Modeling Behavioral Activities Related to IED Perpetration

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Keywords:
Recruitment Modeling, Behavior Modeling, Counter-IED

ABSTRACT: *This paper presents a computational approach to modeling the behavioral aspects of IED perpetration that enables the exploration of those behaviors by an analyst or planner. The modeling framework presented supports the identification of potential interdiction points in the events leading to an IED detonation with a focus on insurgent recruitment and on the motivation to construct, emplace, and detonate IEDs. In many cases, individuals become terrorists or supporters of terrorism through a slow and gradual process wherein established terrorists use targeted approaches to convert individuals into terrorists through phases. Because of this phased approach, a strategic means of quelling terrorism involves understanding the process and exploiting insights to disrupt the IED process at an early stage. Knowledge engineering is used to extract and capture domain knowledge which is then represented in a system dynamics model to support the exploration and identification of behaviors associated with adversarial activities. Interchangeable submodels are used to capture subtleties or differing opinions and to allow for the analysis of expected results of alternative decisions or courses of action.*

1. Introduction

Multiple modeling paradigms can be used to produce models that aid in the understanding of adversarial behavior. Such models are valuable in that they provide a means to analyze and experiment with the impact of potential influences on population behavior (Zacharias, MacMillan, & Hemel, 2008). As subject matter experts are often used to provide an interpretation of social behaviors and applicable psychological theories (e.g., Crenshaw, 2000), a modeler can choose the appropriate modeling approaches to represent a given interpretation. By including behavioral aspects of adversarial activities in computational models, a framework has been developed that supports identifying potentially effective intervention points that may disrupt individuals' behaviors. This paper focuses on modeling terrorist recruitment and their motivations to construct, emplace, and detonate Improvised Explosive Devices (IEDs), where subject matter experts from the United States and the United Kingdom have collaborated to understand these motivations and behaviors.

The approach couples computational and social science research to develop an improved capability to identify and explore the space of likely activities and behaviors of potential IED developers before they have successfully deployed IEDs. Content expertise from researchers within the UK is combined with computer-based analysis technologies for the prediction of individual or group-related activities. UK domain knowledge is provided by investigators who have been involved in UK event analysis and who are currently researching methods to explain terrorism, bombings, and other IED-related activities. Content was also obtained from numerous open-source publications to prevent too heavy of a dependence on subject matter experts (SMEs). Knowledge-engineering techniques are being exploited to extract and capture this domain knowledge. This information is linked with modeling approaches to provide a framework to support the identification and exploration of behaviors of individuals or groups of individuals involved in IED-related activities, with a focus on recruitment and the motivation to construct, emplace, and detonate IEDs.

In many cases, individuals become terrorists or supporters of terrorism through a slow and gradual process (Horgan, 2007). Established terrorists target individuals, usually young men, and try to convert them in phases into terrorists or supporters of terrorism. A key to interrupting terrorism is to understand the process and disrupt it in its early stages. The modeling

framework of this paper uses a set of representations that is appropriate for modeling this gradual process.

Specific modeling methodologies utilized include:

- Mind maps for preliminary knowledge engineering
- System dynamics models (Sterman, 2000) using stocks and flows (items, materials, people, etc.) to represent the overall system behavior of the IED process
- Influence diagrams to show the causal relationships between different aspects of culture and society that affect the IED process

The resulting modeling framework can be used for analysis of recruitment deterrents and potential intervention points within the IED process.

The approach to creating a modeling framework for exploring counter-IED (cIED) efficacy revolves around addressing several major scientific issues at the intersection of behavioral sciences, information science, computer science, and systems engineering, including:

- Identification of the domain knowledge and issues that apply to human behaviors related to IEDs as well as identification of relevant features of individuals to be used as inputs to influence diagrams.
- Identification of relevant features of groups and social interactions to be used as inputs to influence diagrams and to system dynamics models.
- Development of effective, interactive methods of analysis for domain experts to inject feedback into the system.

Figure 1 presents a summary of the approach, where the material in this paper emphasizes the content in the blue boxes. Specifically, information is acquired from multiple sources, including open literature, SMEs, doctrine, and reported scenarios. This information is captured via knowledge engineering methods and incorporated into various model types, including influence models and system dynamics models.

The knowledge capture and transformation works as follows. Information from SMEs, doctrine, documented scenarios / events, and open literature is represented in the structured construct of mind maps by researchers. This information is tagged based on the content it provides (e.g., object, relation, etc.). The tagged information is translated into structured data representations for inclusion into either influence diagrams or system dynamics models. For example, if a mind map identifies a category of people called Active Terrorists, then this is translated as a stock in a system dynamics model. Similarly, the transition of a member of the Grey Population to an Active Terrorist is a flow and represented by an equation capturing the transition as a function of time. Finally, mind map concepts such as opinions of the government influencing the likelihood of involvement in terrorism become represented as directional weights in an influence diagram. The conversion of these concepts to data representations enables the disparate model constructs to be transformed into an analysis tool that incorporates time dependencies of the model components in support of dynamic assessments.

These model components are used to create a modeling environment with specific model instantiations, which are then subjected to evaluation by developers and SMEs. These models can be adapted and updated as new uses and information are obtained. A report by Weiss, et al. (Weiss, et al., 2009) describes the modeling cycle, complete with analyses that can be performed using such a modeling construct. This paper describes the front-end information associated with instantiating the modeling aspects in support of modeling recruitment associated with IED perpetration.

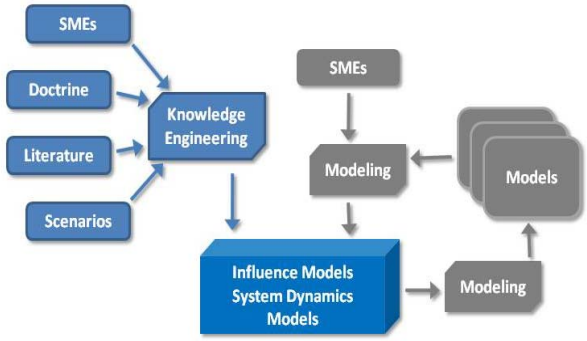

Figure 1. Approach to model construction. The blue boxes are the emphasis of this paper.

2. Information Gleaned from SMEs

Several insightful pieces of information were obtained from SMEs that is not evident in the resulting models, a few of which are discussed.

- Effects of Monitoring Groups. In some regimes where terrorists are aware of being watched, they try to operate in a manner to fool their pursuers, so that interactions become more game-like, with one side trying to outsmart the other side. For IED behaviors, the adversaries have less of a game-like attitude, and they put less effort into influencing the monitoring. Instead, they concentrate more on executing their tasks.
- Common End-State vs. Individual Motivations. Motivations within IED 'teams' are varied.

Participants are not necessarily focused on the end-state. Rather than having common motivations to achieve common goals and attain common results, individual motivations and goals are manipulated to accommodate an individual's end goals, e.g., one person may be motivated by money while another person is politically motivated, and yet another person is affected by peer influences.

- Experts are conflicted as to whether religion is actually a motivator or just used as a 'clean' explanation.

3. Knowledge Engineering Using Mind maps

To create useful models, diligence must be paid to the capture of knowledge from SMEs, literature, and other relevant sources (Burgoon & Varadan, 2006). For SME information capture, a knowledge elicitation document was developed, with details presented in (Weiss, et al., 2009). The document is a structured questionnaire used in interviewing subject matter experts to gather specific information including motivations, purposes, goals, beliefs, perpetrators, supporters, the environment, etc. Figure 2 shows part of this questionnaire's content.

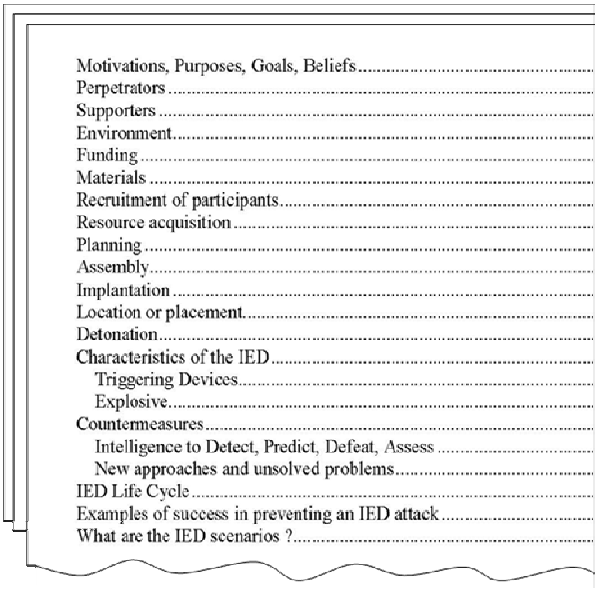

Figure 2. Content of Knowledge Engineering Instrument

Mind mapping is a semi-structured technique for initial representation and organization of knowledge. Figure 3 depicts a portion of one mind map showing how related concepts are interconnected via common elements. Mind maps provide a visualization of concept relationships by showing hierarchical connections between textual concepts. For this research, in addition to obtaining information from numerous literature sources, seven SMEs from the US and UK were interviewed to create a collection of mind maps such as the one in Figure 3.

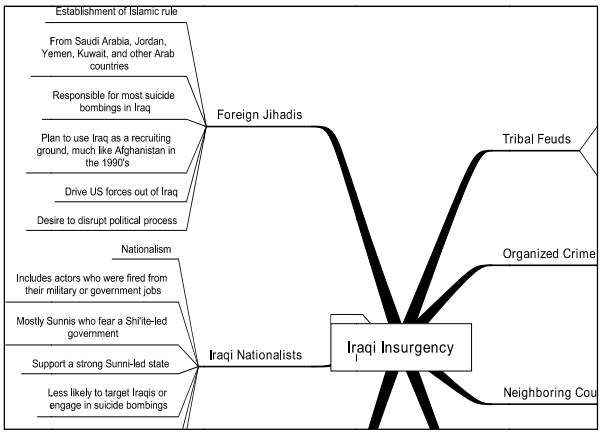

Figure 3. Mind map for preliminary knowledge structuring (portion)

Once domain knowledge has been formally structured, it can be constructed into various representations to support multiple aspects of modeling.

4. System Dynamics Models

A system dynamics model is a type of executable model used to represent and understand the dynamic behavior of a complex system over time (Sterman, 2000). This modeling approach uses *stocks* and *flows* to represent system elements and their relationships with each other. Stocks represent an inventory of an accumulated entity (e.g., IEDs, people), while flows represent how entities move between stocks.

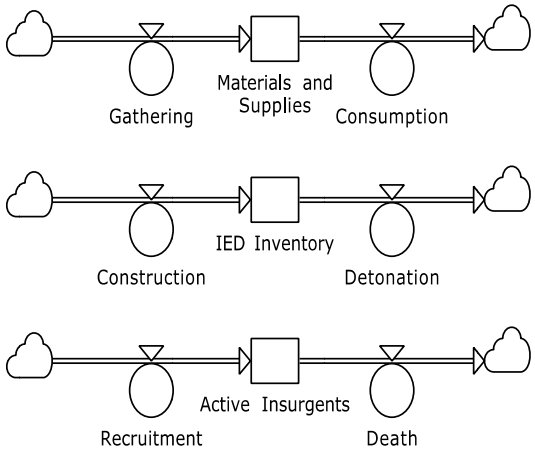

Figure 4 presents a simplified schematic of the core IED perpetration model that has been developed. Stocks are indicated using rectangular boxes. Flows are indicated with double-lined arrows. Clouds, which may take the place of a stock, indicate the world outside the scope of the model where stocks may originate or end.

The core model developed in this research is used as a foundation from which submodels or model expansions are incorporated into the framework, and it encompasses many aspects of the larger IED process. The first graphical line in Figure 4 depicts the process associated with gathering and consuming materials and supplies to develop and emplace IEDs. The second graphical line depicts the process of an IED moving from being constructed through inventory, to being emplaced and potentially detonated. The last graphical line is of particular interest for modeling recruitment in that it reflects many aspects of human behavior associated with IED perpetration.

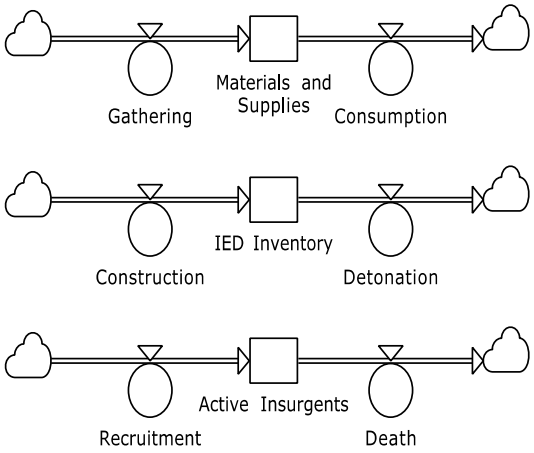

Figure 4. Simplified core model

4.1 The Three Focus Areas

The three graphical areas in

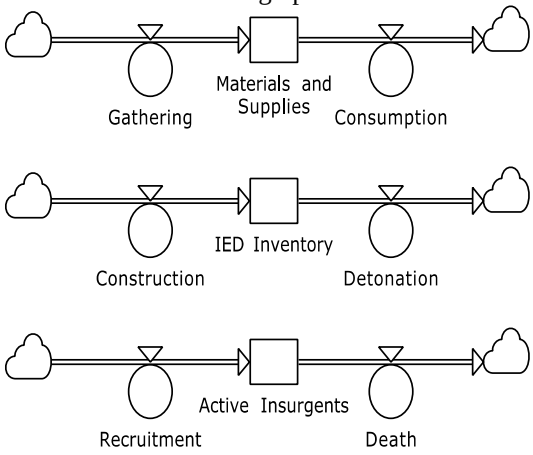

Figure 4 represent three focus areas of the core model, described below.

4.1.1 Materials and Supplies Focus Area

This section of the model is shown in Figure 5. Here, a single stock represents the inventory of generalized materials and supplies available to insurgent groups. Materials are expressed by the generalized unit "item" to represent hypothetical items such as pounds of fertilizer or gallons of fuel. This section of the model contains one stock: *Materials and Supplies*. The input flow, materials *Gathering,* represents actions that cause the accumulation of materials and supplies. The output flow, *Consumption*, represents the use of these materials and supplies in the construction of IEDs. The Materials and Supplies Gathering submodel is presented in Section 5.3.

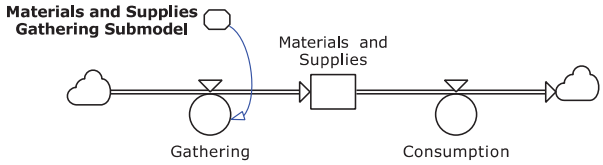

Figure 5. Model components related to IED materials and supplies

4.1.2 IED Process Focus Area

The process of IED deployment is represented in the middle portion of the core model, with five stocks representing actual IEDs, and is shown in **Error! Reference source not found.**. In practice, the process is varied and IEDs move through it in different ways, but this model is a generalized representation that the SMEs felt was reflective of the process. Moving through the diagram, a typical IED is constructed either for the purpose of a particular attack or to be stored for future use. Once it is constructed it is moved into inventory, which may be a traditional form of inventory (such as a warehouse), or it may be stored in a less conventional way (e.g., distributed throughout the community). IEDs may also be held by individuals who have little knowledge of the item's true nature or purpose. Once insurgents have decided to emplace an IED, it is removed from inventory and emplaced in the field or acquired by a suicide carrier. Finally, whenever a target is near, the IED is triggered manually or automatically. Each of these stages is represented in the model by a stock that aggregates the IEDs currently within that stage.

At any point during the process, counter-IED methods may be used to destroy an IED before it is used against a target. This disruption detours the IED and deposits it in the *Disrupted IEDs* stock.

The next step in the modeling is to calculate the flows that represent the transition of stocks from one stage to

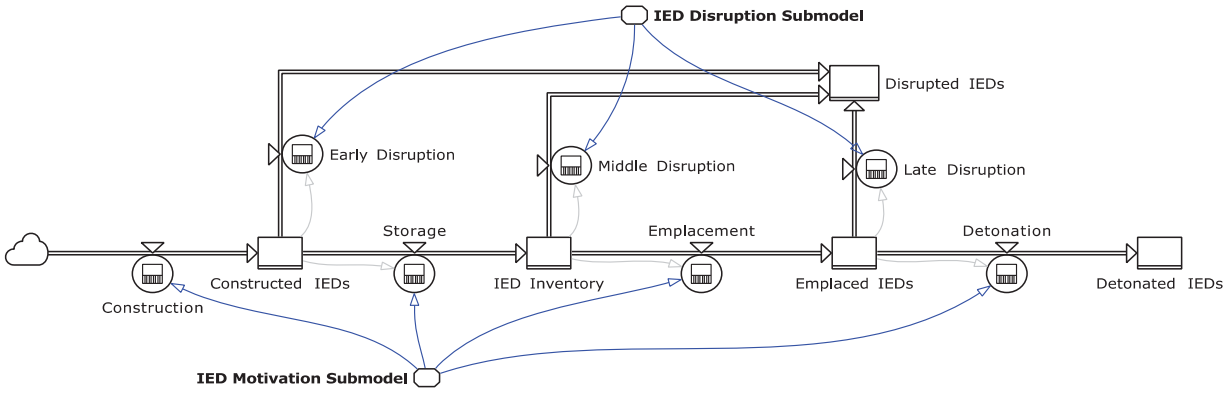

Figure 7. IED Process model components

another. Each flow's value is governed by a corresponding expression derived from other variables in the model that affect it. The movement of an IED between stocks is controlled by a series of flows, which are in turn affected by the number of personnel available within the insurgent groups. The expressions that control how these are related can be identified by an expert or changed by an analyst.

The insurgents' motivations to continue the IED process are represented in the IED Motivation submodel. Research into these motivations is underway and results are included as one of many submodels to allow a series of inputs that drive or reduce motivation.

4.1.3 Personnel Focus Area

Understanding the behavior of people involved in IED activities includes understanding when and where they may be susceptible to being recruited or radicalized. The recruitment process results in several levels of categorization: the *General Population*, the *Grey Population*, and *Active Insurgents*. Each of these groups is represented as a stock within the system dynamics model. See Figure 6.

The stock representing members of the *General Population* shows the transition of a person into a sympathizer (a member of the *Grey Population* susceptible to further radicalization), then into an *Active* participant within a terrorist group. While the indoctrination and recruitment of insurgents is a nuanced and multi-faceted process (Gerwehr & Daly, 2006), the model initially simplifies this so that the critical aspects can be identified.

The system dynamics model shown in Figure 6 indicates how the flows (radicalization, recruitment, deradicalization, disengagement, and death) are controlled by submodels. The core model sees the final result of each submodel as a single value that influences the stocks and flows.

5. Submodel Development Using Influence Diagrams

The use of submodels allows for the development, modification, and reuse of model components as modules within the model. A submodel based on a particular set of assumptions about the environment or about behaviors can then be replaced by a different submodel for analysis or refinement or to incorporate differing views or approaches that SMEs may have. This research leveraged influence diagrams to create the submodel influences on the flows within the system dynamics model.

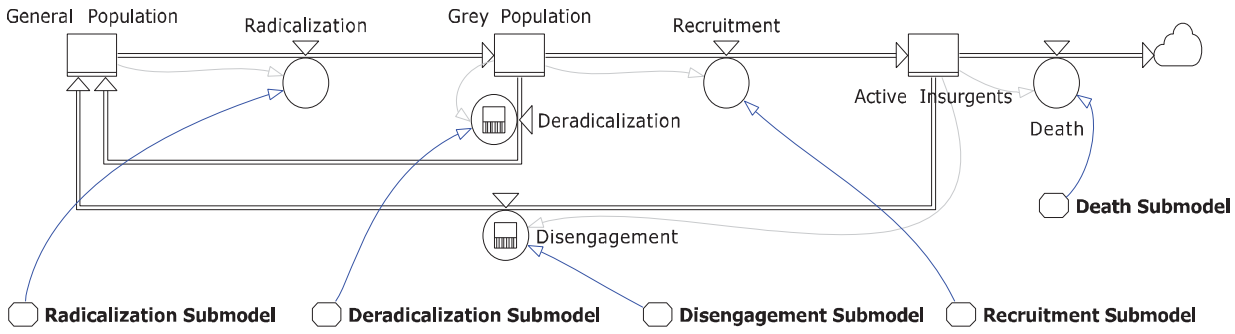

Figure 6. Insurgent personnel model components

An influence diagram is a graphical representation of a group of causal relationships and offers a method to couple the essential elements of a situation, including decisions, uncertainties, and objectives, by describing how they influence each other.

Alternative influence diagrams can be used to explore possible relationships between variables and can be used to provide values to variables that are inputs to stocks and flows. A set of causal relationships that influences these variables can be developed as a submodel for input. In this way submodels can be reused and interchanged to explore the outcomes resulting from different relationships. A model can thus be extended to represent a larger part of a scenario being modeled by attaching multiple, appropriate submodels.

This paper describes three of the submodels that support the core model.

- Radicalization / Deradicalization Submodel
- Recruitment / Disengagement Submodel
- Materials Gathering Submodel

5.1 Population Radicalization and Deradicalization Submodel

Radicalization represents the transition of a person within the *General Population* into the *Grey Population*. This occurs when a previously neutral person has taken a position of sympathy for insurgent beliefs. Insurgent groups achieve this end through various means, such as spreading broad propaganda supporting their goals, or by using community leadership roles as influence. Whenever a person holds a positive view of the insurgents' goals and tactics, that person is considered vulnerable for recruitment.

Deradicalization occurs when the attitudes of an individual are moderated from the radical views of the insurgency to the more mainstream views of the general population.

Figure 8 depicts the submodel showing the variables that affect population radicalization and deradicalization. General factors that affect individuals' behaviors can be grouped into four categories:

- Camus: Moral and religious factors
- Dewey: Social factors
- Smith: Economic factors
- Maslow: Quality of life factors

These factors build on the work of Bartolomei, et al. (Bartolomei, Casebeer, & Thomas, 2004) and were combined using an influence diagram to determine the value of the flows. Influence diagrams represent influences as directional weights that are combined with other weighted inputs via an equation, and where the output is a rate of change. The outputs of these equations are then inputs to the system dynamics model.

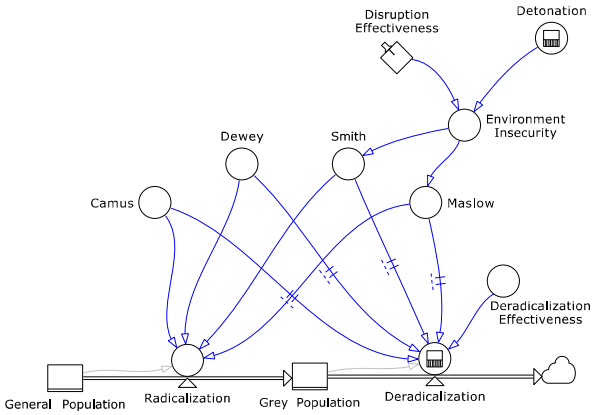

Figure 8. Submodel representing the radicalization and deradicalization of the population

5.2 Insurgent Recruitment and Disengagement Submodel

Recruitment and disengagement represent the voluntary or coerced actions of persons joining or leaving the insurgency. As a person becomes an active participant in the IED process, this person is considered recruited and is represented as a *Recruitment* flow. This may be an overt decision by the participant, or it may be a gradual process in which an insurgent group slowly eases a sympathizer into increasingly more severe tasks. The model considers the person to be recruited whenever he or she is actively involved in the process of constructing, storing, emplacing, or detonating IEDs. *Disengagement* occurs when someone has left the group of active insurgents and reduces the number of active insurgents.

The Recruitment and Disengagement submodel is presented in Figure 9. The variables surrounding the *Recruitment* and *Disengagement* flows represent influences that drive those decisions. A feedback loop is visible within the following chain of variables: *Environment Insecurity* → *Resentment* → *Recruitment* → *Detonation* → *Environment Insecurity*. As such, it can be useful to identify potential intervention points in the recruitment process. Within the model, the value of *Disengagement Effectiveness* can be adjusted as part of the system dynamics modeling to assess effectiveness of counter-IED and counter-insurgency efforts.

5.3 Materials Gathering Submodel

This submodel, shown in Figure 10, depicts the gathering of materials and supplies by the insurgency. As supplies are consumed, the reduction in the *Materials and Supplies* stock yields an increase in the *Supply Deficit*, which leads to an increase in *Supply Gathering Efforts*. The success of these efforts is hindered by increasing the amount of interference by counter-IED actions, represented as *Supply Gathering Interference*. This submodel can be expanded to include aspects such as the gathering of illicit items that cannot be readily purchased or financial resources that allow for the purchase of base materials (National Research Council, 2008).

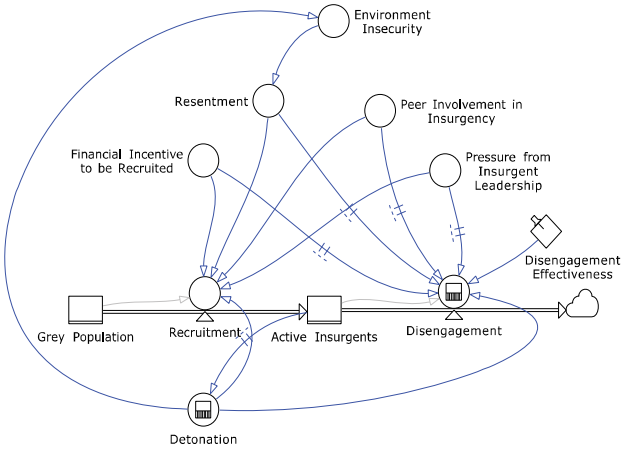

Figure 9. Submodel representing the recruitment and disengagement of insurgents

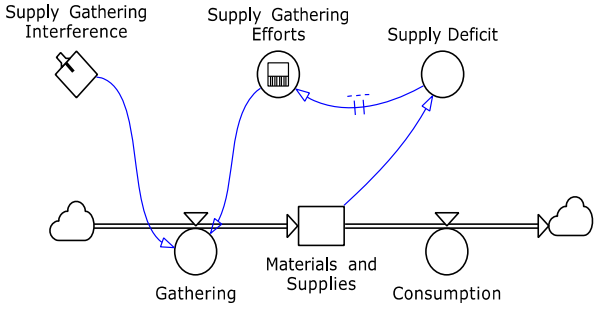

Figure 10. Submodel representing the gathering of material and supplies by insurgents

6. Integration of Model Components

When the suite of model and submodel components is integrated into the modeling framework, a modeling environment is created to assess potential intervention options. This paper presents the components that provide the content and the interactions for the models before the analysis process begins. Once those components are in place, they can be integrated, swapped, modified, and updated to support evaluation of potential intervention options.

The integration framework also supports insertion of different submodels. For example, if two SMEs have differing views on how to disengage insurgents, then Figure 6 can be operated with either submodel feeding the disengagement flow and analyses can be conducted using an integration of these models; preliminary assessments have been conducted (Weiss, et al., 2009), and although there are not immediate plans for a longitudinal study to assess potential interventions, the resulting tool could support such an analysis.

The benefit of such analysis is that, although integrated models will not precisely predict who will become recruited, they can provide insight into two important aspects of the domain:

(1) The relative importance of factors and influences. For example, it may be suggested that the best intervention is to influence the *General Population* before they are radicalized, but if a large part of the population is inherently radicalized, there may not be much benefit in working with the general population. Often, people are radicalized to some extent through their environment. Therefore, a more effective approach may be to address the flow from the *Grey Population* to the further radicalized stage of *Active Insurgent*.

(2) Previously unconsidered aspects of the problem become exposed so that insight may be provided on an issue that may otherwise not been considered. It is easier to play-out unrealistic, but potentially eye-opening, scenarios in a modeling environment rather than real-life.

7. Conclusions

This paper focuses on an approach to component modeling of behaviors related to terrorist recruitment and the motivation to construct, emplace, and detonate IEDs. The approach combines computational and social science research to develop an improved ability to identify and understand activities and behaviors of potential IED developers in a population. The approach uses various modeling techniques, including mind mapping methods for knowledge engineering, system dynamics models for representing system behavior, and influence diagrams for developing submodels to show causal relationships. When the components are integrated, they provide a framework for analysis of recruitment deterrents and potential intervention points associated with IED perpetration.

8. Acknowledgements

This work was supported by a grant from the Office of Naval Research. We would like to acknowledge our colleagues at Penn State (Drs. Kevin Murphy, John Horgan, and Frank Ritter) and the University of Hull (Dr. Caroline Kennedy-Pipe) and thank them for their valuable interactions.

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