Next Generation Trusted Radiation Identification System

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Introduction

The original Trusted Radiation Identification System (TRIS) was developed from 1999 – 2001, featuring information barrier technology to collect gamma radiation template measurements useful for arms control regime operations.[1] The first TRIS design relied upon a multichannel analyzer (MCA) that was external to the protected volume of the system enclosure, undesirable from a system security perspective. An internal complex programmable logic device (CPLD) contained data which was not subject to software authentication. Physical authentication of the TRIS instrument case was performed by a sensitive but slow eddy-current inspection method.[2] This paper describes progress to date for the Next Generation TRIS (NG-TRIS), which improves the TRIS design. We have incorporated the MCA internal to the trusted system volume, achieved full authentication of CPLD data, and have devised rapid methods to authenticate the system enclosure and weld seals of the NG-TRIS enclosure. For a complete discussion of the TRIS system and components upon which NG-TRIS is based, the reader is directed to the comprehensive user's manual and system reference of Seager, et al.[3]

Case Authentication

The NG-TRIS uses a stainless steel cannister, as did the TRIS. The physical authentication method developed for TRIS was eddy current scanning, a very sensitive nondestructive evaluation method. It required a complex custom fixture for mounting and rotating the TRIS case under a probe head, taking about 20 minutes for a scan of the case. We investigated a more broadly applicable technology, flash thermography, which can execute rapid nondestructive detections of tampering for both conductive and nonconductive materials.[4, 5] An initial comparison of the two technologies shows that thermographic signal reconstruction (TSR) was capable of detecting drilled and repaired holes in a steel case (Figure 1). All but the smallest defect was detectable by flash thermography within a few seconds data acquisition time. With future improvement resolution optics and surface coating, we expect equivalent performance from this authentication method.

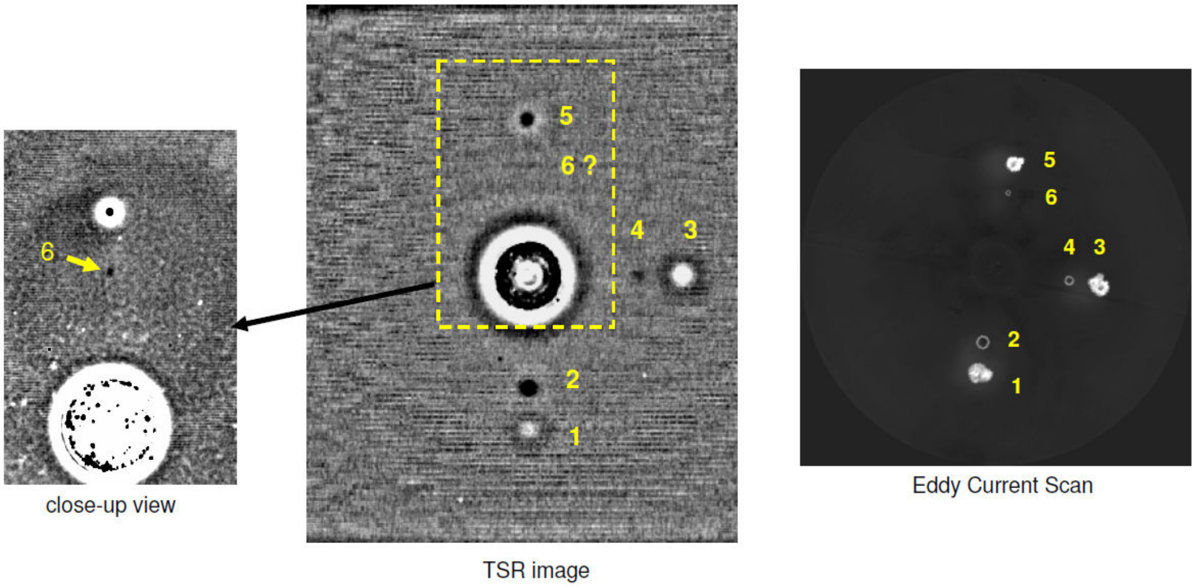

Figure 1. Expertly drilled and repaired holes in the end plate of a steel case. The electrical connection is at center in each image above. Right: eddy current scan detecting 1/16". 1/8", 3/16" holes numbered 1 through 6. Center, and Left: pulse TSR image of the same holes.

As intended for the TRIS system, the expected use of NG-TRIS will involve a case sealing operation via welding under observation of the host and inspecting parties. The integrity of the weld and the identity of the system must be authenticated. We envision applying a reflective particle tag (RPT) as both a weld seal and as a unique identifier.[6] A prototype NG-TRIS weld seal RPT is show in Figure 2. A standoff digital imager is used to align to fiducial marks on the tag.

Figure 2. Prototype RPT applied at the juncture of the NG-TRIS end plate and cylindrical case joint.

The automated RPT system acquires the reference image of the tag immediately after it has been applied. Upon future inspections, the identity of the tag is confirmed by comparing the reference tag image and the inspected tag image's unique patterns of reflections under varying illumination angles (Figure 3).

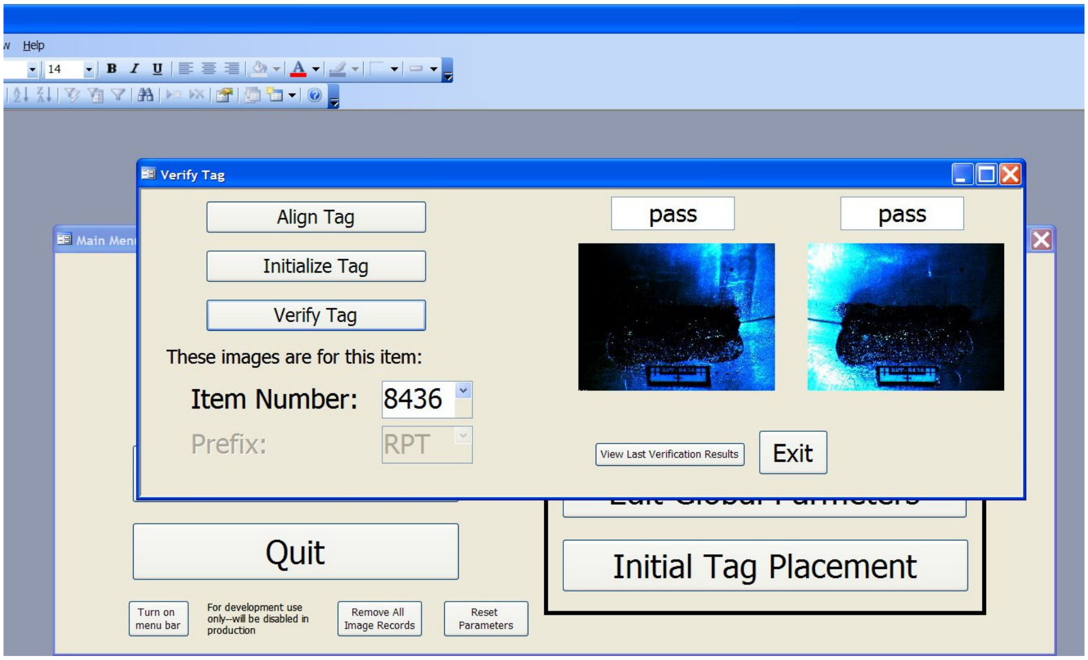

Figure 3. Screen capture of the RPT reader showing a "Pass" condition for left and right illuminations of the NG-TRIS case joint tag.

With the combination of the flash TSR and the RPT authentication methods, we are confident that rapid physical authentication of the integrity and identity of the NG-TRIS case will be achievable under field conditions.

NG-TRIS Prototype Progress and Testing

In late 2007, we resumed the effort to integrate previously fabricated hardware, identify new hardware, and implement full software authentication.[7] We have achieved laboratory operation and test source gamma spectrum confirmation from the NG-TRIS prototype, incorporating the MCA, high voltage power supply, and analog to digital converter (ADC) to the PC104 platform inside the steel case, using a custom photomultiplier tube (PMT) base design.

One of the most challenging aspects of the project has been developing a method to perform firmware integrity verification of complex programmable logic device (CPLD) code on the ADC. Our solution involved readback and reconstruction of CPLD configuration data. While proprietary programming tools support configuration readback and reconstruction, these tools are not suitable for embedded application use in NG-TRIS, due to software authentication difficulty. To overcome this obstacle, we added our own configuration readback implementation to the NG-TRIS. The NG-TRIS CPLD readback process consists of a 9 bit address input to the device followed by a 304 bit data output from the device. This input/output process is repeated until the entire configuration has been read. The data read from the device is not consistently structured, making straightforward configuration readback impossible. The data's structure varies by address, requiring us to account for the data's structure on a per-address basis. The CPLD readback process enables full system hashing of the NG-TRIS firmware.

A performance issue identified during prototype testing may be due to insufficient thickness of the high voltage power supply boards. Remanufacturing is in progress to address this defect. A calibration spectrum from the NG-TRIS is shown in Figure 4, indicating that the combination of PC104-based power supply and custom PMT base are performing satisfactorily.

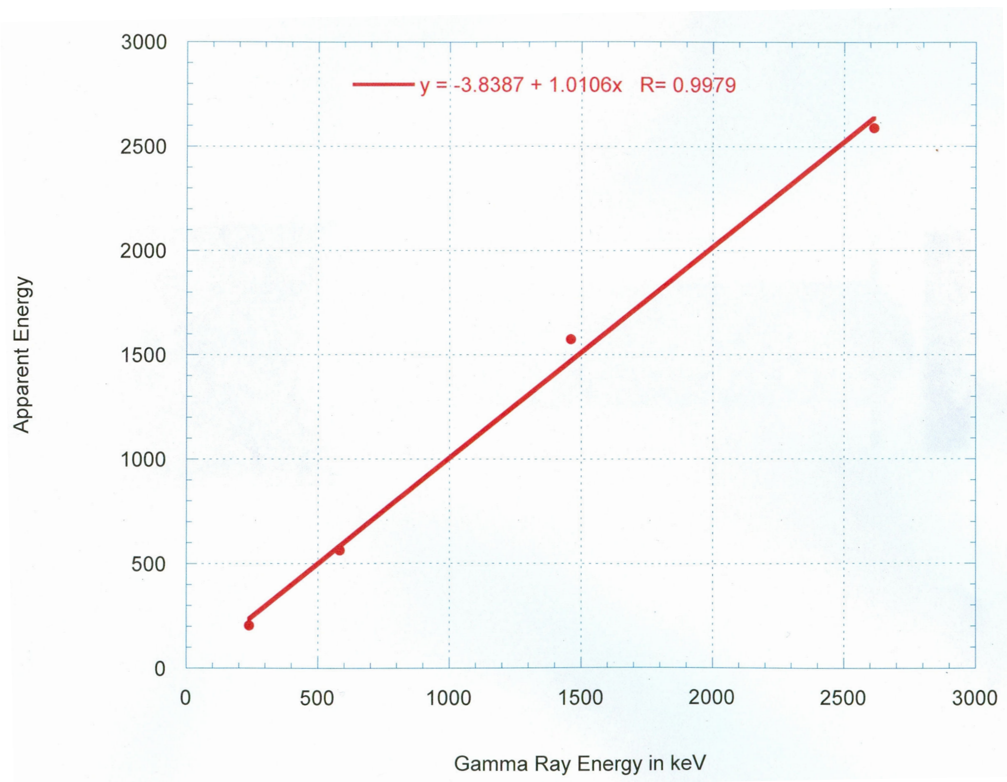

Figure 4. Linear response of NG-TRIS using custom PMT base component.

Due to the expected obsolescence of the PC104 processor board used in the original TRIS design, currently available versions of the 586 CPU board were identified and acquired, which should allow us to eliminate two serial communications boards from the system stack. We also expect lower heat generation from the more advanced processor technology, leading to potential reduction in the steel center plate heat sink thickness. Increased system speed is not yet verified. Combined with the case redesign that has been completed, we estimate several pounds of weight reduction in the final NG-TRIS version.

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