A Battelle White Paper

The Importance of Image Quality and Image Quality Verification with Imaging Based Technology
X-ray systems have been used for civil aviation security screening for decades to provide a means to quickly and efficiently examine the contents of an item (e.g. cabin baggage or hold baggage) non-intrusively. Originally, such systems relied only on screeners to scrutinize the x-ray image on a display to identify potential explosive threats. Beginning in the mid to late 1990s x-ray screening technology advanced to the point that x-ray systems could automatically detect potential explosive threats and highlight them and associated IED components for secondary on-screen review by a security officer, thus enhancing the probability of detection, reducing the false alarm rate and increasing bag throughput. Computed tomography (CT) explosives detection systems (EDS), based on technology used for medical imaging, were the first to provide this capability.

The Federal Aviation Administration (FAA) was the first to implement this technology in the late 1990s. The 9-11 tragedy in 2001 led to the creation of the TSA and accelerated the adoption of this technology in the U.S. The worldwide civil aviation community has been slower to adopt CT EDS, relying instead on other x-ray technology, but is now committed to its use for screening, with deadlines for 100% implementation in different regions of the world ranging from now to 2020 and beyond.

The Federal Aviation Administration (FAA) was the first to implement Computed tomography (CT) explosives detection systems (EDS) technology in the late 1990s.
The Transportation Safety Administration’s (TSA) model as a government aviation security regulator is different from its counterparts in most other countries in that TSA not only specifies requirements and certifies equipment but it also acquires and deploys this equipment at all 440 U.S. commercial airports. In support of this full life cycle model, TSA has developed robust test and evaluation methodologies to ensure the equipment it acquires is working properly before it is accepted for use. TSA’s deep understanding of CT and its experience with testing security screening equipment in general provide an invaluable reference for the rest of the worldwide aviation community relative to the successful acquisition of CT-based screening equipment.

The automatic detection capability afforded by CT is a result of two key elements of the system: 1) the three-dimensional image rendered by the CT; and, the automatic threat detection (ATD) algorithm which analyzes each three-dimensional image to look for suspicious items which it then will “alarm on” and highlight for subsequent review by a screening official. The system’s ability to perform this automatic detection function properly is therefore dependent on both image quality and the ATD. The ATD is based on software and is certified by government agencies (TSA in the U.S. and ECAC in the EU) to detect specific explosive threats in quantities of concern. Since the ATD is embodied in software, it does not degrade once it is developed and compiled. The same cannot be said for the image generation capability of CT which is reliant on the system’s hardware and proper system setup.

440 U.S. commercial airports have been deployed with CT EDS technology.
With a CT EDS, image quality is a function of many hardware and software parameters that support and make-up the imaging subsystem. Key components include the scanner conveyor(s), X-ray tube, X-ray detectors, X-ray gantry, power supplies, and cooling systems. If any of these elements is not working properly it can affect the image quality and thus the ability of the system to detect explosives.

Image degradation caused by certain elements of the system not functioning properly can be so subtle that the naked eye cannot perceive it on a screener’s display yet such image quality degradation can significantly diminish the ATD’s ability to detect threats. Each vendor has their own image quality kit for internal testing purposes, however, these kits do not conform to a commonly agreed standard and may not be adequately sensitive to all relevant system elements that affect image quality. How then does an operator know that their CT is producing images of acceptable quality? The answer is a standardized approach to image quality verification that verifies all key system elements impacting image quality and that has the sensitivity to detect issues that could impact detection performance.

Key CT EDS Imaging Components

Scanner Conveyor  X-ray tube  X-ray Detectors  X-ray Gantry  Power Supplies  Cooling Systems

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TSA has always developed its own test articles for acceptance testing to ensure products meet their standard of acceptance and to assure consistency across all platforms. Up until very recently the TSA test articles for CT were based on a statistical method that was reliable but that only provided a go/no-go result. This system involved many test articles that were logistically difficult to manage and that required regular maintenance. To address these shortcomings and to improve the detail and value of the testing process TSA, several years ago, embarked on a program to develop image quality test phantoms that would directly test the key elements of a CT as described above and provide empirical data that directly (not statistically) assesses CT image quality.

This empirical testing system was developed cooperatively by the Department of Homeland Security (DHS) Transportation Security Laboratory, TSA, the National Institute of Science and Technology (NIST), screening equipment OEMs and Battelle. It consists of two test phantoms, and mathematical formulae for analyzing the CT images produced by the test phantoms when scanned. The system produces 78 image quality metrics that represent the performance of the key CT subsystems and components mentioned above. These 78 parameters are analyzed through the accompanying software to determine the quality of the CT image. The test results can help diagnose specific CT subsystems or components contributing to poor image quality and the test data, if captured on a periodic basis, can be used for trend analysis to anticipate imminent failures and to optimize maintenance. This new standard has been published in the US as ANSI N42.45 2011. It will be published internationally in 2017 as IEC 62945.
In summary, the quality of the images produced by a CT used for security screening is critical to the ability of the CT to automatically detect explosives. CT image quality should be verified as part of the acquisition process for new CT and it should be periodically verified to ensure that the CT continues to produce images of acceptable quality. A new standard has been developed for worldwide use that can be used to perform this image quality verification (ANSI N42.45 (U.S.) and IEC 62945 (international). These standards define test phantoms and associated analytical formulas for determining CT image quality.

Battelle now offers the phantoms and associated analytical software commercially under the trademarked name, Verif-IQ™ X-ray Image Quality Verification System.