X-Ray Automatic Detection of Explosives Containing Fragmentation

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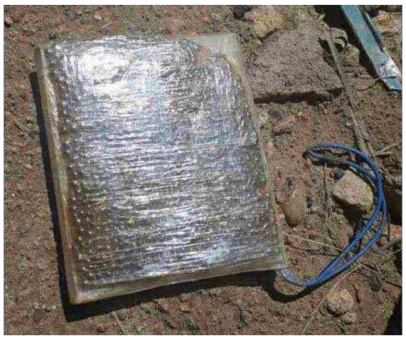
Introduction

DSA Detection recently conducted X-ray automatic detection testing of various IED main charge explosive configurations to examine how they would respond when diverse types of fragmentation ("frag") were added to the main charge. The testing was executed based on current terrorist IED construction trends incorporating frag into an IED main charge. Most explosive detection testing on X-rays that has previously been performed with only an explosive and not with frag added. The goal of this testing is to verify how effective current automatic detection oftware is at automatically detecting an explosive main charge that contains fragmentation.






The above images of IED's represent methods terrorists use to incorporate frag into an IED main charge. Each example portrays a tight layering of frag on the outside of the main charge, a very common technique. The thickness of the main charges varied between ½ inch to 1 inch, and the types of frag were typically always metallic.

Studies have shown that frag incorporated into the main charge dramatically increases the lethal effects of the device. The lethal range becomes increased; the metallic fragments will travel much farther than the blast pressure wave.

Testing Methods

The cabinet security X-ray systems used for the testing were single-generator and multiple-generator systems with 140 and 160 KV generators, verified as calibrated and operating as per the OEM technical requirements for each system. X-ray generator line scopes and detector boards were verified as being within acceptable OEM parameters for each system. Each unit possessed an automatic detection software feature that would "Mark" a potential explosive by placing a red box around any material that falls into the range of an explosive's density and average effective number.

The test articles used were X-ray correct explosive simulants, which matched the density and effective atomic number (Z_{eff}) of the explosive they were simulating. The density and Z_{eff} measurements for each explosive simulant were verified on a laboratory micro CT system.

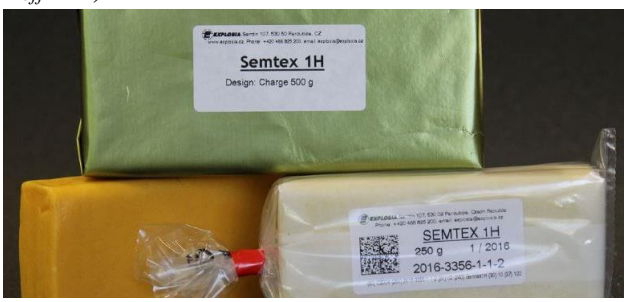
Explosives Simulants used for the testing:

Plastic Explosive C-4

- Density 1.6 g/cc
- Z_{eff} (7.1)

Semtex H

- Density 1.4 g/cc
- Z_{eff} 7.1)



PETN

- Bulk Density 0.8-0.9 g/cc
- Crystal Density 1.77 g/cc
- Z_{eff} (7.0)

Several different types of materials were used for the fragmentation and these were based on the same types used by terrorist in the construction of their IED's. The construction methods and layering used for the testing utilized the same techniques employed by terrorist. Data has shown that the most common method used by terrorist is to tightly layer the fragmentation material on one side of the explosive material. We also used non-metallic fragmentation and even employed methods of construction that would potentially enhance the x-ray system ability to detect the explosive main charge. This was done by layering the fragments in a very loose pattern vs the more common tight patterns we see utilized. This was done to verify if the fragmentation was in fact effecting the detection of the explosive material.

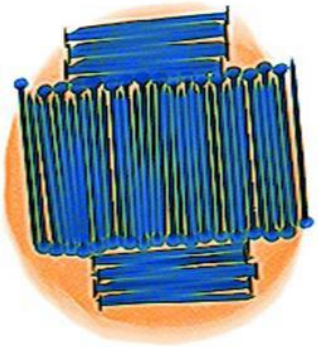
Fragmentation types used for the testing:

Nails, ball bearings, glass, and hex nuts

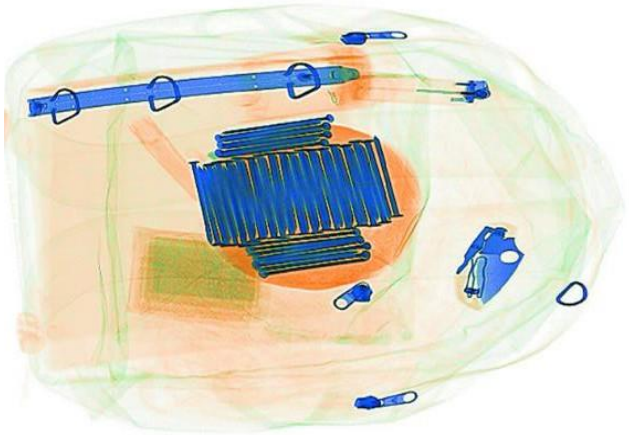
Testing Method:

1. The 1st test conducted is the explosive with no fragmentation, placed on the belt of the system to verify the explosive would AutoDetect (Red box) alarm.

2. The 2nd test is the explosive with fragmentation added to it and placed on the belt of the system to verify the explosive would AutoDetect (Red box) alarm.

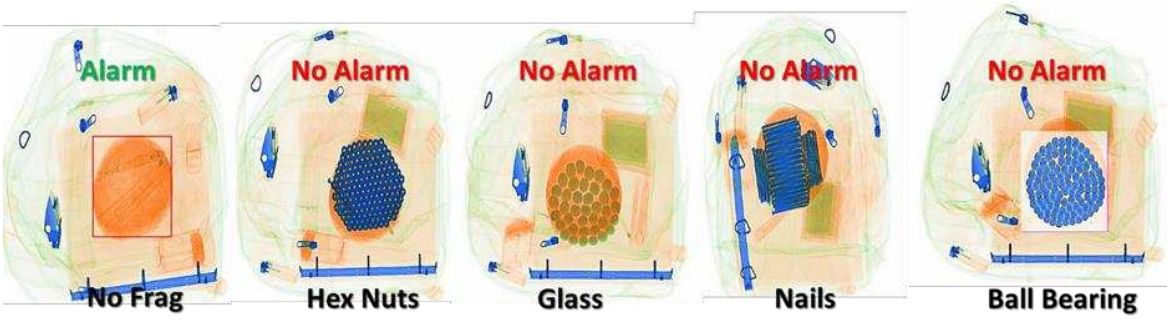


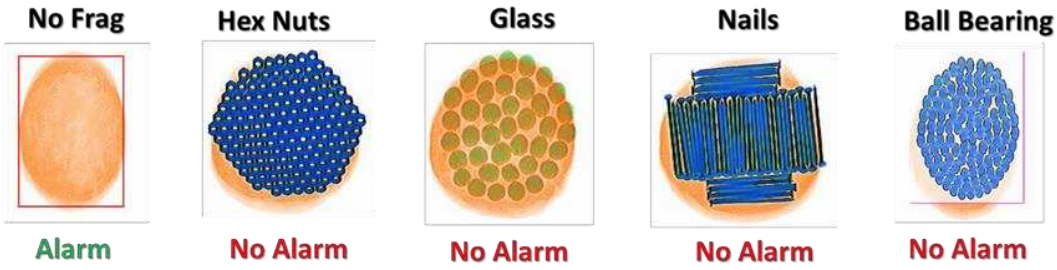
3. The 3rd test is the explosive with fragmentation placed inside a bag with low clutter to verify the explosive would AutoDetect (red box) alarm.



Test Results:

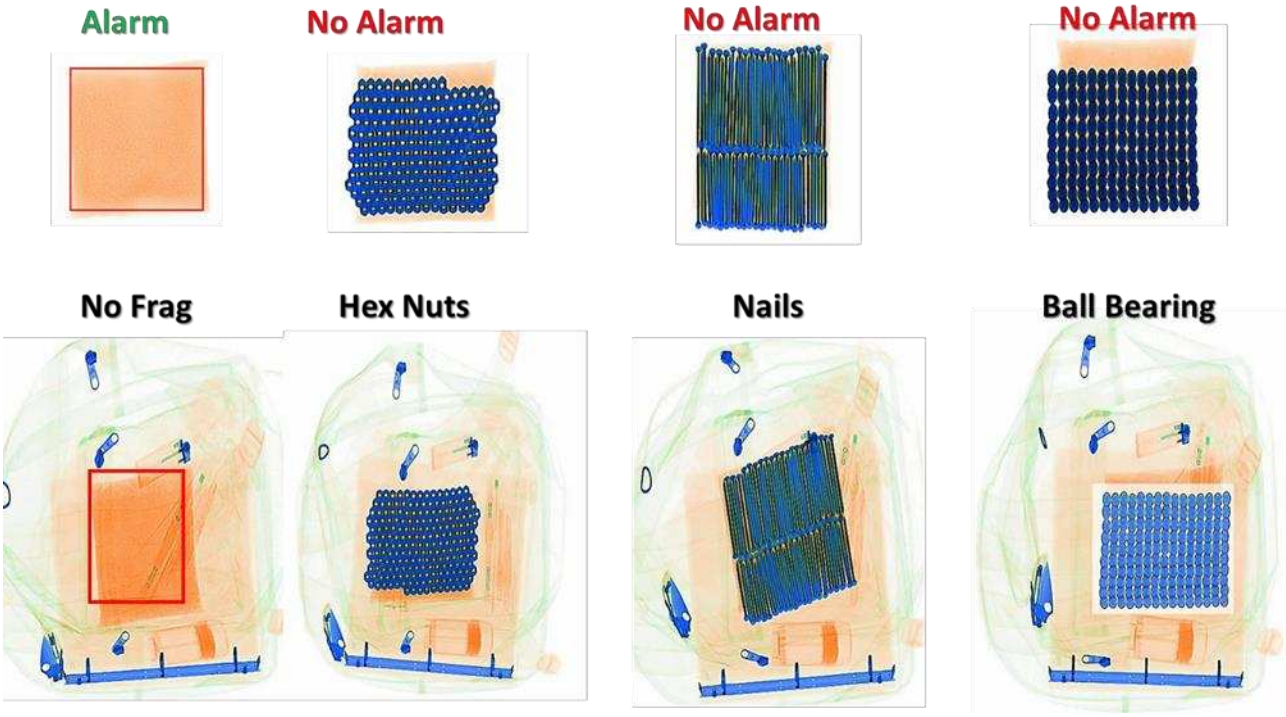
1. C-4 Plastic Explosive (500 grams, 2.54 cm thick, 15.24 cm diameter, 1"x6")



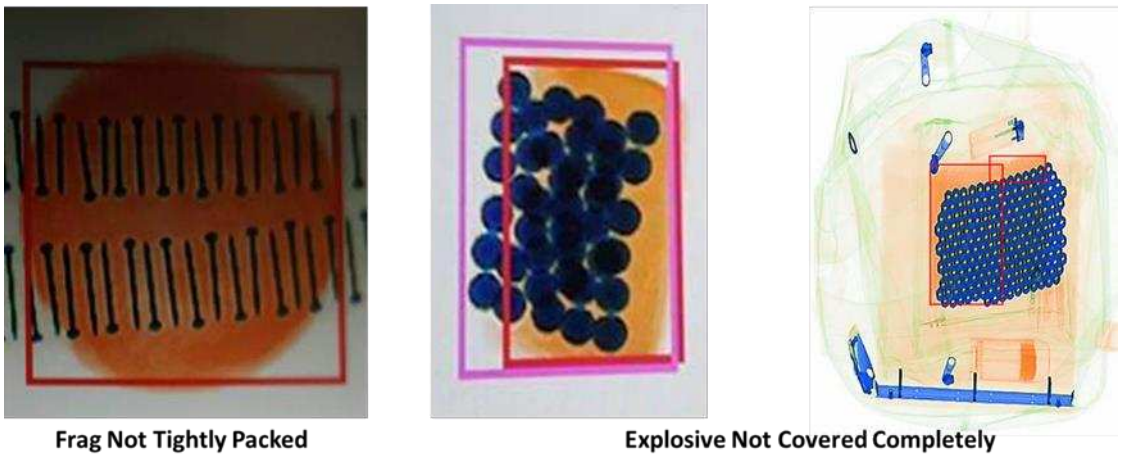


2. SEMTEX Explosive (250 grams, 5 cm thick, 10 cm long, 2”x4”)

3. PETN Explosive (454 grams, 2.5 cm thick, 15 cm long)



4. Frag Packed Loosely



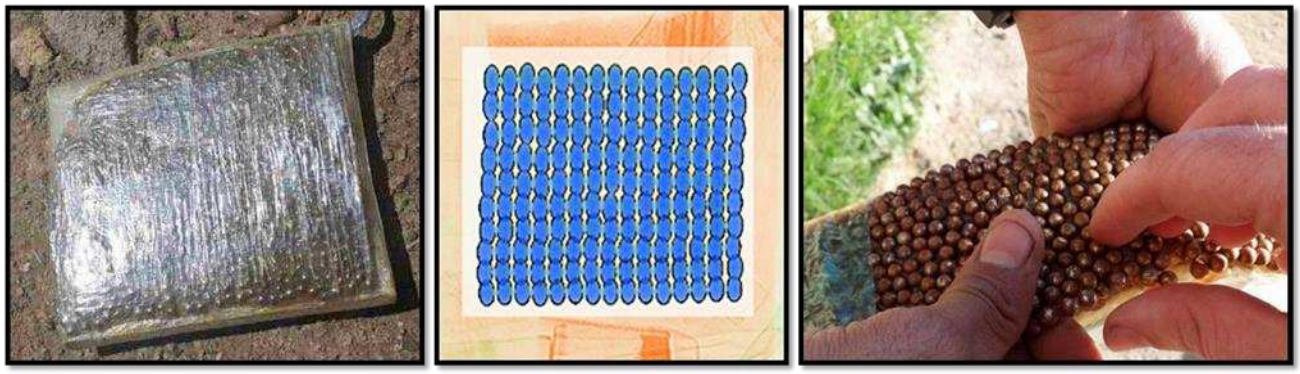
Conclusions:

When the explosive charge was covered with fragmentation, the X-ray's ability to auto-detect the explosive material was negated. The auto-detect feature did not work in almost all cases.

When there were large gaps in between each frag piece, the X-ray successfully auto-detected the explosive. In some cases when the explosive was not completely covered with frag, if enough of the explosive was exposed, the X-ray would auto-detect.

Today's terrorists pack explosive fragmentation very tightly and close together.

It should be noted that almost all examples of terrorist methods of putting fragmentation into the explosive charge have involved tightly packing it without leaving wide gaps. The image below provides a common example and reference of how terrorists pack fragmentation into the explosive.



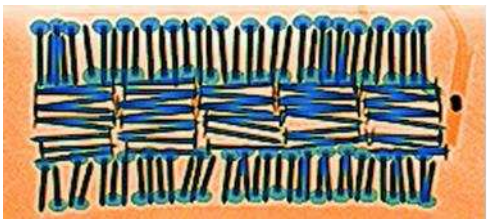
Recommendations

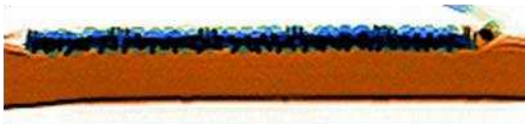
1. Training of X-ray operators should include images of explosive devices with fragmentation to become familiarized with this type of threat.

2. Threat Image Projection (TIP) or X-ray simulator training should include images of IEDs with fragmentation included in the main charge.

3. Security experts should become more familiar with how terrorists build their IEDs and ensure they conduct testing that matches the actual threats.

4. High Density Alert auto-detection features on X-ray systems should be examined more closely to determine their potential to provide better detection on IED threats that contain metallic fragmentation.
    - Dual-view systems during the testing did show the ability to detect the explosive if the fragments did not cover the sides and the threat mass (height) of the explosive was enough to generate an alarm. However if the sides of the explosive's main charge were covered with frag or the height was below the system's threat mass the unit would not auto-detect the explosive.





Dual-View X-Ray Scans