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Global CBN Threat Potential Prioritization Model (G-CBN-TP)

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The Global Chemical, Biological, and Nuclear threat potential model is designed to provide a systematic and defensible technical prioritization of countries based the relative threat potential of each country. Threat potential is defined as the potential for a non-state actor (or terrorist organization) to exploit resources from within the country that support the development of a weapon of mass destruction or effect. This is accomplished by assessing the potential for successful acquisition of materials, expertise, and equipment which are needed in the building of a weapon; and, the presence of a terrorist organization or organizations in the country aiming to develop such a weapon.

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Introduction

The Sandia National Laboratories (SNL) International Cooperative Threat Reduction (CTR) Programs advance U.S. and international threat reduction and counter terrorism goals by promoting safe, secure, and responsible use of chemicals, biological agents, and nuclear materials across the globe. It is essential that cooperative threat reduction programs endeavoring to reduce the CBN threats have a systematic and logical way to identify and prioritize country engagements. A process that can systematically and logically identify and prioritize country engagements will provide a defensible rationale for country engagement, a foundation for strategic implementation of threat reduction measures in a country or region, and a metric to measure the impact of threat reduction activities.

Global CBN Threat Potential Prioritization Model (G-CBN-TP) is designed to provide this systematic prioritization of countries based on the relative threat potential of each country. The goal of the GCBNTP model address the following question: **What is the relative potential for a non-state actor to exploit the infrastructure of a country with the intension of building a weapon of mass destruction or mass effect (WMD/WME)?.** To answer this question, the model has been designed to compare various countries based upon the vulnerabilities of a country's relevant infrastructures and the potential threat posed by non-state actors within the country.

The non-state actor threat and the infrastructure of a country are defined and uniquely modeled three separate modules: global chemical threat potential prioritization model (GCTP), global biological threat potential prioritization model (GBTP), and global nuclear threat potential prioritization model (GNTP). The individual results of these modules can be used for independent decision analysis or combine to look for larger trends regarding global threats.

The technical threat potential captured within the GCBNTP is defined as a two-dimensional problem: 1. the threat posed by a non-state actor and, 2. the ability for a non-state actor to exploit the existing infrastructure of a country to develop a WMD/WME. The GCBNTP model is organized into a series of attributes which define each of these dimensions.

To begin, let's look at each dimension independently.

The assessment of the threat from non-state actors within a country is based upon measuring the known or suspected capabilities and intension of non-state actors; plus, measuring of societal factors regarding a country's overall vulnerability to non-state actors. The societal factors include data regarding the stability of the country, level of corruption, and economic equality.

The assessment of a non-state actor's potential access to a country's infrastructure is based upon assessing two specific objectives.

- The overall scale of the relevant infrastructure of a country compared to other countries; and
- The effectiveness and level of implemented security measures

A country's infrastructure is measured by proxy data which is used to define the extent of relevant academic programs, level of research and development in the country, and extent of the relevant industries within the country.

The effectiveness and level of implement security are measured by informed subject matter opinion of implemented security and control measures and overall security culture. Security and control measures are defined as prevention and detection of, and response to, theft, sabotage, unauthorized access, illegal transfer or other malicious acts involving relevant material. It should be noted that security includes physical protection, personal reliability, material control and accountability, transportations security, information security, and program management. A security culture is the assembly of characteristics, attitudes and behavior of individuals, organizations and institutions which serves as a means to support and enhance safety, security, and standard best practices; these include dual-use/responsible-use considerations. Several institutions and individuals are necessary for the development of an effective security culture: the state, organizations, managers in organizations, personnel, the public, and the international community. A strong security culture should include domestic (governmental, organizations, and personnel) measures, as well as international engagement of best practices and technical/personnel assistance.

Methodology

The GCBNTP model is based upon a multiple objective decision analysis framework. In a multiple objective decision analysis (MODA) approach, the objectives are organized into a hierarchy of factors (here threat and vulnerability factors) where the lowest level objectives are quantified by measurable scoring criteria.[1] MODA is used in decision analysis and risk analysis when problems have multiple objectives, often in conflict that require quantifying explicit value tradeoffs. MODA integrates objective facts explicitly with value preference judgments. MODA models are well proven to help support policy decisions.[2] A MODA model is useful when the decision requires organizing and aggregating many variable and conflicting factors in a clear, transparent and accountable way. Additionally, the MODA approach allows for explicitly documenting when there is a limited amount of available data (e.g. presence of biological agents available in a country) or the measurement of data is problematic. Finally, the MODA approach provides a structured, consistent method for looking at and comparing abstract concepts (in this case, 'threat' and 'vulnerability'), or concepts that can only be approximated due to the limited amount of available data. [3]

The GCBNTP model relies on the creation of a value model to explicitly analyze alternatives on the basis of the defined objectives. The GCBNTP value model consists of four components: defining attributes that measure objectives to be used for evaluating countries, defining value functions for each attribute to convert each to a common scale, assessing weights for attributes when needed to aggregate different attributes into one overall score, and defining an algorithm for combining a country's attribute scores with the weights to produce the overall relative value score. In the first component, objectives are defined in terms of measureable criteria or attributes,[4] where these attributes must be understandable, measurable, non-redundant, and independent. Some attributes are preferentially independent[5] which means that the preferences for criterion Y do not depend on the scores for criterion X. For those attributes that are independent, the attributes can be aggregated using a weighted additive function. For those attributes which are judged to be interdependent, the GCBNTP model either uses a two-dimensional value function to capture the combined attributes or it uses a multiplicative function to appropriately combine the two attributes and still capture the interdependency.[6] Additionally, a value model converts each attribute measurement to a common value scale (i.e., zero to one). Value functions for each attribute were constructed with subject-matter expertise assignment. In GCBNTP, the majority of the value functions are linear. In some cases however, there are some specific functions that

[1] Kirkwood, C. W. (1997). Strategic Decision Making: Multiobjective Decision Analysis with Spreadsheets, Belmont, California: Duxbury Press.
[2] Keefer, D., C. W. Kirkwood, and J. L. Corner (2007). Perspective on Decision Analysis Applications. In W. Edwards, R. Miles, & D. von Winterfeldt (Eds.) *Advances in Decision Analysis* .(pp. 154-176. Cambridge , UK : Cambridge University Press.
[3] Clemen, R.T. and T. Reilly (2004). Making Hard Decisions with Decision Tools Suite Update Edition, South-Western College Publishing.
[4] Clemen, R.T. and T. Reilly (2004). Making Hard Decisions with Decision Tools Suite Update Edition, South-Western College Publishing.
[5] Keeney, R. and H. Raiffa (1993). Decisions with Multiple Objectives: Preferences and Value Tradeoffs, Cambridge: Cambridge University Press.
[6] Ewing, P.L., Tarantion, W., Parnell G.S. (2005), Use of Decision Analysis in the Army Base Realignment and Closure (BRAC) 2005 Military Value Analysis. Decision analysis Vol 3 No 1, March 2006

are exponential or logarithmic. The use of value functions allows the combination of attributes to be aggregated using value as the common yardstick.

Additionally, each attribute is uniquely weighed based upon its impact to the overall potential threat for the country. Subject matter experts (SMEs) are used to determine the weights where needed. A key advantage of the experts doing the weighting are that they are forced to see the trade-offs as they increase or decrease the weight of one criterion over another. Subject matter experts reviewed published articles related to the criteria to help inform the decision process and discussed each criterion prior to defining the weights. Weights were assigned by consensus.

Once the weights are assessed, then the scores of countries on individual attributes are aggregated into a single priority score summing the components that are additive and multiplying the components that are interdependent as described in detail below.[7]

The GCBNTP model collects and analyzes data at a country-specific level. This data is used to score the attributes for each objective. The total weighted score of the attributes provides the Global Threat Priority score for the country that reflects its threat potential. This final score is then used to prioritize the countries modeled relative to each other. Additionally, for each country, this model allows for a detailed analysis of the 'threat' drivers. This detailed analysis can be used in strategic planning at the country level and, over time, this same detailed analysis can be used to demonstrate levels of threat reduction based upon implemented projects.

[7] Parnell, G.S., Jackson, J.A., Jones, B.L., Lehmkuhl, L.J., Conley, H.W., and Andrew, J.M., (1998). "Foundations 2025: A Value Model for Evaluating Future Air and Space Forces", *Management Sciences*, 44:10, pp.1336-1350.

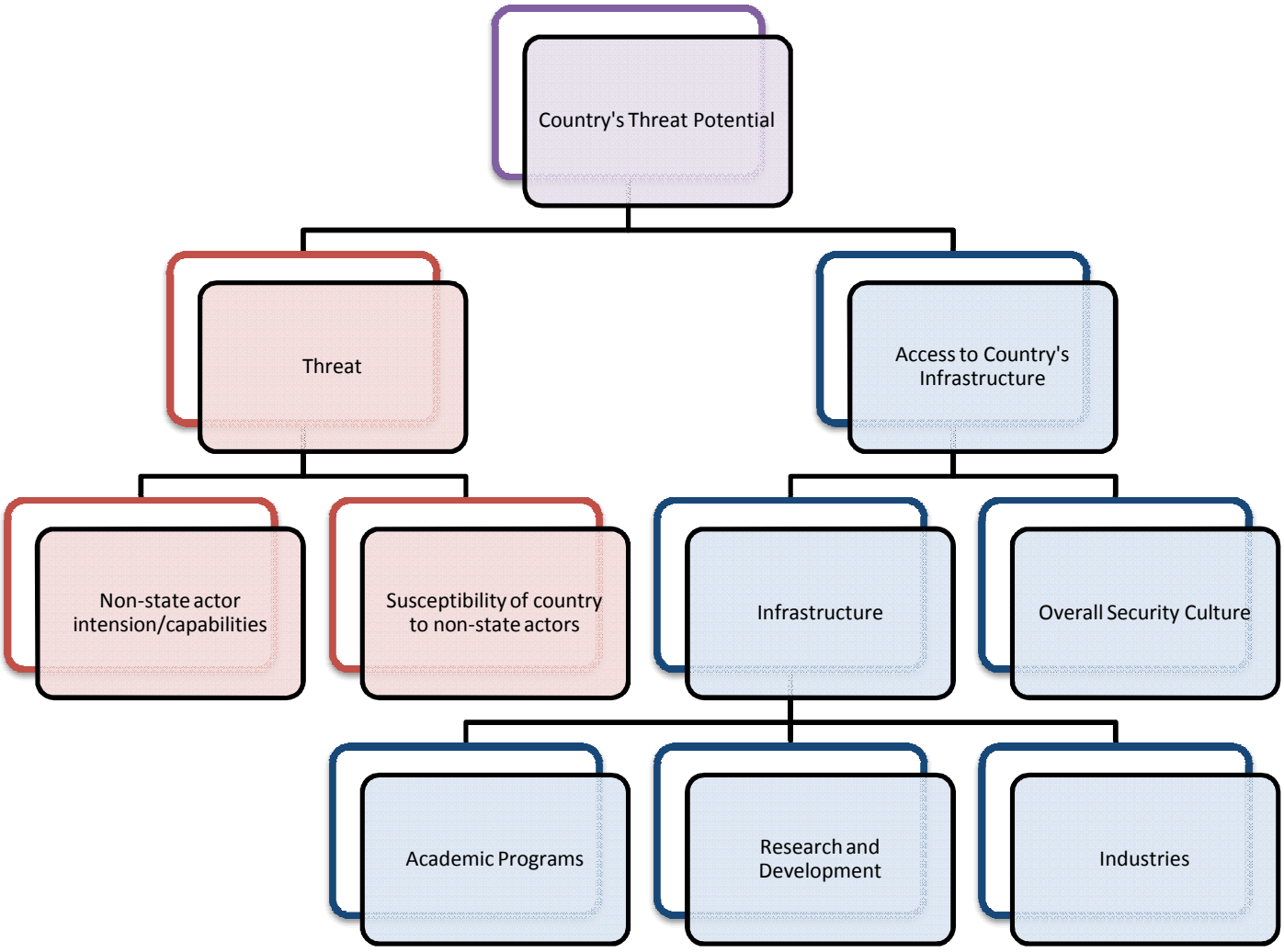

Figure 1: Outline of the generalized decision model

As shown in Figure 1, the highest level objectives are defined as:

- Access to a country's infrastructure; and,
- The threat.

These two high level objectives areas are interdependent therefore combined using a multiplicative value function (or via a two-dimensional graphic).

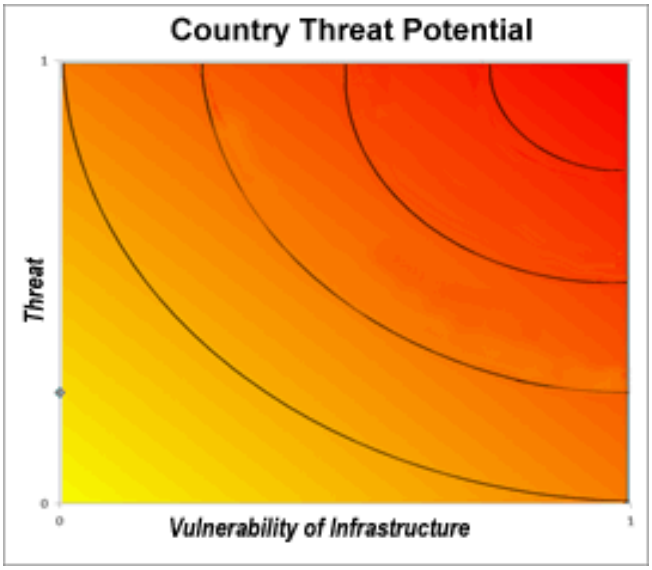

Figure 2: two-dimensional graphic used to combine highest level objectives

For defining the potential access of a country's infrastructure to a non-state actor, the following multiplicative value model was used; this is due to the interdependence between the security culture of a country and the susceptibility of the country's infrastructure:

$$V(x) = \prod_{m=1}^{n} v_m(x_m)^{\wedge} w_m$$

where m is the attribute measure, x_m is the level of the m_{th} attribute measure, $v_m(x_m)$ is the value of the attribute value function at level x_m, and w_m is the weight associated with that attribute measure.

For defining the extent of a country's infrastructure, and in defining the threat within a country, the following additive value model was used to combine all the infrastructure measures:

$$V(x) = \sum_{m=1}^{n} w_m v_m(x_m)$$

where m is the attribute measure, x_m is the level of the m_{th} attribute measure, $v_m(x_m)$ is the value of the attribute value function at level x_m, and w_m is the weight associated with that attribute measure.

Conclusions

The GCBNTP model is designed to provide a systematic prioritization of countries based the relative threat and vulnerability potential of each country. Threat potential is defined as the potential for a non-state actor (or terrorist organization) to exploit resources from within the country that support the development of a WMD/WME. The vulnerabilities consider potential for successful acquisition of relevant materials, expertise, and equipment from a country by a non-state actor.

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