

***Security of radioactive sources.
Implementing the Code of Conduct
and the Export/Import guidance.***

Refresher Course RC-4
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- Security of radioactive sources
- Categorization of radioactive sources
- The Code of Conduct
- Loss of control over the sources
- Security of Radioactive Sources

Security of radioactive sources

Measures to prevent unauthorized access or damage to, and loss, theft or unauthorized transfer of, radioactive sources

Security Culture

Means characteristics and attitudes in organizations and of individuals which establish that security issues receive the attention warranted by their significance

Main Believes

- Credible threat exists;
- Nuclear security is important.



Radioactive source

A ***radioactive source*** means:

- radioactive material that is permanently sealed in a capsule or closely bonded, in a solid form
- includes any radioactive material released if the radioactive source is leaking or broken
- does not include material encapsulated for disposal, or nuclear material within the nuclear fuel cycles of research and power reactors.

Uses of radioactive sources (I)



Irradiators	Used to sterilize food, cosmetics, medical products and supplies, and for other specialized applications such as research applications or for blood irradiation.	cobalt-60	56 to 560,000
		caesium-137	37 to 190,000
Teletherapy	Used for cancer therapy and are commonly found in medical institutions, such as hospitals or clinics.	cobalt-60	37 to 560
		caesium-137	19 to 56
Fixed multi-beam teletherapy	Used to focus gamma radiation from an array of over 200 sources on brain lesions (gamma knife). These are commonly found in hospitals or clinics.	cobalt-60	150 to 370

Uses of radioactive sources (II)

Industrial radiography	Used to test the integrity of various materials, as well as for testing welds in pipes and tanks in the petrochemical industry.	Cobalt-60	0.41 to 7.4
		Iridium-192	0.19 to 7.4
		Selenium-75	3
		Ytterbium-169	0.093 to 0.37
		Thulium-170	0.74 to 7.4
High/medium dose rate brachytherapy	Used for cancer therapy and are commonly found in medical institutions, such as hospitals or clinics.	Cobalt-60	0.19 to 0.74
		Caesium-137	0.11 to 0.3
		Iridium-192	0.11 to 0.44

Uses of radioactive sources (III)

Fixed industrial gauges	Used for process control; for measurement of flow, volume, density, or material presence; and may be placed in locations unsuitable for continuous human presence	cobalt-60	0.0037 to 0.37
		caesium-137	0.00011 to 1.5
		californium-252	0.0014
Well logging gauges	Used in areas where exploration for minerals is occurring, such as coal, oil, natural gas	americium-241/beryllium	0.019 to 0.85
		caesium-137	0.037 to 0.074
		californium-252	0.001 to 0.0041

Dangerous source

- Radioactive source “that could, if not under control, give rise to exposure sufficient to cause severe deterministic effects”
- “Severe deterministic effects”
 - “fatal or life threatening or results in a permanent injury that decreases the quality of life”

IAEA Sources Categorization

- simple and logical method for ranking radioactive sources in terms of their potential to cause harm to human health, and for grouping sources and the practices in which they are used into discrete categories.

IAEA Sources Categorization

- Developing or refining national regulatory infrastructures;
- Developing national strategies for improving control over radioactive sources;
- Optimizing decisions about the priorities for regulation within resource constraints;
- ***Optimizing security measures for radioactive sources, including measures directed against their possible malicious misuse;***
- Emergency planning and response.

IAEA Safety Standards

for protecting people and the environment

Categorization of Radioactive Sources

Safety Guide

No. RS-G-1.9



Categories of radioactive sources

Category	Exposure to individual source	Exposure due to source dispersion	
		By Air Risk Area	In Water
1	Extremely dangerous to the person	$\emptyset \approx 1\text{km}$	Unlikely
2	Very dangerous to the person	$\emptyset \approx \text{Hm}$	No immediate risk
3	Dangerous to the person	$\emptyset \approx \text{m}$	Virtually impossible
4	Unlikely to be dangerous to the person	Risk area $\emptyset \approx \text{m}$	No risk
5	Most unlikely to be dangerous to the person	No risk	No risk

Basis of Categorization in Safety Guide

- Based on the potential for sources to cause harm to human health
- Determined in the first by the "Activity Ratio," A/D , where:
 - A = the activity of a source material in a given practice
 - D = the value which will yield pre-defined (deterministic) dose consequences

Summary Table

Category	Activity Ratio (A/D)
1	$A/D \geq 1000$
2	$1000 > A/D \geq 10$
3	$10 > A/D \geq 1$
4	$1 > A/D \geq 0.01$
5	$0.01 > A/D \geq \text{Exempt/D}$

Categorization Method

- A/D ratios are calculated for radionuclides in a variety of practices
- The assignment of radionuclides to categories is further refined based on other factors, such as:
 - physical and chemical form
 - source shielding
 - circumstances of source use
 - accident case histories

Summary Table

Category	Source and practice	Activity Ratio
1	Radioisotope thermoelectric generators (RTGs) Irradiators Teletherapy sources Fixed, multi-beam teletherapy (gamma knife) sources	A/D 1000
2	Industrial gamma radiography sources High/medium dose rate brachytherapy sources	1000 > A/D 10
3	Fixed industrial gauges that incorporate high activity sources Well logging gauges	10 > A/D ≥ 1
4	Low dose rate brachytherapy sources (except eye plaques and permanent implants) Industrial gauges that do not incorporate high activity sources Bone densitometers Static eliminators	1 > A/D 0.01
5	Low dose rate brachytherapy eye plaques and permanent implant sources X ray fluorescence (XRF) devices Electron capture devices Mossbauer spectrometry sources Positron emission tomography (PET) check sources	0.01 > A/D ≥ Exempt/D

Aggregate Sources

- Multiple sources in close proximity in a single storage or use location
- If sources with a single radionuclide are aggregated, sum the total activity, A , and divide by D to calculate the A/D Ratio
- If sources with several radionuclides are aggregated, use the following formula:

$$\text{Aggregate A/D} = \sum_n \frac{\sum_i A_{i,n}}{D_n}$$

Where:

$A_{i,n}$ = Activity of Each Individual Source, i , of Radionuclide, n

D_n = D Value for Each Radionuclide, n

Code of Conduct on Safety and Security of Radioactive Sources

- approved by the Board of Governors of the International Atomic Energy Agency (IAEA) on 8 September 2003.
- It replaces the version published by the IAEA in March 2001

Code of Conduct Scope

- Category 1, 2 and 3 radioactive sources
- Nuclear Material Excluded
 - Except radioactive sources including Pu-239
- State may wish establish regulatory control over radioactive sources within categories 4 and 5

Code of Conduct on Safety and Security of Radioactive Sources

- Not legal binding document
- On 19 September 2003, the General Conference, urged each State to write to the Director General stating:
 - it fully supports and endorses the IAEA's efforts to enhance the safety and security of radioactive sources; and
 - it is working towards following the guidance contained in the revised Code.

Code of Conduct Status

- More than 80 States have stated their political commitment with the Code
- Presently status could be checked at

http://www.iaea.org/Publications/Documents/Treaties/codeconduct_status.pdf

Code of Conduct Objectives

- achieve and maintain a high level of safety and security of radioactive sources;
- prevent unauthorized access or damage to, and loss, theft or unauthorized transfer of, radioactive sources, so as to reduce the likelihood of accidental harmful exposure to such sources or the malicious use of such sources to cause harm to individuals, society or the environment; and
- mitigate or minimize the radiological consequences of any accident or malicious act involving a radioactive source.

Code of Conduct

Achievement of the Objectives

- objectives should be achieved through the establishment of
 - an adequate system of regulatory control, applicable from the stage of initial production to final disposal, and
 - a system for the restoration of such control if it has been lost.

General Principles

- Safe and secure management of radioactive sources.
- Effective national legislative and regulatory system
- Appropriate facilities and services
- Training
- National Register of radioactive sources
- Early notification of significant incidents
- Prevention of orphan sources risks
- Recycling of used sources
- Responsibilities of the licensees
- Threat and vulnerability assessments
- Protection of confidentiality of sensible information

Legislation and regulation

CODE OF CONDUCT ON
THE SAFETY AND SECURITY OF
RADIOACTIVE SOURCES

放射源安全和保安行为准则

CODE DE CONDUITE SUR
LA SÛRETÉ ET LA SÉCURITÉ
DES SOURCES RADIOACTIVES

КОДЕКС ПОВЕДЕНИЯ ПО
ОБЕСПЕЧЕНИЮ БЕЗОПАСНОСТИ И
СОХРАННОСТИ РАДИОАКТИВНЫХ
ИСТОЧНИКОВ

CÓDIGO DE CONDUCTA
SOBRE SEGURIDAD TECNOLÓGICA
Y FÍSICA DE LAS FUENTES
RADIATIVAS

مدونة قواعد السلوك بشأن أمان المصادر
المشعة وأمنها



IAEA
International Atomic Energy Agency

- Governmental responsibilities
- Effective control
- protection against exposure to ionizing radiation
- specify the requirements for the safety and security

Regulatory Body

- Independence, Power and Authority
- Resources
- Performance



Import / Export Principles

- Radioactive sources in Categories 1 and 2
- transfers are undertaken in a manner consistent with the provisions of the Code
- prior notification
- Import authorization
- Export authorization
- Exceptional Circumstances
- Re-entry of disused sources
- Transit or transshipment through the territory of a State

Security responsibilities distribution, State (I)

- State
 - prescribes and assigns **governmental responsibilities** to relevant bodies including an independent regulatory body to assure the security of radioactive sources;
 - establishes **security requirements** for radioactive sources and includes a **system of evaluation and licensing** or other procedures to grant authorizations;

Security responsibilities distribution, State (II)

- State
 - places the **prime responsibility** for the security of radioactive sources **on the persons being granted the relevant authorizations;**
 - provides for **measures to reduce the likelihood of the attempt** of malicious acts;

Security responsibilities distribution, State (III)

- State
 - establishes ***punishable offences*** covering malicious acts involving radioactive sources;
 - ***mitigates or minimizes*** the consequences of malicious acts involving radioactive sources.

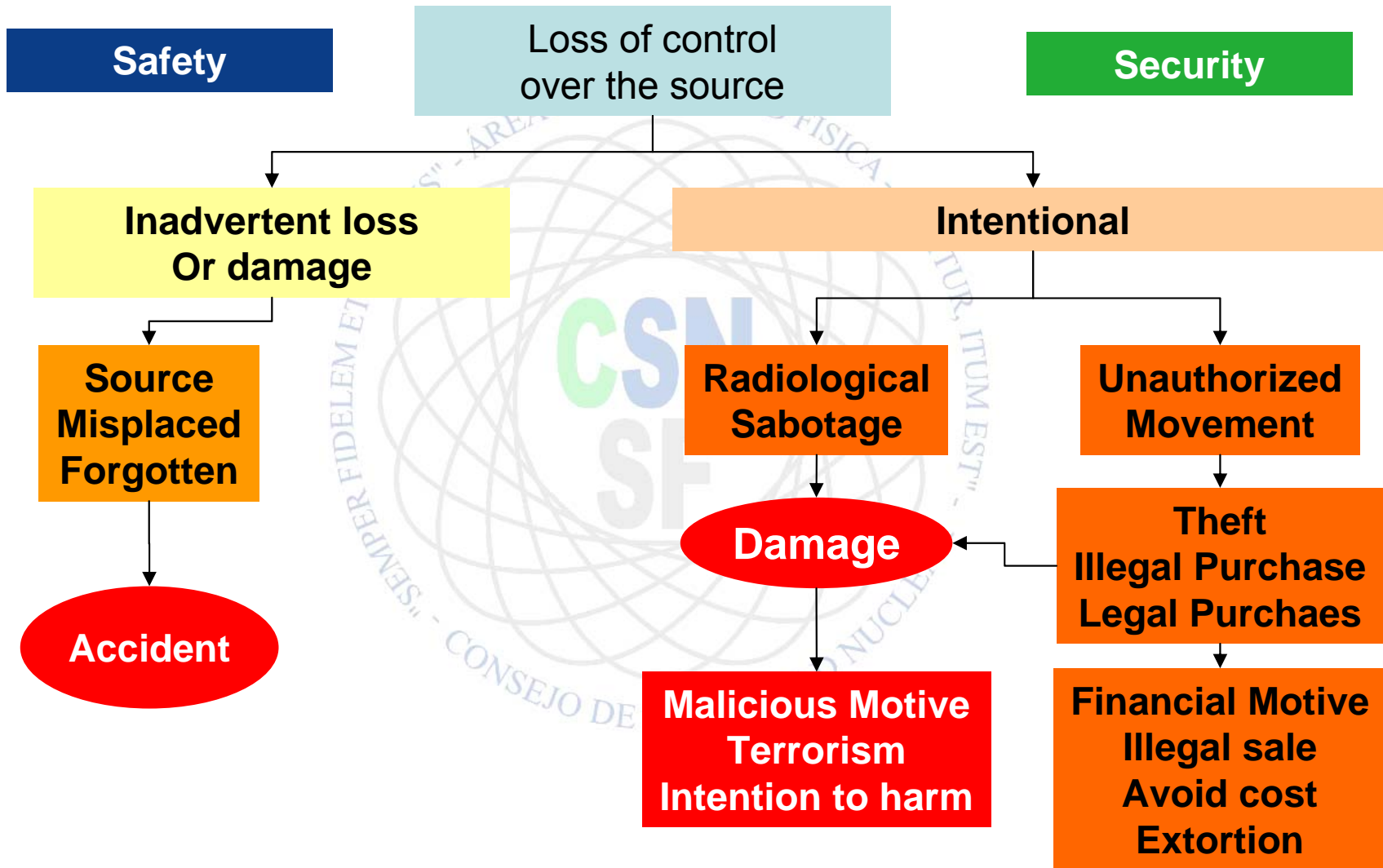
Security responsibilities distribution, Licensees (I)

- have the **prime responsibility** for implementing and maintaining security measures for their authorized radioactive sources in accordance with national requirements.
- should ensure that their personnel and their contractors are **suitably trained** and meet the requirements for trustworthiness set by the regulatory body.

Security responsibilities distribution, Licensees (I)

- *should ensure that the **presence of sources is verified at the prescribed intervals**, and that any **discrepancies are promptly investigated and reported** to the regulatory body. Processes should be in place to ensure that, where practicable, all Category 1 and 2 sources for which they are authorized are identifiable and traceable.*
- *should **promote a security culture**, and establish a management system commensurate with the levels of security, to ensure that:*

Loss of control of radioactive sources



Illicit acts involving nuclear or radioactive materials



Criminal
Aims

Radiological sabotage

Radioactive facilities

Transportation

Terrorist attack

Radiological Dispersion Devices (RDD)

Radiological Exposure Device (RED)

Illicit trafficking

Radioactive material theft

Radioactive material smuggling

Radioactive material illegal purchase...

Innocent
Aims

Inadvertent movement

Loss

Abandon

Accident

...

Prevention of Malevolent Acts

- Physical protection of radioactive sources
- Recovery of orphan sources and strengthening of control over vulnerable sources
- Prevention of Illicit Trafficking
- Emergency preparedness and respond to minimize or mitigate consequences of malevolent acts.

Physical protection of radioactive sources – Basic Concepts

- Target
- Threat
- Required level of security



Physical protection of radioactive sources – Basic Concepts - Target

- Attractiveness of the sources
- Consequences of the loss of control



Physical protection of radioactive sources – Basic Concepts - Threat

- National threat assessment
- Attributes and characteristics of adversaries who could attempt malevolent acts
- Motivation, intentions and capabilities
- National Community of Intelligence with other agencies and departments

Physical protection of radioactive sources – Basic Concepts - Threat

- Design Basis Threat
 - Regulatory tool
 - Design of physical protection systems
 - Evaluation and upgrade of existing physical protection systems
 - Requirements on the performance of physical protection system

Required security level

Graded approach

- the highest consequence sources should receive the greatest degree of security
 - the current evaluation of the threat,
 - the relative attractiveness of a radioactive source,
 - the nature of the radioactive source and
 - potential consequences associated with the unauthorized removal of and sabotage against

Security functions (I)

- ***Deterrence***
 - an adversary is dissuaded from undertaking the attempt.
- ***Detection***
 - the discovery of an attempted or actual intrusion which could have the objective of theft or sabotage of a radioactive source.
- ***Delay***
 - impedes an adversary's attempt to gain unauthorized access or to remove or sabotage a radioactive source

Security functions (II)

- ***Response***
 - the actions undertaken following detection to prevent an adversary from succeeding or to mitigate potentially severe consequences.
- ***Security management***
 - the development of procedures, policies, records, and plans for the security of radioactive sources

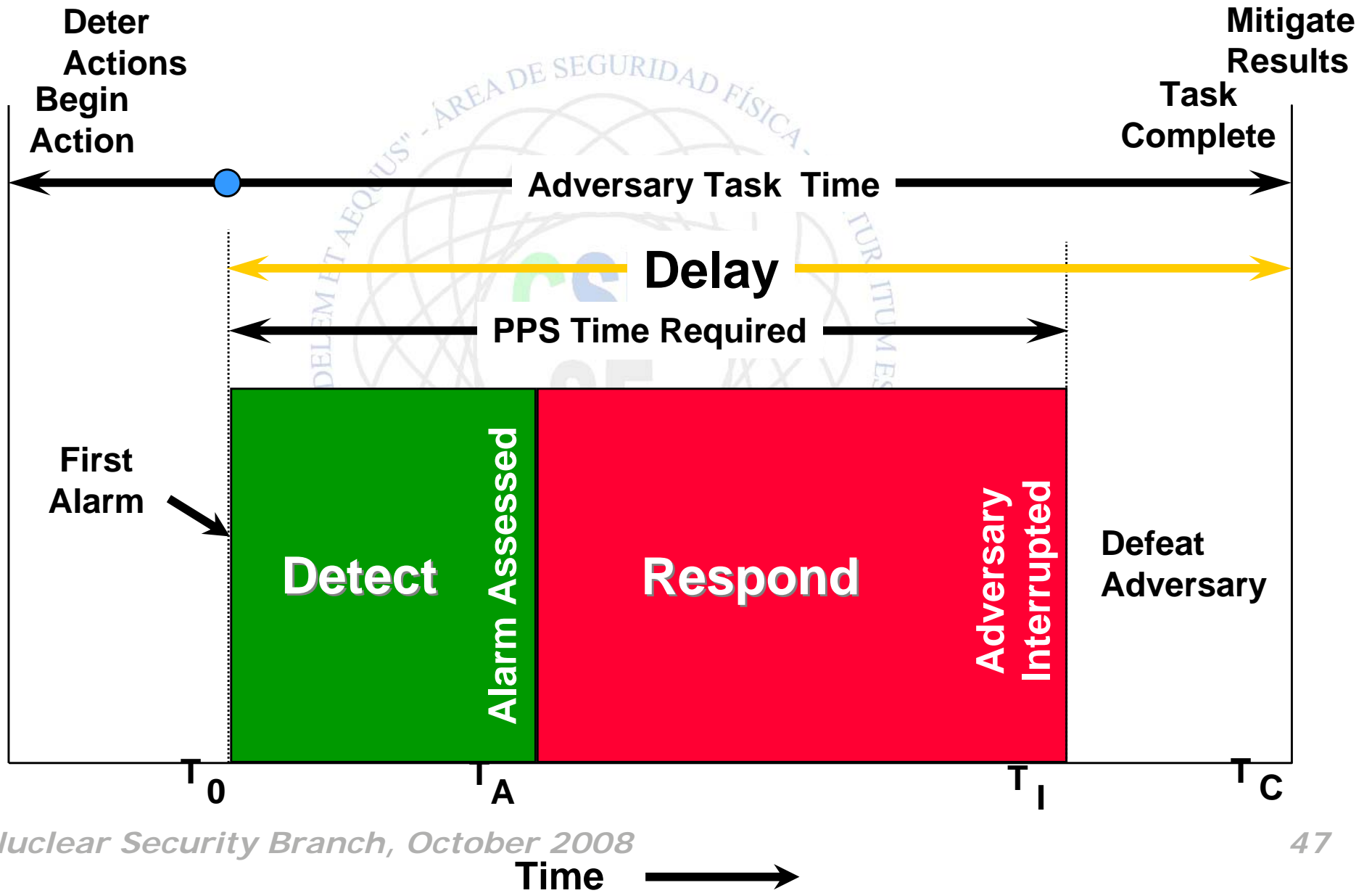
Security functions (II)

- ***Response***
 - the actions undertaken following detection to prevent an adversary from succeeding or to mitigate potentially severe consequences.
- ***Security management***
 - the development of procedures, policies, records, and plans for the security of radioactive sources

Design and evaluation principles

- Deterrence
- Detection before delay
- Detection requires assessment
- Delay greater than assessment plus response time
- Balanced protection
- Defence in depth

The Principle of Timely Detection



Regulatory approach to establish security requirements

- Establish graded security levels with corresponding goals and objectives for each security level.
- Determine the security level applicable to a given source.
- Select and implement a regulatory approach.

graded security levels with associated goals and objectives

- Security level A
 - Prevent unauthorized removal of a source.
- Security level B
 - Minimize the likelihood of unauthorized removal of a source.
- Security level C
 - Reduce the likelihood of unauthorized removal of a source.

graded security levels with associated goals and objectives - Detect

Security Functions	Security Objectives		
	Security Level A <i>Goal: Prevent unauthorized removal</i>	Security Level B <i>Goal: Minimize likelihood of unauthorized removal</i>	Security Level C <i>Goal: Reduce likelihood of unauthorized removal</i>
Detect	Provide immediate detection of any unauthorized access to the secured area / source location	Provide immediate detection of any unauthorized access to the secured area / source location	
	Provide immediate detection of any attempted unauthorized removal of the source (e.g. an insider)	Provide detection of any attempted unauthorized removal of the source	Provide detection of unauthorized removal of the source
	Provide immediate assessment of detection	Provide immediate assessment of detection	Provide immediate assessment of detection
	Provide immediate communication to response personnel	Provide immediate communication to response personnel	
	Provide a means to detect loss through verification	Provide a means to detect loss through verification	Provide a means to detect loss through verification

graded security levels with associated goals and objectives Delay and Response

Security Functions	Security Objectives		
	Security Level A <i>Goal: Prevent unauthorized removal</i>	Security Level B <i>Goal: Minimize likelihood of unauthorized removal</i>	Security Level C <i>Goal: Reduce likelihood of unauthorized removal</i>
Delay	Provide delay after detection sufficient for response personnel to interrupt the unauthorized removal	Provide delay to minimize the likelihood of unauthorized removal	Impede the unauthorized removal
Response	Respond to assessed alarm in time and with sufficient resources to interrupt and prevent the unauthorized removal	Provide immediate initiation of response	Implement appropriate action in the event of unauthorized removal of a source

graded security levels with associated goals and objectives Security Management

Security Functions	Security Objectives		
	Security Level A <i>Goal: Prevent unauthorized removal</i>	Security Level B <i>Goal: Minimize likelihood of unauthorized removal</i>	Security Level C <i>Goal: Reduce likelihood of unauthorized removal</i>
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Response	Respond to assessed alarm in time and with sufficient resources to interrupt and prevent the unauthorized removal	Provide immediate initiation of response	Implement appropriate action in the event of unauthorized removal of a source

graded security levels with associated goals and objectives Security Management

Security Functions	Security Objectives		
	Security Level A <i>Goal: Prevent unauthorized removal</i>	Security Level B <i>Goal: Minimize likelihood of unauthorized removal</i>	Security Level C <i>Goal: Reduce likelihood of unauthorized removal</i>
Security Management	Provide access controls to source location that effectively restrict access to authorized persons only	Provide access controls to source location that effectively restrict access to authorized persons only	Provide access controls to source location that effectively restrict access to authorized persons only
	Ensure trustworthiness for individuals involved in the management of sources	Ensure trustworthiness for individuals involved in the management of sources	Ensure trustworthiness for individuals involved in the management of sources
	Identify and protect sensitive information	Identify and protect sensitive information	Identify and protect sensitive information
	Provide a security plan	Provide a security plan	Provide a security statement
	Ensure a capability to manage security events covered by security contingency plans	Ensure a capability to manage security events covered by security contingency plans	Ensure a capability to manage security events covered by security contingency plans
	Establish security event reporting system	Establish security event reporting system	Establish security event reporting system

Security levels & Categories of Sources

Security Level	Source and practices	Category
A	Radioisotope thermoelectric generators (RTGs) Irradiators Teletherapy sources Fixed multi-beam teletherapy (gamma knife) sources	1
B	Industrial gamma radiography sources High/medium dose rate brachytherapy sources	2
C	Fixed industrial gauges that incorporate high activity sources Well logging gauges	3
Apply measures as described in the <i>Basic Safety Standards</i> [5]	Low dose rate brachytherapy (except eye plaques and permanent implants) Industrial gauges that do not incorporate high activity sources (Typically portable) Bone densitometers Static eliminators	4
	Low dose rate brachytherapy eye plaques and permanent implant sources X ray fluorescence (XRF) devices Electron capture devices Mossbauer spectrometry sources Positron emission tomography (PET) check sources	5

Select and implement a regulatory approach.

- Prescriptive approach
- Performance-based approach
- Combined approach



Prescriptive approach

- appropriate combination of threat and potential consequences is low
 - simplicity in implementation for both regulatory body and operators
 - ease of inspection and auditing.
- relative lack of flexibility to address actual circumstances
 - an operator can be in compliance with prescribed measures, and yet not meet the aim of the security system

Performance-based approach

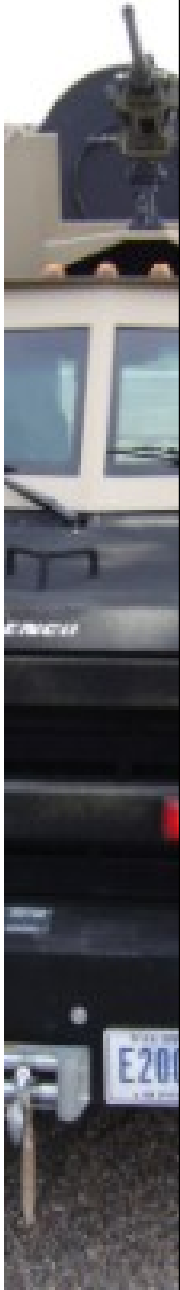
- an effective security system can be composed of many combinations of security measures,, that
 - each operator's circumstances can be unique.
- requires both the operator and the regulatory body to have relatively high levels of security expertise

Combined approach

- Flexibility.



Thank you very much for your attention



Key Principles on Security State (I)

- that the radioactive sources within its territory, or under its jurisdiction or control, are ***securely protected*** during their useful lives and at the end of their useful lives; and
- the ***promotion ... of security culture*** with respect to radioactive sources".
- ***prime responsibility for ... , the security of radioactive sources*** on the ***licensees***;
- ***measures to reduce the likelihood of malicious acts, including sabotage,***
- ***Mitigate or minimize the radiological consequences of accidents or malicious acts*** involving radioactive sources;"

Key Principles on Security - State (II)

- ***appropriate facilities and services for intervention in the event of a malicious act*** involving a radioactive source;
- establish a ***national register*** of radioactive sources. Categories 1 and 2. ***information contained should be appropriately protected*** .
- ***promote awareness*** of the safety and ***security hazards*** associated with orphan sources
- ***emphasize*** to licensees ***their responsibilities for (...)*** ***security of radioactive sources***.
- define ***its domestic threat, and assess its vulnerability with respect to this threat***

Key Principles on Security

- Legislation and regulation

- ***prescribe and assign governmental responsibilities to assure*** (...) and ***security*** of radioactive sources;
- ***specify the requirements for*** the safety and ***security of radioactive sources*** and of the devices in which sources are incorporated.
- ***requirements for security measures to deter, detect and delay the unauthorized access to, or the theft, loss or unauthorized use or removal of radioactive sources*** during all stages of management"
- ***requirements relating to the verification of*** the safety and ***security of radioactive sources, through*** safety and ***security assessments***, monitoring and verification of compliance, and the maintenance of appropriate records;

Key Principles on Security - Regulatory Body (I)

- ***promotes the establishment of a*** safety culture and of a ***security culture*** among all individuals and in all bodies involved in the management of radioactive sources.
- ***establishes systems for ensuring that, where practicable, radioactive sources are identifiable and traceable***, or where this is not practicable, ensures that in place; ***alternative processes for identifying and tracing those sources are***
- ensures that ***inventory controls are conducted*** on a regular basis by persons with authorizations;

Key Principles on Security - Regulatory Body (II)

- requires the ***prompt reporting*** by authorized persons of loss ***of control over***, and of incidents in connection with, ***radioactive sources***
- provides guidance on appropriate levels of ***information, instruction and training on*** the safety and ***security of radioactive sources to licensees***

Key Principles on Security - Regulatory Body (II)

- requires the ***prompt reporting*** by authorized persons of loss ***of control over***, and of incidents in connection with, ***radioactive sources***
- provides guidance on appropriate levels of ***information, instruction and training on*** the safety and ***security of radioactive sources to licensees***

Key Principles on Security - Regulatory Body (III)

- ***establish regulations and issue guidance*** relating to (...) ***security of radioactive sources***;
- require those who intend to manage radioactive sources to seek an authorization, and ***to submit***: (...); and (ii) ***a security plan or assessment*** as appropriate
- ***obtain any relevant and necessary information from a person with an authorization***, in particular ***if that is warranted by revised safety or security assessments***;

Key Principles on Security - Regulatory Body (IV)

- attach clear and unambiguous conditions to the authorizations issued by it, including conditions relating to:
 - minimum performance criteria and maintenance ***requirements for equipment and systems used to ensure the safety and security of radioactive sources;***
 - measures to determine, as appropriate, ***the trustworthiness of individuals involved in the management of radioactive sources;*** and
 - ***the confidentiality of information relating to the security of sources;***