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Title: Nuclear Security Objectives of an NMAC System

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IAEA 60 Years
Atoms for Peace and Development

Nuclear Security Objectives of an NMAC System

Speaker: LANL

9/7/17

Learning Objectives

After completing this module, you should be able to:

Describe the role of Nuclear Material Accounting and Control (NMAC) in comprehensive nuclear security at a facility

Describe purpose of NMAC

Identify differences between the use of NMAC for IAEA safeguards and for facility nuclear security

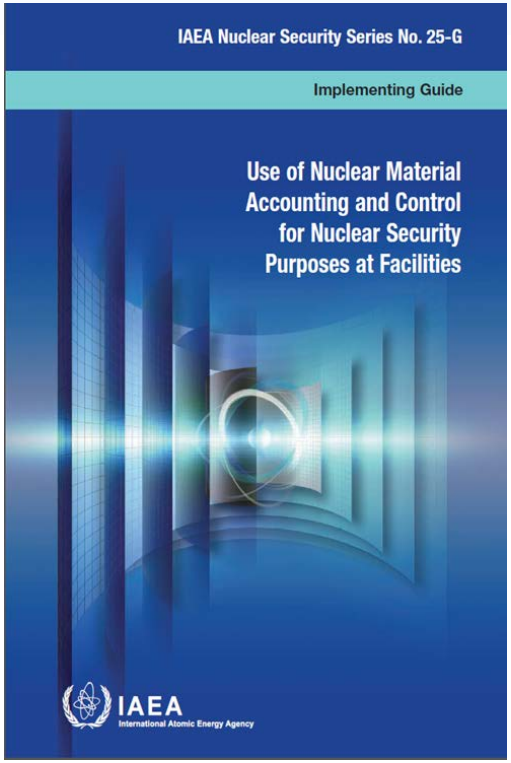
List NMAC elements and measures

Describe process for resolution of irregularities

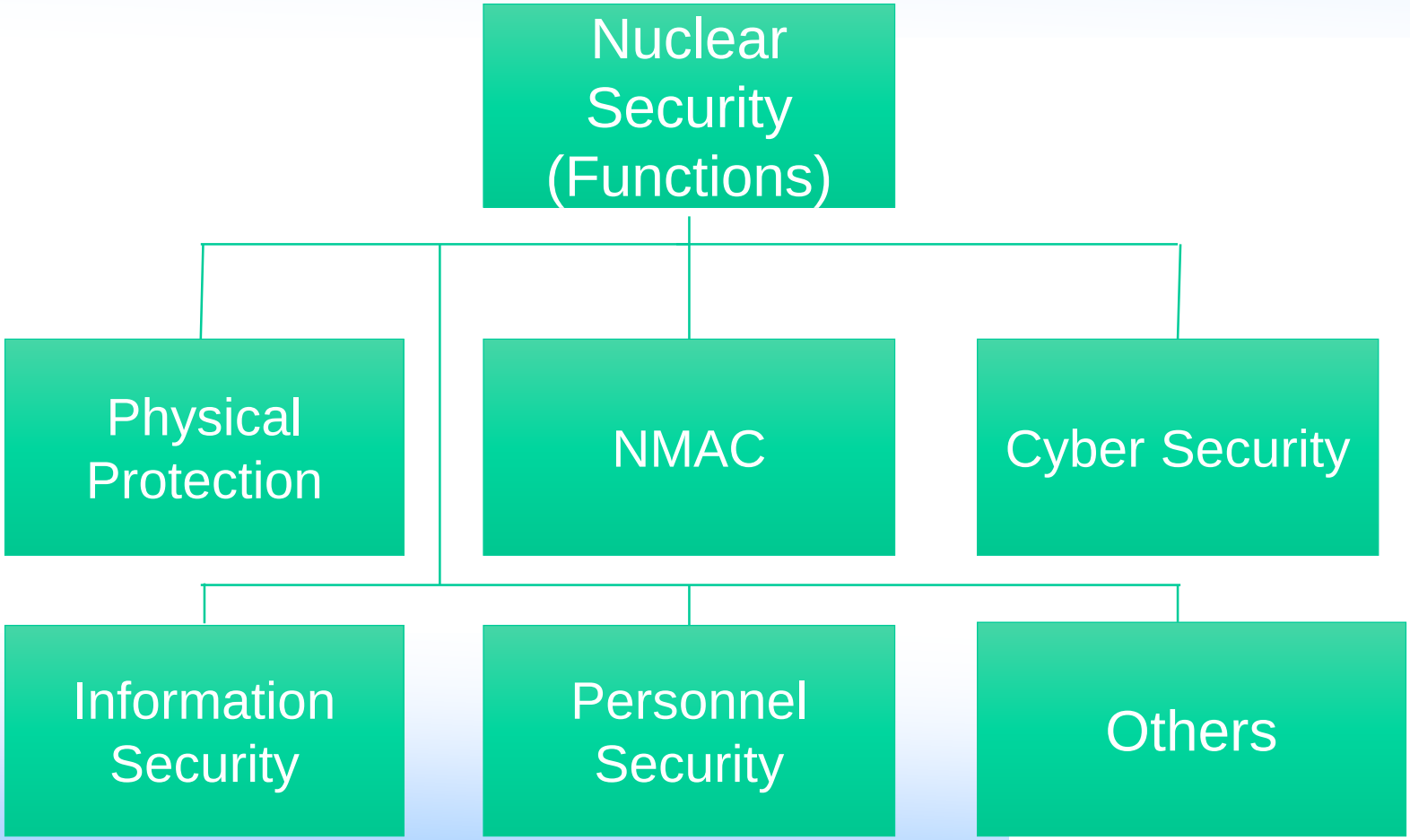
INFCIRC/225/Revision 5

3.26 The operator should ensure control of, and be able to account for, all nuclear material at a nuclear facility at all times. The operator should report any confirmed accounting discrepancy in a timely manner as stipulated by the competent authority

IAEA published new guidance in 2015 to address NMAC for nuclear security



How Can We View Nuclear Security at a Facility?



What Does an NMAC System Do?

Provides information to the facility Operator:

- Type, quantities, and location of the nuclear material
- Definition of facility accounting boundaries, known as material balance areas (MBAs)

Tracks nuclear material through storage, handling, and use

Provides administrative and technical measures to control nuclear material during all activities

Source: LANL

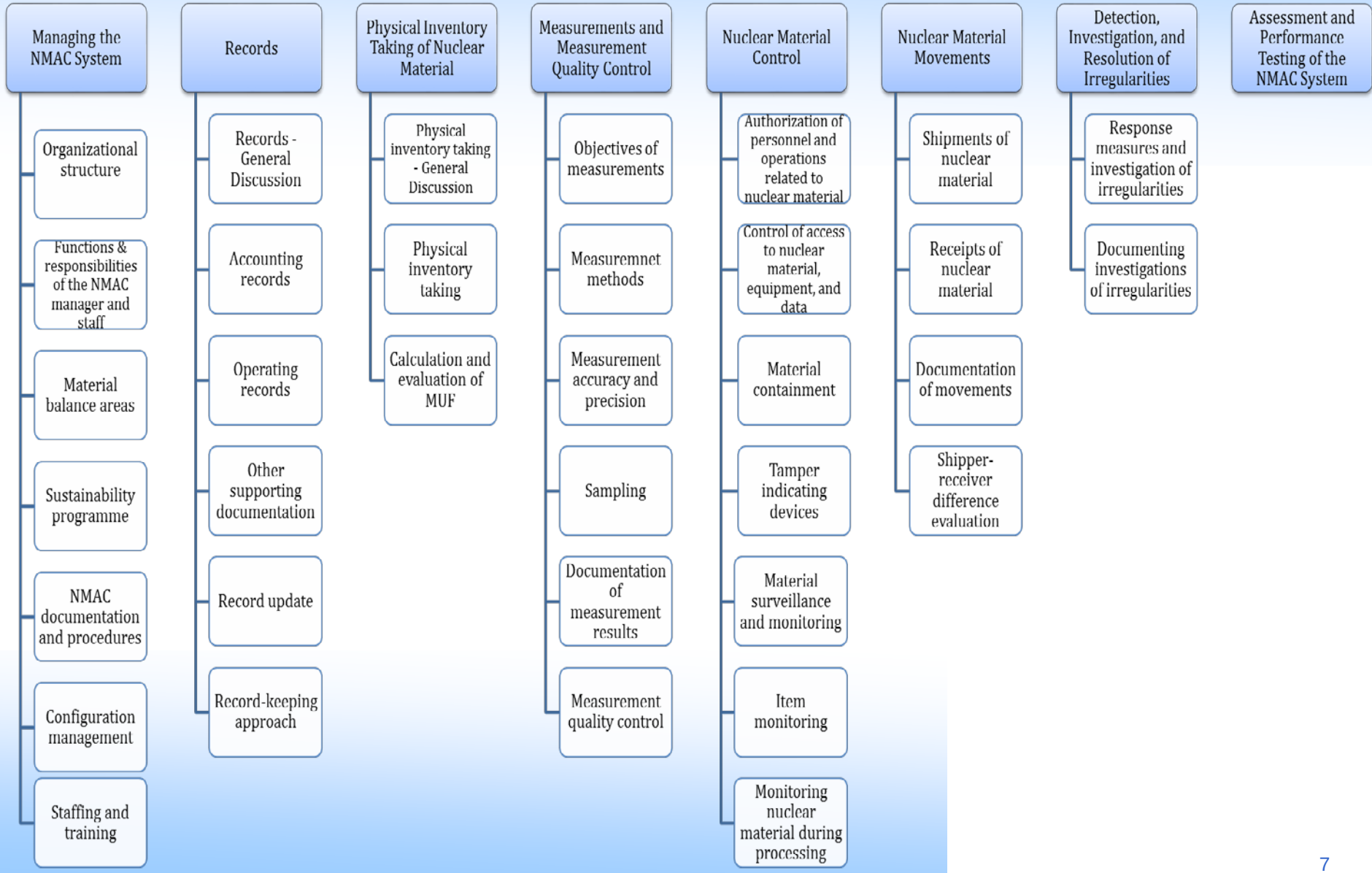
What Does an NMAC System Do? (cont'd)

Through periodic physical inventory taking, assures that all nuclear material is present in its

- Assigned location
- Specified quantities

Provides process for identification and investigation of irregularities involving nuclear material, including response

Elements and Measures from NSS-25-G



How Does NMAC Contribute to Nuclear Security?

When properly implemented, NMAC measures can detect unauthorized removal of nuclear material by an insider

- The possibility of being detected serves as a deterrent to the insider to not attempt the malicious act
- The NMAC system provides the primary way to detect protracted theft (multiple thefts of small quantities)

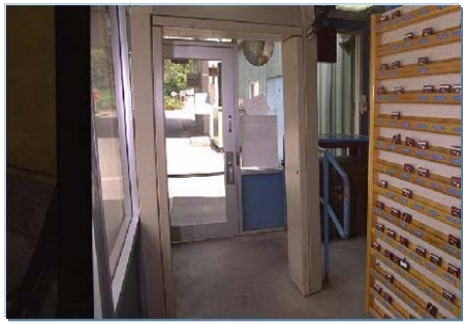
If nuclear material is stolen

- NMAC can provide critical information about what has been stolen—material type and quantity—to ensure that any recovery of the material is complete
- The NMAC system can provide legal evidence about the inventory of the facility to be used in court

NMAC and the Insider

Example of how NMAC aids physical protection system

- A nuclear facility includes the best physical protection system in the world—best guns, toughest fences, and smartest guards
- At the end of a shift, the workforce leaves the facility, passes through the access control point, gets in vehicles, and drives out of the parking lot



Source: IAEA

Did a nuclear material theft occur?

- The physical protection system may not be able to answer that
- NMAC measures can deter theft by an insider and has the information necessary to resolve questions of theft

Source: IAEA

NMAC and Outsider

Example:

- An external assault team has just attacked a nuclear facility
- Can you tell if a theft of nuclear material occurred?

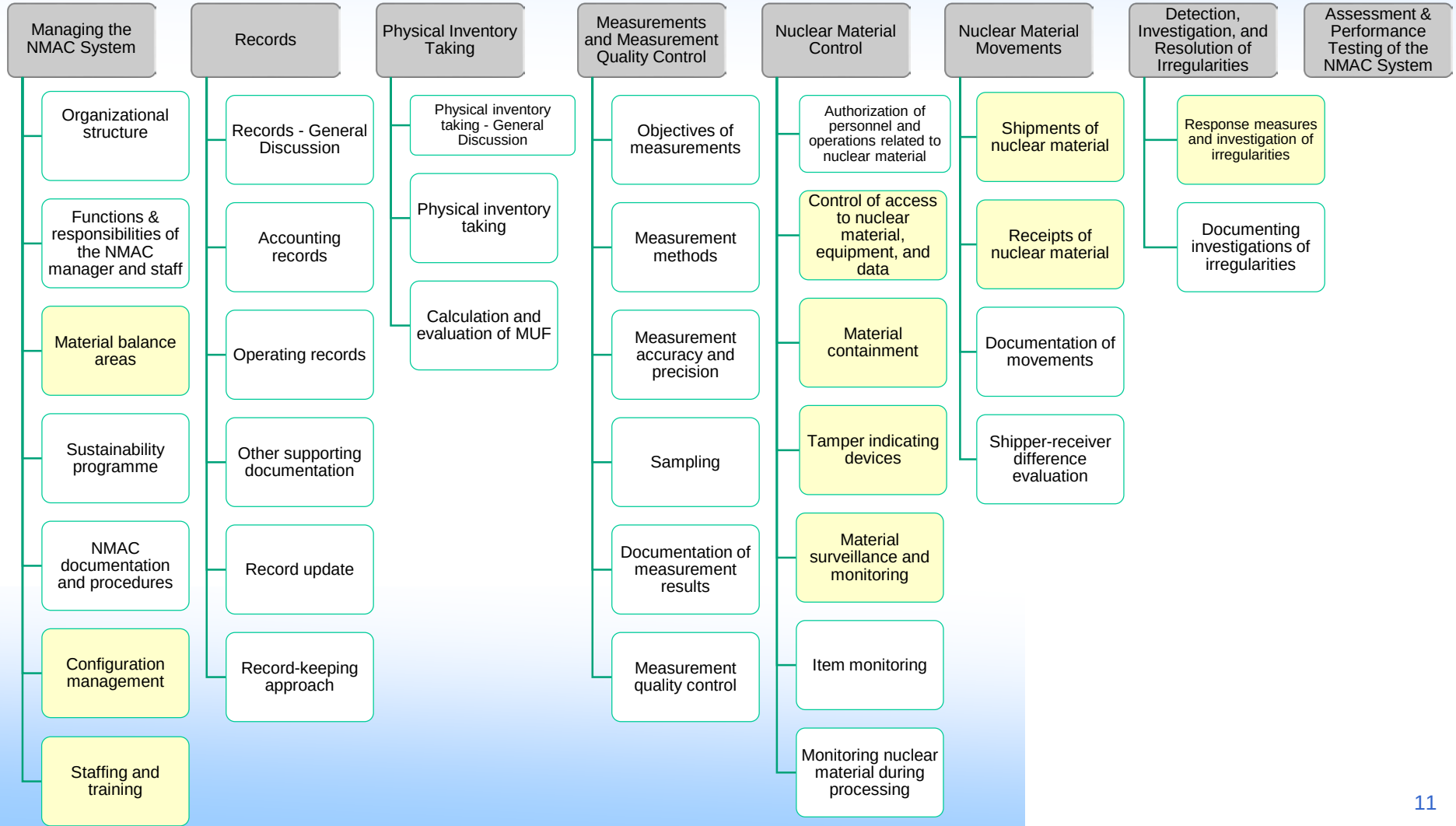
  Probably—through visual observance, RPMs, and other physical protection or safety alarms.

Can the physical protection system tell what was stolen?

- No—only the NMAC accounting system can do that

Source: IAEA

Overlap between NMAC and PP



Coordination between NMAC and Physical Protection

Because of the many overlaps between NMAC and Physical Protection careful coordination and well defined communications are required

Some examples of important areas include:

- Control of access to nuclear material – coordination between NMAC, Physical Protection, and Operations organizations determines who and when access to nuclear material is necessary and how it is authorized
- Contraband detection (x-ray, metal detectors) – some materials can be used to shield nuclear material from radiation detectors so that material needs to be designated as contraband as well as weapons or other items like USB drives
- Surveillance – some measures or equipment may be used by either NMAC or Physical Protection and the information provided needs to be communicated on a need-to-know basis
  - Cameras
  - Two-person rule

IAEA Safeguards and Facility Nuclear Security

IAEA 60 Years Atoms for Peace and Development

Safeguards

Detect a State's clandestine nuclear weapons program

- Verify correctness of a State's declaration to provide meaningful assurance of non-diversion of declared nuclear material

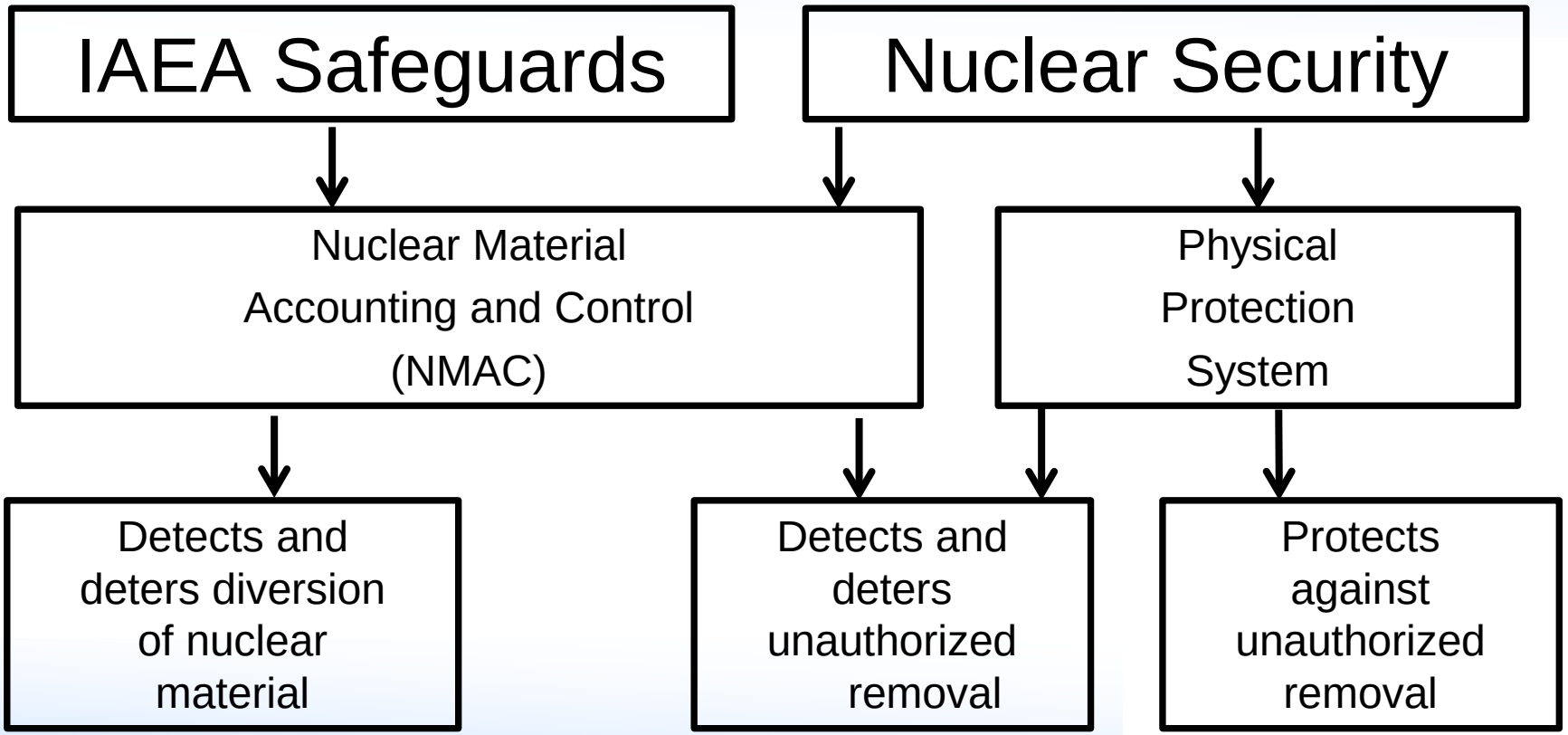
Nuclear security

- Nuclear security

Prevent and/or detect attempts to steal nuclear material by a terrorist or criminal Insider

- Protect against non-State Actors (criminal, terrorist, etc.)

Safeguards & Nuclear Security Both Use NMAC



Why NMAC Accounting Is So Important

A facility licensee must know what materials they have in order to:

- Design effective physical protection (security) systems
- Track, ship and receive nuclear materials
- Assist in the identification and recovery of stolen material
  - Is the material in bulk or an item?
  - What form is it?
  - Is it easily transportable?
  - What is its mass and isotopic composition?
  - How was it measured and what is the error?

Source: IAEA

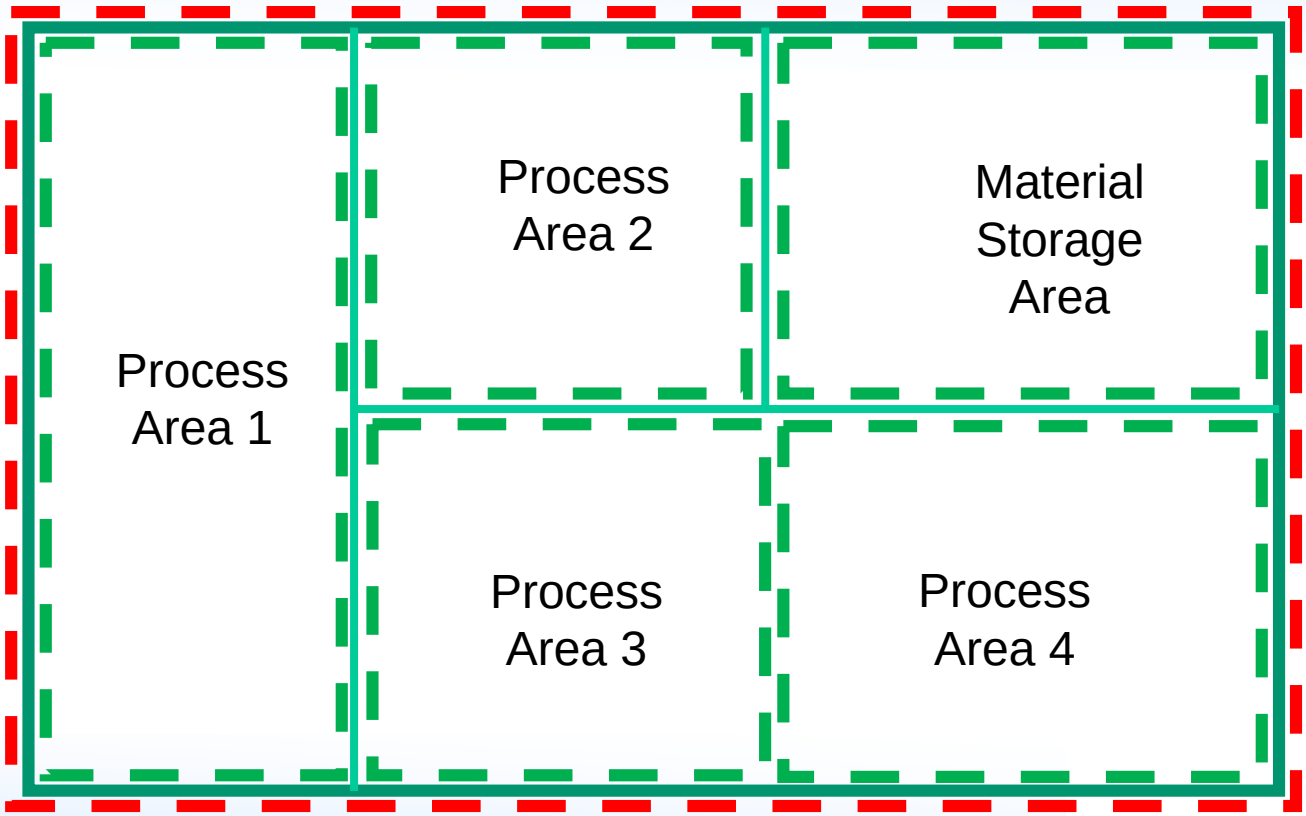
NMAC Uses
Material Balance Areas (MBA)

An MBA is a designated area in a nuclear facility that facilitates accounting for material

- The quantity of nuclear material during each movement into or out of an MBA can be determined
- A physical inventory of nuclear material in each MBA is conducted periodically to establish the quantity of nuclear material in MBA and material balance

For security use and to enhance control, an MBA is typically smaller than those used in Safeguards

Nuclear Security vs. Safeguards MBAs



Material Balance Equations – General Theory

Material inventories and flows must “conserve mass”

Material Balance Equation:

- MB = Begin Inventory – End Inventory + Input Transfers – Output Transfers
- MB is sometimes referred to as

  Inventory Difference (ID)

  Material Unaccounted For (MUF)

Why is MUF important?

MUF is the difference between the amount of material that should be in the MBA based on the accounting records and the amount that is actually there as established by the Physical Inventory Taking (PIT)

MUF should be zero, but it could be positive or negative.

A non-zero MUF must be investigated to determine why it is not zero.

A non-zero MUF could be the first indication of unauthorized removal by an insider adversary

For a unscheduled PIT completed as a result of an alarm condition the results of the MUF calculation provides information on whether an unauthorized removal was completed

IAEA Use of Term "MUF"

IAEA uses the term MUF when discussing the Material Balance Equation and slightly different terms:

$$MUF = PB + X - Y - PE$$

Where

PB = beginning physical inventory

X = increases

Y = decreases

PE = ending physical inventory

Calculation of MUF is explained in more detail in section 5.5 of the IAEA's Nuclear Material Accounting Handbook, IAEA Services Series No. 15

Process Hold-up

Process Hold-up is a term used to describe the accumulation of nuclear material inside processing equipment

- Nuclear material accumulates in cracks, pores, and regions of poor circulation within equipment
- Pipes, tanks, ducts, furnaces, gloveboxes all can have hold-up

Hold-up must be accounted for in order to determine if material has been stolen since it will look like material is missing

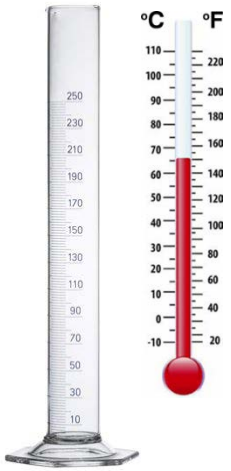
Even after equipment is cleaned out, it may still be necessary to measure hold-up using non-destructive assay equipment

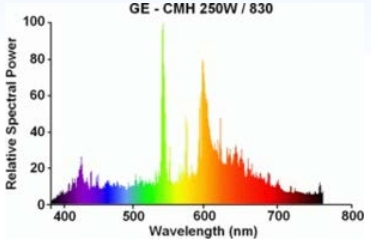
Source: LANL

Examples of Nuclear Materials Measurement Techniques

Physical Techniques

- Weight
- Volume
- Heat
- Elemental Light Emission



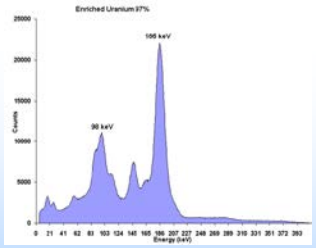


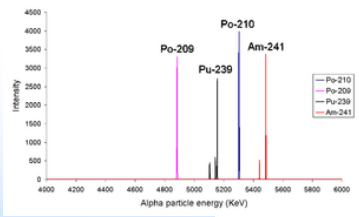
DA

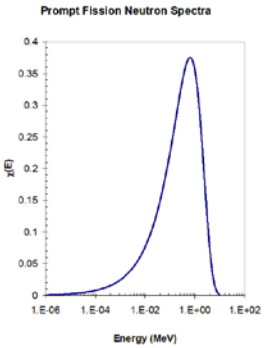
NDA

Nuclear Techniques

- Gamma rays
- Alpha particles
- Neutrons







Source: IAEA

Destructive Assay Analytical Techniques

Provide

- Very accurate measurements
  Often used to look for trickle diversion
- Measurement standards
- Assurance about quality & independence of on-site measurements
- Periodic verification of operator measurement systems
- Trace element analysis

Ignition-Gravimetry

Automatic Titrator

Thermal Ionization Mass Spectrometer

Source: IAEA

Non-Destructive Assay

Benefits

- Measures quantity or specific attribute(s) of nuclear *without* physically affecting the measured item
- Cost effective
- Can often be applied where DA is not possible
- Fast, efficient way to obtain results in field
- Has many applications in fuel cycle facilities for verifying the operator's material declaration

Source: IAEA

Why Is Nuclear Material Control so Important?

Maintain continuity of knowledge about nuclear material properties, including their location
Control who has access to the materials
Help detect any unauthorized handling or movements
Identify irregularities that may have occurred

Source: IAEA

Examples of Material Control

Two-person rule

Material containment

Material surveillance

Item monitoring

Monitoring material undergoing processing

Tamper indicating devices

Administrative checks

Authorization of activities

- Compartmentalization
- Tie downs
- Dual locks and key combination control
- Radiation portal monitors
- Handheld monitoring (for rad/metal)
- Material access control

Access to Nuclear Material

Physical protection system normally controls access to

- Facility
- Protected areas
- Buildings

Employees are authorized to access these areas

- An employee can be considered as a potential insider

NMAC and physical protection system are intended to control access to nuclear material by insiders

Material Containment

Purpose of material containment is deterring and detecting any actions that could lead to its unauthorized removal or misuse

Material containment can be provided by

- Structural features of a facility, containers, or equipment used to establish the physical integrity of an area or items
- Examples include vaults, storage containers, storage pools etc.

Material containment is most effective when used with material surveillance

Source: BBC.co.uk

Source:Internationalvault.com

Material Surveillance

Material surveillance is intended to detect the unauthorized access to or movement of nuclear material

Methods of surveillance include:

- Administrative measures
- Technological measures

Note

- This training course discusses material surveillance measures implemented by the Operator as part of its nuclear security program
- It does not address material surveillance measures implemented for the purposes of IAEA Safeguards

Tamper Indicating Devices (TID)

Have a unique identifier

Are applied to objects for the purpose of detecting unauthorized access

- Do *not* protect the physical integrity of the object
- Are designed to indicate that access has occurred

Source: IAEA

Monitoring Nuclear Material Items

IAEA 60 Years Atoms for Peace and Development

Nuclear material item

- Discrete container of nuclear material
- Discrete piece of nuclear material

Information verified during monitoring includes

- Integrity
- Location
- Identification

Items of nuclear material should be monitored between scheduled physical inventories

Source: IAEA

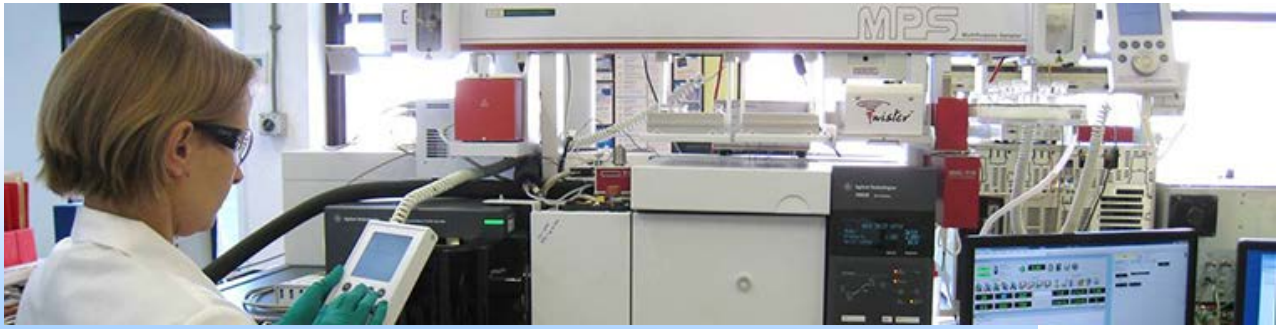
Monitoring Nuclear Material during Processing

Control of nuclear material should be maintained during processing

Monitoring during processing

- Generally a statistic evaluation of the input and output of the process to detect any unauthorized removal
- Can be implemented around a single process unit or processing line

Source: GrandHavebtribune.com



Source: Intertek.com

Physical Inventory Taking (PIT)

Nuclear facilities conduct periodic physical inventories

All nuclear material should

- Be measured at the time of physical inventory, or
- Have a prior measurement whose integrity is assured

Physical inventory is compared to accounting book inventory

Physical inventory

- Confirms the presence of nuclear material
- Accuracy of the book inventory
- Provides evidence the facility accounting system is effective

Source: IAEA

Movements of Nuclear Material

Nuclear material is particularly vulnerable during movements

Movements include:

- Shipments and receipts between facilities
- Transfers within a facility between MBAs
- Relocations within an MBA

Source: IAEA

What is an Irregularity?

NSS 25-G definition:

- An unusual observable condition which might result from unauthorized removal of nuclear material, or which restricts the ability of the facility operator to draw the conclusion that unauthorized removal has not occurred.

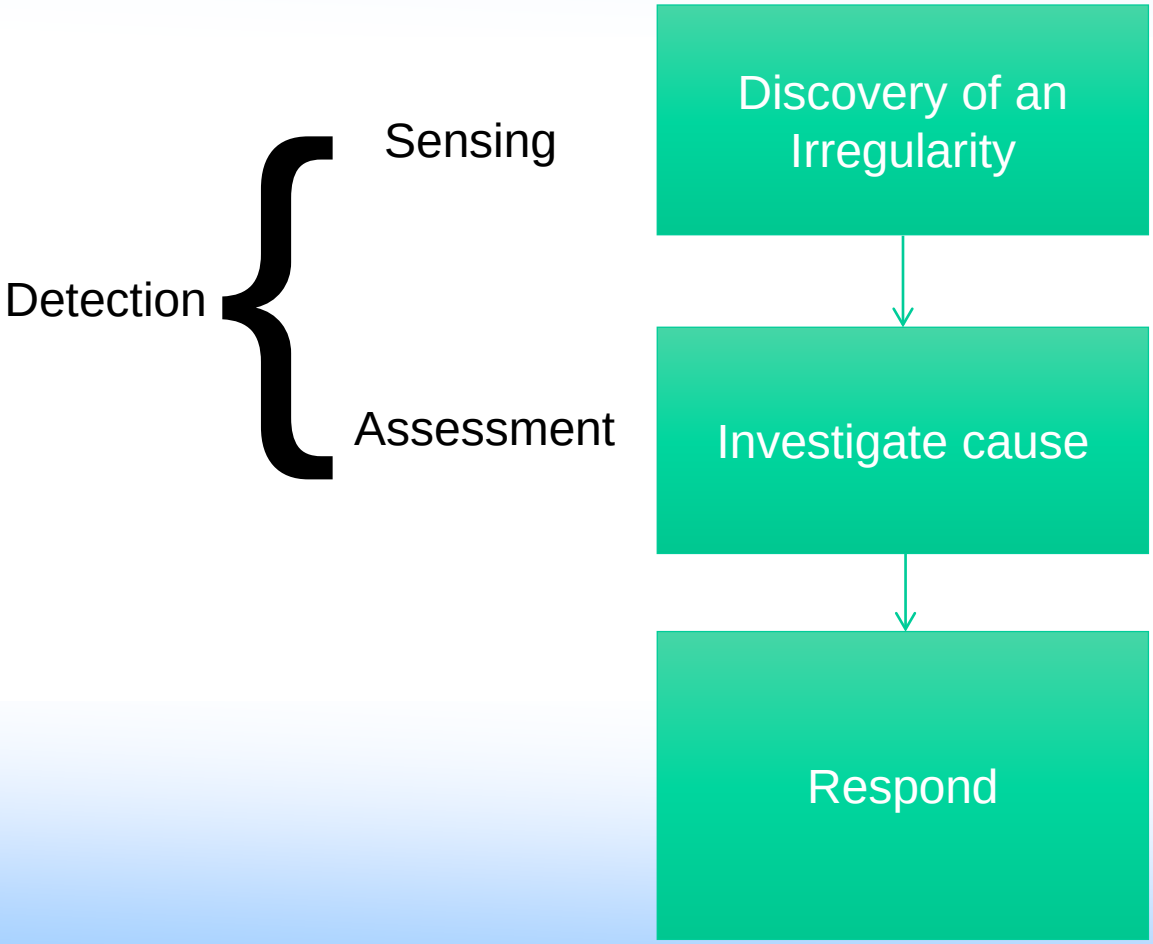
Essentially, an irregularity “triggers” an investigation

- For nuclear security, the investigation may determine if the irregularity was caused by malicious insider activity

Source: homeguides.sfgatecdn.com

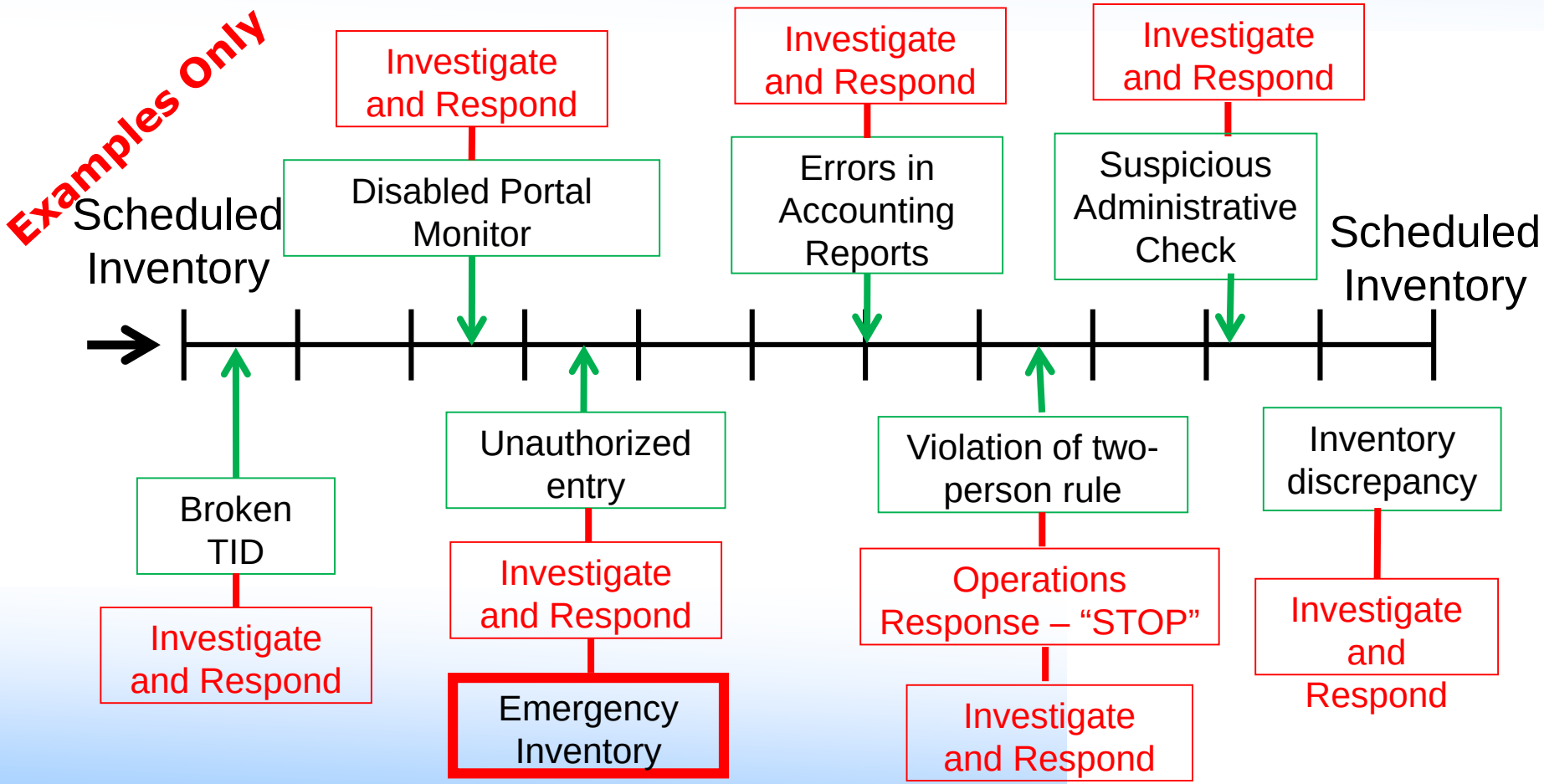
In construction industry, small irregularities might provide an indication of a much larger problem. For example, these micro cracks in concrete might lead to a bigger problem

NMAC Irregularities Require an Investigation and Response



- The discovery of an irregularity by the NMAC System requires an investigation to determine the appropriate response
- Examples of controls that lead to the discovery of an irregularity (which might be “sensed” by the NMAC System) are provided on the next slide

Detection of Irregularities Shortens Detection Time of an Insider Action



Examples of Irregularities

- Container of nuclear material not in the assigned location
- Difference between the documented shipping weight and the measured receiving weight
- Facility area was accessed without authorization
- Broken TID or seal
- Failure to fill in log books
- Violation of the two-person rule

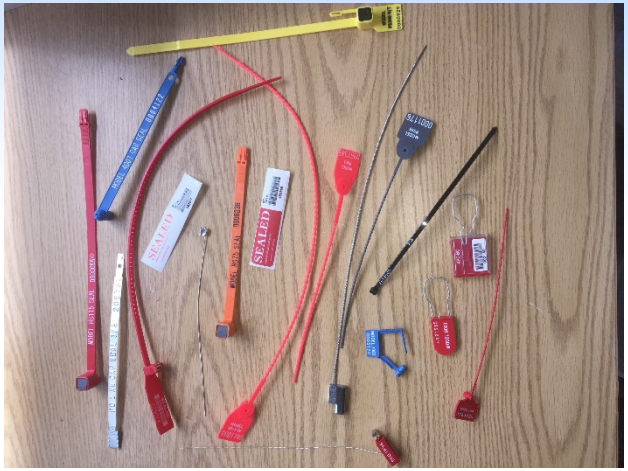
Source: barbarno.com

TID Irregularities

IAEA 60 Years Atoms for Peace and Development

Types of TID irregularities

- Broken
- Missing
- Shows signs of being tampered with
- Does not match the recorded identity



Source: LANL

Possible actions

- Measure nuclear material in the container or object with the affected TID

  Notify Security

  Conduct PIT if nuclear material is missing

- Consider all possible causes including accidental (broken during handling or movement) and malicious actions (unauthorized removal by an insider adversary)

Monitoring Irregularities

An irregularity would include a nuclear material item not in its recorded location

Possible actions to respond

- Conduct a search of the area adjacent to the location where the nuclear material item should be

  Review the operations and accounting records for any movements of the item that were not accurately recorded

  Notify security personnel if the item is not quickly located

- Initiate an emergency PIT in MBA or location where the irregularity was discovered

  Expand to the entire facility if the item is not located

Shipping / Receiving Irregularities

An irregularity is a difference between the shipper and receiver difference that exceeds the established criteria

Possible actions

- Isolate the shipment

  Evaluate and recalibrate (if necessary) the measurement equipment

  Check for other indications of unauthorized removal

  Re-measure nuclear material items and re-check uncertainties from shipper and receiver (possibly by different organization to ensure no conflict of interest)

  Interview receiving facility personnel; shipping facility and transport personnel

    Confirm adherence to required procedures including the two-person rule if applicable

Investigation of Irregularities

Formal, documented process per facility procedure

Critical irregularities

- For example, nuclear material missing from its assigned location
- Require immediate investigation and response

Others

- For example, item in incorrect location may not appear critical initially
- Carefully investigate and treat as if irregularity indicates malicious insider activity and unauthorized removal of material

Area and all nuclear material associated with possible irregularity should be isolated or protected until investigation is complete, if possible

Corrective Actions

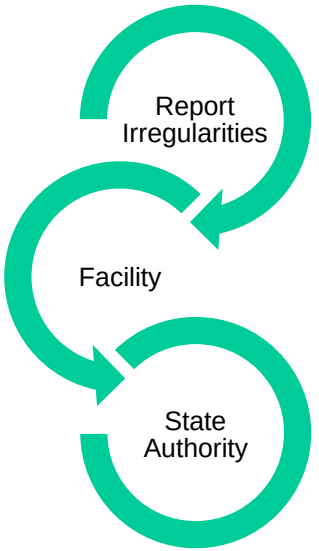
Address and mitigate all contributory factors and causes identified

- Develop and implement a corrective action plan to address root cause
- Actions taken to correct an irregularity depend on type and severity of irregularity
- Facility procedures should identify level of management responsible for final correction of investigation and, where appropriate, required notification to the Competent Authority
- Conduct follow-up evaluation to ensure actions taken to correct root cause are effective
- Monitor irregularities to identify trends that could be indicative of insider attempts at unauthorized removal of nuclear material

Reporting

Procedures for reporting irregularities should be developed before they are needed

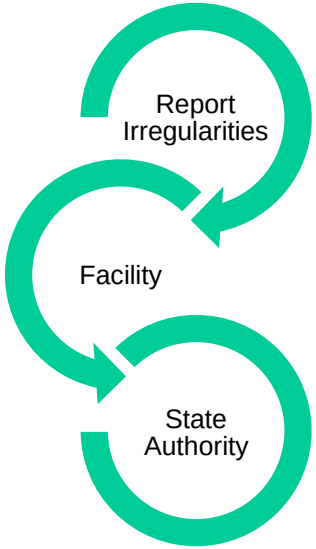
- All irregularities should be reported to facility management and to Competent Authority, if required
- If nuclear material is determined to be missing, the facility contingency and/or emergency plan should be initiated
- Discovery of an irregularity, investigation of the irregularity, and measures taken to correct the irregularity should be documented



Reporting (continued)

Competent Authority

- Establishes requirements for content of report
- For example, description of irregularity, date/time, steps taken to investigate, corrective actions, and steps taken to prevent recurrence



Key Takeaways

NMAC helps track and manage a facility's nuclear material holdings, providing valuable information in an investigation

- Types and quantities of nuclear material
- Specific locations

NMAC measures can serve as detection triggers

- Initiate prompt investigation and resolution of irregularities involving nuclear material, reducing time in detecting insider activity
- Serve as deterrent to insider theft because of increased likelihood of detection