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Risk Informed Approach for Nuclear Security Measures for Radioactive Material Under Regulatory Control

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Background

NSS 20 recommends that a State should use a risk informed approach. NSS 14 recommends that a State should decide what level of risk is acceptable and apply a structured approach to reduce unacceptable risks to an acceptable level. However, the details of the practical approach that a State should follow to achieving this is not clearly addressed.

Objective

This paper will present an approach that States could use estimate risk and thereby apply a risk informed approach to the development of an effective Nuclear Security Regime.

Introduction

Risk assessment and risk informed decisions are intuitive in people. We make decisions everyday on risks we face—so much so that it becomes sometimes subconscious. We do this by accessing what can go wrong in an activity, and comparing it to the benefit of the activity. We do this when undertaking dangerous activities like skydiving, spelunking, and scuba diving; or when making mundane daily decisions like driving a car, starting a furnace, or climbing a ladder. We assess the risk in terms of consequence severity and the likelihood of the consequence occurring, and then compare these to the benefit.

Each of us has a threshold of risk acceptance that informs us of which risks we will take, and which we will not. In other words what likelihood of a given consequence severity we accept and what we reject. Accepting a risk does not mean the risk is desirable—on the contrary risk based on adverse consequence is undesirable—but rather that the benefit of the activity justifies the risk. The decision process for risk acceptance is personal (e.g. two people with identical benefit, consequence and likelihood could reasonably reach opposing decisions). The decision process likely could not be clearly described in a manner that others could understand. Further, the amount of risk that a person accepts likely varies over time and with other circumstances, such as mood, and recent or upcoming events.

The graph below represents risk in terms of consequence and likelihood. Theoretically, each of us could plot on this graph each risk we face in life. However, doing so assumes we can quantify the consequence and likelihood, or at least estimate it with high confidence. We could also theoretically define the threshold for risks that we accept. Risks equal to or below this threshold are those we accept, and risks above are those we do not (for a certain activity/benefit). If we could plot these, we might find inconsistency in our risk acceptance for different tasks. But plotting this is not possible due to the complexity of determining consequences and likelihoods for events, and the difficulty defining which are acceptable and which are not.

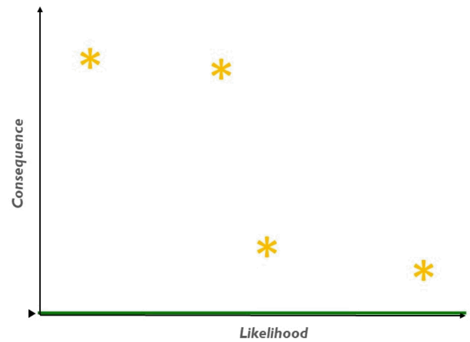

FIGURE 1. RISK SPACE: CONSEQUENCE SEVERITY VERSUS LIKELIHOOD OF THE CONSEQUENCE

Security Risk of Radioactive Material

Similarly, States make decisions on risk based on benefits. An example of risk acceptance by States is found in driver licensing. All States permit citizens to drive automobiles, even though, by so allowing, the State realizes that a percentage of drivers will become fatalities each year. The reason States accept this risk, is that the benefit to society of driving is judged to exceed the risk.

However, States do believe the risk of driving to be acceptable at certain speeds, and without certain safety precautions. These methods to mitigate risk include speed limits, seat belts, and rules for the condition and skill of the driver. These mitigating risks are designed to reduce the likelihood and/or consequence severity of driving, but they do not eliminate the risk.

Similarly, States could try to understand and estimate the security risks posed by radioactive sources, and compare them to the benefits of their usage to determine what is acceptable for society. Like we all do, this would be accomplished by estimating the severity of consequences for the radioactive material as well as the likelihood of these consequences occurring.

Also like people, States could try to explicitly establish the threshold for acceptable risk. This definition would inform States when mitigating measures should be employed, and even how much mitigation is necessary to reduce a particular security risk to within the acceptable threshold. An explicit and clear definition of acceptable risk is needed, since, as mentioned, we all have different tolerance for risk, and so if left to the imagination of the beholder, could result in inconsistent assumed acceptance thresholds.

We can confidently state that risk can be represented by consequence severity and likelihood, but we cannot determine nor even estimate risk with high confidence, due to uncertainty in estimates of both consequence severity and likelihood. Nevertheless, there is a need to estimate risk to the degree we can in order to inform the application of mitigating measures (e.g. security measures), and to identify situations where the benefits of radioactive material are not sufficient to outweigh the security risks, even when mitigating measures are applied to reduce the risk.

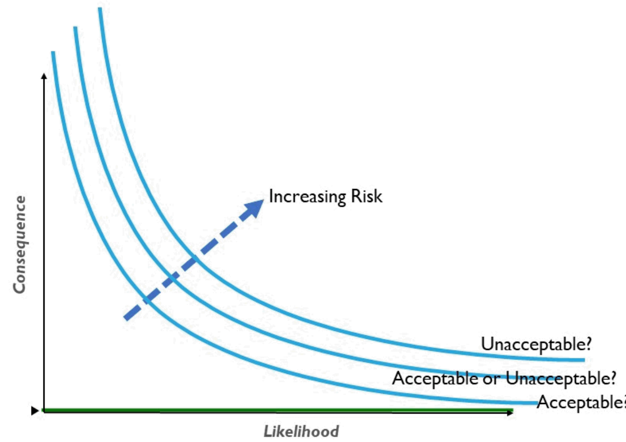

FIGURE 2. RISK SPACE: LINES OF CONSTANT RISK DRAWN

Due to the difficulty in clearly estimating risk combined with the need to clearly define an acceptable risk threshold, States have instead estimated risk by ignoring likelihood and using consequence severity as a surrogate for risk. Consequences are grouped into the following three types of consequences:

- *Health Effects*, including deterministic and stochastic health effects, including fatalities;
- *Economic Effects*, including costs of clean up, costs of evacuation and displacement of persons, costs of monitoring and medical care of persons, costs of lost revenue due to closed facilities, etc;
- *Psycho-Social Effects*, including public fear and panic, loss of confidence in government, changes in lifestyle, etc.

However, as there is difficulty estimating the consequence severity of the three categories of consequences that result from a malicious act involving radioactive material, consequence severity is only based on health effects. The A/D value is used as a surrogate for consequence severity. The A/D value is the ratio of the activity of a material divided by a value deemed to be its dangerous activity—the threshold for deterministic or stochastic health effects. Using consequence severity based on health consequences alone to represent risk is the generally adopted approach by Member States.

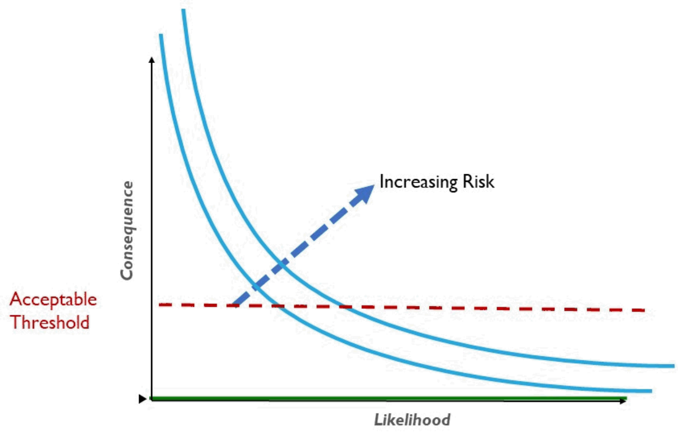

FIGURE 3. IMPACT OF USING A/D TO REPRESENT ACCEPTABLE RISK

To address the implications of using A/D as a surrogate for risk, States should consider, prior to assigning a security level, the likelihood that each of the sources has to a malicious act, and consider the other two types of consequences that might result from a malicious act.

Estimating Security Risk of Radioactive Materials

In order to estimate these components of risk, it is necessary to what we know, and how these could be decomposed to give insight into consequence severity and likelihood.

A State knows:

1. what threats they are confronted with;
2. what radioactive materials they possess; and
3. what security is in place and in what facilities the radioactive materials are stored and used.

Decomposing threat into its intentions and capabilities, we can see that intentions directly influence likelihood.

Decomposing radioactive materials into their physical properties (isotope, activity, form), and attractiveness factors where the materials are used/stored (ease of handling, accessibility, availability, and ease of initiation) we can see that the physical properties, when combined with threat capabilities, can influence the consequence severity; and the attractiveness factors can influence likelihood.

Considering the security system and the adversary capabilities together, we gain insight into the security vulnerabilities, which directly informs the likelihood.

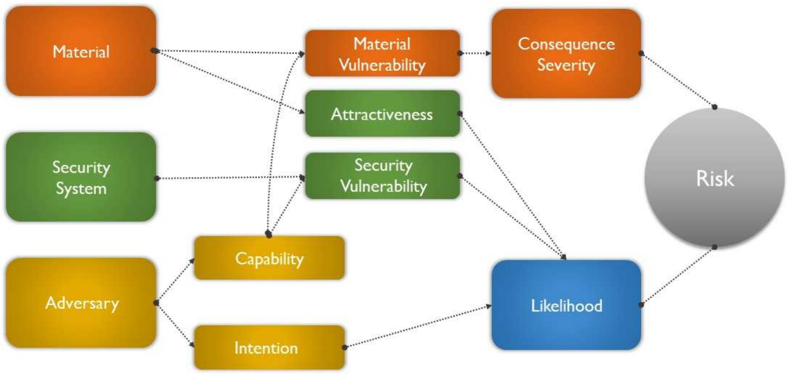

FIGURE 4. RISK: INFLUENCING FACTORS

Understanding what influences consequence and likelihood is useful in gaining insight to the risk posed by radioactive materials. There is lots of uncertainty in estimating these factors, and therefore the resulting consequence severity and likelihood; however, there still can be broad nuclear security regime insights gained from the effort to make these rough estimates.

Qualitative approaches to estimate the factors influencing consequence severity and likelihood can be estimated qualitatively by experts. Tools to facilitate this include use of word ladders[1] that are developed to established clear, distinguishable and assessible criteria for the different ratings; and risk registers to display visually the output of the assessment. A word ladder could be developed for each of the attractiveness and consequence factors.

Threat Assessment Rating	Capability	Intention
Very High	Adversaries have successfully attacked similar targets	Adversaries have a current intention to attack the target
High	Adversaries have the capability to attack the target	Attack of the target is consistent with the intentions of the group
Medium	Adversaries have some capability to attack the target	Attack is not consistent with their intention, depending on current circumstances
Low	Adversaries currently have little capability	Adversaries have little intention to attack the target
Very Low	Adversaries currently have no capability	Adversaries currently have no intention to attack target

FIGURE 5. EXAMPLE THREAT WORD LADDER

These qualitative assessments can be useful in providing insight to a State and can serve as a basis of risk management decisions within the State; however, the qualitative assessment is by nature imprecise, and this imprecision and associated uncertainty must not be lost in the interpretation of the output.

[1] A word ladder is a text description of meaning of qualitative ratings (e.g. Very high, High …) for a given factor.

Once the likelihood and consequence severity are estimated for each source in a State, it would be desirable to gain a holistic view of the overall risk these pose to a State. A risk register is a means to highlight the radioactive materials in risk space, a State gains insight into the contributions of each to the State's risk.

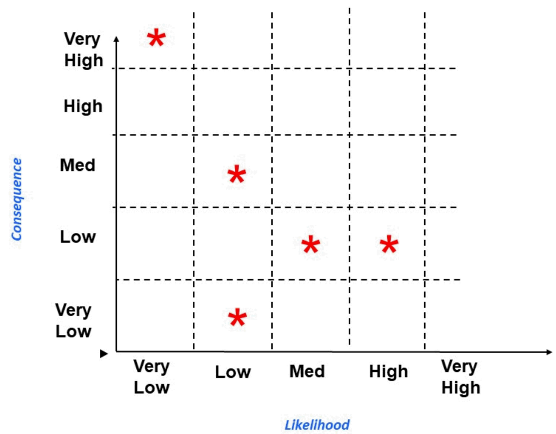

FIGURE 6. RISK REGISTER DISPLAYING THE RELATIVE RISKS OF THE MATERIALS IN A STATE

Summary

In summary, risk informed approach to the Nuclear Security Regime can be achieved by estimating the risk factors for each material in use or storage and assemble these on a risk register to provide a high level into security risk.

REFERENCES

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Security Recommendations on Radioactive Material and Associated Facilities, IAEA Nuclear Security Series No. 14, IAEA, Vienna (2011).

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[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Risk Informed Approach for Nuclear Security Measures for Nuclear and Other Radioactive Material out of Regulatory Control, IAEA Nuclear Security Series No. 24-G, IAEA, Vienna (2015).