

# **Evidence for Correlation of X-ray NII Image Quality Indicators (IQI) and Operational Performance (PD & PFA) in a Cargo Environment**

Presented at ADEPT 8/18/2022

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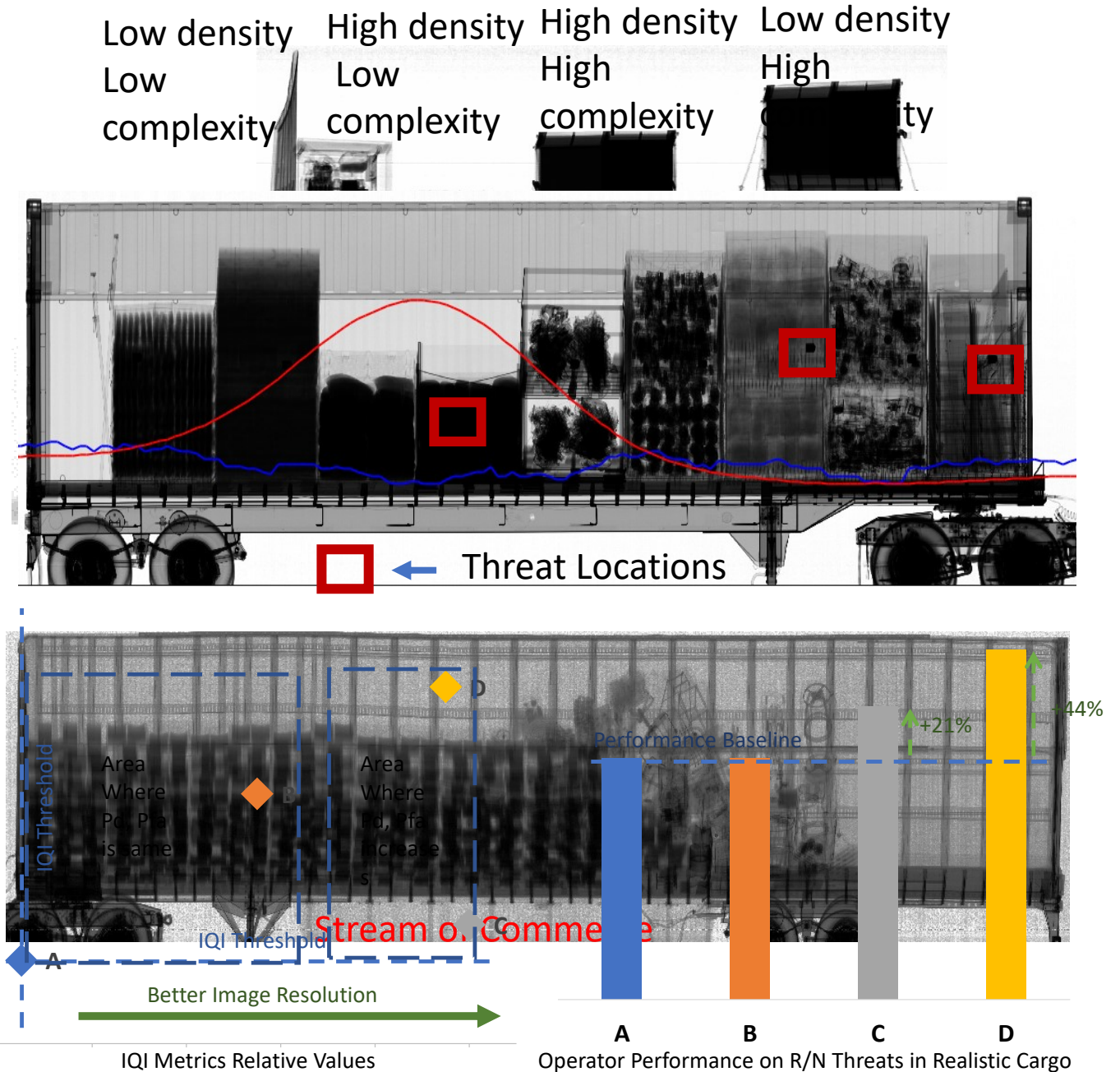
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# IQI and Operational Performance

## So What Who Cares?

- CWMD and CBP has acquired X-ray NII data on
  - ANSI N42.46 IQI test objects
  - Representative SOC cargo with test objects for probability of detection, PD
  - SOC cargo for probability of false alarms, PFA
- These results reveal a correlation between IQI and Performance (PD, PFA)



# Recommendations

- NII Specifications require emphasis of higher spatial resolution and contrast sensitivity at high attenuation
- Data collections and characterizations are needed in the areas of lower contrast threats (e.g., narcotics vs. RN) to develop better NII systems.
- NII Systems with automated or assisted contraband detection algorithms will require more demanding IQI capabilities and will need to fuse multiple modes of inspection
  - Seven other large scale characterization tests have been performed on prototype NII systems coupled with the above results help us form further recommendations
  - For example, dual energy, radiation detection, fast and thermal neutron activation

# Image Quality Factors

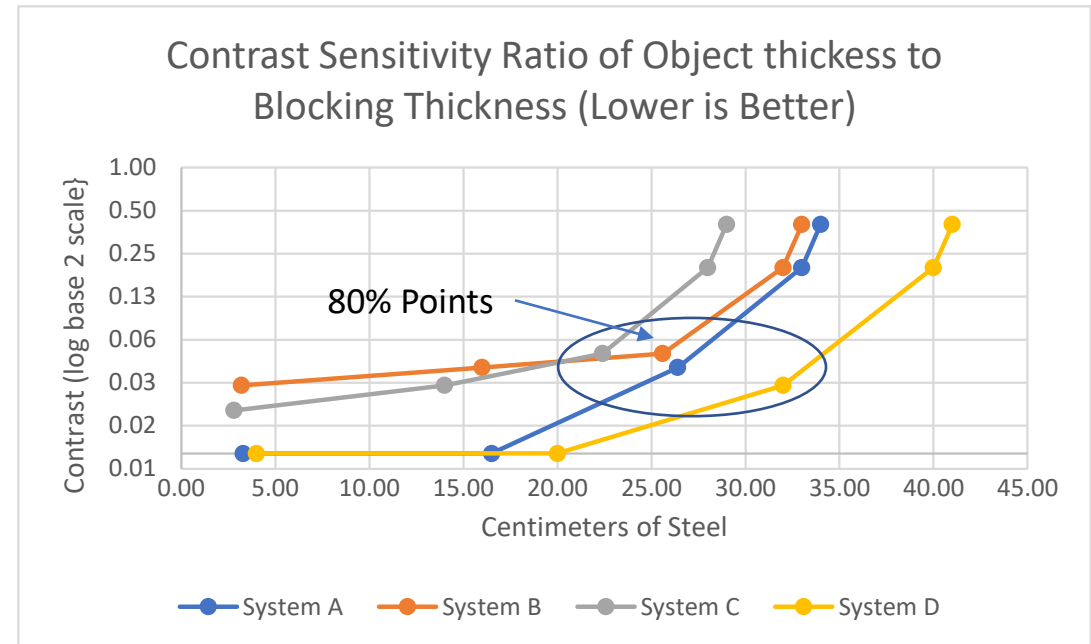
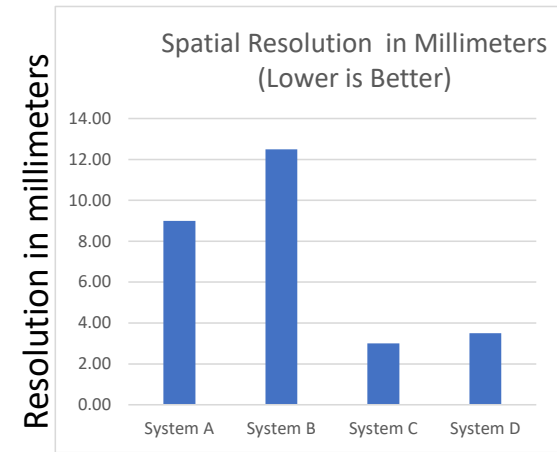
ANSI 42.46 measures Contrast and Spatial Resolution, this is the Primary way systems are specified for Contract Award

Contrast Sensitivity describes the minimum thickness (a) of an object detectable as a function of the thickness of material penetrated (b) by the X-ray System

Contrast in % is  $100 \cdot a/b$

Spatial Resolution is the ability to discern 3 bars of a given width (w) spaced by a distance of (w). ANSI 42.46 only measures this with very high contrast (no attenuation due to cargo). Other tests have shown that attenuation can decrease resolution by as much as 3 to 8 times.

We take 2 test examples where the IQI factors and Operator Performance against threats in Cargo were measured under realistic cargo conditions. Each test had 2 systems (A,B and C, D) with acceptable Contrast and Resolution per Specifications



# Typical IQI and Operational Images from Cargo NII Systems

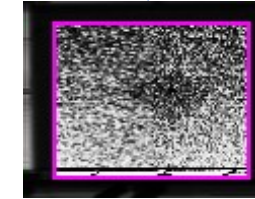


**Resolution  
System B 12.5 mm**

**Resolution  
System A 9 mm**

**Contrast System B 3%**

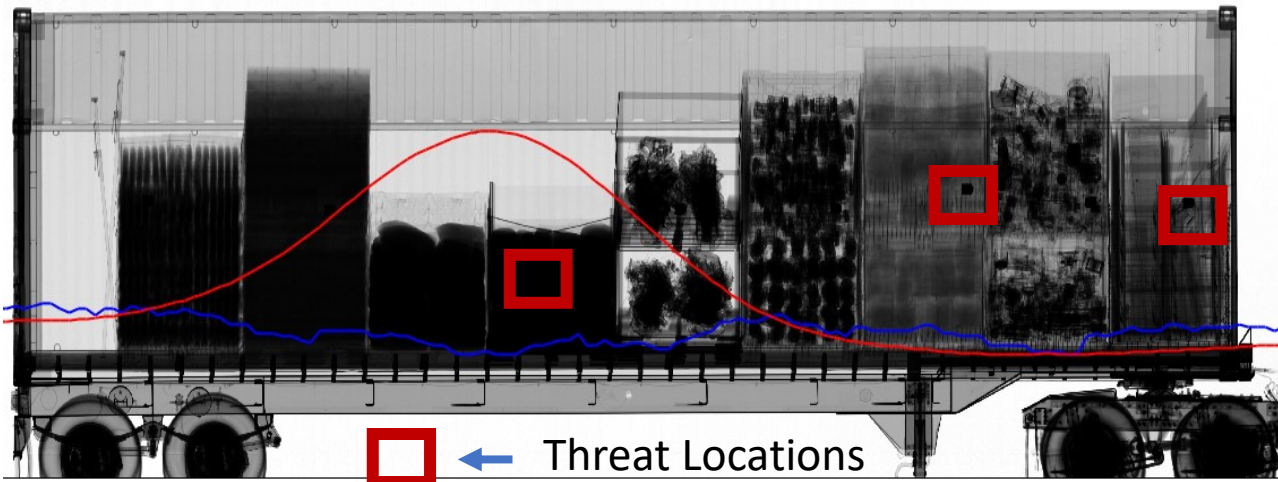
**Contrast System A 1.5%**



**Steel  
thickness  
15 cm**

Low density	High density	High density	Low density
Low	Low	High	High
complexity	complexity	complexity	complexity

3 mm resolution on right 25 mm resolution on left  
To really understand the ability to declare threats like below  
We need not measure resolution with blocking material



# Observations on IQI Vs. Operational Performance and ATR

## IQI Observations

- Systems B and C have threshold Contrast Sensitivity at 80% attenuation
- Systems C and D have highest resolution
- All 4 systems are same energy sources

## Operational Testing Observations

- System D performed for the threats tested about 45% better than A and B
- System C performed for the threats tested about 21% better than A and B
- System A and B had similar Detection Performance, but System A had a lower contrast and resolution than system B which resulted in higher False Positives
- The combination of Contrast sensitivity and Spatial resolution can predict Operational Performance in this data set

**Automatic Recognition algorithms typically require more resolution than humans**

- Seven other large scale characterization tests have been performed on prototype NII systems coupled with the above results help us form further recommendation

