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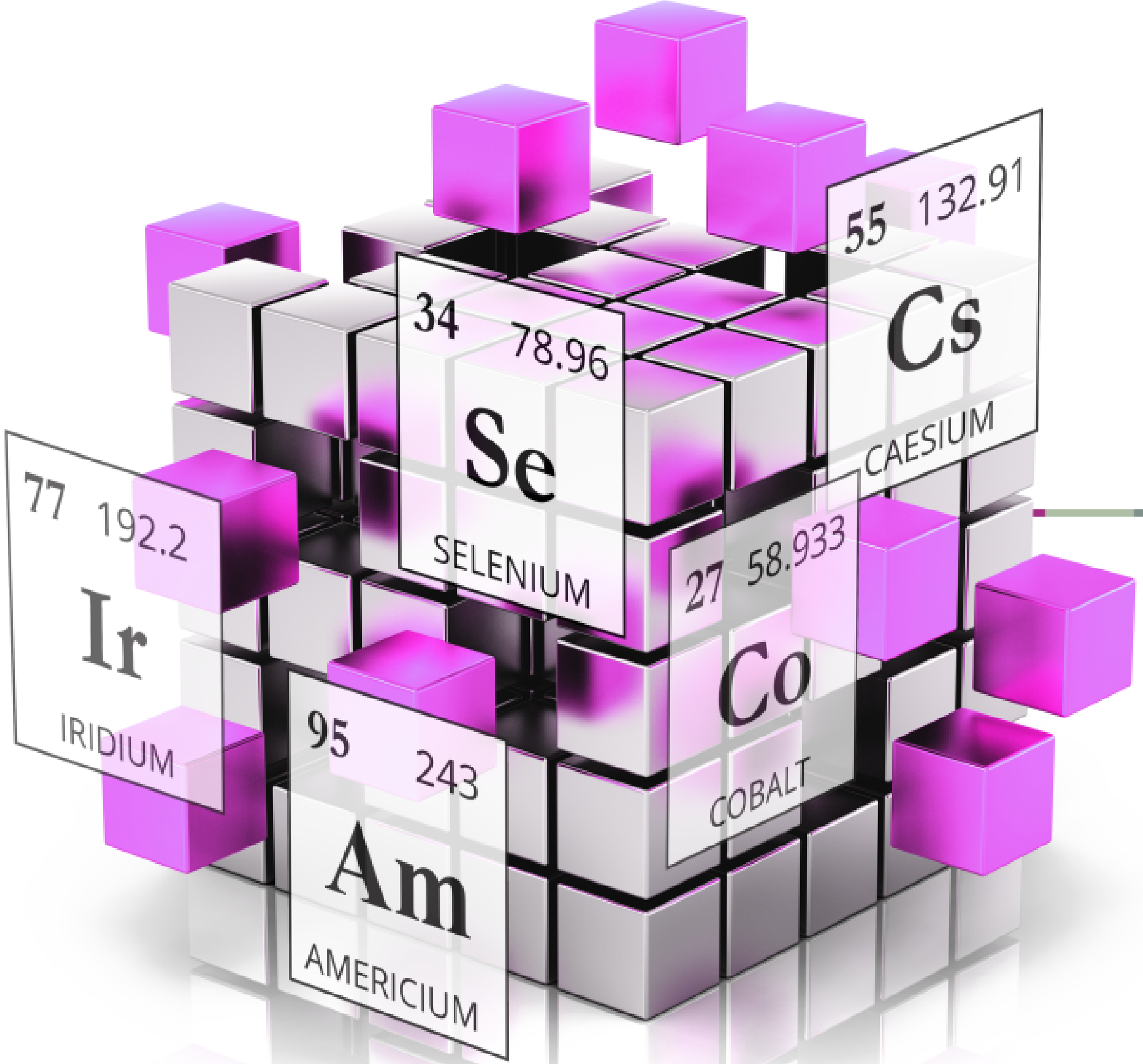

A Risk-Based Methodology for the Prioritization of Radioactive Sources

PRESENTED BY

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Why prioritize radionuclides?

Accidents

Reduce probability of large scale contaminations from stolen or discarded sources

Theft and Adversarial Use

Provide or require security systems and protocols for sources that might be used by an adversary in a radiological exposure device or radiation dispersal device

Meet or exceed regulatory intentions

Ensure the IAEA Code of Conduct requirements are met for the most important sources

The *downselect* process is a systematic approach that focuses on those sources with the most risk.

The following steps were taken to generate the final list of high-priority radionuclides:

1. List of All Possible Nuclides
2. Stable vs. Radioactive
3. Half-life Analysis (Short-Lived)
4. Specific Activity Analysis (Long-Lived)
5. Global Production
6. Applications/Use of Radionuclides
7. Categorization of Sources

The first two steps identify all identified radionuclides.

Step 1: List all nuclides

- Used LiveChart of Nuclides by the IAEA
- The initial list consisted of 3283 nuclides (through Z=118)

Step 2: Remove stable nuclides

- 245 stable nuclides were identified in the IAEA database
- Removed all non-radioactive nuclides and nuclides with unknown half-lives
- 3038 radionuclides left after this step

Step 3 eliminates those radionuclides with half-lives too short to result in significant consequences.

Approach:

Generated a histogram showing the number of radionuclides vs. half-life in single-day bins

2555 radionuclides have a half-life shorter than 1 day

Chosen Threshold/Limit:

All radionuclides with half-life shorter than 36 days were removed along with 104 nuclides with unknown half-life

- 1 year is 10 half-lives
- Unknown half-lives are typically too short to measure

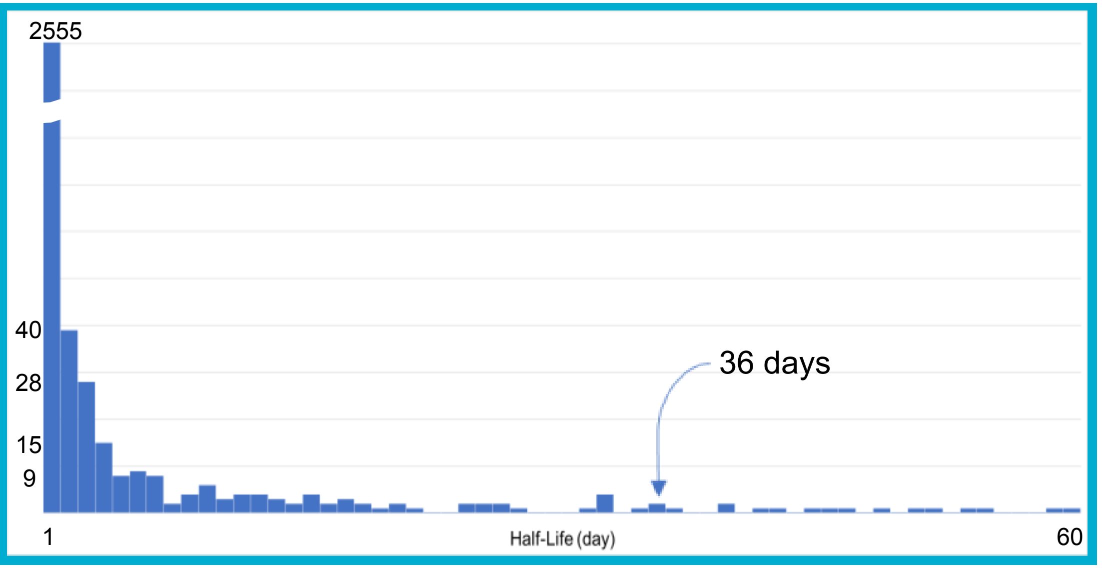
Considerations:

All dose will be delivered during that 1st year

More than 85% of the radionuclide will decay within 90 days

214 radionuclides remain

Number of Radionuclides vs. Half-Life in days



Step 4 removes those too heavy to be useful for resulting in significant negative consequences.

Approach:	Chosen Threshold/Limit:	Considerations:
Calculated specific activity (Bq/g) for all remaining radionuclides	All radionuclides with weight per 37 GBq (1 Ci) greater than 45 kg were removed	Shielding and/or other materials to be stolen will increase weight to greater than 45 kg
Used mass per GBq to set limit	Equivalent to removing all radionuclides with specific activity lower than 822 Bq/g	Difficult to produce or extract considering the required equipment and knowledge
	(half-life > 6.8×10^7 years)	173 radionuclides remain

Mass similar to the objects in images:

image: http://1.bp.blogspot.com/-sT7ZvHWBQJ8/VcJgL2eop6I/AAAAAAAABTQ/00OkYbzkyaA/s1600/download%2B%25281%2529.jpg

image: http://2.bp.blogspot.com/-HnOcLBodeaY/VcJisG20t-I/AAAAAAAABTk/xCfROi_WarY/s1600/download%2B%25283%2529.jpg

image: http://seesheilashrink.blogspot.com/2015/08/things-that-weigh-100-pounds.html

Step 5 considers availability of radionuclides in terms of whether they are actually produced worldwide.

Approach:

Downselected all radionuclides that are not being produced globally

The data on radionuclide production was collected by reviewing:

- All radionuclides produced by research reactors worldwide (IAEA registry)
- Published literature on radionuclide production via cyclotrons globally
- Published literature on medical radionuclide production in the US and other countries
- All radionuclides available for purchase in the United States

66 radionuclides remain

Step 6 eliminates those without medical or industrial use.

Approach:

Only radionuclides with known medical or industrial use were considered

- i.e., within a device, radiopharmaceutical

https://www.itnonline.com/sites/itnonline/files/styles/content_large/public/X0000_Elekta.Leksell.Gamma_.Knife_.Icon__3.jpg?itok=CEUIcpEg

http://www.theratronics.ca/images/productPics/Raycell_Mk1.jpg

http://www.meditelhealthcare.com/shimadzu-angiography-in-6-different-private-hospitals-in-antalya

39 radionuclides remain

The revised downselect process identified 39 radionuclides of consideration, including availability.

Application	Source
Medical	^{22}Na, ^{68}Ge, ^{85}Sr, ^{89}Sr, ^{88}Y, ^{99}Tc, ^{125}I, ^{153}Gd, ^{188}W
Tracer Studies	^{7}Be, ^{14}C, ^{59}Fe, ^{65}Zn, ^{73}As, ^{124}Sb
Calibration	^{63}Ni, ^{113}Sn, ^{127}Xe, ^{239}Pu
RTGs	^{90}Sr, ^{238}Pu, ^{242}Cm, ^{244}Cm
Neutron Sources	^{227}Ac, ^{241}Am, ^{252}Cf
Radiography	^{75}Se, ^{192}Ir
Irradiators	^{60}Co, ^{137}Cs
Others	^{3}H, ^{26}Al, ^{36}Cl, ^{55}Fe, ^{109}Cd, ^{195}Au, ^{203}Hg, ^{207}Bi, ^{234}U

Step 7 focuses on single source availability and completes the analysis.

Approach:

Radionuclides used at Category 1 & 2 and high-activity IAEA Category 3 values

- Analysis of radionuclides used at high levels of Category 3 values did not add any new radionuclides to the list

Eight radionuclides were used in quantities that fall within Category 1 and 2 limits

^{90}Sr, ^{238}Pu, and ^{244}Cm were removed because their use is limited