differences in response time. This shows screeners maintained high performance for the system's primary target despite miscues elsewhere.

Target-absent trials
False alarm rates on target-absent images and response times did not differ significantly between conditions, indicating that screeners kept the combined human–machine false alarm rate within acceptable levels even when EDSCB produced more errors (Figure 5).

Operator Trust and Compliance
Screeners' subjective trust ratings of EDSCB did not differ significantly between conditions and were in the

Target-present images

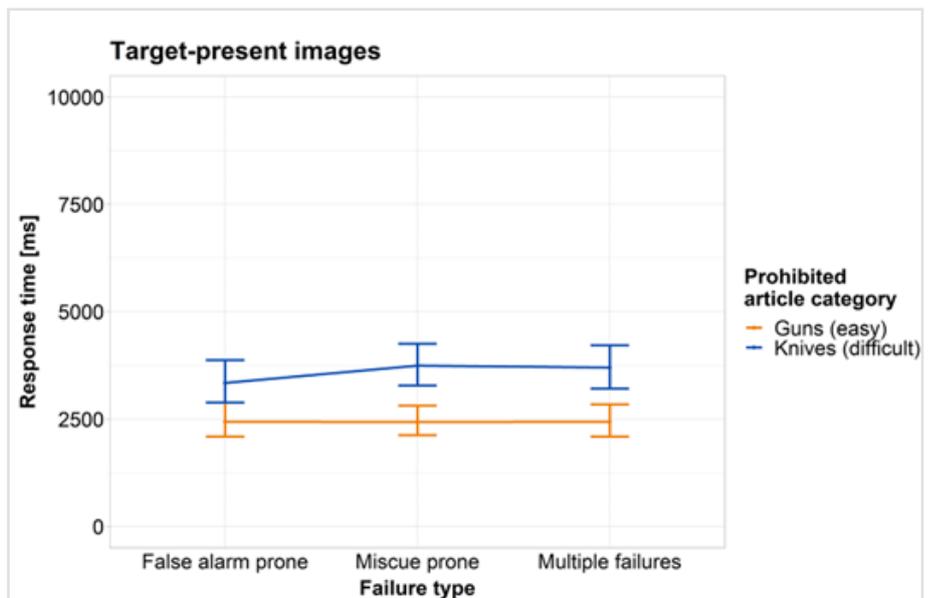*Figure 4: Target-present response times by EDSCB failure type condition and prohibited article category. Error bars show 95% confidence intervals.*

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medium range (≈3 on a 7-point scale). However, behavioral compliance— responding to EDSCB alarms —did vary. Compliance with incorrect alarms was much lower in the miscue-prone condition than in the false alarm-prone condition (Figure 7). This indicates that screeners recognized miscues and adjusted their behavior rather than becoming complacent.

CONCLUSION

This study confirmed previous research showing that EDSCB is beneficial, but we found that false alarms and miscues of these systems can distract attention. Screeners should get clear instructions to visually inspect the whole X-ray image when there is an EDSCB alarm to ensure that they do not miss a prohibited article elsewhere in the X-ray image. The effects we found depend on the false alarm rates of the EDSCB. Implementing 3D CT EDSCB is recommended because such systems have lower false alarm rates than multi-view EDSCB [1].
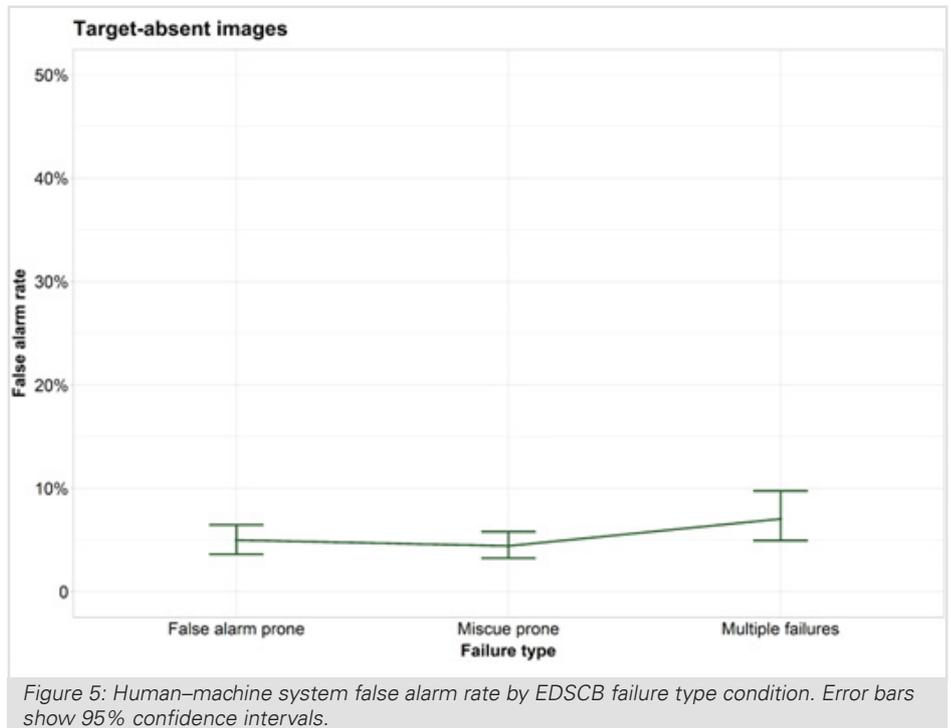

Figure 5: Human–machine system false alarm rate by EDSCB failure type condition. Error bars show 95% confidence intervals.
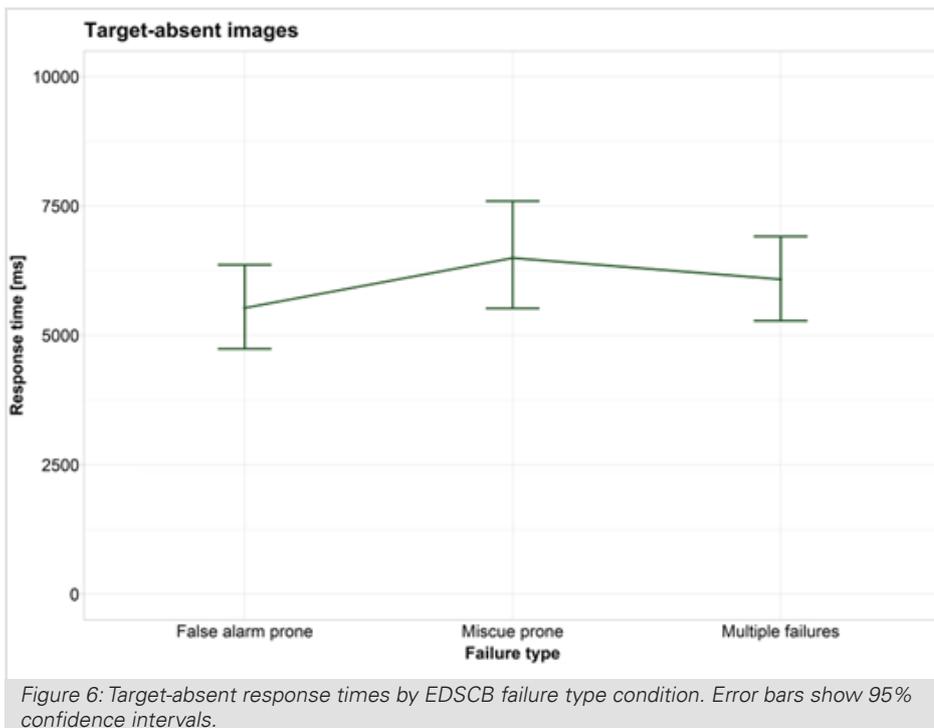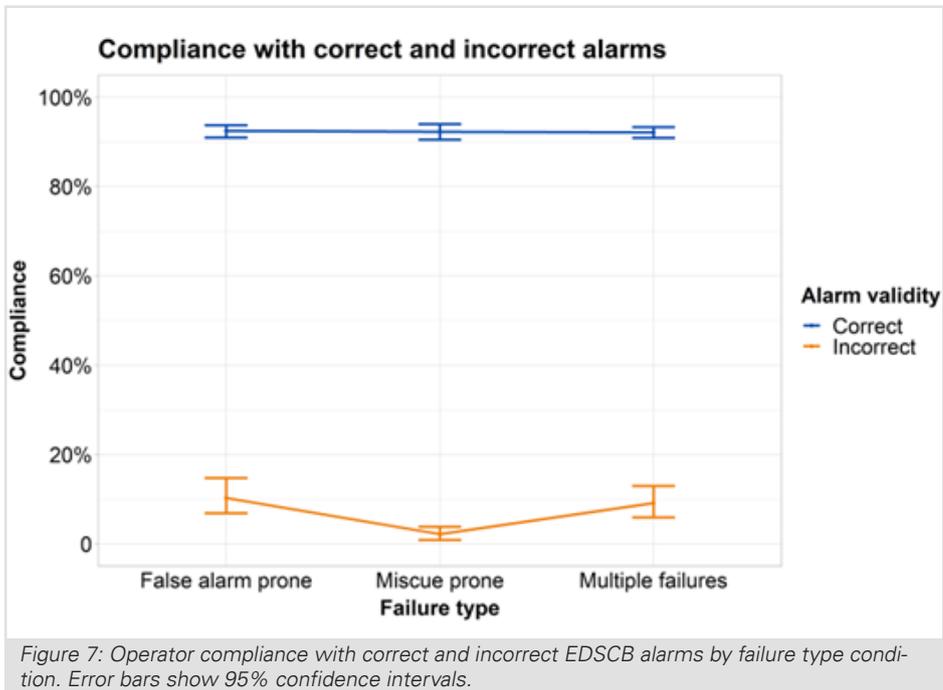

Figure 6: Target-absent response times by EDSCB failure type condition. Error bars show 95% confidence intervals.

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Figure 7: Operator compliance with correct and incorrect EDSCB alarms by failure type condition. Error bars show 95% confidence intervals.

REFERENCES

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[2] Huegli, D., Chavaillaz, A., Sauer, J., & Schwaninger, A. (2025). Effects of false alarms and miscues of decision support systems on human–machine system performance: A study with airport security screeners. *Ergonomics*. doi.org/10.1080/00140139.2025.2453546 [PDF]

[3] Huegli, D., Merks, S., & Schwaninger, A. (2020). Automation reliability, human-machine system performance, and operator compliance: A study with airport security screeners supported by automated explosives detection systems for cabin baggage screening. *Applied Ergonomics, 86*, 1-12. doi:10.1016/j.apergo.2020.103094 [PDF]

INTERVIEW WITH BORDER SECURITY MANAGEMENT CLIENTS

Text: Sara Bracceschi

Border security management is the comprehensive set of strategies, processes and measures governments use to protect national borders, controlling the movement of people and goods while deterring illicit activities and upholding national security and economic interests. It involves managing legitimate trade and travel alongside preventing illegal entries, smuggling, human trafficking, and the entry of terrorists, weapons, and illicit substances. Border control measures serve a variety of purposes, ranging from enforcing customs, sanitary and phytosanitary, biosecurity regulations to restricting migration. Their success relies on cooperation, technology, risk analysis, and the effective management of border control points like airports, ports, and land crossings.

Border security management is carried out mostly by customs organizations, agriculture departments, border security agencies, ports authorities, and immigrations agencies. For some of those, the list of illicit goods to be detected is growing and changing. Non-intrusive-inspection systems, like X-ray equipment significantly supports those organizations in the detection of weapons, drugs, explosives, biosecurity threats and other contraband while expediting trade. Nevertheless, the machine is only as good as the human behind it. This requires focus and investment on the human factor.

In this newsletter's article, you will hear directly from some of CASRA's customers how they have addressed the challenge of enhancing the human-machine systems' performance in X-ray screening. We are honored to feature the fol-lowing organizations in this article, which is a compendium of interviews carried out with :

› Cathy Hodge, Assistant Director – Detection Technology Section with the Australian Department of Agriculture, Fisheries and Forestry (DAFF)

› Sandra Hormazabal Hernández, National Training Department, Deputy Directorate of People Management and Development, Chilean Customs

Before presenting the responses to a number of questions posed by CASRA, the interviewees provided, a brief summary of their organizations.

The Australian Department of Agriculture, Fisheries and Forestry's objective is to work towards a more sustainable and prosperous Australia through biosecurity, production and trade. The department strives to achieve this through partnerships and regulations to protect and grow the country's agricultural, fisheries, forestry, food and fibre industries. Due to its unique flora and fauna and geographic isolation, Australia has much stricter biosecurity controls for incoming goods compared to most other countries.

The mission of the Chilean Customs is to oversee foreign trade at borders and within the national territory to contribute to tax collection, promoting lawful, efficient, safe and transparent trade for citizens. In the accomplishment of such mission, X-ray systems strengthen the auditing strategy, based on risk management and the use of intelligence, by effectively applying technologies and support tools.

Let's hear directly from the interviewees.

WHAT IS YOUR ORGANIZATION'S APPROACH TO TRAINING PERSONNEL ASSIGNED TO THE ANALYSIS AND INTERPRETATION OF X-RAY IMAGES?

Similarly to what stated by the Chilean Customs, Cathy Hodge from DAFF commented to CASRA that X-ray technology is a critical part of Australia's preventative biosecurity system. X-ray screening of passenger baggage and international mail is a major safeguard to identify potential biosecurity risk material in large volumes at Australia's border. This includes screening for plant and animal material that could carry pest borne diseases and harm Australia's industries.

"Currently our screening officers undergo a combination of online learning and on-the-job training" – said Cathy. "This consists of X-ray safety training and a short image recognition package through CASRA's XRT as part of initial training upon employment. In terms of ongoing training, this varies across locations".

Cathy continues: "Our new approach is to achieve national consistency in X-ray training and verification. This would mean regular training in image recognition and an annual test to verify competency, all completed through XRT. We are doing this by partnering with CASRA, which is expanding a biosecurity image library and building bespoke modules for us".

To ensure new training and testing requirements are suitable to the needs of DAFF's screening officers, the department launched a training pilot in September 2025. Officers are validating the images and have the opportunity to provide

feedback on every image over a three-month period.

In a similar vein, Sandra from Chilean Customs said that "It is fundamental for the Customs of Chile to empower image analysis operators based on their performance with the various equipment available to the Customs administration and to create experts in image analysis and interpretation of the images generated with non-intrusive inspection systems".

sentation" – commented Cathy.

"While we don't work under an international regulatory framework like security screeners, many lessons from security screening can be translated to biosecurity screening. Maintenance of competency through new, regular training is just as important. This will help officers identify risk material efficiently and prevent entry into the country, thereby protecting animals, plants, farms, and the environment from pests, diseases, and weeds. Bios-

cess for non-invasive technology operators, demonstrating noticeable progress. For that reason, the platform access was renewed for multiple years in 2025.

HOW HAS YOUR TRAINING PROGRAM BEEN RECEIVED BY THE OFFICERS ASSIGNED TO X-RAY IMAGE ANALYSIS?

DAFF's Biosecurity Officers assigned to the pilot group have generally welcomed being involved in validating the images that will be incorporated into future train-
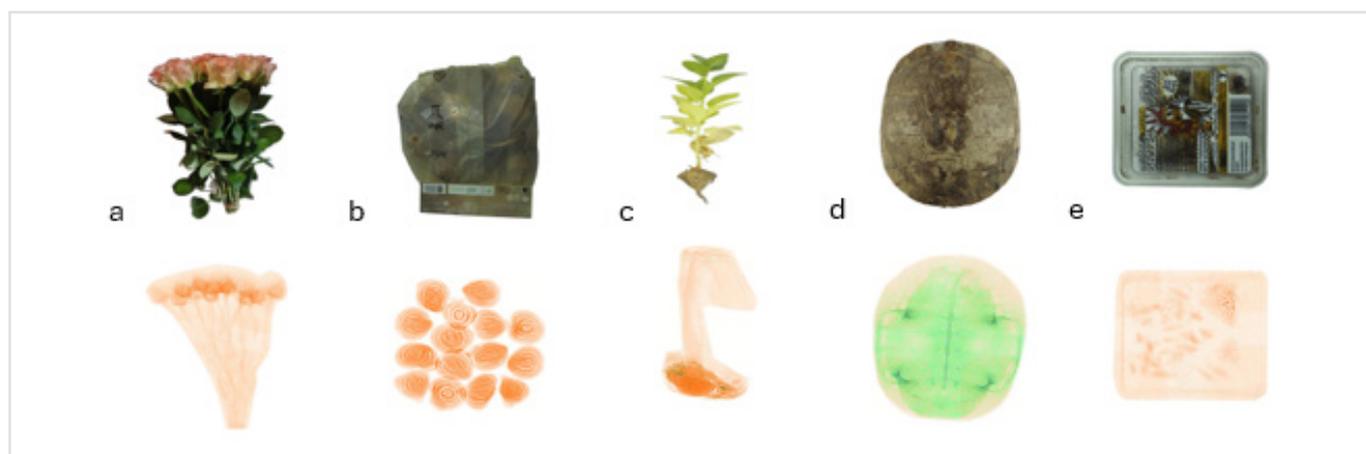

Figure 1: Examples of plants (a, b, c) and animals (d, e) to be detected by DAFF's screening officers. The images show a photo of the real object as well as the corresponding X-ray image of it.

WHAT WAS THE MOTIVATION TO IMPLEMENT A TRAINING PROGRAM (TAKING INTO CONSIDERATION THERE ARE NO REGULATIONS)?

Cathy replied: "In DAFF we are cognizant that our screeners perform a complex role." DAFF's officers must be familiar with the X-ray presentation of a vast number and variety of items, including biosecurity risk items and non-concerning items. The job must also be performed quickly in busy environments. In addition, items that are of biosecurity interest to DAFF may change over time, and every-day items packed in suitcases and containers also change with time.

"We need to refresh our training to be more reflective of this real-life environment, both in the number and types of items, and the complexity of their pre-

ecurity risk items of concern to Australia are vast and varied, so it is important that we have an accurate simulated environment so that officers can maintain their skills and learn to identify rarer risk items that they may not see every day" – she added.

As for the Chilean Customs, the main motivation behind their investment in a training program stems from the risks assessed by the department in keeping previous internal programs. In particular Sandra expressed: "Our previous training programs were limited to internal training with a very inward focus, and we were not considering future nor international threats". XRT was firstly implemented by the Chilean Customs in 2024 and has greatly contributed to the national Customs service by evolving the training pro-

ing and testing. It is important for DAFF to collaborate directly with them regarding how each image compares to what they have seen on-the-job. XRT has a feedback option that the officers can use as they progress through the pilot module, and Cathy and her colleagues are closely monitoring all the comments in real-time to consider any adjustments needed.

Within Chilean Customs, the implementation of a training program initially generated some reservation as it was the first time that simulation was used for training. However, as the officers became more familiar with the process over the course of the program, it has been accepted well, leading to improvements in its use and more effective practices.

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CAN YOU SHARE ANY RESULTS – FOR EXAMPLE INCREASED DETECTION; REDUCTION IN IMAGE ANALYSIS TIME; PERSONNEL RETENTION AND DEVELOPMENT – THAT THE TRAINING PROGRAM HAS PRODUCED?

When asked about training results Cathy explained that "At this stage, in DAFF we don't have results from the training pilot which has only been operating for a few weeks. However, we are encouraged by the research conducted by CASRA demonstrating an increase in screening capability and efficiency from regular computer-based training (CBT) that utilizes large, reflective and regularly updated image libraries".

In addition to what the other interviewees already said, Sandra from Chilean Customs mentioned that "the results obtained are varied and very useful. Among them, we can mention the increased motivation of our staff in developing the skills of a non-invasive technology operator.

THE AUSTRALIAN DEPARTMENT OF AGRICULTURE, FISHERIES AND FORESTRY IS AT THE FOREFRONT ON A GLOBAL SCALE WITH ITS COMMITMENT TO NOT ONLY DELIVERY TO ITS SCREENING OFFICERS X-RAY IMAGE TRAINING IN BIOSECURITY THREATS BUT TO ALSO IMPLEMENT A CERTIFICATION PROGRAM WHICH IS CURRENTLY BEEN DEVELOPED WITH CASRA. THIS IS AN EXCITING PROGRESSIVE DEVELOPMENT WHICH WE DO NOT OFTEN SEE, ALTHOUGH MUCH NEEDED, OUTSIDE OF THE AVIATION INDUSTRY. CAN YOU TELL US MORE ABOUT THAT PROGRAM AND WHY CERTIFICATION IS A STEP THAT DAFF HAS DECIDED TO IMPLEMENT?

The certification part of DAFF's program will be about officers doing an annual test within XRT. This will come after of-

Figure 2: Biosecurity X-ray images with food and nuts displayed in XRT's training module developed for DAFF.

ficers have had opportunity to train sufficiently on a training module. The pilot will ensure parameters set within the test, such as difficulty level and pass grades, are appropriate to workforce needs.

"We are not sure exactly what a revitalized national training and verification program will look like, as we don't want to pre-empt the pilot results" – commented Cathy. "Importantly, we will be consulting thoroughly inside our organization during the development and implementation of a new national approach. We are confident our officers do an excellent job and frequently detect biosecurity risk items through X-ray. This is shown in the reality TV show Border Security which is viewed in more than 150 countries. However, from a domestic regulatory perspective, it is important that we provide objective assurance to our commu-

nity regarding one of Australia's first lines of defense for identifying biosecurity risk material in large volumes at the border" – she concluded.

An annual test will allow for assurance and verification in line with the department's regulatory responsibilities. The Australian Inspector-General of Biosecurity, an independent official who is responsible for reviewing the department and advising the ministry, also recommended that all officers undergo reaccreditation in image analysis every year.

WHAT ADVICE DO YOU HAVE FOR OTHER ORGANIZATIONS REGARDING THE IMPLEMENTATION OF THEIR TRAINING AND/OR CERTIFICATION PROGRAM?

DAFF's advice would be to follow a scientific and evidence-based approach as
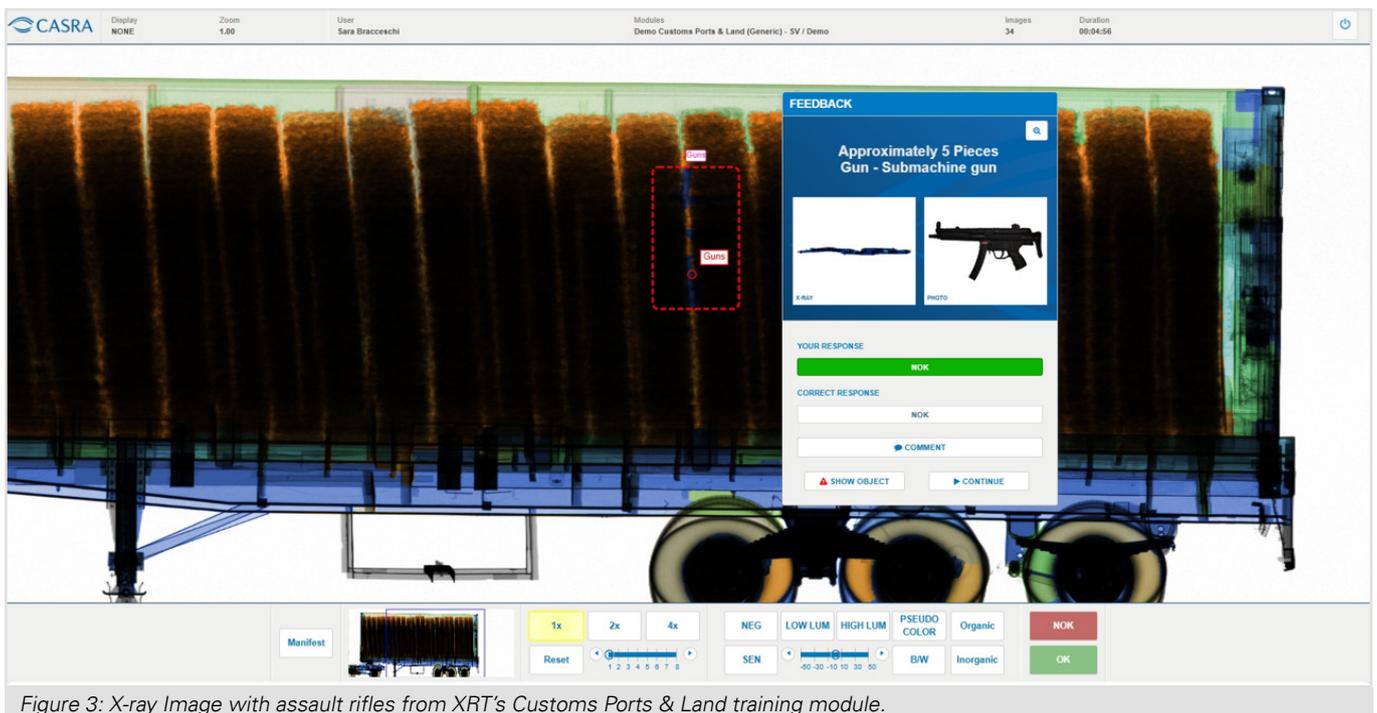
Figure 3: X-ray Image with assault rifles from XRT's Customs Ports & Land training module.

much as possible in the context of your own area's needs. For DAFF this meant focusing on CBT with a great increase to their image library. DAFF also learnt about the effectiveness of adaptive training and are incorporating CASRA's adaptive algorithm into the pilot and final module.

For Chilean Customs, it is always important to consider programs that address risks and topics at the forefront globally, in order to better combat organized crime. Constant practice and knowledge of the equipment and different types of merchandise, as well as the evolution of concealment methods, which are ever changing, is key.

Cathy concluded: "For us there are effective domestic levers. However, we note it is important to have consistent and effective screening worldwide, whether it is for the purpose of screening for dangerous goods, or biosecurity risk items".

CASRA thanks the participants very much for their great collaboration and partnership.

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