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Tamper-Indicating Enclosures, a Current Survey

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NNSA National Nuclear Security Administration

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- Special thanks to Karl Horak for his initial contributions to this work

Introduction

- Tamper-indicating technologies are critical elements of verification regimes
- Tamper-indicating devices (TIDs)
  - Designed to leave non-erasable, unambiguous evidence of access or entry
  - Well-suited to be applied through hasps or over recognized openings
  - *Unable* to provide evidence of adversary by-passing recognized openings
- Tamper-indicating enclosures (TIEs)
  - *Able* to provide evidence of adversary by-passing recognized openings
  - Volumetric or surfaces
  - Complex issue
  - Not as much R&D

Complexity of TIEs

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- Non-standard shapes and sizes
  - Large material containers to TID body to custom equipment protection (radiation detector)
- Items under protection are both host and inspector owned
- Cost-prohibitive to secure complex items (room, odd geometry)
- Tamper attempts must be detectable
- Solutions must be robust
- Adversarial skills

An ontology

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Scale of Use	Functional Characteristics	Verification Mechanism
TID/Equipment Bodies	Shell Integrity Indicators	Visual Inspection
Monitored Item Enclosures	Event Assessment or Recording	Active Signals
Rooms	Internal Environment	Enclosure Integrity

An ontology

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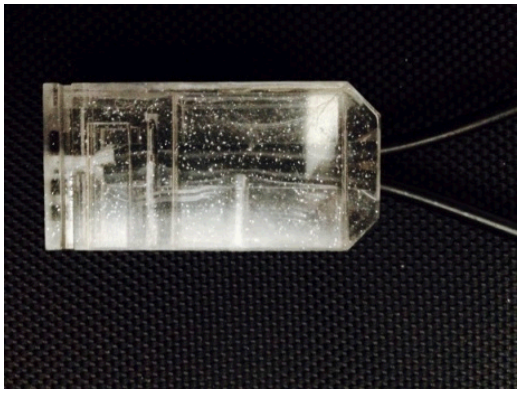
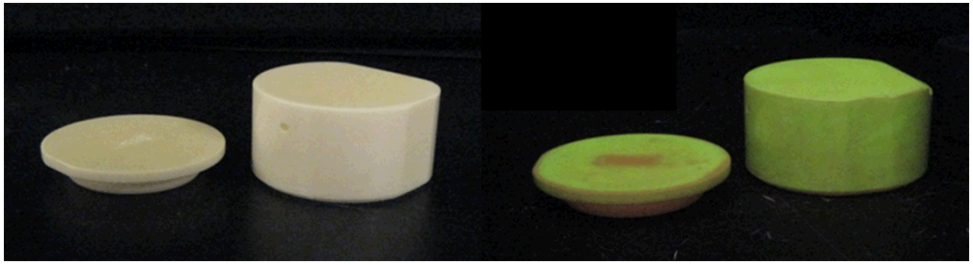
Scale of use – TID/equipment level



Cobra 5 seal with embedded hematite, Aquila. Photo courtesy SNL.

"Frangible" Glass Seal, IAEA

NGSS using anodized aluminum, Canberra



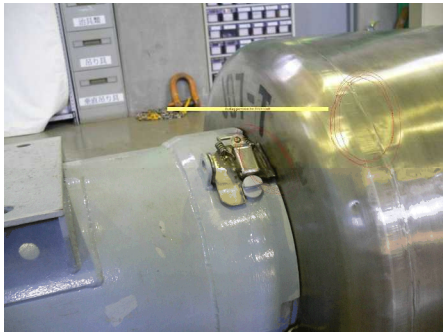
"Frangible" Ceramic Seal, with fluorescent tamper-indicating coatings, SNL/SRNL

Other (not shown):

- Patterned plastics/composites
- Internal fiber mesh (EOSS/NGSS)
- RMSA anodized aluminum

Scale of use – enclosure level

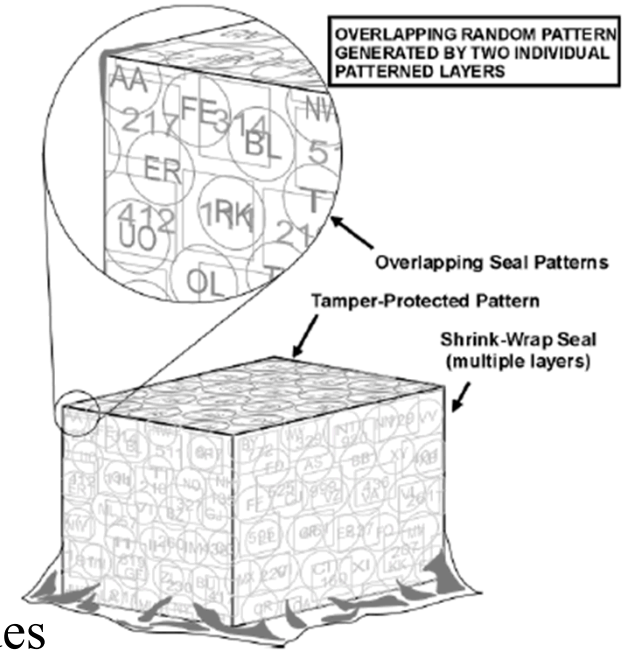
"Inspector owned" IAEA cabinet, painted using a powder process



"Facility owned" cask

Options:

- X-ray fluorescence (XRF)
- Fiber optics
- Tamper-indicating shrink wrap
- Conductive fabric

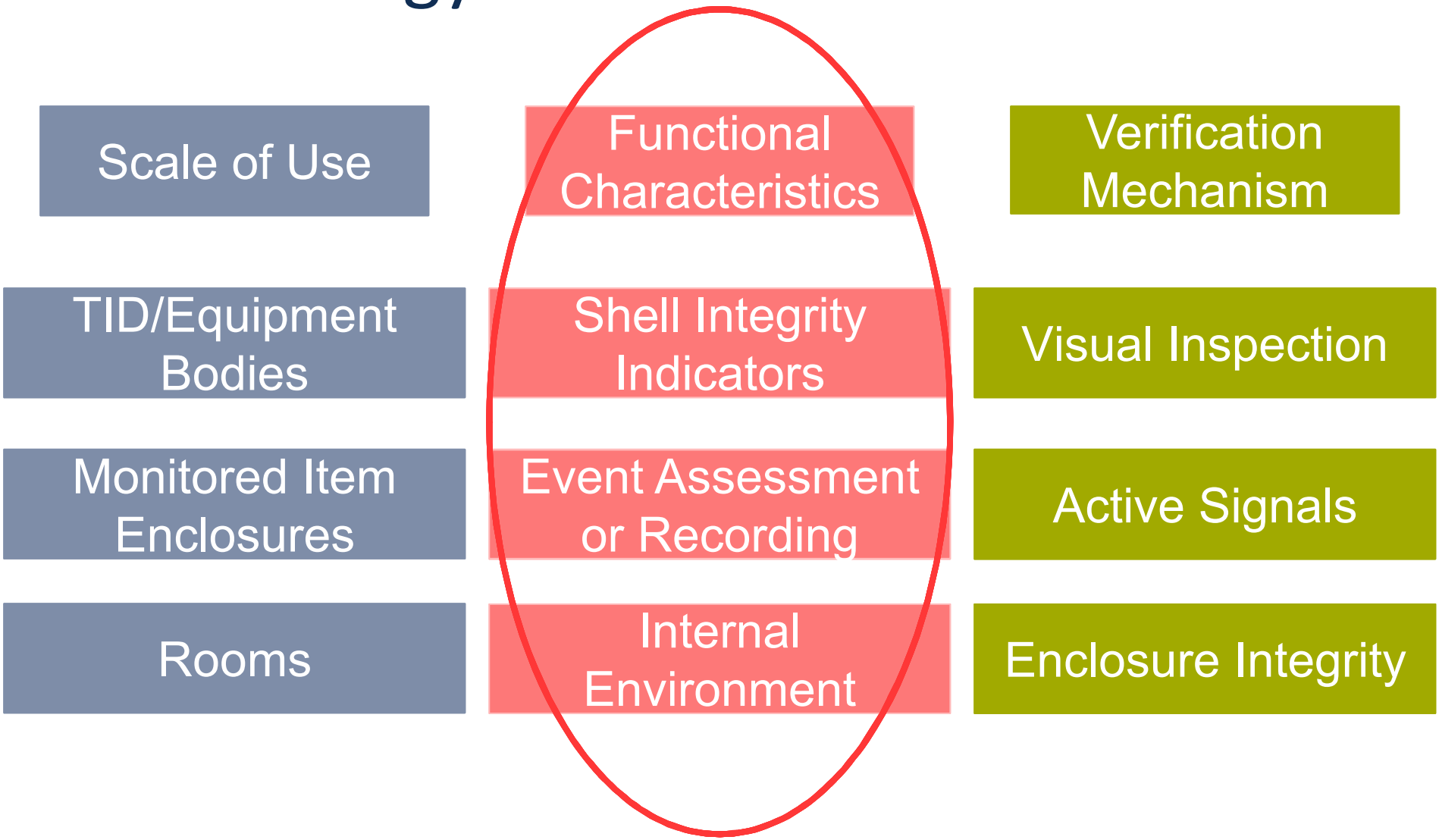


*At this scale, could be issues with accessing backsides and underneath items for visual inspection

Scale of use – room level

- Objective?
  - Physical integrity
  - Entry
- Integrity
  - Tamper-indicating coatings (paint, spray coatings)
  - Flash thermography
- Entry
  - Microwave/infrared sensors
  - Switches
  - Require authenticated event logging
- Issues
  - Visual inspection of integrity could be difficult unless tamper response is significant

An ontology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Functional – shell integrity

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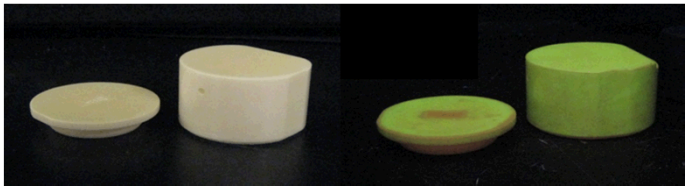
Indicate breach of outmost shell

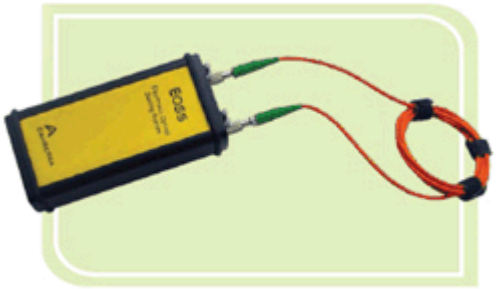
Anodized aluminum, NGSS and RMSA

Glass Seal and Ceramic Seal are “frangible”

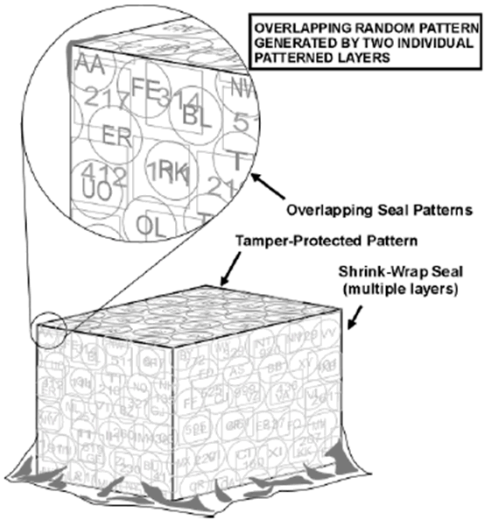


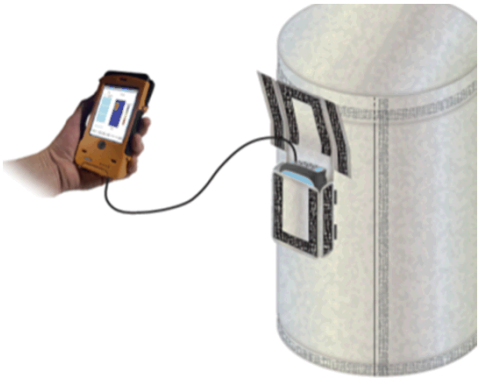
Ceramic Seal has tamper-indicating fluorescent coating

EOSS and NGSS use fiber mesh inside



Tamper-indicating shrink wrap and Whole Container Seal (WCS) prototype from ORNL applied externally

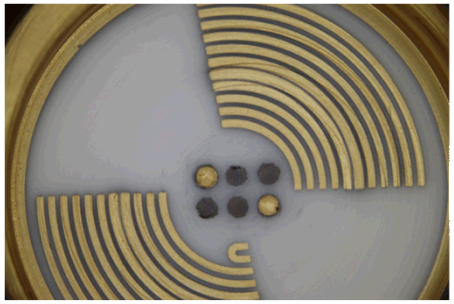


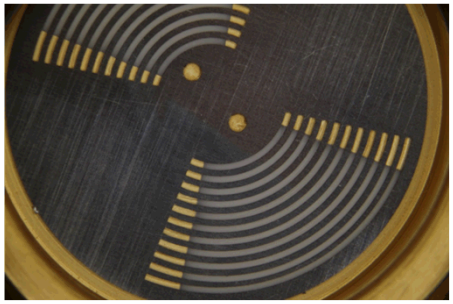


Functional – event assessment

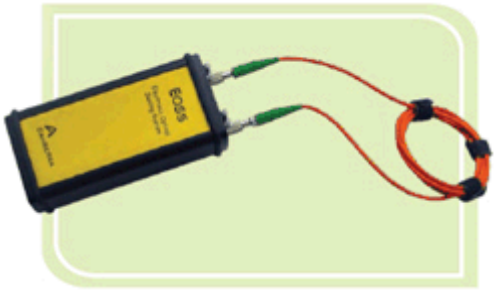
Tamper is automatically "recorded"

EOSS and NGSS use fiber mesh inside

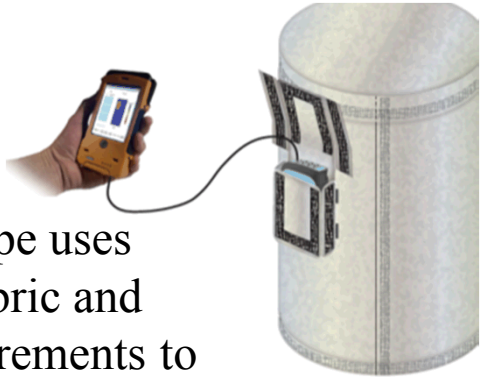




Conductive tamper planes in Ceramic Seal cap



*Data must be recorded and authenticated

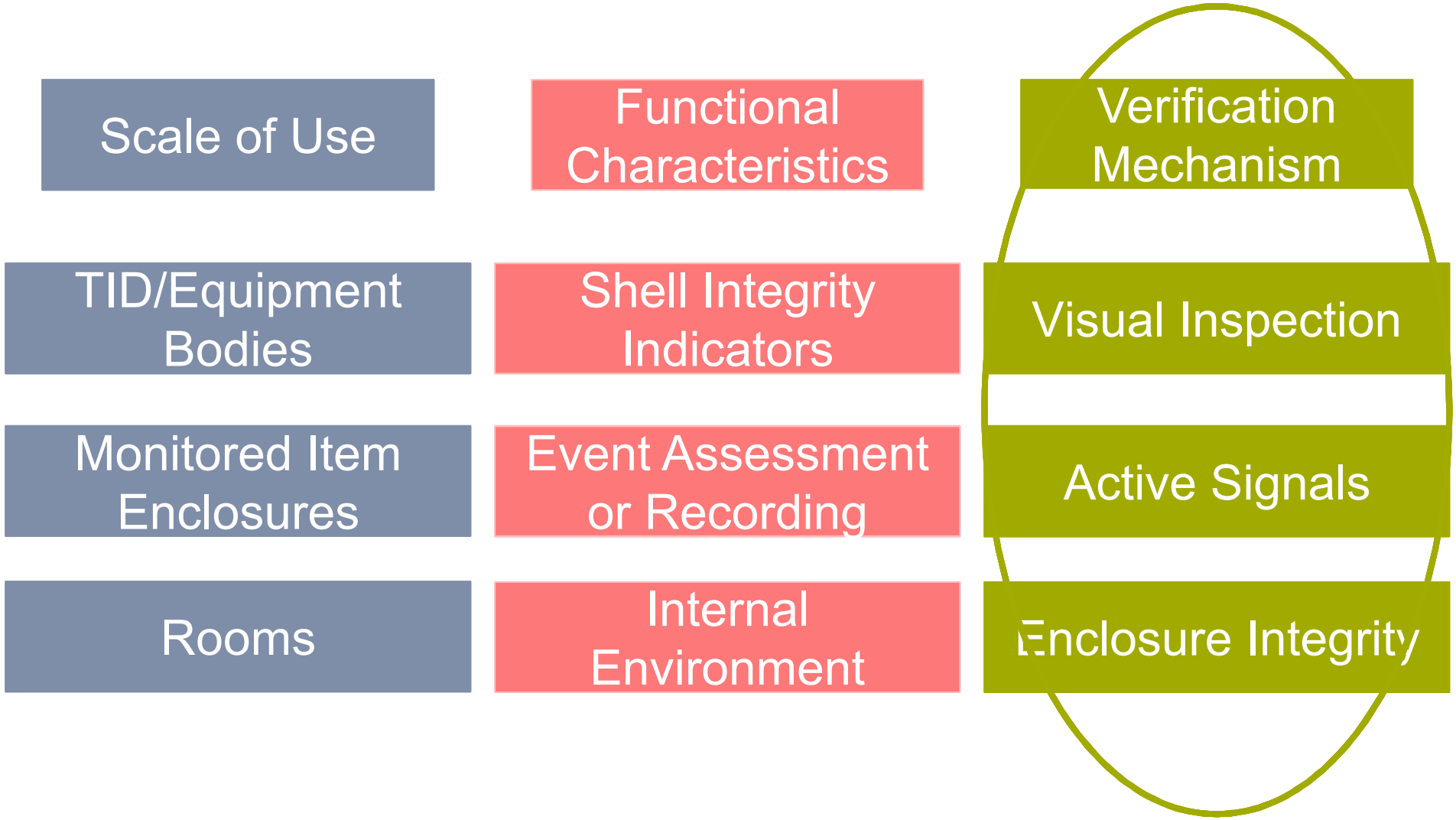


WCS prototype uses conductive fabric and resistance measurements to monitor tamper

Functional – internal environment

- Monitors key features of internal environment within enclosure
- Light, moisture, pressure, RF
- Either environment must not be able to be reestablished or change must be recorded and authenticated (non-erasable evidence)

An ontology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Verification - visual Inspection

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- Can be low cost and simple concepts
- Human eye, camera images, instrument assisted (i.e., UV)
- Can be scalable
- Relies on careful visual inspection to detect sophisticated penetrations or repairs
  - Can be difficult to detect
  - Best design – obvious response to tamper
- Examples
  - Anodized aluminum
  - Frangible seals
  - Patterned plastics/composites
  - Tamper-indicating shrink-wrap

Verification - active signals

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- Rely on electronic signals from sensors that indicate enclosure has been breached
- Allows verification without inspector involvement or inspector presence
  - Remote monitoring possible with some technologies
- Varied scalability
- Requires power and ability to store authenticated messages
- Can be more costly and complex
- Examples
  - Fiber optics
  - Conductive tamper planes
  - Monitored conductive fabrics
  - Environmental sensors

Verification – enclosure integrity

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- Active penetration-detecting technologies
- Particularly useful for facility/host owned items or items in which modifications are not allowed
- Enclosures may be constructed from materials not considered TIEs
- Item/enclosure dictates verification technology
  - Material
  - Size
- Active interrogation methods may not be allowed by host
- Costs related to interrogating equipment
- Examples – eddy current, flash thermography

Conclusions

- TIEs are a complex topic
- Application for TIE determines where it falls in ontology
- Ontologies can be useful for scoping design or selection of TIEs for an application
  - Scale
  - Functional characteristics
  - Verification mechanism
- Current selection seems limited
- Need new technologies with obvious visual responses