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Modeling Transnational Terrorists' Center of Gravity: An Elements of Influence Approach

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THESIS

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Abstract

Since the September 11th terrorist attack, there has been an increased emphasis on understanding and modeling terrorists groups. While several efforts have focused on identifying transnational terrorists' centers of gravity (COGs), most of these efforts have proposed COGs using a traditional nation-state paradigm. In today's "global village", terrorist groups are no longer limited by locality and national boundaries. With the increasing threats from transnational terrorist groups, new paradigms and models are necessary to properly analyze today's, and tomorrow's, conflict. Analysis should be based on the identified and quantified transnational terrorists' COGs and their associated interactions. Unfortunately, not all of the transnational terrorists' COGs and their interconnected cause and effect relationships are fully known or understood. This research effort suggests a single COG, Public Support as the transnational terrorists' key driver. An influence diagram-like approach was used to collect, organize, and display the COG and its key elements of value. These qualitative influence diagrams serve as a basis to develop a system dynamics model where quantitative measures were applied to the interactions. A prototype model capable of capturing and utilizing time-persistent and higher order effects that provides insight to decision makers regarding alternative strategic policies and courses of action (COA) against transnational groups has been developed and illustrated against a notional transnational terrorist group.

For my husband, my daughter, and my late Father-in-law

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MODELING TRANSNATIONAL TERRORISTS' CENTER OF GRAVITY: AN ELEMENTS OF INFLUENCE APPROACH

1. Introduction

1.1. Background

"Know the enemy and know yourself…" (Sun Tzu, 1963: 84). Sun Tzu's observation applies perhaps more than ever today than when he first penned it. In light of both the September 11th attacks and the changing state of the world, the United States has an increasing need to understand its enemies. Today's enemy differs from the enemies of Clausewitz's day (1976). Conflict is not as traditional as attacking and defeating an adversary's fielded military forces (Clausewitz, 1976: 596). Today's conflict involves fighting terrorists and transnational groups who possess global reach, both of whom do not fight by the classic accepted principles and rules of warfare. This new form of warfare has been referred to as 4th Generation Warfare (4GW) (Lind, Nightengale, Schmitt, Sutton, and Wilson, 1989:1). It represents a move away from conventional force-on-force conflict to asymmetrical and guerrilla-type warfare. The term 4GW is often used synonymously with asymmetrical warfare. (Wilcox and Wilson, 2002: 2).

According to the National Intelligence Council's report, *Global Trends 2015: A Dialogue about the Future with Non-government Experts* (2000: 14), the future of conflict for the United States in the near and mid term will be asymmetric warfare. Asymmetrical warfare is defined by Joint Forces Command (JFCOM) as "the waging of

unbalanced or un-proportioned armed or unarmed war against the enemy" (JFCOM Glossary, 2004:1). It can also be thought of as a threat that is considered to be unusual (Gray, 2002: 5). Asymmetric threats are also referred to as those in which

> state and nonstate adversaries avoid direct engagements with the US military but devise strategies, tactics, and weapons—some improved by 'sidewise' technology—to minimize US strengths and exploit perceived weaknesses (Global Trends 2015).

The War on Terrorism is a prime example of 4GW. It is a conflict between unbalanced enemies when viewed in terms of traditional military power. This is a key trait of 4GW and asymmetric warfare. Additionally, the trend in the conduct of terrorism is estimated as moving away from state-sponsored terrorism to more flexible and diverse transnational networks (Global Trends 2015). Since this is the type of conflict that the U.S. has been involved in since at least September 11, 2001, the military needs to gain a greater understanding of the transnational groups who have embraced this style of conflict against the Unites States. One way to undertake this daunting task is through identifying and modeling the adversary's centers of gravity (COGs) and their interactions. It is critical for the military not only to identify, but also to quantify, an adversary's COG interactions in order to effectively plan for and analyze effects-based operations (EBO). To accomplish this task, it is imperative that in-depth consideration is given to what action will achieve the desired effect. The ultimate goal of an operation is to get inside the adversary's decision making process and to influence their actions; but without prior knowledge of their COGs, it is extremely difficult to systematically work towards that goal (Waggett, 2004: 4-5).

A difficult first step to modeling this new style of warfare is identifying the appropriate COG for the transnational groups of interest. An equally difficult concept adding to the complexity of the model is the specifications of interactions. Life is a dynamic event with many interactions; COGs and their key elements of influence are no different. It is improbable that a COG stands alone and that the destruction or degradation of one of the key elements does not induce systematic effects across COGs. Interactions can be so strong that one can no longer just look at the actions that led to the interaction, but should consider the interaction effect by themselves (Jervis, 1997: 7). Additionally, these interactions may produce time-persistent effects that are also critical to consider (Jervis, 1997: 1). Within the construct of EBOs, it is essential, in order to make effects based decisions, to discover as much information as possible about enemy COG interactions and the time-persistent effects of targeting them in order to make effects-based decisions (Wentz and Wagenhals, 2004: 10-11).

The resulting effects from operations can be short-term or long-term and can at times appear to be conflicting. However, this common occurrence is not necessarily undesirable. When conducting EBO planning, both short- and long-term effects will exist. In order to achieve a long-term objective, or effect, operations resulting in undesirable temporary conditions may be necessary. For example, targeting the Al-Qaeda leadership may, in the short-term, cause the growth of new leaders within the organization: certainly an undesired effect (Mallory, 2002: 14). But if these new leaders are then targeted and captured or prosecuted, members from the next level down will need to step up to fill the leadership role or risk potential degradation or collapse of the organization over time (Casebeer and Thomas, 2004: 35). Since the overall, long-term

desired effect is to neutralize the Al-Qaeda leadership, then the short-term impact is in conflict with the long-term desired impact. However, in the long-term, Al-Qaeda could eventually run out of qualified people to take over the leadership roles, thereby resulting in the desired impact.

EBOs view the enemy-as-a-system, as seen in John Warden's five rings model, and seek to gain insight into both the direct and indirect effects that occur throughout the system (McCrabb 2001: 9). Therefore, COG interactions that cause these higher-order effects need to be modeled. A model that could begin to provide the capability to identify and quantify COG interactions while possessing the ability to capture time-persistent and higher order effects would be most effective in analyzing EBOs. It could also provide the ability to weigh policies, options, and courses of action, gaining insight into their potential effects.

1.2. Problem Statement

The current military concepts of COGs reviewed in this thesis fall short in modeling transnational terrorists COG interactions. There are several models of COGs, but they do not adequately model or account for interactions. For example, Warden's five rings model is a comprehensive representation for a country's COGs, but it does not explicitly identify or quantify COG interactions. Additionally, the current models are designed for analyzing a country or state. With the onset of 4GW and the increase of threats from transnational groups, these models may be insufficient to properly analyze today's, and tomorrow's, conflict.

A model capable of capturing and utilizing time-persistent and higher order effects would provide insight to decision makers about what strategic policies and actions

should be taken in operations against transnational groups in order to achieve desired effects. It would also be beneficial to provide knowledge regarding any potential undesired effects.

In order to model warfare against transnational groups, their COGs and their associated interactions must be identified and quantified. Once identified, there must be a strong emphasis on quantification. These interactions must then be examined for possible time-persistent and higher order effects. Unfortunately, all of these COGs and their interconnecting cause and effect relationships are not known or understood. Even though the U.S. has been involved in the War on Terrorism for almost four years, little is known about what constitutes terrorist COGs let alone how they interact (Mitchell and Smelser, 2002: 5).

The overall goal of this research is to identify key factors in influencing transnational terrorist groups and to use these to model their generic COGs influences and interactions. Once established, these influences can then be applied with an array of techniques. In this study, system dynamics simulation techniques are used to illustrate and evaluate the effects of transnational terrorist groups' COG interactions in quantitative terms. For the scope of this research, the assumptive generalization is that most transnational groups have similar strategic COGs, although they may be of varied importance to each group. Additionally, the COGs discussed throughout focus only on the strategic level of warfare.

1.3. Summary

This introduction highlighted the importance of identifying and quantifying the strategic COGs of transnational terrorist groups in order to more effectively conduct

EBOs. Given these considerations, a model that is capable of exploiting time-persistent and higher order effects would be beneficial in providing insight to decision makers about what strategic policies and actions should be taken to achieve the desired effect. It is also necessary to be able to provide knowledge regarding any potential undesired effects. The relevant literature on COGs, COG models, and system dynamics modeling is presented in Chapter 2. The identification of key elements of value and their relationship to the COG is discussed and displayed using an influence diagram-like structure in Chapter 3. The methodology for construction of a general transnational terrorist center of gravity interaction model is presented in Chapter 4. The general COG model is then applied to a notional scenario in Chapter 5. Conclusions are drawn and areas for further research are identified in Chapter 6.

2. Literature Review

2.1. Introduction

This chapter provides an overview of the open-source literature pertinent to modeling transnational terrorist COG interactions. It reviews the concept of COG, summarizes many of the current COG models, and then reviews the systems dynamics literature.

2.2. Center of Gravity Literature

The concept of COGs is not new. It was introduced in the nineteenth century by Clausewitz in his book, *On War*, and today is still a critical topic (Schalch, 1997: 1). According to Clausewitz,

> one must keep the dominant characteristics of both belligerents in mind. Out of these characteristics a certain center of gravity develops, the hub of all power and movement, on which everything depends. This is the point against which all our energies should be directed (Clausewitz, 1976: 595-596).

In order to successfully accomplish what Clausewitz suggests, it is important to find out as much as possible about the enemy's "moral and physical character", including their associated COGs (Strange and Iron, 1996: I-12). There are no models that can help if this first step is not done accurately (Strange and Iron, 1996: I-12).

Recently, the concept of COGs has been incorporated into several joint publications (Strange and Iron, 1996: I-1). Joint Publication (JP) 3-07, *Joint Doctrine for Military Operations Other Than War,* JP 1, *Warfare of the Armed Forces of the United States*, and JP 5-0, *Doctrine for Joint Planning Operations*, all discuss the concept of

COGs. Each claims that the determination of the enemy's COGs, and sometimes our own COGs, is critical for planning and executing successful military operations (Schalch, 1997: 1). Specifically, JP 5-0 states that "the most important task confronting campaign planners in this process is being able to identify friendly and adversary strategic centers of gravity" (JP 5-0, 2002: IV-12). JP 1 maintains that

> finding and attacking enemy COG is a singularly important concept [and] means concentrating against capabilities whose destruction or overthrow will yield military success (JP 1, 1995: III-8).

Additionally, Colonel Eikmeier, in his article entitled *Center of Gravity Analysis* asserts that "the center of gravity is too important a concept to guess at" (Eikmeier, 2004: 2). Based on these statements and highlighted facts, it is clear that the concept of COGs is still relevant and still important part of planning and executing operations.

While the military is aware of the importance of COGs in planning and executing operations, joint doctrine does not specify employment methods nor does it provide a common framework for identifying and applying COGs (Schalch, 1997: 1; Eikmeier, 2004: 2). Historically, this uncertainty has been a factor in why the various services apply the concept differently. The Army and Navy typically focus on a single COG, the Air Force sees multiple centers, and the Marines equate COG to critical vulnerability (Echevarria II, 2004: 10). A critical vulnerability is a critical element that is vulnerable to attack (Eikmeier, 2004: 2). An attempt to unify the concept was made resulting in the following joint definition:

> those characteristics, capabilities, or localities from which a military force derives its freedom of action, physical strength, or will to fight (JP 1-02, 2004: 80).

The definition was later modified in JP 5-00.1 where the same basic definition remains but *localities* are replaced by *sources of power* (JP 5-00.1, 2002: GL-3).

As stated earlier, Clausewitz (1976: 595-596) defined COGs as "the hub of all power and movement, on which everything depends." He viewed them not as the source of strength, but as "the point where the forces of gravity converge within an object in the context of modern elementary physics" (Echevarria II, 2004: 13). The COG is the hub that connects the enemy's strengths, but is not the strength itself.

Even though a joint definition of COGs has been created with the original Clausewitzian concept as its foundation, there are those who claim that it has been distorted from Clausewitz's intentions (Eikmeier 2004: 2). Strange and Iron reviewed the original version of *On War*, as well as several different translations that led them to propose a new definition of COGs. Both claim the new definition more accurately captures the concept Clausewitz was trying to present. The definition they proposed is as follows:

> Centers of gravity (CG) are the physical or moral entities that are the primary components of physical or moral strength, power and resistance. **They don't just contribute to strength; they ARE the strength.** They offer resistance. They strike effective (or heavy) physical or moral blows. At the strategic level, they are usually leaders and populations determined to prevail. At operational and tactical levels they are almost invariably specific military forces (Strange and Iron, 1996: II-7).

Strange and Iron claim that by having a new, easier to understand definition, planning for operations will be made simpler (Strange and Iron, 1996: I-1).

Strange and Iron have also compiled a list of three criteria that they claim need to be met if one is to accurately identify COGs using Clausewitz's original concept (Strange and Iron, 1996: I-15). In order to meet these criteria, a COG must be dynamic, must be

obvious, and must be "powerful enough to strike effective, if not heavy, blows" (Strange and Iron, 1996: I-15). These three criteria were considered in this study when determining the appropriate COG for transnational terrorists groups.

Strange and Iron concluded the first part of their review of the Clausewitian COG concept by stating what they thought "centers of gravity are and what they are not" (Strange and Iron, 1996: I-15).

> They are **not** characteristics, capabilities or locations ... **They are dynamic and powerful physical or moral agents of action or influence that possess certain characteristics and capabilities, and benefit from a given location or terrain** (Strange and Iron, 1996: I-15).

The definition they proposed is not all that different from the current joint definition; their proposed definition is mainly a question of semantics. It is important, however, to be aware of the work by Strange and Iron as it raises excellent points about not only the current COG concepts but also forces more in-depth thinking about the COGs that are chosen.

Given key definitions of COGs found in the literature, it is necessary to review what the literature says about the number of COGs that can exist. It is also important to keep in mind when making this determination that the focus of this research is at the strategic level. Clausewitz advised finding as few COGs as possible (Echevarria II, 2004: 13), a viewpoint with which Dr. Vego, Professor at the Naval War College, is in agreement. Vego postulates that "the higher the level of war, the smaller the number of COGs" (Vego, 2002: 3). This follows directly from the concept that there are fewer objectives to accomplish at the higher levels (Vego, 2002: 3). Consequently, the strategic

level should have only one COG, while the operational and tactical levels may have multiple COGs (Vego, 2002: 3).

While Clausewitz and Vego both seek to limit the number of COGs, there are others who think there can be, and perhaps should be, multiple numbers. Warden proposes as many as five COGs in his "enemy-as-a-system" model (Warden 1995: 3). This is a claim supported by *Combating Terrorism in a Globalized World* (2002), a report completed by the Student Task Force on Combating Terrorism at the National War College, which also lists five COGs. There are others who claim there is only one COG with multiple supporting decisive points, also referred to as critical vulnerabilities.

Haberkern (2004), Schweitzer (2003), and Bliss (2004), producing separate strategic research projects at the U.S. Army War College determined that there was only one main COG, but it could be influenced or affected through several decisive points. Further discussion of the specific multiple COGs that Warden and the Student Task Force's report, as well as the other authors proposed single COGs, are further discussed later in the chapter, and are listed in Appendix A. The different sets of COGs for the various types of conflict are also delineated in Appendix A. Table A-1 lists the different COGs experts say is relevant to traditional warfare while Tables A-2, A-3, and A-4 show what many experts propose as COGS for terrorists, transnational terrorists, and insurgents.

Before appropriate COGs can be identified, the type of conflict engaged in needs to be determined. According to Clausewitz, this is the first and most important strategic question that must be answered (Clausewitz, 1976: 88-89). For this research effort, this signifies defining the nature of the conflict used by the transnational terrorist groups.

In order to properly determine the nature of the conflict, the definition of terrorism warrants review. According to the JP 1-02, terrorism is defined as

> the calculated use of violence or threat of violence to inculcate fear; intended to coerce or to intimidate governments or societies in the pursuit of goals that are generally political, religious, or ideological (JP 1-02, 2004: 534).

Consider the 2001 attacks on the World Trade Center. While the action itself was an act of terror, initially no terrorist groups claimed responsibility nor were any demands made (*Combating Terrorism in a Globalized World*, 2002: 9-10). Concurrently, Al Qaeda, the group ultimately determined to be responsible, has declared a holy war on America (*Combating Terrorism in a Globalized World*, 2002: 10). The September 11th attacks were just one of the terror actions taken in as part of the *fatwa* issued in 1998, stating that it is every Muslim's duty to wage war on the U.S. (*Combating Terrorism in a Globalized World*, 2002: 9-10).

Al Qaeda is an Islamic transnational terrorist organization whose "goal is to establish a pan-Islamic Caliphate throughout the world" by partnering with allied Islamic extremists to overthrow the existing non-Islamic governments and driving Westerners and non-Muslims from Muslim countries (Krepinevich, 2004: 2). Al Qaeda is not just trying to incite terror and fear and overthrow a government; they are trying to change the "global balance of power" by uniting all Muslims to fight against the West (*Combating Terrorism in a Globalized World*, 2002: 10).

The definition of insurgency warfare is "a protracted, multi-phased struggle, whose objective is to overthrow the existing order" (Krepinevich, 2004: 2). Al Qaeda, with its stated goals, falls under this definition. Furthermore, the battles in Afghanistan

and Iraq are insurgencies in that elements of the deposed regimes along with foreign terrorists are trying to seize or retake power for themselves (Krepinevich 2004: 1-9). If it can be assumed that transnational terrorist groups have the same or similar goals, then the goals of these transnational groups fit the definition of insurgency warfare. Based on the above definitions showing that Al Qaeda and the upheaval in Iraq and Afghanistan as insurgencies, the conflict can be classified as global insurgency (*Combating Terrorism in a Globalized World*, 2002: 10).

2.3. Strategic COGs

Given these suppositions regarding the nature of the conflict, the potential strategic COGs can be identified. Using the joint definition, and keeping in mind Clausewitz's concept of COG, an extensive search of the open-source literature was conducted to identify the strategic COG for transnational terrorist groups'.

Since the type of warfare being waged is a global insurgency, the COGs chosen should be appropriate for counterinsurgency warfare. According to FMI 3-07.22, *Counterinsurgency Operations*, the COG in a counterinsurgency is popular support, not only for the terrorists but for the U.S. and its Partners as well (FMI 3-07.22, 2004: 2-13). The insurgent forces need to be separated from the local population in order to defeat them. Simultaneously the U.S. and its Partners need to be exercise dillegence in conducting themselve's conducive to sustaining popular support at home (FMI 3-07.22, 2004: 2-13). If the local populace perceives the US and its Partners as using excessive force, the local populace may be alienated, thereby causing support for the insurgents (FMI 3-07.22, 2004: 2-13).

Counterinsurgency doctrine describes the relationship between the insurgents and the "local" population as based on an insurgency within a nation state. Classically, nation state insurgents have been closely dependent upon "local support" from within the national population in which they function. This local support may include the majority of the local population or may be generated from a specific oppressed subgroup within the population. However, the focus of local support has been within a nation's or a region's population.

The transnational terrorists groups, represented by Al Qaeda, Jemaah Islamiyah, various international supremist groups, and others, have re-defined the concept of "local support" in a globally interconnected world. Empowered by technology, the global web, and a common affinity, these transnational groups depend upon a "local support" group that spans the globe. These global, transnational "local" populations typically posses some element of common culture, beliefs, religion, perceived oppression or biases that create a global affinity group of like minded individuals, forming the locus of a transnational terrorists group's support. While their sub-groups may have originated within specific nations, these transnational terrorists have chosen to pursue overarching global goals, even at the expense of postponing the achievement of some of the individual national goals (Anonymous, 2004). The Transnational Terrorist Affinity Group (TTAG) for any given transnational terrorists group, whether Islamists for Al Qaeda and Jemaah Islamiyah or bigots for some of the racists groups, provide the "local population" from which the group draws supporters, finances, and members. The TTAG makes up the population, with a common affinity of beliefs, religion, culture, kinship or presumed oppression that supports the transnational terrorist insurgency.

The above discussion has delineated the "local" population from which transnational terrorist groups draw their support. The review of the positions taken in the open source literature on the COG for an insurgency needs to be continued. There are several who agree that popular support is the strategic COG for insurgencies. Clausewitz wrote that the COG for a popular uprising is the "personalities of the leaders and public opinion" (Clausewitz, 1976:596). Donnelly and Serchuk (2002: 5) add that the COG in counterinsurgencies is U.S. public opinion. They discuss how the terrorists involved in an insurgency know that the way to win is to holding out and wearing down the resolve of the opposition.

Several strategic COGs have been proposed for traditional warfare, as well as warfare against terrorists, transnational terrorists, and insurgents. They are shown in Appendix A, Table 11 - Table 14. Based on the various arguments, the number of times each COG appears, how well the COG stands up against the JP 1-02 COG definition, and the type of warfare being waged, it is clear that one COG stands out above the rest: popular support. Table 1, first offered here and repeated in Appendix A, shows that several sources agree with the proposed COG for an insurgency.

Table 1: Insurgents Centers of Gravity (by source)

Margulies	Krepinevich	FMI 3-07.22	Clawson	Eland	Shreves	Clausewitz	Donnelly, Serchuk
U.S. Will to Fight	Nation's Target Population	Public Support for Insugents	US Public Opinion	Sanctuary	Popular Support	Leaders	U.S. Public Opinion
	External Supporting Power's Population	U.S. Public Support	Local Pubic Opinion	Source of Arms and Supplies		Popular Appeal	
				Support of Significant Part of Population			

Reiterating a point that Table 1 highlights: the terrorists' strategic COG is not only their popular support, but popular support for their opposition as well (FMI 3-07.22, 2004: 2-13). Clearly, popular support for the insurgents and U.S./Partners popular support for the conflict fulfill the requirements of both the definition and Clausewitz's concept of COG. Together, support for terrorists and lack of support by the US/Partners for the conflict allows the transnational groups freedom of action and the will to fight. Without popular support, the terrorists will be denied sanctuaries where they can hide, train and plan, denied financial support necessary to support members and operations, freedom of passage between countries and regions, and new recruits. Additionally, without popular support for the US/Partners efforts, the transnational terrorists groups gain even more freedom of movement without fear of capture.

An example of how important popular support can be is found in the Vietnam War. In 1968, prior to the Tet Offensive, the majority of the U.S. still supported involvement in the war; however, this drastically changed when the bloody images of the Tet Offensive were broadcast on television screens all over America (Williams, 2004: 1).

While the U.S. was focused on destroying the Vietcong forces, the North Vietnamese were making efforts to gain local support (Curry, 2002: 3). Williams suggests that this was the turning point in the war. Not only were Americans unwilling to continue to pay such a high cost to achieve victory, they had started to see a difference in the visual media and the war reports from the government. The result was that the erosion of popular support accelerated (Williams, 2004: 1). Thus, North Vietnam achieved overall victory even though they lost the military battles (Williams, 2004: 1).

While neither the conflict in Iraq nor the overall conflict transnational terrorists engage in are identical to the Vietnam War, there are similarities and lessons to be discussed. The main similarity is the importance of the role of popular support. As was touched on earlier, the Vietnam War may have been lost because not enough attention was paid to winning over the population (*How the US Lost the War in Vietnam*, 2004: 7). Vietnam is an example of how only winning militarily is not always enough (Williams, 2004: 1).

In the current conflict in Iraq, the U.S. appears to be more aware of the importance of winning the hearts and minds of not only the Iraqis, but those of the U.S. and the global Arab population as well; however, more focus is required on efforts to garner support (Williams, 2004: 1). Events such as the prison abuse scandal at Abu Ghraib have greatly contributed to a decrease in popular support, for the U.S., especially among the Arab world (Williams, 2004: 1).

2.4. Centers of Gravity Models Literature

Having established the nature of the conflict and the strategic COG, the current COG models in the literature were reviewed. The two most prominent theories dealing

with strategic paralysis presented since Clausewitz first introduced the concept of using COGs to achieve this end are Warden's Five Ring theory and Boyd's Observe, Orient, Decide, and Act (OODA) loop theory. Strategic paralysis stresses utilizing military power and all instruments of national power to paralyze the enemy, both physically and psychologically, thereby compelling them to accept a desired end state.

Fadok (1995:2) maintains that Warden's theory is primarily Jominian in nature while Boyd's follows the Clausewitzian approach. The Jominian tradition believes that the practice of war is based on a set of general principles or rules, that war is complex, and that war is linear (Fadok, 1995: 34-35). Both Warden's and Boyd's theories focus on ways to achieve strategic paralysis. The difference between them is that Warden's theory looks strictly at how attacking the COGs can achieve this goal whereas Boyd's theory examines the enemy's process of thought and action in order to gain strategic paralysis. While Boyd's theory does not explicitly use the term COG, like Warden's, elements of Boyd's OODA loop are analagous to COGs in that they are elements that, if targeted properly, can achieve total collapse of the system.

Warden's Five Rings model is "practical, concrete, and linear" and focuses only on the physical aspect of warfare (Fadok, 1995: 47-48). Warden's original model proposes five COGs: leadership, organic essentials, infrastructure, population, and fighting mechanism (Warden, 1995: 3). He assumes that the most important center of gravity is leadership and that all action should be targeted towards it (Warden, 1995: 3). This assumption, that leadership is the most important COG, may become problematic when applied to transnational groups' COG. If the main COG driving a group is their common culture and beliefs, then targeting the leadership may not produce the strategic

results proposed by Warden (Fadok, 1995: 25). It may be that there are sufficient members of the group at the mid-levels who will step up and fill leadership vacancies. This is exactly what Al Qaeda has reportedly been doing to fill the gap left by the death or capture of many of their leaders (Johnston and Sanger, 2004: 1). Leadership may be distributed enough to sustain the loss of several key leaders; this has been a principal of our own national command structure. Worse, the elimination of a leader may have the undesired affect of creating a martyr for the cause.

Another limitation of Warden's model is that it does not quantify the links between COGs and target systems (EBO Draft CONOPS, 2004: 12). For example, if the bridges in a city being attacked are the key to bringing down the transportation COG, then they should be weighted in the model to show their importance and value. Furthermore, Warden's model is viewed as a linear model, but asymmetric warfare and center of gravity interactions are not linear; they are complex non-linear systems (Fellman, 2004: 3). Due to these issues, Warden's model, while an insightful starting point, has limited capability in modeling COG interactions in asymmetric conflict as initially proposed.

In contrast, Fadok (1995: 35-36) suggests Boyd's theory of focusing on the enemy's mental state is founded on the Clausewitzian tradition which views warfare as nonlinear and focuses on the intellect. This approach has several good points. It has the needed ability to deal with nonlinearity and to focus on getting inside the mind of the enemy as a way to influence them. However, the theory of operating faster inside one's OODA loop than the enemy may not always produce the desired results. A 4GW enemy may not care about the tempo of war. For example, a transnational group may use this to

their advantage. If they refuse to try to keep pace with the faster U.S. OODA loop, then they may eventually frustrate the U.S. and ultimately achieve victory (Fadok 1995: 18). While both theories are relevant to COG studies and provide an excellent starting point, they are not sufficient on their own for 4GW. Neither approach incorporates COG interactions, considers the resulting time-persistent and higher order effects, or makes an attempt to quantify COGs or their interactions.

Barlow (1993: 7) presents a useful model that discusses seven National Elements of Value (NEVs). It is pictured in Figure 1. Barlow's NEVs are leadership, industry,

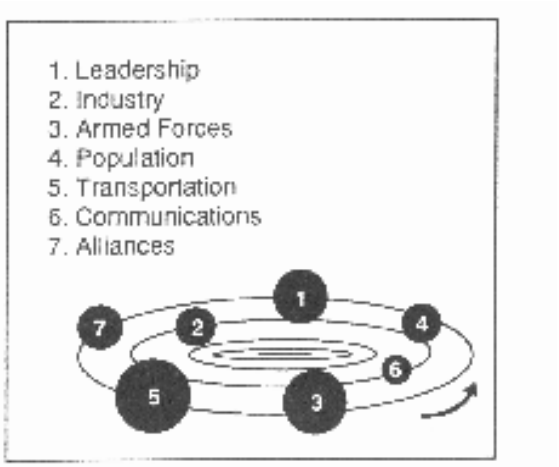


Figure 1: Model of Dynamic National Elements of Value

armed forces, population, transportation, communications, and alliances (Barlow, 1993: 6). These are very similar to Warden's five COGs, but are broken into more categories (Warden, 1995: 3). Barlow's term, NEV, can almost be interchanged with the term COG, but he makes a clear distinction that a NEV is not a COG since most COG models do not include interactions (Barlow, 1993: 17). He claims that a problem with the historical views of COGs is the belief that destroying or neutralizing one target can cause strategic paralysis to the enemy. He argues that "NEVs are interdependent" and that it is

more realistic to assume there are dynamic relationships and interactions among the seven NEVs (Barlow, 1993: 5). Even if one NEV is more important than the others by itself, it may be affected by the other NEVs. Thus, the destabilization of any one NEV could cause a disruption to all NEVs (Barlow, 1993: 5). Warden discusses the interaction indirectly in his discussion of parallel domain of a nation (Warden, 2004).

Barlow's model is referenced and expounded upon in the EBO Draft CONOPS where it is translated into three-dimensions as shown in Figure 2 (EBO Draft CONOPS, 2004: 12). This new representation adds the interactions, or inter-dependencies, of the NEVs that Barlow discussed in his original article (Barlow, 1993: 6). In both the original model and the one shown in the EBO Draft CONOPS, the sizes of the spheres indicate the importance of that node to the leadership. The new addition is the links, or interactions, between the NEVs where the thickness of the links indicates the level of importance of each NEV to the other NEVs (EBO Draft CONOPS, 2004: 13).

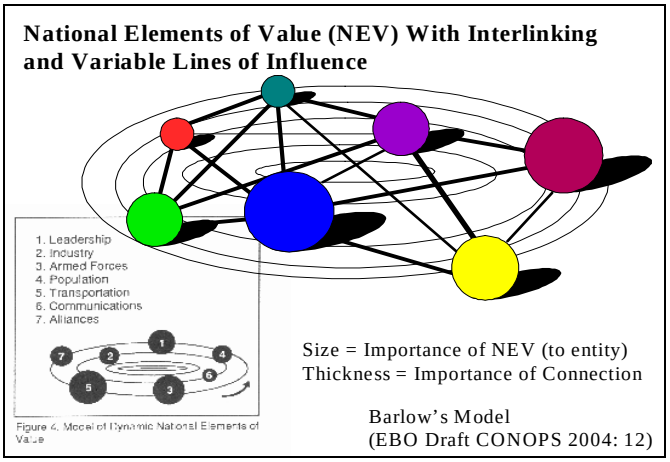


Figure 2: McCrabb's Adversary Reaction Model

Overall, Barlow is aware of the importance of interactions, but his model still focuses on a nation-state and its COGs. This is problematic since the COGs or NEVs of a

country are not the same as those of a transnational group. Tomlin (2001: 15) suggests it is more likely that a transnational group will have, to a greater or lesser degree, the following as their COGs: culture, ethnicity, religion, ideology, network structure, or financial support. These are clearly different than those listed in Barlow's model. Additionally, Barlow's model does not provide any quantitative method for analyzing the effect targeting one NEV may have on the other NEVs or the enemy as a whole.

Another useful model is CAESAR II/EB. CAESAR II/EB is a tool designed by Dr. Alexander Levis and his group at George Mason University "to support the analysis of an adversary's actions and reactions to Blue's activities so that COA (Course of Action) options could be evaluated in a rigorous manner" (Wagenhals and Wentz, 2004: 4). It uses influence nets and Colored Petri Nets (CP net) as a way to support the chronological aspects of COA evaluation (Wagenhals and Wentz, 2004: 5). The influence net provides a probabilistic model that indicates effects given a set of COAs whereas the CP net provides the analysis of effects over time (Wagenhals and Wentz, 2004: 5). The model starts with a set of COAs and then relates these events to effects based on a known network of influencing relationships (Wagenhals and Wentz, 2004: 5). The model then uses probabilistic modeling to produce a set of potential effects, both desired and undesired, using indicators to measure the effects (Wagenhals and Wentz, 2004: 5). The output is in the form of probability profiles that graphically show how much effect the original COAs have on the probability of terrorist actions or attacks (Wagenhals and Wentz, 2004: 7).

CAESAR is very useful for providing COA comparison, and is one of few that provide the capability to quantify COG interactions. However, the results depend on

having complete and accurate data sets, a difficulty common to most models. The challenges to modeling transnational groups' COG interactions are many. The main challenge is that the scenario to be modeled must be understood, and is often done using subject matter experts and other analysts (Wagenhals and Wentz, 2004: 16). Since terrorist group networks are not very well understood and there are limited transnational terrorist subject matter experts available to the planners in a war zone, this is problematic. Obtaining knowledge of the causal relationships within the network further complicates building a model. Even if all the required data were not known, the model would be a very effective planning tool; however, it still would not be sufficient on its own for modeling the COG interactions for transnational terrorist groups. The reasons for this are that CAESAR II/EB does not model persistence, does not differentiate between the effects of a sequence of different actions, and was designed for use in research where trial and error experimentation was used in developing and assessing COAs (Wagenhals and Wentz, 2004: 21); all of which are necessary functions if one is to accurately capture the interactions of transnational terrorist groups' COGs in a timely and useful manner.

McCrabb created a model on how adversaries react to U.S. or friendly actions. The model looks at the way that an enemy "might react" and is shown in Figure 3.

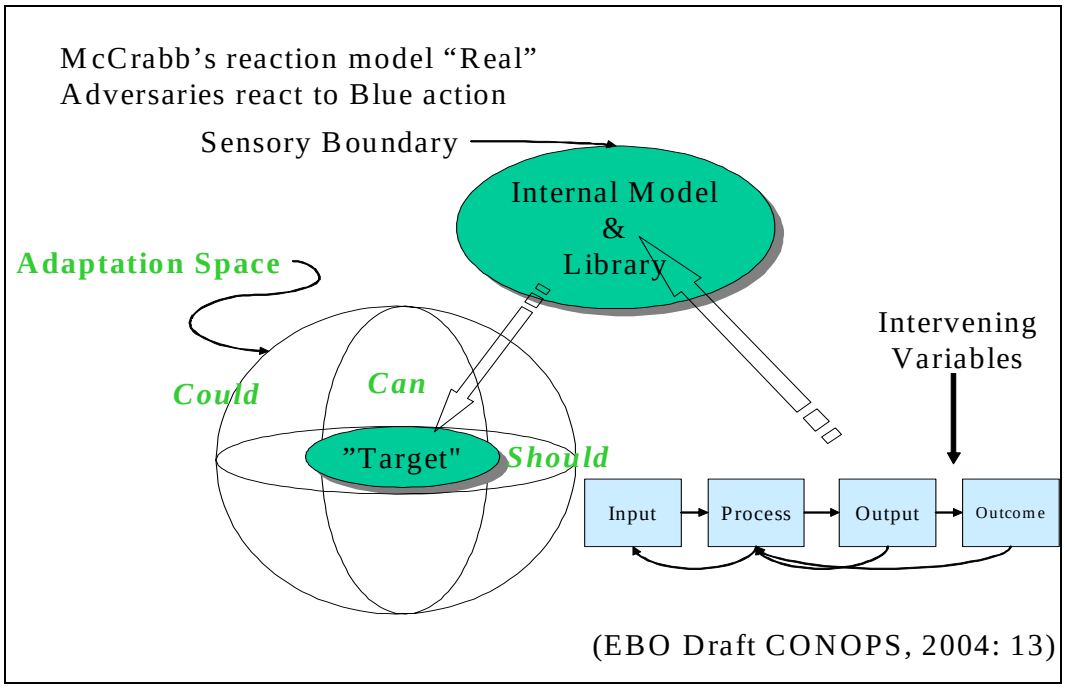


Figure 3: McCrabb's Adversary Reaction Model

This is broken into three parts: how they "should react", how they "can react", and how they "could react" (EBO Draft CONOPS, 2004: 13). How they should react is based on assessments of known capabilities, how they can react is based on capabilities they are assessed to have, and how they could react is based on capabilities they may have that "they are not now known to possess" (EBO Draft CONOPS, 2004: 13-14). A positive attribute of this model is that it provides indicators that the U.S. can look for (EBO Draft CONOPS, 2004: 14). With the push to plan based on a desired effect, this model becomes very relevant.

A final model that is reviewed here is found in the draft CONOPS for Effects-based Operations, version 2.0. This document provides a construct for EBOs that rely heavily on COG interactions as a means to predict direct and indirect effects (EBO draft

CONOPS, 2004: 9). It develops a conceptual model that is a composite of the Warden, Barlow, and McCrabb models (EBO draft CONOPS, 2004).

The composite model that is presented in the draft EBO CONOPS is a three dimensional diagram that makes connections between campaign planning and COG analysis to enable accounting for expected adversary reactions (EBO Draft CONOPS, 2004: 14). This composite model, see Figure 4, is designed to provide commanders

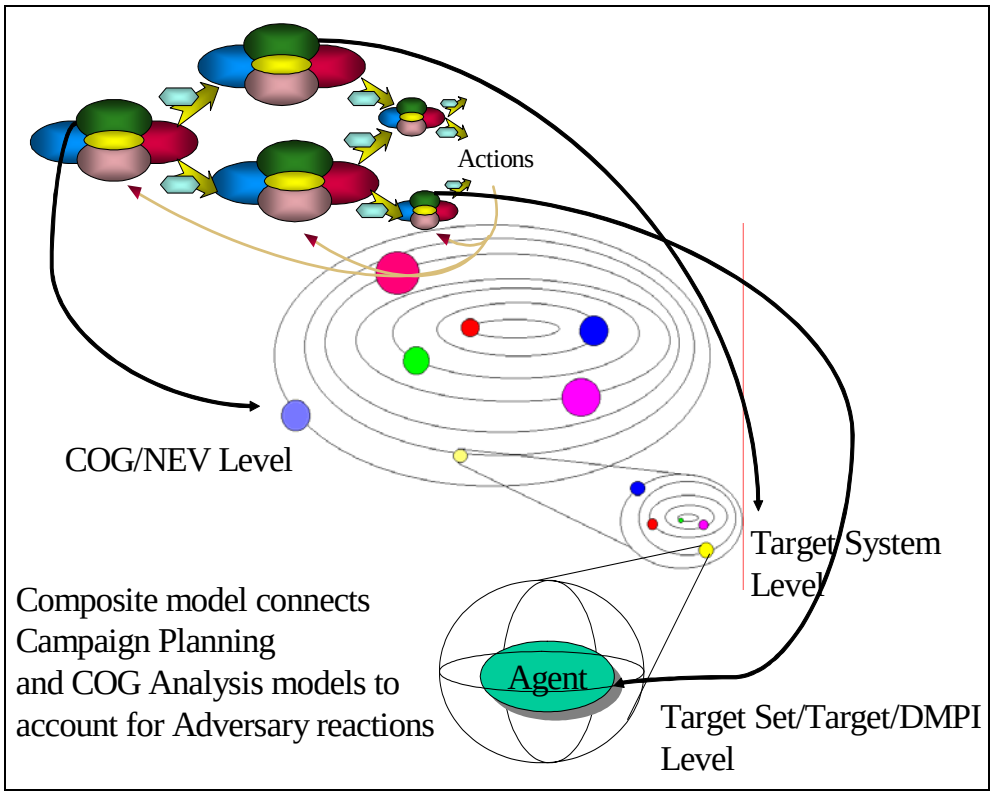


Figure 4: EBO Composite Model

the capability to analyze effects (EBO Draft CONOPS, 2004: 14). Using Warden's enemy-as-a-system COG model permits analysis of the state of the adversary and using McCrabb's reaction model adds the ability to analyze COAs (EBO Draft CONOPS, 2004: 14). This model is useful in that it provides quantitative results on recommended COAs when used in war gaming (EBO Draft CONOPS, 2004: 15). The drawback is that

war gaming takes time that may not be available. It may be difficult to war game the appropriate scenario, especially with the unexpected and dynamic nature of terrorist attacks.

2.5. System Dynamics Literature

System dynamics methodology was first used in business applications (Forrester, 1961), but it has also been applied to defense issues with effective results (Coyle, Exelby, and Holt, 1999: 372). This section will first review the pioneering work by Jay Forrester and then it will cover applications in defense analysis.

Created by Jay Forrester in the 1950's and first introduced to the world in his 1961 work, *Industrial Dynamics* (Radzicki, 1997: I-2), system dynamics characterizes social systems

> as flow rates and accumulations linked by information feedback loops involving delays and non-linear relationships. Computer simulation is then the means of inferring the time evolutionary dynamics endogenously created by such system structures. (Lane, 1997:1037)

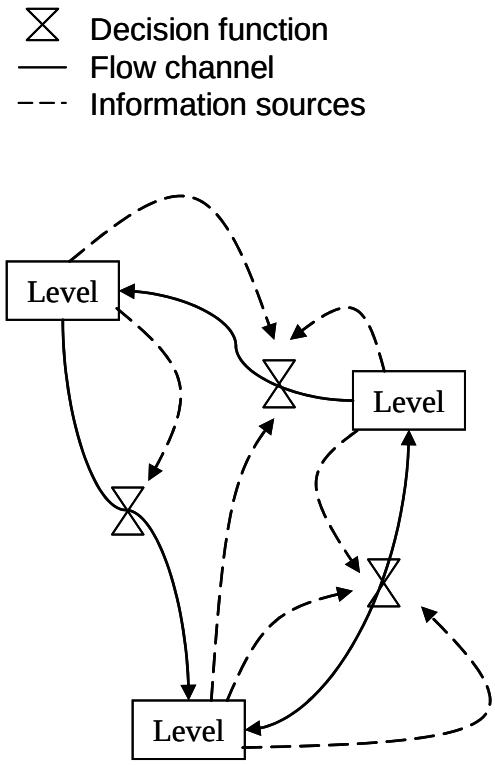
In this book, Forrester introduced the concept of information-feedback systems as the basis of industrial dynamics and used the following definition:

> An information-feedback system exits whenever the environment leads to a decision that results in action which affects the environment and thereby influences future decisions. (Forrester, 1961: 1)

He also discussed the structure of a dynamic system model. It is a structure of alternating levels (i.e., accumulations) and flow rates (i.e., decisions) that can be modeled using a relatively simple framework regardless of the size of the model (Forrester, 1961: 67). Forrester suggests all system dynamics models should be capable of describing cause-

effect relationships, have a simple mathematical nature, and be extendable to many variables (Forrester, 1961: 67).

The level variables and flow rates in a dynamic system are connected by information-feedback loops, while the decision functions (or rate equations) determine the properties of the rate flow between levels (Forrester, 1961: 69). The decision functions are only dependent on information that is known about the different levels to determine the rate flows (Forrester, 1961: 69). The rate equations determine how the available information is transformed into flow and shows the difference between the desired objective and the observed state (Forrester, 1969: 14). For example, if the objective is to reduce the number of terrorist attacks by a particular group against the U.S. by 80% and the current state is at 20% reduction, then the level variables will show this 60% discrepancy. A basic model presented by Forrester that shows levels, flow rates, and decision functions is shown in Figure 5 (Forrester, 1961: 67).



(Source: Forrester 1961: 67)

Figure 5: Basic System Dynamics Model

The rectangles in Figure 5 represent levels, the solid lines represent flows, and the dashed lines represent sources of information. The levels are the accumulations that occur in the system (Forrester, 1961: 67-68). Examples of levels are inventories, bank balances, and number of employees. Levels can also be used in information networks since according to Forrester (1961: 68), "'awareness levels' exist in the mental attitudes that influence decisions." This provides the ability to capture levels of satisfaction, of optimism, and of recollection of past events (Forrester, 1961: 68).

The value of each level is calculated from the accumulated difference between the inflow and the outflow (Forrester, 1961: 68). These rates of flow along the flow channels are controlled by decision functions, also referred to as rate equations, and are shown by

the hourglass “valve” in Figure 5. These valves determine the flow between the various levels in the system (Forrester, 1961: 68). Some examples of rates are flows of people from one place to another.

The valve, or decision function, can be thought of as the mechanism that controls the amount of water flowing from a faucet, a level, into a bathtub, another level. If the valve is turned on just slightly, the rate of water flow between the faucet and bathtub will be very low; however, if the valve is opened completely, then the rate of flow will be much higher. The amount of water in the bathtub at the end of a set time period will be determined by the decision function.

Sometimes it is difficult to distinguish between levels and rates. A good test for this is to consider if the variable of interest would exist if the system were brought to rest (Forrester, 1961: 68). If all activity in the system stopped, a level would still have value. For an inventory level, the number of items in stock would not drop to zero if all deliveries ceased. Rates, on the other hand, would drop to zero if the system came to rest. If the delivery rate of an item was stopped, then the flow rate ceases to exist until the system starts moving again (Forrester, 1961: 68).

The bathtub example demonstrates flow in only one direction; however, flows do not need to be one-way, they can flow in both directions which are shown in Figure 5 by the flow channel with two arrow heads. While flow can go both ways, the amount of flow in each direction is controlled by different rate functions since the rate of flow in one direction may be much faster than in the other direction; therefore, even though flows are often drawn as a single flow channel, there are usually two separate channels where flow occurs at different rates. Since feedback systems are characterized by behavior that

is not always evident by inspecting the parts by themselves, it is critical that these systems follow the above mentioned concepts of feedback systems (Forrester, 1961: 61).

Forrester also asserts that when formulating a model, system interconnections, time delays, amplifications, and information distortion are all needed to determine the stability and growth of the system under consideration (Forrester, 1961: 61). Time delays need to be modeled since the behavior of dynamic systems strongly relate to the time-sequence relationships between different levels or actions within the system (Forrester, 1961: 62). These delays can occur in all parts of the system and should be incorporated into model formulation in order to appropriately capture time-persistent effects caused by the behavior of the system.

Forrester used amplification to imply "a response from some part of a system which is greater than would at first seem to be justified by the causes of that response" (Forrester, 1961: 63). Amplification is captured in the decisions that control flow rates (Forrester, 1961: 63). Information distortion, on the other hand, refers to distortion that occurs to the information flow in the system caused by time delays, amplifications, and other factors, such as prejudice, political environment, or past history (Forrester, 1961: 63). Information distortions need to be included in the model since information is the input to decisions (Forrester, 1961: 63). A final important point Forrester makes in his 1961 work is that the variables used in the model must be measured in the same units as the variables in the real system and should properly reflect any time-sequential relationships that exist in an attempt to preserve the true dynamic nature of the information-feedback system (Forrester, 1961: 63).

In 1969, Forrester continued his development of systems dynamics and feedback systems with *Urban Dynamics* in which he used systems dynamics to analyze the growth or decay of an urban environment over time. The concepts he used can be applied to most dynamic systems, as is demonstrated by this new application; therefore, it is applicable to modeling the dynamics of transnational group COGs and their interactions while capturing any time-persistent or higher order effects.

One concept Forrester discussed in *Urban Dynamics* is that of closed-system boundaries. The closed-system boundary level defines the border within which the system interactions will take place that produce the particular behavior characteristics of the system (Forrester, 1969: 12). "The boundary is chosen to include those interacting components necessary to generate the modes of behavior of interest" (Forrester, 1969: 12) and to eliminate outside factors that do not give the system its intrinsic characteristics (Forrester, 1969: 12). In terms of transnational group COGs as a dynamic system, the closed boundary includes the dynamic behavior generated by the COGs as well as the characteristic behavior of their interactions while eliminating all other group characteristics as being irrelevant.

Systems dynamics focuses on a system's behavior over time (Radzicki, 1997: III-2). In order to build a computer simulation model of a dynamic system that accurately characterizes the system, the components that are interacting and causing the behavior of interest need to be estimated (Forrester, 1969: 13). A critical first step in building a dynamic model is to identify the key variables and determine their behavior patterns. Once this is done, a model that mimics these patterns can be used for testing potential

policies or COAs that are aimed at changing the behavior of the system in a desired manner (Radzicki, 1997: III-3).

According to the U.S. Department of Energy's *Introduction to System Dynamics* (1997), systems exhibit "patterns of behavior", also referred to as "time paths," that can be grouped into five distinct families: linear, exponential, goal-seeking, oscillation, and s-shaped (Radzicki, 1997: III-3). The majority of all systems behave in the manner of one of these categories (Radzicki, 1997: III-3).

The first family of time path is the linear family. This family includes such relationships as equilibrium, linear growth, and linear decline (Radzicki, 1997: III-3). The general population, not trained in system dynamics, most often thinks that systems are linear; however, most systems do not exhibit linear growth and decay (Radzicki, 1997: III-3). It is usually when a system does not have any feedback that a true linear time path is generated (Radzicki, 1997: III-3). It is important to note that few systems exhibit an equilibrium pattern (Radzicki, 1997: III-3). Since it is a "state of perfect balance" where the system does not change, nor is there any pressure to change, it is not found very often in real life systems (Radzicki, 1997: III-3).

The second family is the exponential family. Exponential growth and exponential decay fall into this group. This family represents the majority of real systems, since real systems often exhibit one of these patterns (Radzicki, 1997: III-3). The third distinct family of time paths, the goal-seeking family, is related to the exponential family in that it is similar to the exponential decay function (Radzicki, 1997: III-3). Within this family are two types of time paths: those seeking zero and those seeking a non-zero goal (Radzicki, 1997: III-3).

The fourth time path family is the oscillation family. This family houses the most common dynamic behaviors seen in the world and contains many clear-cut patterns (Radzicki, 1997: III-3). Four of the most common oscillating patterns are: "sustained, damped, exploding, and chaos" (Radzicki, 1997: III-3). Sustained oscillations are patterns that have a periodicity of one. Damped oscillations are time paths that are relaxed or "damped" over time by some process which decreases the amplitude (Radzicki, 1997: III-3). Exploding oscillations, on the other hand, can grow rapidly until they either settle down into a sustained pattern, or they keep growing until it tears apart the system (Radzicki, 1997: III-3). The last oscillating pattern is chaotic behavior. This time path results in an irregular pattern that oscillates but never repeats – in essence, an infinite periodicity (Radzicki, 1997: III-3). This behavior pattern is unique in that it is "an essentially random pattern that is generated by a system devoid of randomness" (Radzicki, 1997: III-3).

The fifth distinct time path family is the s-shaped family. This path is a combination of the exponential growth and the goal-seeking behavior (Radzicki, 1997: III-3). Specifically, the system starts with an exponential growth pattern and, as it nears its limits or capacity, changes to a goal-seeking behavior (Radzicki, 1997: III-3).

2.6. Defense applications

The method of system dynamics has been used successfully as a tool in analyzing defense problems (Coyle, Exelby, and Holt, 1999: 1). While other operational analysis tools have a valued role in defense analysis, there is a distinct place for "models which exploit the power of system dynamics in taking an overall view of problems" (Coyle, *et al*, 1999: 1). It also provides insight into how a system is affected by non-linearities

(Coyle, *et al*, 1999: 1). This property makes it useful in modeling combat which is non-linear (Coyle, *et al*, 1999: 1). Coyle was the first to explore using system dynamics for combat modeling when he published a model of a hypothetical World War III (Coyle, *et al*, 1999: 1). By using the system dynamics methodology, sensitivities were able to be explored much more than a model built just on narratives (Coyle, *et al*, 1999: 1).

Unfortunately, even though there are many cases of system dynamics used in defense analysis Coyle found few of them in the published literature (Coyle, *et al*, 1999: 1). A few of the areas in which this methodology has been used are command and control system effectiveness assessment, search and rescue, the "millennium bug", and defense costing and procurement strategy (Coyle, *et al*, 1999: 1).

One specific area where research has recently been done is post-conflict reconstruction, also known as Phase IV operations. Richardson (2004: iv) applied system dynamics to the problem of post-conflict reconstruction, and showed it was a viable method for simulating public order and safety. He developed a generic system dynamics model for Phase IV operations and then applied it to a notional scenario based on Operation Iraqi Freedom (Richardson, 2004: 62).

While there is evidence that the military is utilizing system dynamics to analyze defense issues, one main area where they have yet to really focus research efforts is counter-terrorism (Smith, 2004: 2). According to Smith (2004), in an article discussing the role of modeling and simulation as a decision tool, a complete analysis of the terrorist threat, which is by nature dynamic, has not yet been done; consequently, "there are currently no models that capture all aspects of terrorism and look for warning signs of future actions" (Smith, 2004: 2). Smith (2004: 7) summarizes his findings by stressing

the military's need for a model to represent "the will of sympathetic individuals to support terrorist networks." In order for such a model to be effective, it should incorporate the cultural, psychological, and humanitarian environment (Smith, 2004: 7).

"System dynamics is a powerful methodology and computer simulation modeling technique for framing, understanding, and discussing complex issues and problems (Radzicki, 1997: I-1)." It also "provides the basic building blocks" needed in order to create a model that will show the behavior of a "complex real-world system" over time (Radzicki, 1997: III-1). Based on this information and the literature reviewed above, it is not surprising that systems dynamics techniques can be extremely useful in helping decision makers to understand the nature of the complex problems they are regularly faced with (Radzicki, 1997: Overview-1). Furthermore,

> the success or failure of a particular policy initiative or strategic plan is largely dependent on whether the *decision maker* truly understands the interaction and complexity of the system he or she is trying to influence. (Radzicki, 1997: Overview-1)

Since transnational terrorist groups are basically complex networks (Marion and Uhl-Bien, 2002: 8), systems dynamics provides a means to model these networks and to gain insight into how to strategic COAs will effect them.

A note of caution is necessary, however. System dynamics models are difficult to verify and validate. This has been the approaches "Achilles Heel". It is a powerful approach, but must be carefully verified, validated and accredited.

2.7. Summary

This chapter provided a review of the pertinent literature on COGs, some of the current COG models, systems dynamics, and transnational terrorist groups' centers of

gravity. Based on the literature reviewed, a single strategic COG emerged: popular support. In Chapter 3, the key supporting elements of popular support will be discussed and their relationship to the main COG and each other will be shown.

3. Methodology

3.1. Introduction

Based on the literature review presented in Chapter 2, a center of gravity (COG) interaction for transnational terrorists model was created to show the key elements of influence that affect the overall level of popular support. This chapter will first discuss the top-level influence model. Next, it will decompose the popular support model into four influence sub-models. Two of which will be discussed in detail in this chapter. They will be repeated in Appendix B along with the other two influence diagram-like approaches in order to provide a single location for all of the diagrams and details.

3.2. Influence Models

Based on the development presented in Chapter 2, the strategic COG for transnational terrorist groups is popular support. Based on this premise, a top-level influence model (see Figure 6) was created to show the existence of inter-relationships between the four key components of popular support. This top-level model is intended to be a pictorial representation of the relationships between the components of popular support in order to provide an aggregate framework of interactions within the model overall; it is not where the specific interactions actually occur.

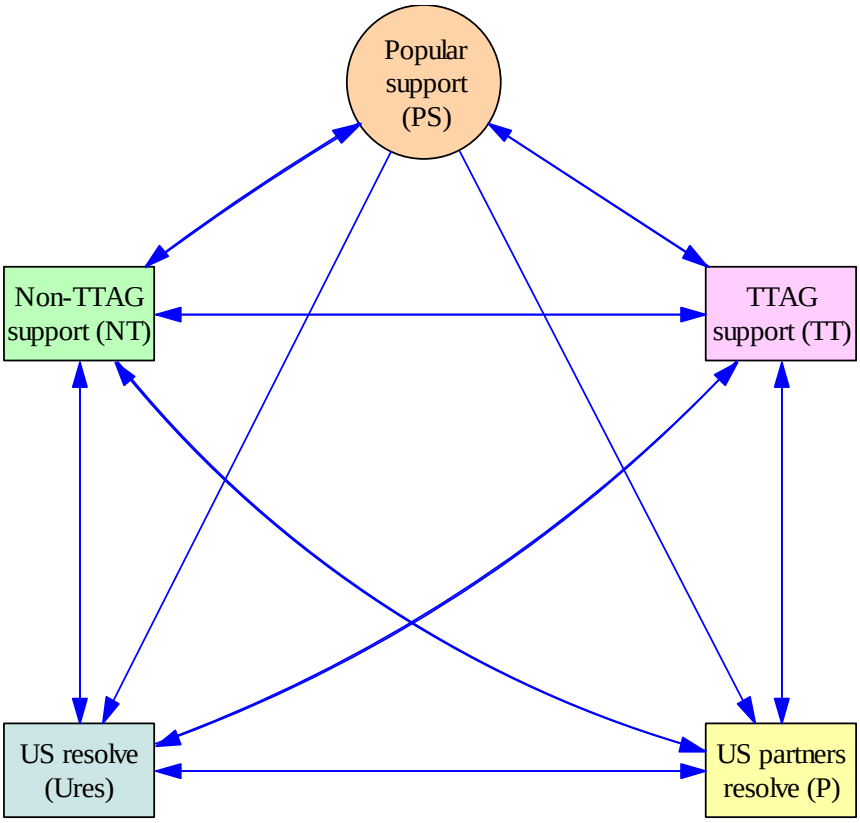


Figure 6: Top-Level Transnational Terrorist Strategic COG Influence Model

The influences displayed in Figure 6 represent the existence of connections between lower-level components of the sub-models and Popular Support (PS) – the key COG for a transnational terrorist group. The four sub-models provide an aggregate level look at each of the components determined by key elements of influence within each sub-model. These components are used to determine the current level of PS.

Before discussing the model, however, the four components must be defined and explained. The first two components that influence popular support for the terrorists are the Transnational Terrorist Affinity Group (TTAG) and the Non-TTAG. The TTAG represents the segment of the global population that consists of those who are similar to the terrorists in either their culture, beliefs, perceived oppression and, possibly, religion and believe they are disfranchised with their governments or society in general. This is

the population from which the terrorist group draws its principal support and followers. On the other hand Non-TTAG refers to those who are not similar to the terrorists in culture or beliefs and are not in the affinity group from which the transnational terrorists are actively trying to recruit.

The TTAG and Non-TTAG together comprise the global population. Either someone is in the TTAG or they are not. For example, Al Qaeda is a transnational terrorist group that is based on an extremist Muslim ideology (Bliss, 2004: 7). For Al Qaeda, the TTAG might be the global Muslim population and the Non-TTAG would then be the remainder of the global population; thus, a U.S. citizen who is a Muslim would be counted in the TTAG, whereas, a non-Muslim U.S. citizen would be counted in the Non-TTAG population. The same would apply to any U.S. Partners' populations. It is important to note, however, that membership in the TTAG population does **not** imply membership in the terrorist group; only that one is in the population segment that is the terrorist group's principal source of support.

The other key components represent the coalition's resolve to resist the terrorists. While total allied resolve is critical, it is identified as two key components, the analyst's home nation and the rest of the coalition. These other two components, U.S. resolve (Ures) and U.S. Partners' resolve (P), reflect the level of resolve each has for continuing the conflict.

In Figure 6, the strategic COG, popular support, is represented by a circle as is traditional, whereas the four components, which are also levels, are shown as rectangles. The arrows indicate that an influence exists, with the arrowheads showing the direction of

influence. In this diagram, the arrows are dual-headed since each component affects all four components, as well as the strategic COG.

Since the strategic center of gravity is popular support, both for the terrorists' as well as the U.S. and its Partners (FMI 3-07.22, 2004: 2-13), both aspects need to be considered when modeling the COG interactions. Therefore, the model was designed to reflect the components that combine to make up the level of global popular support for the terrorists, as well as those that join together to form the level of resolve for the U.S. and its Partners, which influences the TTAG and Non-TTAG.

The four key components of popular support were chosen based on open source literature from which the interactions between the components and the main COG were identified (Kohn 2001: 2; Cragin and Daly 2004: 37). According to The Associated Press (2004: 1), one of the goals of transnational terrorist groups is to drive a wedge between the U.S. and its Partners. Additionally, they are actively trying to recruit popular support for their cause from the moderates within their TTAG and from within the Non-TTAG, by capitalizing on and distorting any perceived negative aspect of the U.S. and its Partners' GWOT policy (Associated Press, 2004: 1). This is an attempt by the terrorists to simultaneously attract support for their cause while minimizing the resolve of the U.S. and its Partners for the war effort (Associated Press, 2004: 1). The four components are necessary in order to accurately capture popular support.

According to Nye (2004b: 16-20), the U.S. cannot hope to win the GWOT by itself; the U.S. needs to work with other countries. If the U.S. becomes so unpopular that the majority of the global population disagrees with its actions and policies, the terrorists

will have a distinct advantage (Nye, 2004b: 16-20). Thus, the interaction between the U.S. and its Partners is critical.

It has also been observed by Nincic (1995: 1), that the ability of a democratic government to use of force as a method of policy is contingent upon public approval, or popular support. Nincic further asserts that while other groups, such as Congress and lobbyists, influence strategic policy, "the ultimate measure of a democratic policy's viability is the extent to which it enjoys broad societal support" (Nincic, 1995:1-2). This further highlights the need for including US resolve and US Partners' resolve as critical elements in the model.

At the top-level of the model, Popular Support (PS) represents the number of the people in the global population that support the terrorists. The TTAG (TT) and Non-TTAG (NT) represent the number of supporters for the terrorists from each respective group, and US resolve (Ures) and Partners' resolve (P) correspond to the number of supporters for the GWOT efforts from each group. Viewing the model from bottom to top, the US resolve and the Partners resolve influence each other as well as the Non-TTAG and the TTAG. US resolve and Partners resolve, however, do not feed directly into popular support, but they do provide indirect influence on popular support. This occurs through the Non-TTAG and TTAG by way of the effector variables that reside in multiple influence submodels. Looking at the next level up, the TTAG and Non-TTAG, which representing the overall global support for the terrorists', indirectly influence US resolve and its Partners' resolve. Additionally, the TTAG and Non-TTAG, both directly and indirectly, contribute to, and influence the overall level of popular support for the terrorists. The nature of the relationships of all the model components is discussed next.

Starting with PS and working down, equations for the relationships are proposed. While the exact relationship between TT and NT will depend on the groups modeled, a simple generalization represents the level of PS as the sum of the membership of the TTAG and Non-TTAG. This yields the following general equation for calculating PS:

$$PS = TT + NT, \tag{3.1}$$

where *TT* represents the number of terrorist supporters from the TTAG, and *NT* represents the number of terrorist supporters from the Non-TTAG. The other variables in the model, Ures and P, represent the number of supporters from U.S. and from its Partners countries, respectively, that support their countries GWOT efforts. Ultimately, the goal, from the U.S. perspective, is to reduce support for the terrorists while maintaining or increasing resolve at home. Defining PS as the overall support for terrorists provides a way to gage how effective the GWOT is going. If PS declines over time, then the terrorists are losing support. If it increases, that means they are growing in popular support.

The top-level model was decomposed into influence sub-models for each of the four components. These influence sub-models display the key elements of value that affect each respective component and highlight interactions between the four components.

It is important to note that the sub-models were designed with the U.S. perspective in mind. Since the purpose of the research is to build a model that will provide insight to a decision maker on the effects of potential strategic courses of action (COAs) on terrorists PS, the model is presented from the U.S. viewpoint rather than the terrorists' viewpoint.

3.3. TTAG Support Influence Sub-model

The first influence sub-model that will be discussed in this chapter is the TTAG support sub-model. The TTAG sub-model (see Figure 7) is presented using an influence diagram-like display.

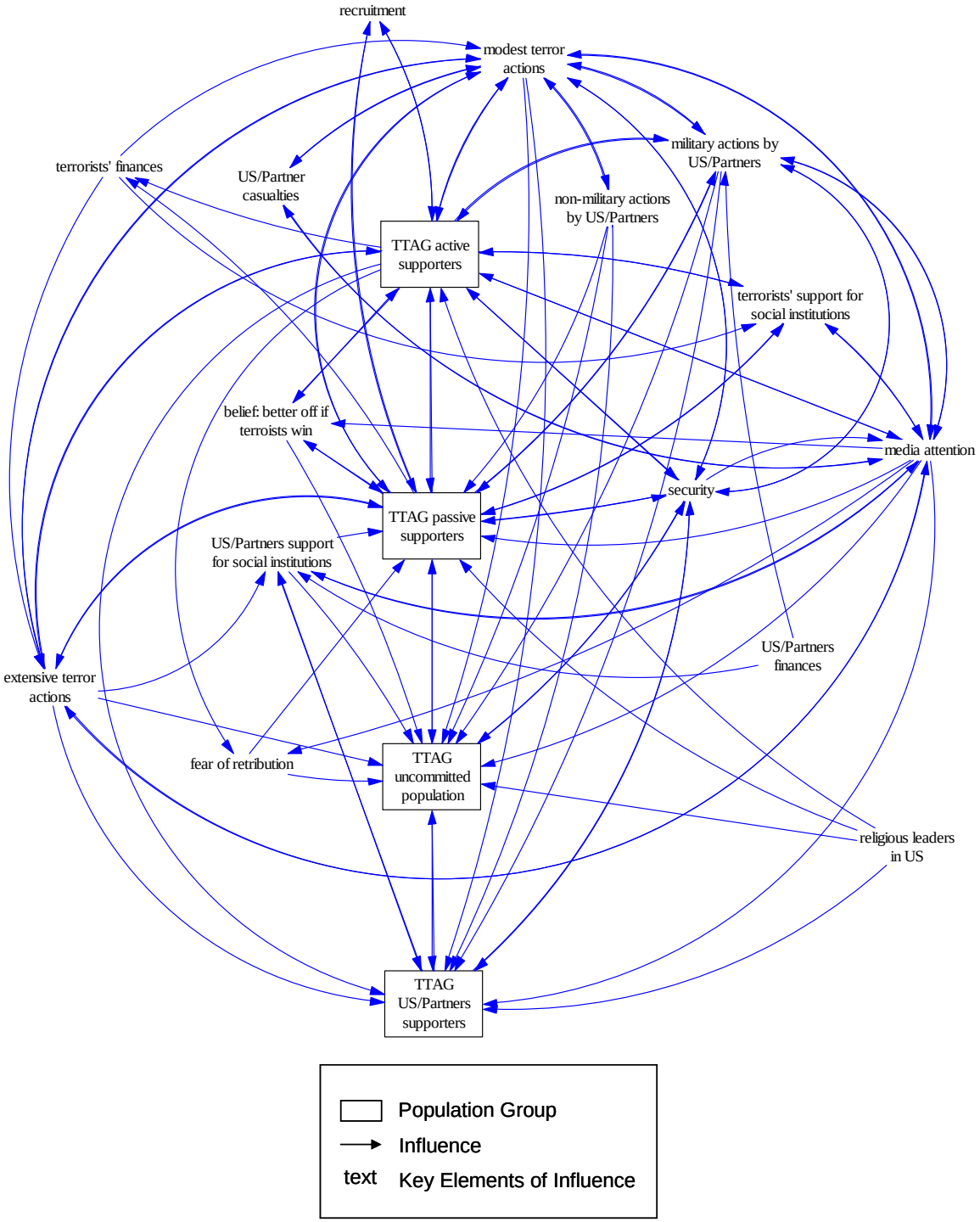


Figure 7: TTAG Support Influence Sub-model

The influence diagram-like display shows several key elements of value that, based on the literature, affect the overall level of TTAG support. It consists of four

population groups: TTAG active supporters, TTAG passive supporters, TTAG uncommitted population, and US/Partners' supporters.

According to AFP 3-20 (1990: III), active and passive support can be in the form of ideological, political, economic support or sanctuary. APF 3-20 also provides definitions and examples of both types of supporters. Active supporters usually agree with the group's ideology and include those who provide money, information, safe houses, medial services, food, weapons, and safe passage. Examples of active supporters are states, religious centers, schools, wealthy individuals, businesses, charities, Diasporas, and the anti-Western community (AFP 3-20 1990: III). Since the strategic COG in this research is popular support, the focus within this sub-model is on groups that contribute to or affect the level of popular support. For this reason, the active operators of the terrorist groups, the ones who actually carry-out the attacks, are included in the "active supporters" group since they are the terrorists and count towards the level of popular support within the TTAG. Therefore, all individuals matching the definition of "active supporter" just outlined who are from the Transnational Terrorist Affinity Group (TTAG) are considered to be members of the TTAG active supporters group.

Passive supporters are those who "are sympathetic to the terrorists cause, but either will not or cannot assume an active role" (AFP 3-20 1990: III). Their support may be a result of blackmail or intimidation. "Passive support may be unwitting; for example, contributions to 'charitable' causes or other ruses" (AFP 3-20 1990: III). Individuals from the TTAG population who passively support the terrorists are modeled as members of the TTAG passive supporters group.

The uncommitted population within the TTAG includes those who are not supporting either the terrorists or the U.S. and its Partners; they are neutral. According to Krepinevich (2004: 4), the majority of the population is uncommitted and provides support to the terrorists only when coerced or when it is clear who will or has already won.

The influence between the active and passive supporters goes both ways. They both influence each other. The active supporters influence the passive supporters through recruiting activities and terror actions (Cragin and Daly 2004: 35), and by playing on their shared culture or affinity, while the passive supporters affect the active supporters by providing financial aid, public displays of support, and minor logistical support (AFP 3-20 1990: III).

The last group that needs to be defined is US/Partners' supporters. This group represents those in the TTAG who support U.S. and its Partner countries' war effort.

While there are more layers of elements that influence the level of support from within the TTAG than are shown here, these key strategic elements of value were chosen based on the scope of this research and the strategic level of fidelity the model is intended to represent. To ensure the influences in the model are clearly understood, the key elements chosen for Figure 7 are defined next.

3.3.1. Key Elements of Influence

Modest terror actions are defined as those actions carried out by the terrorists to further their cause through the use of fear. These attacks can be directed at any group or person the terrorists decide may benefit their cause. Often the attacks are directed at opposition forces or opposition countries populations and infrastructure, but are not

limited to them. Examples of these actions are bombings, kidnapping, and assassinations. According to the Air Force Studies and Analysis Agency's (AFSAA) report, *FY04 Capability Review and Risk Assessment (CRRA) Analytic Methodology*, modest terror attacks refer to the number of friendly casualties sustained in an attack and are defined as "tens of citizens/troops killed and citizens overseas attacked/injured" (2003: 20). Extensive terror actions are characterized by "thousands to tens of thousands of citizens/troops killed/injured and citizens oversees killed/taken hostage" (AFSAA, 2003: 20). Extensive terror actions are by definition larger in scale than a modest terror action. The attack on September 11 on the World Trade Center is an example of an extensive terror action. It had a far greater impact than a suicide bombing that might, in general, only kill a few innocent civilians or troops. Additionally, an extensive act will get far more media attention than a small scale terror attack. A key assassination could also be considered an extensive act. (The cause of specific key assassinations has not been explicitly modeled here, but could be added if desired.)

Since there is such a distinction between modest and extensive attacks in terms of number of casualties and damage caused and their impact can be very different on the various groups of interest, they are identified separately in this model. Both of these key elements of value affect the US/Partner number of casualties which is defined as the number of U.S. and Partner troops and civilians that are wounded or killed as a result of the conflict. It is through these effects, the sub-models interact.

Terrorists' support for social institutions represents all actions taken to help the populations within the TTAG, such as donations to Universities or religious education centers, hospitals, or schools. *Fear of retribution* represents the fear people in the TTAG

have that the terrorists will harm them or their families if they do not support the terrorists or if they support the U.S. and its Partners. The element *belief: better off if terrorists win* represents the perception of the members of the TTAG that they will be better off if the terrorists win than if the U.S. and its Partners win.

Security is defined as the level of security felt by the population in the areas affected by military actions. For example, in terms of the current conflict in Iraq, security would refer to the level of security inside Iraq and on its borders. The geographic area could be much broader, depending on each specific conflict. *Media attention* is defined as the amount of attention, positive or negative, given by the media to the terrorists and activities surrounding them. This attention includes reporting on the terrorist group's modest and extensive terror actions and their support for social institutions, as well as coverage of U.S./Partners' reactions to or actions to prevent terror actions. The U.S./Partners' actions include, military and non-military actions, along with support for social institutions. Military actions are generally assumed to be done in response to the actions of the terrorists, as are non-military actions, such as economic sanctions, but also includes actions to establish and provide security and to train indigenous forces. *U.S./Partners' support for social institutions* includes financial aid and security to groups such as USAID. In addition, it includes humanitarian actions by the military reconstruction teams or troops such as digging wells, re-building schools, or passing out water to villages.

Terrorist finances are defined as the total amount of funds they have access to for planning and conducting operations, supporting group members and their families, funding social institutions, and many other activities. This money may come from a

variety of sources, to include donations from individuals, from nation states, from front businesses, or from involvement in the drug trade. *US/Partners' finances* represent the amount of funds available or allocated for use in fighting the GWOT. This money would be divided into separate funds, such as one for support of military actions and one for support of reconstruction actions.

Religious leaders in the U.S. represents the negative public statements made by several key religious leaders in the U.S. which may be seen by the members of the TTAG as views shared by the U.S. government. In many Islamic nations, the government is not separate from the church (Anonymous, 2004: 3-4); therefore, a less worldly Islamist might believe that the U.S. religious leaders are speaking for, and with the support of the government, even though that is often not the case in a nation that values the separation of church and state.

3.3.2. Influences

Now that the nature of the relationships between the four population groups have been discussed and all the terms in the sub-model have been defined, the influences that the key elements have on the population groups in the TTAG, as well as on the other elements in the sub-model in Figure 7, will be discussed. Some of the influences are fairly obvious, while others are not.

An obvious influence is the affect an extensive terror action will have on the U.S. and its Partners' supporters. If the attacks on September 11th are any indication, the use of these types of attacks can lead to at least a temporary acceleration in support for the war on terrorism among the U.S. and its Partners' supporters, as well as the uncommitted population within the TTAG. On the other hand, an extensive attack is an effective

recruiting tool for the terrorists since it will often draw passive supporters into the active ranks. The influence between active and passive supporters and extensive terror attacks also exists. Active terrorists conduct the extensive terror attacks and passive supporters provide the logistic support needed to plan and carry-out the attacks.

Additionally, modest terror actions may keep increasing in scale and scope in order to maintain the shock value, or the level of terror each attack is intended to create, eventually reaching the level of an extensive terror attack threshold. Once an extensive terror attack is successfully complete, the active ranks, as well as many passive members, will be highly motivated by their success to keep fighting, potentially resulting in an increased number of modest level terror actions.

Another obvious influence is that of the media. Media attention affects a variety of elements. Terrorists often conduct terror attacks to garner media attention which provides them with publicity for recruiting from the passive and uncommitted populations. Media attention can also provide the motivation members need to continue attacks. "For from being completely steadfast and resolute, terrorists are driven by the need for action and audience support, and long periods of time between actions make for restlessness, feelings of isolation and entrapment, and a heightened tendency for internal conflicts over means and ends." (Mitchell and Smelser, 2002: 21-22). Without constant activity, terrorists motivated more by the actions than the ideology of the group may lose focus; therefore, media attention is modeled to influence the terror actions of the terrorists. Media attention is also a significant contributing factor to the level of fear of retribution people feel. Seeing people being kidnapped and beheaded on television may

be an affective method of persuading people to become supporters or at least remain neutral.

Media attention also affects whether the active, passive, and uncommitted populations believe they will be better off if the terrorists win. If the news is reporting that the U.S. is losing and cannot hope to achieve victory, or worse if spun to imply the Coalition is oppressing the TTAG, this belief may become widespread and, since some people refrain from choosing sides until they see which side is winning (Krepenevich, 2004: 1), this form of media attention can impact the uncommitted population. It can also strengthen the support from the active and passive supporters since it is motivating to believe one's side is winning. If an uncommitted person moves to being a terrorist supporter because of media influence, then that increases the terrorists support while decreasing potential supporters for the U.S. Media attention for the terrorists can also cause a person who is currently a supporter of the U.S. and its Partners to change their mind and start supporting the terrorists through constant re-enforcement of an extremist ideology that the Coalition is evil.

Media attention is not only given to the terrorists' actions, but to actions by the U.S. and its Partners as well. Often media coverage is linked to the military response of the U.S. and its Partners to a terror attack, but it can also be caused by non-military actions by the U.S. and its Partners or U.S./Partners' support for social institutions in the geographic areas of conflict or non-military actions, such as economic sanctions or political rhetoric. Even though spectacular terror attacks appear more attention grabbing, the non-military actions taken by both sides do get reported in the media. It is the reports about the non-military actions and support for social institutions that have positive impact

on the U.S. and its Partners' supporters. The reports' impact usually reduces the number of U.S. and Partner casualties. For example, more media reporting on troops re-building schools or digging wells should have a positive affect on the number of U.S. supporters while having a negative or neutral affect on the terrorists. On the other hand, if the media reports that the U.S. led sanctions are causing Iraqis to starve, then there is a definite impact on opposition support (Klevans, 2003: np).

Military actions by the U.S. and its Partners' receive the most negative media attention, although non-military actions can also receive negative press. For this research it is assumed that military actions receive the largest amount of negative media coverage for the Coalition with non-military actions receiving less negative media attention. As stated above, economic sanctions fall under non-military actions and often get reported negatively in local press due to number of deaths by starvation. It is for this reason the model assumes negative media attention for non-military actions instead of positive attention. However, the nature of the relations can be altered if a specific situation warrants.

Many of these actions are done with the knowledge that they will receive media attention, such as U.S. support for social institutions. While they are not done with the sole purpose of gaining positive media attention, this fact may be part of the decision process when deciding on a Courses of Action (COA). This same type of relationship holds for the terrorists. However the terrorists may be more motivated towards supporting specific, cause related social institutions because of the positive media attention it will garner.

The level of security is also seen to influence many of the key elements in Figure 7. It affects the ability (or lack thereof) of the active and passive membership to move about freely, which increases their ability to conduct terror actions; security affects the number of military and non-military actions performed by the U.S./Partners. It affects the members of the uncommitted population since who they choose to support is often driven by fear or by the perception of which side is winning. Finally, security affects the U.S./Partners' supporters group by directly impacting the number of U.S. and Partner casualties. This, in turn, affects these groups' support level.

The reciprocal relationship exists for most of the abovementioned elements and security. The active supporters influence the level of security since they are the ones conducting attacks aimed at destabilizing the area and decreasing security. The passive supporters have a similar affect in that they provide support to the active members which allows for the actions that decrease security. In addition, the passive supporters often hide the terrorists, allowing them to conduct attacks, thus decreasing security. The uncommitted population affects security by not reporting knowledge about the terrorists to the U.S. and its Partners. Finally, US/Partner supporters impact the level of security by providing information about the terrorists' whereabouts or any other general knowledge helpful in defeating the terrorists.

Fear of retribution has a significant influence on members of the passive and uncommitted groups. If someone curtails their activities because they are afraid they will be kidnapped and beheaded for speaking out against the terrorists, they are clearly affected by fear of retribution. This may cause them to remain uncommitted or to

become a passive supporter. This fear is generated by the horrific actions of the active terrorists who play a key role in causing fear of retribution.

The last set of influences to be discussed involves religious leaders in the U.S. If the TTAG of interest believes there is no separation of church and state, then any negative public statements that allied clergy espouse may anger people in all four groups within the TTAG, perhaps causing them to become more pro-terrorist. This could even result in current U.S. supporters becoming passive supporters or at a minimum, uncommitted.

The supporting documentation found during the literature review for the TTAG Support Influence Model is listed in, Table 15 - Table 20 of Appendix B. Figure 7 is repeated in Appendix B along with the other influence sub-models.

3.4. U.S. Resolve Influence Sub-model

The other influence sub-model to be discussed in this chapter is the U.S. resolve sub-model. It is shown in Figure 8. This sub-model is important because it represents the impact of several key factors on the overall level of resolve in continuing a war on terrorism. The sub-models interact through the common elements. The elements in this sub-model that have not already been discussed are defined next.

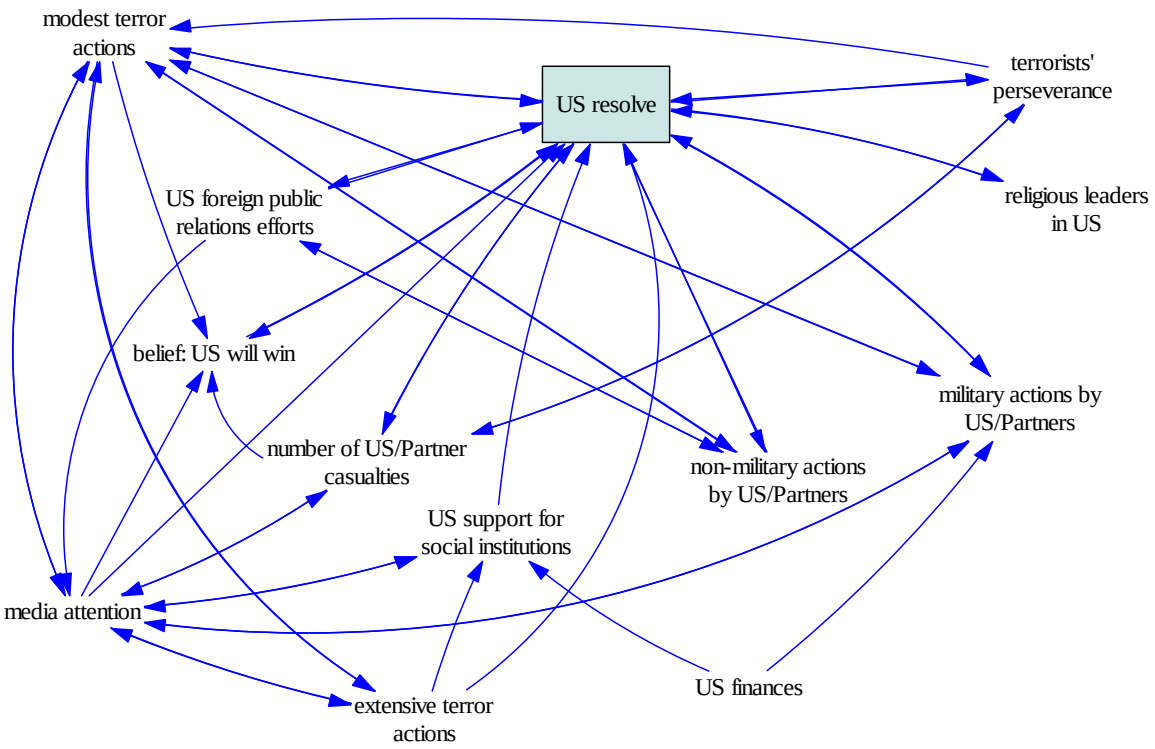


Figure 8: U.S. Resolve Influence Sub-model

3.4.3. Key Elements of Value

The new elements in this sub-model are *US foreign public relations efforts*, the *belief that the US will win*, and the *terrorists' perseverance*. The *US foreign public relations efforts* represents the actions by the U.S. that are done to affect relations between the U.S. and foreign countries. An integral component of this is strategic communications (Gjelten, 2005: np). This includes attempts at improving relations with our Partners as well as the countries who are not currently supporting the U.S./Partners' war efforts. The *belief that the US will win* captures the perception of the U.S. citizens on how well the war is going. The last element to be defined is *terrorists' perseverance*. This refers to the persistence of the terrorists; their continued level of terror attacks over time. For example, if the rate of attacks decreased over the period of one year, then their persistence could be presumed to be declining.

3.4.4. Influences

As stated in Chapter 2, these models have been designed from the U.S. perspective; thus, potential U.S. strategic COA needed to be included. All of the elements in Figure 8 have an affect on the level of the U.S. resolve in fighting the GWOT, and the level of U.S. resolve, in turn, influences most of these elements as well.

To eliminate redundancy, any relationships between effector variables in the TTAG support influence sub-model that also exist in the US resolve sub-model will not be reviewed here. For discussion on these duplicated interactions, refer to the influences section of the TTAG support influence submodel.

The U.S. foreign public relations efforts are modeled to impact U.S. resolve. If the rest of the world, including current partner countries, is against the U.S.'s actions, then there is a definite need with today's global community for increased foreign relations efforts with a large focus on strategic communications. The reverse relationship also exists. If the U.S. resolve is high, then this confidence may influence the amount of effort put into foreign relations with other countries within the TTAG and Non-TTAG. In addition, foreign relation efforts by the U.S. also receive large amounts of media attention. For example, when the U.S. government holds talks with other countries on how best to work together on the GWOT, it is modeled as receiving positive media attention.

The media also plays a large role in U.S. resolve. The media reports on the terror attacks as well as the actions of the U.S. and its Partners. This leads to the American public seeing assaults on U.S. troops and installations. Conversely, the media does report on the good actions that the U.S. and its Partners are doing, such as digging wells, re-

building schools, or passing out water to children. However, if the reports of the negative consequence of conflict greatly outnumber positive reports, then U.S. resolve may eventually wither. As the casualties in the Vietnam War increased coupled with the perception that the war was un-winnable, the U.S. resolve to keep troops in Vietnam eventually fell so low, especially after the Tet Offensive, that the U.S. withdrew (Williams, 2004:np). If, on the other hand, media reports show more positive reports, then U.S. resolve will be higher which should impact the belief that the U.S. will win. There is the possibility, though, that a negative report or series of reports may ignite the U.S. population's anger and cause an increase in determination to fight, thus increasing US. Resolve.

Media attention also interacts with terror actions and extensive terror actions in a reciprocal manner. The attention of terror actions, both modest and extensive, influences U.S. resolve. The constant media coverage of terror attacks can wear down U.S. resolve while the terror actions, in turn, influence the amount of media attention the terrorists are given. Similarly, an extensive terror action will certainly receive a high degree of media coverage around the globe which affects U.S. resolve to fight the terrorists who have attacked them. The reverse relationship also exists. The terrorists are known to conduct terror attacks to gain media attention, which implies that the high media attention an extensive attack will garner may motivate them to conduct more extensive attacks.

Modest terror actions and extensive terror actions are modeled to also have an important influence on the overall resolve of the U.S. While persistent terror actions on a small scale may eventually erode U.S. resolve, the result of extensive terror actions will typically have the opposite affect. As a result of the September 11th attacks on U.S. soil,

the support for the U.S. to wage the war on terrorism skyrocketed; however, the current conflict in Iraq, which is characterized by persistent smaller scale terror attacks, may be having a negative impact on U.S. resolve.

The terrorists' perseverance is characterized by a continued level of attacks over a time intended to wear down the U.S. and Coalition resolve. The terrorists believe if they can hold on and keep attacking, eventually the U.S. resolve will weaken. In a cyclical manner, if the terrorists perceive that the U.S. resolve is declining due to their perseverance, they will be motivated to continue their attacks. Terrorists' perseverance also directly affects the number of U.S./Partner casualties. This model assumes that the more the terrorists attack, the more the rate of casualties per attack increases. (It should be noted that this may not always be the nature of the relationship. In some instances the Coalition may increase defenses in order to combat the higher frequency of attacks, thus decreasing casualties. This relationship could be modeled based on the specific situation.) Additionally, the more the terrorists see their perseverance is successful, the more they will be encouraged to persevere.

US finances influence both military actions by US/Partners as well as US support for social institutions since both activities depend on funding. Military operations need equipment, troops, and logistic support and since donations or financial aid is a primary method of supporting social institutions, finances are assumed to have an impact on the US ability do these actions.

The last key influence to be discussed is the effect of religious leaders in the U.S. on U.S. resolve and vice versa. Even though there is a separation of church and state in the U.S., several prominent religious leaders have close ties to key political figures and

take part in many political functions. This may give the impression to the Non-TTAG and TTAG public that a view expressed about the war on terrorism by one of these religious leaders reflects the views of the government. Whether this is true or not, the level of U.S. resolve may be affected by religious leaders in the U.S. The reverse relationship also exists. The level of resolve of the general population will influence statements religious leaders might make about the war on terror.

As in the TTAG support influence sub-model, all of the elements that affect U.S. resolve are not modeled; thus only the key elements of influence fitting the strategic scope of this research. In order to improve the flow of the presentation, the supporting sources for the influences in Figure 8 are shown in Table 21 and Table 22 in Appendix B. The sources for the other sub-models are also shown in Appendix B in Table 22 - Table 30.

3.5. Summary

This chapter presented a top-level influence model and discussed the four components of the main COG - popular support. This top-level model was then decomposed in to four influence sub-models, two of which were presented in detail in this chapter. The key supporting elements of value for each component were displayed in each sub-model and the qualitative relationships were then discussed. All four influence sub-models are displayed and discussed in Appendix B. In Chapter 4, the overall influence model is translated into one system dynamics model that captures and quantifies the key aspects of popular support.

4. System Dynamics Model

4.1. Introduction

In Chapter 3, the key elements of value for popular support were identified and developed in an overall influence-like model. As part of this influence-like model, four influence sub-models were then constructed in order to display the key elements and their interactions within the four identified components of popular support. Two of these sub-models were discussed in detail in Chapter 3, the other two are discussed in Appendix B. This chapter describes the translation of the top-level model and its supporting influence sub-models into a notional strategic level system dynamics model. While a systems dynamics approach was chosen for this thesis, other methods, such as SIAM or decision analysis techniques, could have been employed.

First, a determination was made on which of the key elements displayed in the influence diagram-like displays in Chapter 3 and Appendix B should be included in the system dynamics model. Based on the limited availability of unclassified data for transnational terrorist groups, an exact nature of the relationships in the influence models was not determined. A streamlined system dynamics model was created using a subset of the key elements of value. These key elements were chosen based on the frequency in which they appeared in the open-source literature and their expected level of importance in affecting popular support. The actual key elements selected in an operational analysis are situation dependent and can be included or excluded as warranted. Additional

elements, not displayed in the influence sub-models, may also be added as needed for the particular transnational terrorist group being modeled.

After selecting the key elements to be included in the notional example, a system dynamics model for transnational terrorists' center of gravity (COG) interactions was developed and implemented using Vensim (*Vensim5 User's Guide*, 2002), a system dynamic software. For each interaction defined in the system dynamics model, a relationship was developed. The resulting model is shown in Figure 9. The boxes in the model represent levels, or state variables, and the plain text represents effector variables, or auxiliary variables.

In an attempt to enhance understanding and to present the model in an easily readable format, the model shown in Figure 9 does not show every variable that was used in calculating the rates of flow and the interactions between effector variables. Figure 9 presents an aggregated view of the system dynamics model where the conversion equations and associated variables and parameters have been collapsed and are represented by the arrows. The model is shown in its entirety later in the chapter, along with an explanation of the mappings used to translate actions, funds, and media items into persons per month. This is a key to understanding the model since the entities that are moving in the model are people. A discussion of two feedback loops in the notional model is also included using the full form of the model.

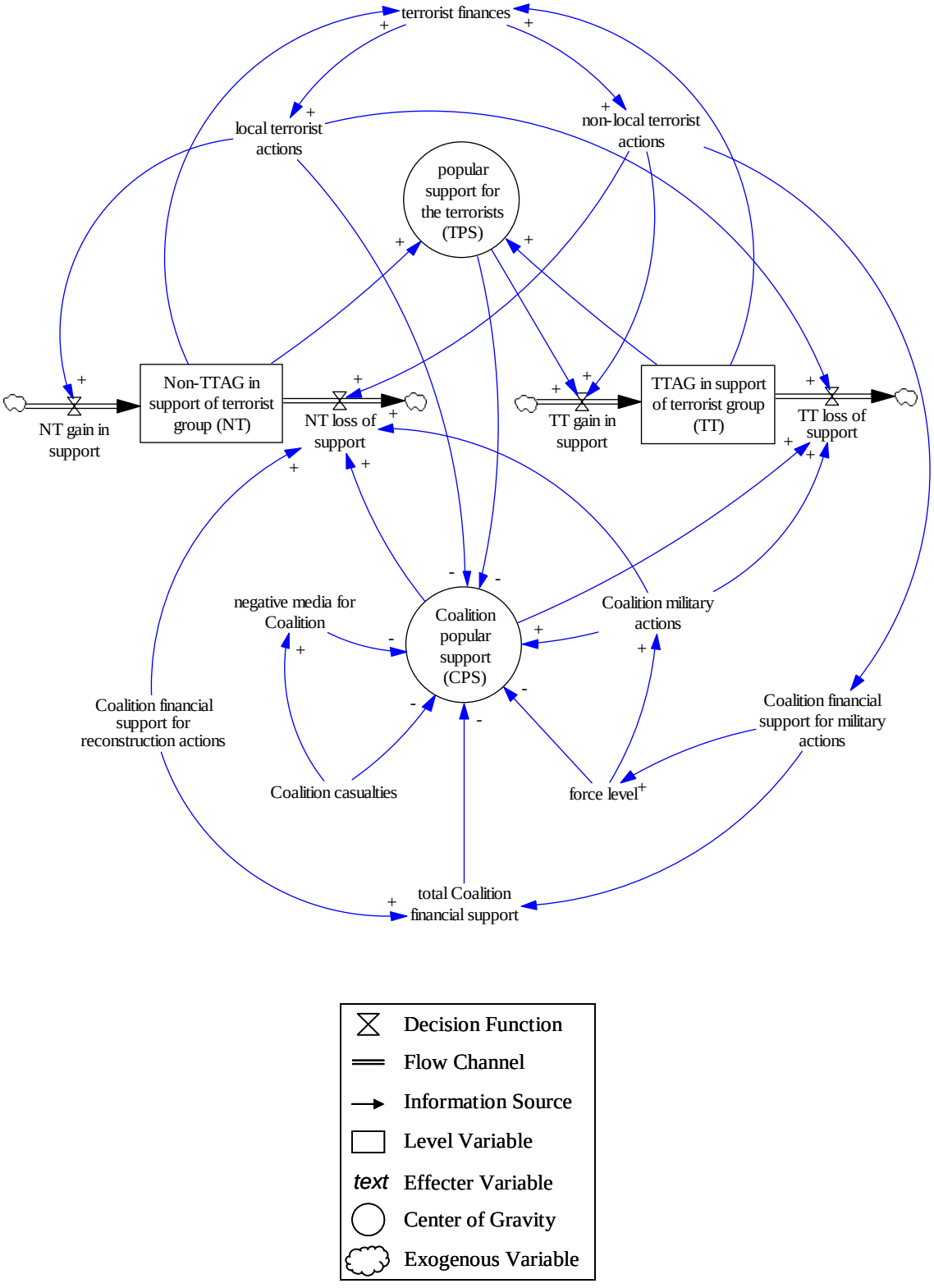


Figure 9: Transnational Terrorists' Systems Dynamics Model

In the aggregated system dynamics model, plus/minus signs have been added to the arrowheads to indicate the nature of the effect resulting from the aggregated equations. A plus sign indicates an increase in the source variable causes an increase in the destination variable. An example of this is the relationship between *terrorist finances* and *local terrorist actions*. As the level of terrorist finances increase, the ability to conduct local terror actions also increases. A negative sign signifies that an opposite relationship exists; an increase in the source variable causes a decrease in the destination variable and vice versa. For example, there is an arrow from Coalition casualties to CPS with a negative sign. This means that as the number of Coalition casualties increase, the number of people who support the Coalition's efforts in fighting the conflict will decrease in this particular example. It should be noted that in Figure 9 Coalition represent the U.S. and its Partners.

4.2. Effector Variables

The effector variables used in the model were derived from the key elements of value in the influence sub-models presented in Chapter 3. The ones included in the illustrative model are listed below along with their units of measure:

1. Terrorist finances (billions of dollars / month)
2. Local terrorist actions (actions / month)
3. Non-local terrorist actions (actions / month)
4. Coalition financial support for reconstruction actions (billions of dollars / month)
5. Coalition financial support for military actions (billions of dollars / month)
6. Total Coalition financial support (billions of dollars / month)
7. Negative media for Coalition (actions / month)
8. Coalition casualties (persons / month)
9. Force level (persons / month)
10. Coalition military actions (actions / month)
11. Popular support for the terrorists (TPS) (persons / month)
12. Coalition popular support (CPS) (persons / month)

While *TPS* and *CPS* are used as effector variables in the model, they are represented in the illustrative model by circles to distinguish them as the COGs of interest. Additionally, since these two variables are the responses of interest in the notional example, it is helpful for them to be easily distinguished from the other variables.

Before discussing other parts of the model, the effector variables are defined to clarify their use in the model. The two key effector variables are *TPS* and *CPS*. *TPS* represents the number of people from the both TTAG and Non-TTAG populations who, either actively or passively, support the terrorists. While no distinction has been made between active and passive supporters in the notional example, it could be incorporated should an increased level of fidelity be required. *CPS* represents the total number of people from the Coalition populations that support the Coalition efforts. The countries included in the Coalition do not have to remain static. For different conflicts that arise, such as the conflict in Afghanistan and the conflict in Iraq, different nations may work together causing the Coalition composition to change from one conflict to another. Due to the potential changing nature of the Coalition, its composition in any model should be limited to a specific conflict or situation in order to accurately capture their popular support.

Terrorist finances represents the total amount of funds available to the specific transnational terrorist group of interest per month. *Local terrorists actions* represents the number of terrorist actions that are carried out by the group of interest in the area of conflict. This area of conflict will be situation dependent. *Non-local terrorist actions* is defined as the number of large scale attacks that occur outside of the defined region of

conflict. An example of an extensive attack is the September 11th attacks. Spectacular actions such as key assassination could also be counted in this variable if desired, but has not been modeled in this illustration example.

The total *Coalition financial support* effector variable represents the total amount of funds in billions of dollars that is spent on the conflict. *Coalition financial support for reconstruction action*s and *Coalition financial support for military actions* added together to determine the total Coalition financial support. *Coalition financial support for reconstruction actions* includes all money spent for rebuilding infrastructure in the war torn areas, for strategic communication activities, for donations to international aid agencies, and for any non-military actions that are aimed at improving the economic, social, and political stability in the region. Any money spent towards Coalition troops rebuilding schools or any other social infrastructures are counted in this category in this example. *Coalition financial support for military actions* represents the amount of money in billions of dollars that goes to supporting force level, military equipment, and logistic support for all military related activities to the conflict. If funds are used in some manner for military operations, it is included in this value.

Coalition casualties are defined as the number of military and civilian personnel from the Coalition countries that are either killed or wounded as a result of the conflict. This illustrative model includes all casualties, but the method of counting casualties can be defined differently as desired for the particular situation being modeled.

Negative media for Coalition represents the number of media reports that present a negative image or viewpoint about the Coalition, either regarding their military or non-military actions. These reports can be in any form of media, printed or broadcasted over

television, radio, or the internet. An example of a negative media report might be a news story on the death of a Coalition soldier which casts it a senseless waste rather than a regrettable but worthy sacrifice. *Coalition military actions* are defined as any action that involves fighting or use of potential violence by Coalition troops. These include offensive and defensive actions that directly relate to the specific conflict being fought. Examples of such actions are security patrols, actions to secure cities, and fighting back insurgents from cities or installations. These actions can vary in size and scale, and this variability has been built into the model. The *force level* variable represents the number of Coalition forces actively fighting and supporting the conflict. It is assumed in the model, that the required number of forces needed to successfully conduct operations is available. It also assumes that the amount of money for Coalition military actions is allocated to be sufficient for meeting force level requirements. Thus, even though the arrows show military spending affecting force levels, enough money is assumed to be given in this example scenario to maintain the desired force level. Now that all of the effector variables for the illustrative model have been defined, the levels and rates are defined next.

4.3. Level Variables and Rates

Two level variables were included in the example: the *TTAG in support of terrorists (TT)* and the *Non-TTAG in support of terrorists (NT)* and are measured in units of persons. These two level variables capture the number of people from within each respective group who actively or passively support the terrorists. Each level has two associated rates. These rates and their associated levels are shown in Table 2.

Table 2: System Dynamics Model Levels and Rates of Change

Level	Direction of change	Associated rates
TTAG in support of terrorists	+	*TT gain in support*
	-	*TT loss of support*
Non-TTAG in support of terrorists	+	*NT gain in support*
	-	*NT gain in support*

The rate equations used in calculating *TT* and *NT* determine how many people flow between the respective levels at each time step and are functions of various effector variables in the model. The amount of flow in either direction is determined by the values of effector variables that are combined together to generate a flow that either increases or decreases a specific level over time. While the rates control the amount of flow between of the two levels, this scenario does not keep track what happens to people as the leave either the *TT* or *NT*. It is assumed that they either become neutral or Coalition supporters, but this aspect is not recorded in the design of this notional example.

4.4. Relationships

Now that the effector variables, levels, and rates have all been defined for this illustration, the nature of their relationships to terrorist popular support and Coalition popular support, as well as to each other is discussed. All of the general functions for these relationships used in this example scenario are shown in Appendix C.

The TT and NT levels have a direct impact on the level of TPS since the two groups of people add together to provide the total number of people that support the terrorists. They also have a direct impact on the terrorist finances since donations are

made to the transnational terrorist group from members of both the TT and the NT and on the basis of their perceived strength. As TT and NT increase, the amount of money flowing into the terrorists bank accounts is modeled to increase accordingly. The model assumes that not everyone who is a supporter donates money, but a percentage consistently will.

Terrorist finances are assumed to directly affect the ability of the terrorists to conduct local and non-local terrorist actions in this scenario. The model assumes that the terrorists require a certain amount of money to conduct different types of attacks. The more funds available, the more they are able to either conduct a non-local, extensive attack or to increase the number of local, modest scaled attacks. If they have sufficient fund, they may be able to do both simultaneously. Of course, the ability to conduct non-local actions implies the terrorist group of interest has the global reach capability to do so. This capability has been assumed to be an inherent characteristic of all transnational terrorist groups.

Local terrorist actions are modeled in this notional scenario to increase support from the Non-TTAG and decrease support for the TTAG, and for the Coalition. Local terrorist actions will cause a small, but steady increase in support from people within the Non-TTAG. This is primarily due to people in the Non-TTAG who for some reason approve of a particular local action, based on its target, or are in agreement with the purpose for which the specific attack was conducted. However, the opposite relationship exists between local terrorist actions and support from within the TTAG. As the local terrorist actions increase in frequency and continue steadily over a long period of time, members of the local populace will grow weary of the attacks and the violence and will

stop supporting the terrorists. The rate at which they stop supporting is estimated as S-curve since it is assumed that it will take a while for enough people to grow sufficiently weary of the attacks to stop providing supporting, but once a certain threshold is reached, the numbers should rapidly increase up to a point. It is also assumed that not all of the population will leave the terrorists regardless of the level of attacks, so the rate should then level off at a certain upper end threshold or limit.

Local terrorist actions are modeled to also have a negative affect on Coalition popular support. As the attacks increase in frequency and continue over time, the Coalition populations may perceive that the Coalition's efforts are achieving the intended goals and thus should be stopped. This is based on research that shows people are less willing to support a war they do not believe they are winning (Voeten and Brewer, 2004: 18).

Non-local terrorist actions directly affect NT loss of support and TT gain in support and Coalition financial support for military actions. As non-local terrorist actions occur, members of the Non-TTAG tend to be outraged, at least for a period of time following the extensive attack, yielding in a loss of support for the terrorists. This is modeled in the illustration to represent the sympathy from the Non-TTAG members for the affected people. This appears in the model as a large pulse in loss of support for the terrorists from within the Non-TTAG, but it does not prevent support from eventually climbing back to previous levels of support. The closer in time non-local actions occur, the harder it is for the NT to recover.

Non-local actions also directly affect TT gain in support. As non-local terrorist actions occur, large numbers of people within the TTAG see the success of the terrorists

and are motivated to join the fight. The amount of increase also appears in the model as a pulse which results in a set time period where the TT grows dramatically. The non-local actions also impact the level of Coalition financial support for military actions. As these actions occur, there is a corresponding increase in military actions in order to respond to the attack. For this illustrative example, the way to generate an increase in military actions is through increasing military spending. Therefore, a pulse of extra money occurs every time a non-local action occurs.

Total Coalition financial support directly affects Coalition popular support. This scenario assumes that as more money is spent on the conflict, the more likely the Coalition populations are to decrease their support. This is a result of people seeing their tax dollars, or countries' resources, being used in regions where they cannot directly see the effects. It is often easier to gain support for spending when the results are visible.

Coalition spending on reconstruction actions impacts both the total amount of Coalition financial support and NT loss in support in this notional example. It causes a loss of supporters from within the Non-TTAG since reconstruction actions improve the quality of life in the region of conflict and help to reduce reasons for discontent or anger at the Coalition. It also impacts the total amount of Coalition financial support since it is added with the amount of money spent for military actions to calculate the total amount spent. Coalition financial support for military actions also affects the Coalition force level. The force level depends on money for equipment, logistics, and troops. Without this financial support the necessary force level could not be maintained.

Coalition military actions are assumed to directly affect CPS, NT loss of support, and TT loss of support in the scenario. Each military action may result in some number

of terrorists being killed or detained, which directly causes a loss of supporters from both the Non-TTAG and TTAG. Coalition military actions also impact the level of CPS. As military actions increase in frequency and scale, it provides more opportunities for people to see or hear about Coalition success rather than just about the terrorists successful actions; thus increasing Coalition popular support. It should be noted that in the example modeled, this relationship is the only positive impact on Coalition popular support. This in no way implies that other factors cannot produce positive results. Additional factors and relationships should be included, as appropriate, for the situation being modeled.

The number of Coalition casualties directly affects the level of CPS as well as the number of negative media reports for the Coalition. As casualties increase, the level of support for the war will decrease in this illustration. The amount of decrease over time is modeled as an S-shaped pattern. When casualties are low, the decrease in CPS is minimal, but once a certain threshold in the number of casualties is reached, decrease in support occurs more rapidly, in an exponential manner. However, it is assumed that the number of casualties will not completely drain CPS, so an upper bound on the impact of casualties on CPS is established which is asymptotically approached.

In this example, the number of Coalition casualties impacts the number of negative media reports for the Coalition. This is based on the fact that casualties are reported in the media and are assumed in the scenario to produce news stories that are presented or perceived in a negative manner for the Coalition. The number of negative reports per casualty depends on many factors that are not explicitly modeled, but should be included in a specific model where such data is available. Negative media for the

Coalition, in turn, directly influences CPS. As the number of negative reports increase, it causes a drain on CPS.

The last set of direct influences included in this notional illustration originates with the level of Coalition popular support and the level of popular support for the terrorists. As CPS increases, the model assumes that some members of the TTAG and Non-TTAG that are supporting the terrorists will change their stance and stop supporting them. This rate of change is most likely small, but the exact nature of the relationship could be modeled given the correct data. This loss of support indirectly causes a drain on TPS. Popular support for the terrorists has a similar affect on CPS. As popular support for the terrorists grows, it causes some member of the Coalition to waiver in their support for the effort, thus causing a decrease in overall Coalition popular support. The exact rate of flow for this drain on CPS will depend on the situation.

4.5. Mapping Used in the Model

Now that all the elements of the model have been defined and the nature of the relationships explained, the full model is presented and an explanation of how actions and funds were translated into persons. The model used for simulating this illustration is shown in an overview in Figure 10.

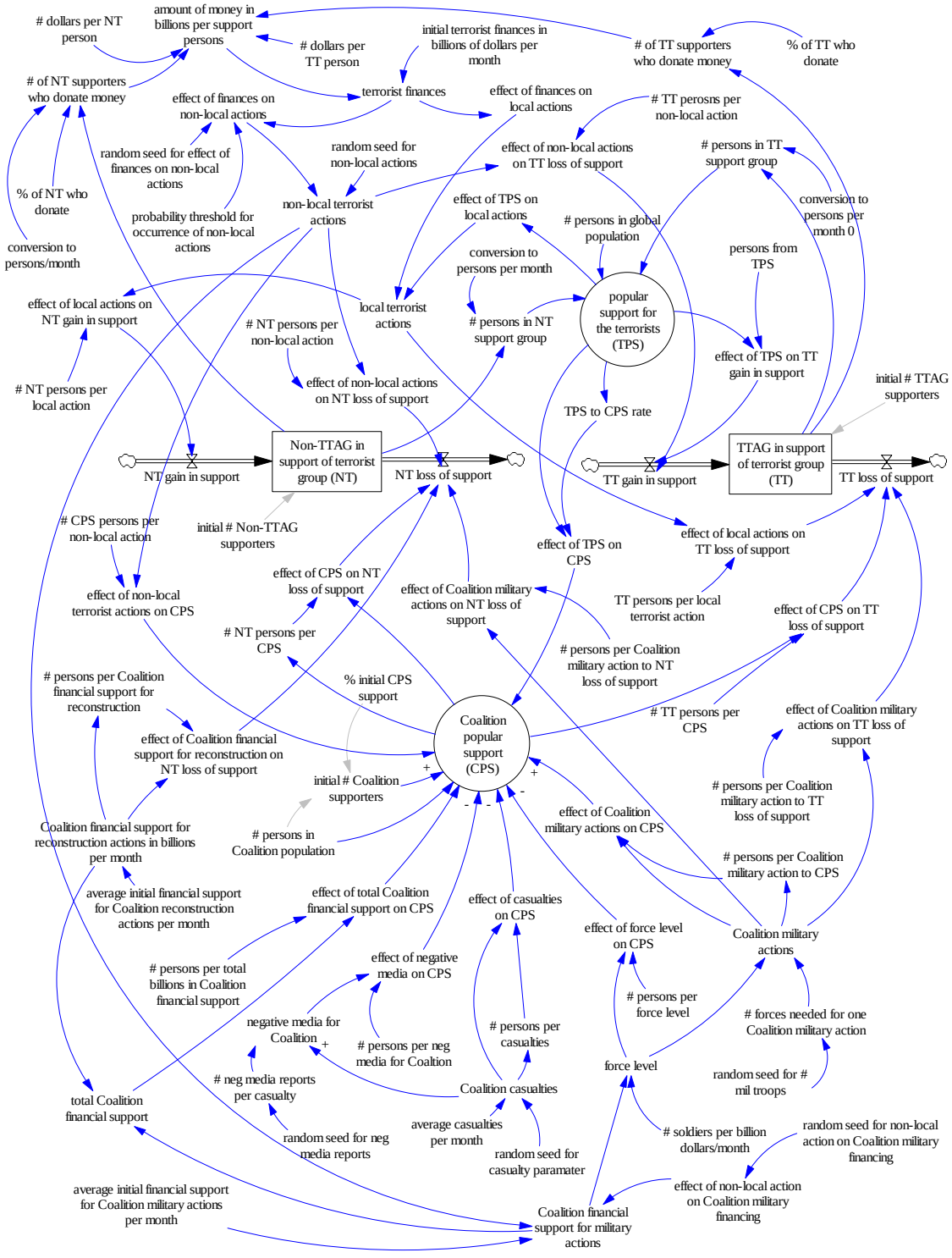


Figure 10: Transnational Terrorists COG System Dynamics Illustrative Model

Reviewing the full model, it is easy to see that by adding all the variables needed to create the desired unit conversion to people the model has grown more complex and is difficult to display on one page. However, presenting the model in its full form is necessary to fully explain the unit conversions that were used for this scenario. Due to the number of variables and unit conversions that occur in the model, not every unit conversion is discussed. Only enough are explained to provide an understanding of the unit conversion process.

All of the effector variables are presented in units of actions per month or billions of dollars spent per month. Since the entities of interest in the model are persons, a mapping to translate these actions and billions of dollars into persons per month was developed. For example, consider *total Coalition financial support* which has as units billions of dollars per month. In order to convert this into persons per month, an additional parameter and variable were created: *# persons per total billions in Coalition financial support* and *effect of total Coalition financial support on CPS*, and were given units of persons per billion of dollars and persons per month respectively. *The effect of total Coalition financial support on CPS* is where the unit conversion occurs and the variable is able capture the desired entity, people. It is calculated using the following general equation:

$$\begin{gathered} \textit{effect of total Coalition financial support on CPS} = \\ \textit{\# persons per total billions in Coalition financial support} * \\ \textit{total Coalition financial support} \end{gathered} \tag{4.1}$$

This equation takes the number of people who are expected, based on the billions of dollars in total spending, to stop supporting the Coalition efforts and multiples it by the number of billions of dollars being spent, resulting in units of persons per month. A

simple way to describe this rate is that it is the number of people who stop supporting the Coalition for every billion dollars spent. For example, if the Coalition spends a total of 10 billion dollars in one month and the number of people expected to stop supporting the Coalition efforts per billion dollars spent is 5, then 50 people will be subtracted from the number in the CPS for that month. Because it is parameterized, it can be adjusted as situations or rates change.

Another sample unit conversion involves NT to *# of NT supporters who donate money*. This mapping involves three variables. NT is a level, which has as units, persons, so conversion to persons/month is needed to ensure the proper units result from the calculations performed. The variable *# of NT supporters who donate money* has as units persons per month and represents the expected number of people from NT who donate money each month. The parameter *% of NT who donate* represents the percentage of NT supporters who donate money each month. The general form of the equation for calculating the variable, *# of NT supporters who donate money*, is:

$$\begin{array}{c} \textit{\# of NT supporters who donate money} = \\ \textit{(\% of NT who donate * NT) / (conversion to persons/month)} \end{array} \qquad (4.2)$$

This equation provides the desired information about the number of people from within the NT who donate money to the terrorists each month. The same type of unit conversion is used for the TT population.

A third unit conversion that is used translates actions per month into persons per month. Consider the positive relationship between *Coalition military actions* and *CPS*. The effector variable *Coalition military actions* has as units actions per month and *CPS* has as units persons per month. In order to determine the amount of impact of the

effector variable on CPS, it must be translated into persons per month. The parameter used accomplish this is *# persons per Coalition military action to CP* which has as units persons per action. The variable that actually gives the number of people who start supporting the Coalition efforts each month due to the influence of military actions is the *effect of Coalition military actions on CP*. This variable is calculated using the following general equation:

$$\begin{array}{c} \textit{effect of Coalition military actions on CPS} = \\ \textit{\# persons per Coalition military action to CPS}* \\ \textit{Coalition military actions} \end{array} \qquad (4.3)$$

The other variables in the model are all calculated in a similar manner depending on the specific units of each effector variables. Through the addition of all the extra variables displayed in Figure 10, the effector variables are able to be mapped from their original units to the desired entity of persons. The "radio dial" nature of the variables allows the ability to model a variety of scenarios and situations. This allows the model to properly capture the multiple cause and effect relationships and to produce the desired output: *TPS* and *CPS*. The supporting Vensim text code for Figure 10 is shown in Appendix E. The actual values and specific equations provided in Appendix E were used in the notional illustration presented in Chapter 5.

4.6. Feedback Loops

The ability to model feedback loops that occur within a complex system made the system dynamics methodology a good approach for modeling transnational terrorists' COG interactions. Recall that a feedback loop is present when a variable or level feeds back into itself. There are several feedback loops in the model presented in Figure 10.

This is not surprising given the complex nature of modeling human behavior and attitudes. Since feedback loops often cause higher order interactions and behavior for which it is difficult to determine the cause, this section traces through several feedbacks. Tracing through a feedback loop ensures and reinforces the understanding of how the variables affect the complexity of the model.

While not all the feedback loops in the illustration are reviewed here, this section will walk through two paths, via levels and rates, in order to demonstrate the dynamic feedback and interactive properties of the model. The paths discussed in this section are highlighted in the model in order to facilitate easier tracing through the paths.

The feedback loop discussed is highlighted in Figure 11 in the following manner. The starting point, Coalition financial support for military actions, has been represented as a hexagon and the arrows along the loop have been made thicker than the others. The path feeds back into itself after traversing through several variables and a level. The order of the specific variables, rates, and levels as they are reached or included in the feedback loop are listed below:

1. Coalition financial support for military actions
2. Force level
3. Effect of force level on CPS
4. Coalition popular support (CPS)
5. Effect of CPS on NT loss of support
6. NT loss of support
7. Non-TTAG in support of terrorist group (NT)
8. # of NT supporters who donate money
9. Amount of money in billions per support persons
10. Terrorist finances
11. Effect of finances on non-local actions
12. Non-local terrorist actions
13. Coalition financial support for military actions

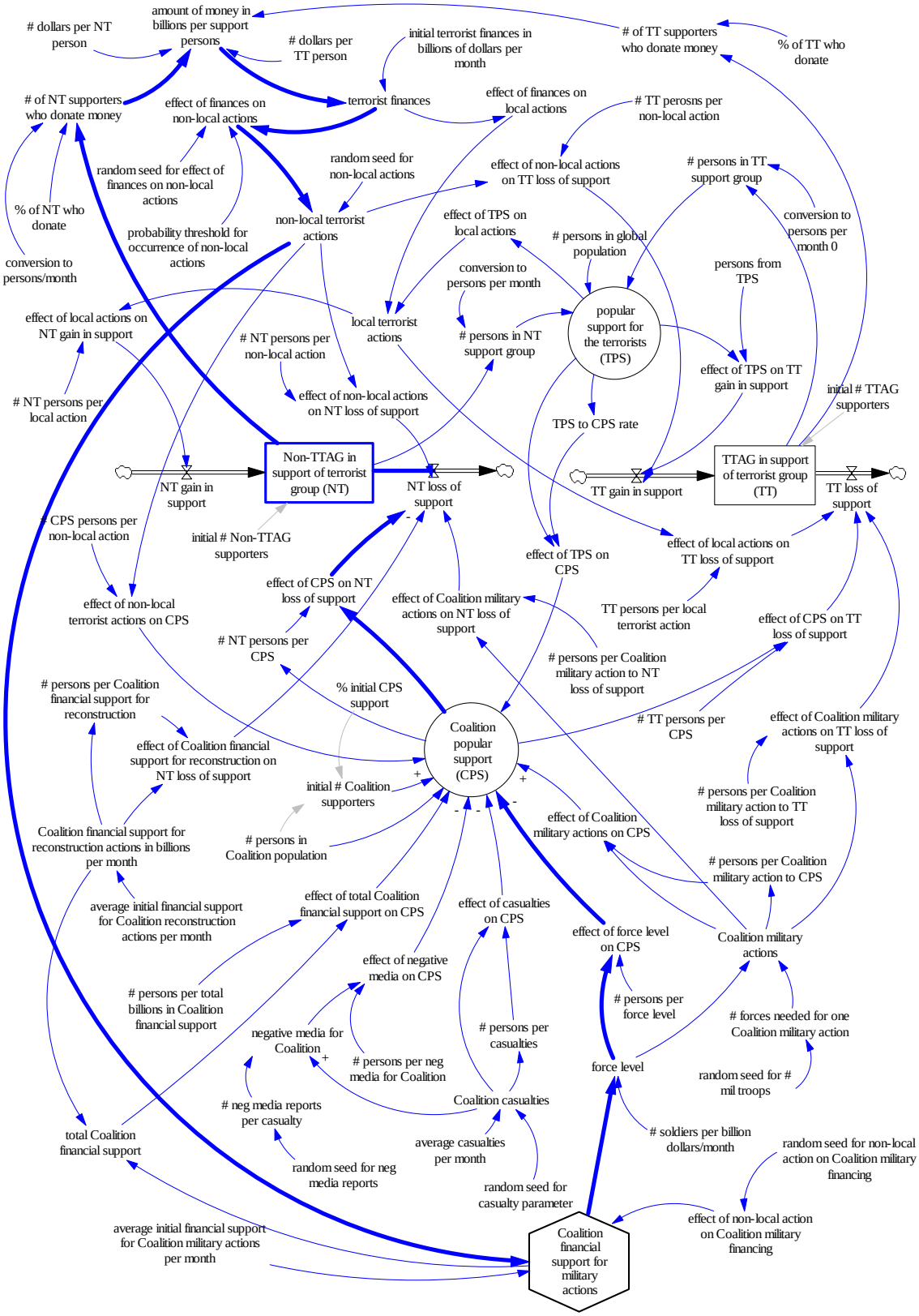


Figure 11: Feedback Loop

The feedback loop starts with *Coalition financial support for military actions* which directly feeds into *force level*. The amount of funds for military actions determines the number of Coalition troops that will make up the overall force level. *Force leve*l in turn, influences the variable, *effect of force level on CPS*. This variable captures what effect the force level has on CPS and sends that effect to CPS where decreases the total number of Coalition supporters. Next, the calculated value for CPS impacts the variable, *effect of CPS on NT loss of support*. This rate of change represents the number of people from the Non-TTAG that stop supporting the terrorists based on the current level of influence from the CPS. This rate supports the decision function *NT loss of support* which helps determine *NT,* the number of terrorist supporters from within the Non-TTAG. *NT loss of support*, through *NT who donate money* to the terrorists each month. A percentage of the NT will donate and this parameter multiplied by NT is represented by the variable *# of NT supporters who donate money*. This value then feeds into the total amount of donations the terrorist group receives from both the *TT* and *NT*. This sum then affects the variable *terrorist finances* which represents their total available funds from all sources. *Terrorist finances* in turn affects the variable effect of finances on non-local actions which captures the effect that the level of finances have on the terrorists ability and willingness to conduct non-local terrorist actions. *Non-local terrorist actions* then carries information back to *Coalition financial support for military actions* and causes a temporary increase in the amount of funds allocated for military spending. This is due to the fact that a military response to a non-local attack (an out of theater action), which will likely occur, will require more troops and equipment which means more money is needed. Upon reaching this variable, the feedback loop is closed

and Coalition financial support for military actions has fed information through the system that has returned back to influence itself.

Clearly, as the information flows through these feedback loops, they pass through several variables, levels or rates that can change or modify the information, through distortion or amplification, which results in behavior that is often difficult to understand. Since there are so many variables involved in these feedback loops, especially in the example provided, it is easy to see how the model can capture the complex interactions in these dynamic settings. Unfortuneatly, this also makes it difficult to judge the full inpact of a single element. This difficulty in determining the cause and effect relationship makes sense when dealing with transnational terrorist group COG interactions. Anytime interactions are modeled, especially human interactions, the complexity of the system increases and it becomes more difficult to determine the exact cause of a behavior, especially since there will most likely be secondary and tertiary effects. While there are more feedback loops in the illustrative model, each could be traced should one choose to examine a specific feature. As the next chapter will show, a proper experimental design can aid in identifying key factors.

4.7. Summary

This chapter illustrated the translation of the influence sub-diagrams into a strategic level system dynamics model for modeling transnational terrorists' center of gravity interactions. The effector variables, levels, and rates used in the example scenario were discussed and their specific utilization in the example defined. The relationships and interactions between the different variables in the example were then described. Next the mapping that was used to translate the effector variables, which were measured

in units of actions per month and billions of dollars per month, into units appropriate for the entity being modeled, people, which was measured in persons per month. Finally, the presence of feedback loops in the model was discussed and two feedback loops were traced through. In Chapter 5, an illustration of the model's use is given using a notional scenario with notional data.

5. Illustration and Results

Chapter 4 discussed a general form of the transnational terrorists' center of gravity (COG) interactions system dynamics model developed in this research. This chapter presents an illustration of how the model can be applied to a specific situation. This is done by first outlining a notional example of a transnational terrorist group and an associated Coalition. The general form on the transnational terrorists' COG interactions model was then applied to this notional scenario, and the results of this simulation are presented and analyzed.

5.1. Notional Scenario: KAOS vs. Control

This notional scenario investigates the key elements of value that impact the terrorists' COG: popular support. The two groups involved in this notional scenario are KAOS, the transnational terrorist group of interest, and Control, which is the name of the Coalition. In this scenario, KAOS is a transnational terrorist group with global reach capability who wish to dominate the world. The Control Coalition fears what may happen if KAOS is successful in their quest for domination. Since intelligence assessments indicate that KAOS will not hesitate to act in a global manner, the Control Coalition has decided to investigate political, economic, and military options to reduce the threat of attack by KAOS and to be prepared in the event of an attack.

5.2. Variables

The effector variables that influence the levels of popular support for the terrorists, as well as Coalition popular support in this illustration, are the same as those used in the general form of the model. (see Figure 9)

The specific functions and values or distributions used in the notional example are listed in the Vensim text code format in Appendix D. Most of the data and rates of change in the illustration are notional and only apply to this specific fictional scenario. The only data that was drawn from open source literature was in regards to the average number of Coalition casualties per month. The icasualties.com website, which reports casualties from OPERATION Iraqi Freedom, was used to generate the minimum, maximum, and mean parameters for the Poisson random distribution used in this scenario.

To ensure the reader understands the equations that are used in this scenario and understands how Vensim expresses them, an example of one rate of change equation as it appears in Vensim text code is given next. The format Vensim uses is first shown and then how the rate of change is actually calculated is explained. Consider the rate of change TT loss of support, which is written in Vensim in the following format:

$$\textit{TT loss of support} = \textit{INTEGER(effect of Coalition military actions on TT loss of support+effect of CPS on TT loss of support+effect of local actions on TT loss of support)} \quad (5.1)$$

TT loss of support measures the number of persons per month from the TTAG who had previously been supporters, but have stopped supporting the terrorists. This value is calculated by summing together the number of persons per month who stop supporting

due to the influence of Coalition military actions, the level of CPS, the local terrorists actions that occur, as well as the number of supporters who are killed by Coalition or terrorists actions. Each of these "effect of" variables in the function is calculated separately and is where the mapping from actions or dollars into persons occurs. The "INTEGER" part of the function was used to ensure an integer value was returned since the entity being calculated is people. It should be noted that "INTEGER" can mean two things in Vensim depending on how and where it is applied. In equation 5.1, which calculates a rate, "INTEGER" returns the integer part of the number; however, "INTEGER" is also used to represent the integration function used level calculations.

5.3. Design of Experiment

A system dynamics model, such as the one presented in Chapter 4, could provide insight to decision makers on which elements of value are the key drivers of popular support, both for the terrorist group and for the Coalition. This type of information would help decision makers decide how best to employ Coalition instruments of power and establish proper policies to effectively fight in a conflict.

In order to identify which parameters were statistically significant in effecting both popular support for the terrorists as well as Coalition popular support, an experiment was designed to test the effects of several parameters in the model. The design used for this experiment was a custom six factorial, three-level design that only considers first and second order interactions. (This specific design was generated using the custom design feature in JMP 5.1.) The six factors that were chosen are listed along with their associated levels in Table 5.1.

Table 3: Design of Experiments Key Factors

Code	Factor	Level		
		Low	Medium	High
A	% of TT who donate	0.2	0.5	0.8
B	probability threshold of non-local action	0.97	0.94	0.9
C	persons from TPS	0.00001	0.0001	0.001
D	average casualties	500	1050	1700
E	Coalition financial support for reconstruction actions	1.25	2.5	17.8
F	Coalition financial support for military actions	5.94	23.75	47.5

These six factors were chosen to illustrate how the key drivers of popular support can be identified through an experiment. While other factors could have been chosen, these six were selected to ensure both popular support for the terrorists and Coalition popular support as responses were accounted for by the factors. The experiment varied each of the six factors of interest at three levels: low medium and high value. The resulting design matrix is shown in Appendix E. Five replications were completed at each design point.

The levels used in the experiment were chosen for a variety of reasons. It was decided to vary the percentage of people from the TTAG supporters who donate money each month by plus and minus 30 percent to model a wide range of percentages. The probability threshold of non-local terrorist actions, which directly impacts how often attacks will occur, may appear to be listed backwards, but it should be noted that the higher the probability threshold, the lower the chance an attack will occur. For this reason the “low” level is actually a higher value than the “high” level. The factor, persons from TPS, which represents the number of people who are expected to start

supporting the terrorists for each number already supporting, was increased by a factor of 10 for the high level and decreased by a factor of 10 for the low level. The average casualties per month were varied using the low and high values from the icasualty.com statistics. An assumption was made that as reconstruction spending increased, military spending should decrease, so the low level for reconstruction spending was 75 percent of the total spending and the low for military spending was set at 25 percent of the total spending. The high levels were determined by multiplying the medium level for both by 200 percent.

5.4. Simulation Control Parameters

The simulation control parameters used for this notional scenario are listed and described in Table 4.

Table 4: Vensim Control Parameter

Control Parameters	Setting	Units	Description
FINAL TIME	120	Month	The final time for simulation.
INITIAL TIME	0	Month	The initial time for the simulation.
SAVEPER	TIME STEP	Month	The frequency with which output is stored.
TIME STEP	1	Month	The time step for the simulation.

(Note Vensim lists the values for each variable at the beginning of each time step in the output file.)

Five replications of the 96 design points were run on a Pentium III computer for a total of 480 simulation runs and output was collected on the two responses of interest, popular support for the terrorists (TPS) and Coalition popular support (CPS) for each run.

5.5. Average Results over Time

The average output data for TPS and CPS over the 480 runs is presented in Figure 12 and Figure 13. Figure 12 and Figure 13 show the average rate of change per month for both KAOS and the Control Coalition. The trend over time for the average rate of change in popular support per month for KAOS (see Figure 12) can be fit to a 4^{th} order polynomial function. It yields an increase in magnitude over time. The rate of change for the Control Coalition popular support, on the other hand, appears to be oscillating with a net change of almost zero across the 120 month time period, which shows no real growth or decline over the entire simulation (see Figure 13).

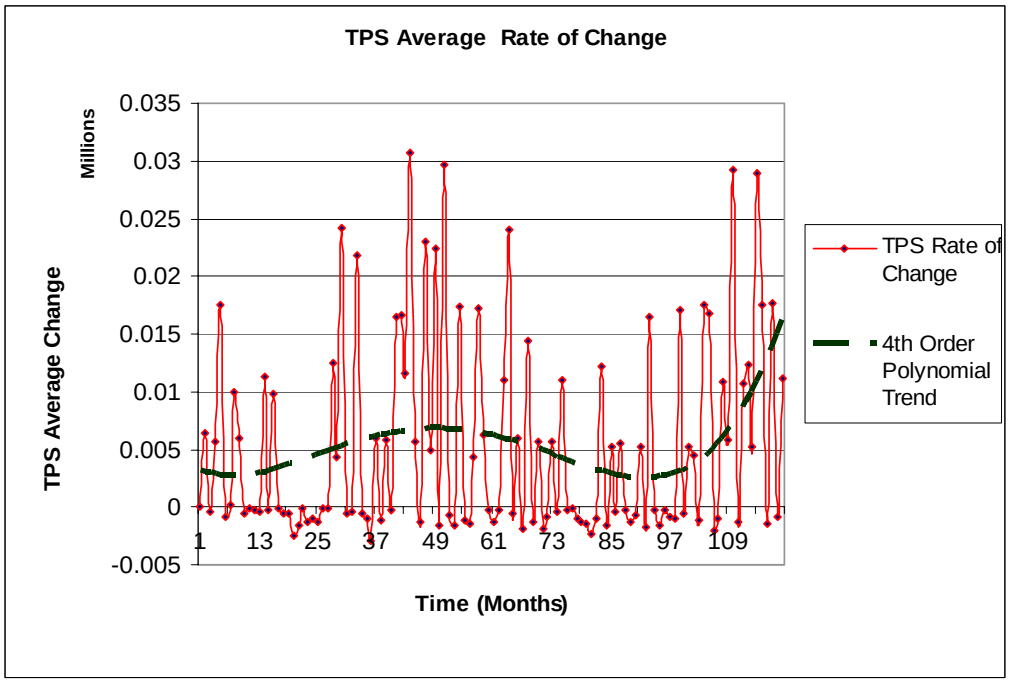


Figure 12: TPS Average Rate of Change

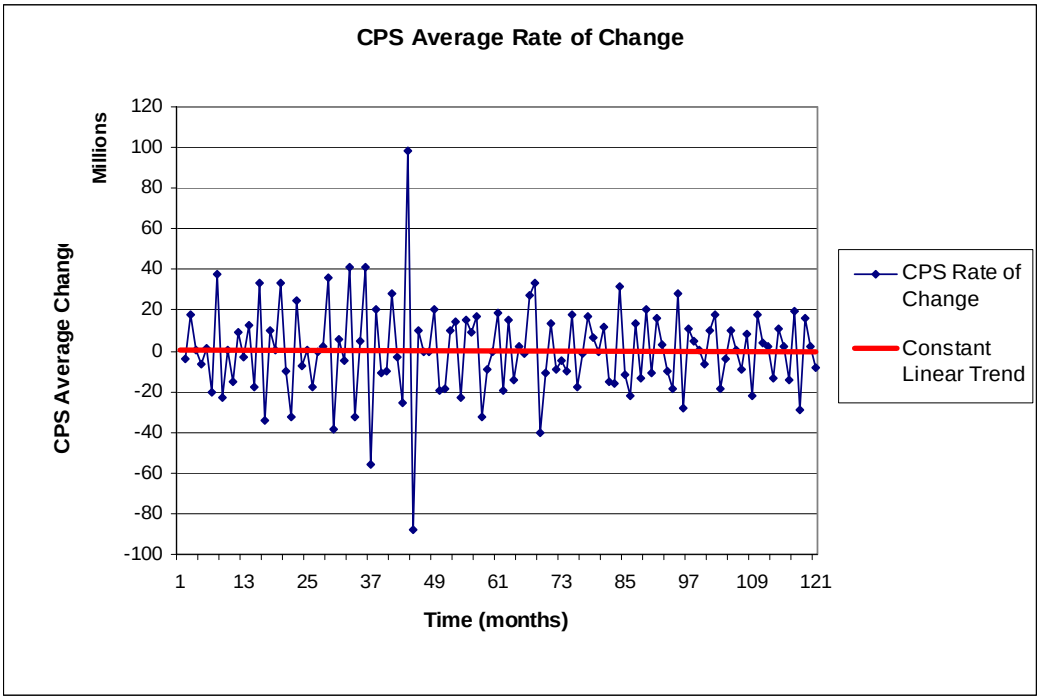


Figure 13: CPS Average Rate of Change

The reason for these trends appear to be due to the notional data set that was used in the illustration, to the noise in the random functions used since some had large variances, or to the multiple feedback loops in the model. The cause of large increases or decreases in popular support per month, such as the one at month 44 for CPS, may be a combination of noise and multiple effector variables reaching either high or low levels simultaneously and producing a large amplification. The specific cause of the large increase in rate of change for CPS at month 44 was examined, but no single cause was identified. This demonstrates the difficulty in determining root causes, especially when the effect is a secondary or tertiary effect as this particular spike may be.

Figure 14 and Figure 15 show the trend over time for both TPS and CPS using three design points on the same graph. The factors at run 48 were almost all at their high

level, the factors for run 70 were all at their low levels, and the factors for run 87 used a combination of levels.

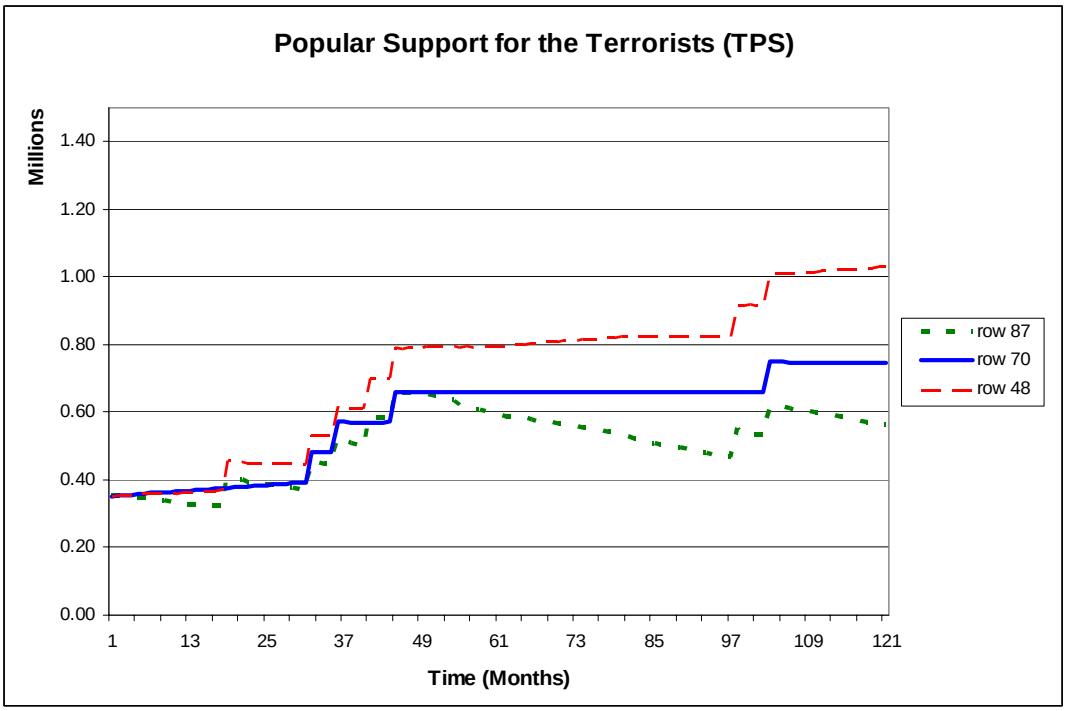


Figure 14: TPS Sample Trends over Time

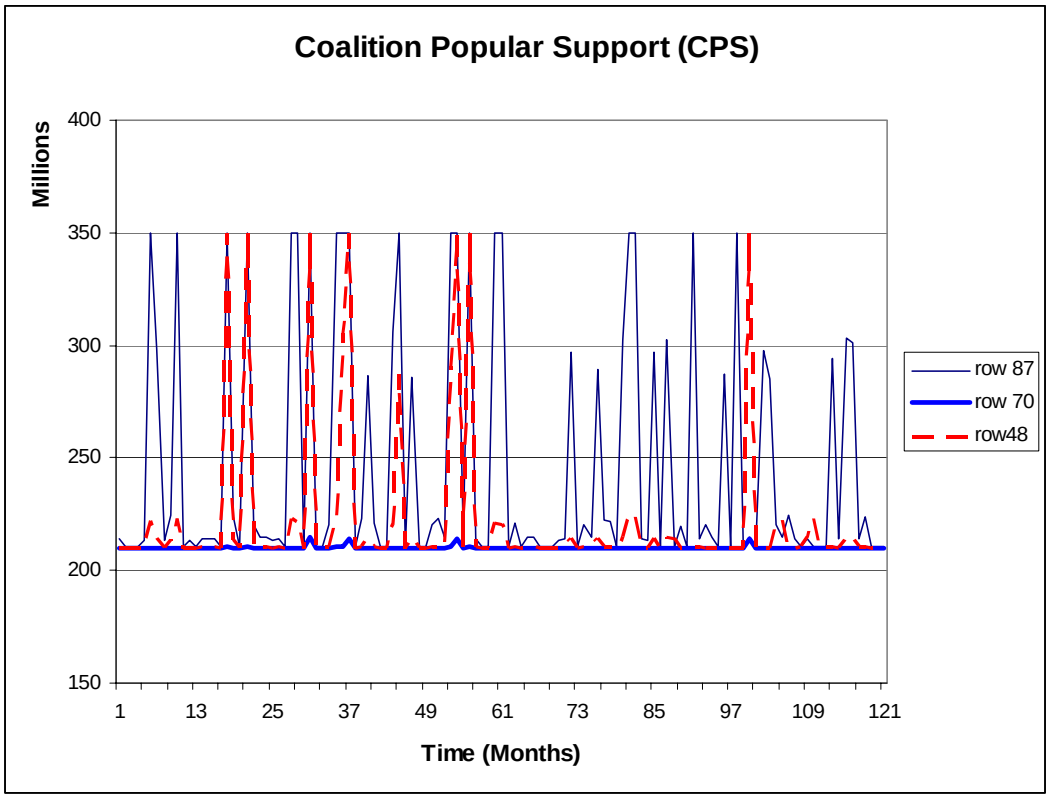


Figure 15: CPS Sample Trends over Time

These charts show that for this notional example, varying of factors at different levels can produce a large amount of variation in the resulting output. In the CPS chart, this is clearly evident since run 87 and run 48 have much larger amplitude than run 70. This type of information may be important to a decision maker who wants to minimize fluctuations in popular support for the Coalition.

The TPS chart also shows the affects of varying the factor levels. The combination of factor levels for run 87 appears to have the greatest impact on decreasing popular support for KAOS. If this were a real scenario, the information presented in Figure 14 could provide the decision maker insight on which policies at what levels should be implemented to achieve the desired effect. The data used in both the CPS and TPS charts are only from one run of each design point, and as such should not be used to

make broad assessments; however, they demonstrate how one could use the simulation information to provide insight for determining strategic courses of action.

The figures shown in this section illustrate how one could use the model and simulation results to gain insight on the net change per month as well as the trend over time in popular support for both groups of interest. It is important to note that the results displayed in this section are strictly related to the notional KAOS versus Control scenario and should not be used to make decision for any other situation.

5.6. Short, Medium and Long Term Results

While it is interesting to see the net changes in support per month and the average rate of change over time, it is also important to any decision maker to see what results can be expected in the short-term, medium, and long-term since they are often asked to plan for all three phases of a conflict. In order to provide this type of insight, regression models were built to predict the response given a particular factor, or combination of factors, using a 1 year, 5 year, and 10 year timeline. The data used in building these models were the output values at the end of these three time periods, **not** averages. This was done for both the TPS and CPS response variables.

A value of 0.05 was chosen as the significance level for including factors in the model. This was done for all regression models discussed in this research. The regression method used for all models in this research was stepwise regression so that the factors and their order of significance in the model could be determined. The interpretation of the models will be discussed after all three of the models have been presented since the differences or similarities between them will be of interest.

5.6.1. TPS: One Year Model

Using the criteria listed above, the resulting model with coded variables, -1 for the low level, 0 for the medium level, and 1 for the high level, for TPS at the end of one year was built and is shown in equation 5.2. (see Table 3, page 5.4 for the uncoded factors)

$$\begin{aligned} TPS\ (1\ year) = {} & 384332.5 \\ & 33392.87 * B \\ & -9249.31 * E \\ & -13293.7 * F \\ & 11966.71 * B^2 \end{aligned} \qquad (5.2)$$

This equation shows the degree of significance for each factor in the model. Specifically, it shows that when all factors are set to 1, the probability threshold of non-local action factor is more than three times as large as the other factors. Additionally, the F value for each of the factors included in the model indicates the order in which each factor entered the model. (See Table 5) Clearly, probability threshold of non-local action has a much higher F value than the other factors and it appears again the model as a square term, so one would expect it to be the explain the most error of all the factors in the model.

It is interseting to note that this equation is a quadratic function, which supports the proposition made earlier in this thesis that transnational terrorist center of gravity interactions are non-linear. Of course, this model is based on notional data and further testing with real data sets would be needed to confirm this. Table 5 shows the lack of fit for the model is not significant which is good, since we want it to fit.

Table 5: TPS (One Year) Results

Source	F Value	Prob > F	
Model	64.8619	< 0.0001	significant
B	182.719	< 0.0001	
E	16.7237	< 0.0001	
F	27.9559	< 0.0001	
B^2	6.96486	0.0086	
Lack of Fit	0.03003	1.0000	not significant

The actual model for TPS at the end of one year with the uncoded factors is shown in equation 5.3. Notice that by uncoding the factors into the actual numbers used for their low, medium, and high levels in the experiment, the coefficients in the model change.

$$\begin{aligned} \textit{TPS (1 year)} = {} & 384332.5 \\ & 33392.87 \ * \textit{prob threshold of non-local actions} \\ & -9249.31 \ * \textit{Coalition financial support for reconstruction actions} \\ & -13293.7 \ * \textit{Coalition financial support for military Actions} \\ & 11966.71 \ * (\textit{prob threshold of non-local actions})^2 \end{aligned} \quad (5.3)$$

This model had an *R-Squared* = 0.3533 and an *Adj R-Squared* = 0.3478. *R-Squared* gives the percentage of error, or variance, that can be explained by the model. The actual *R-Squared* value alone is not as important as the difference between it and the *Adj. R-Squared.* The closeness of the *R-Squared* and *Adj R-Squared* for the TPS one year model indicates that the regression model does not have unnecessary variables. The *Adj. R-Squared* value also provides insight into how well the model can predict the response of interest. One has to be careful, however, when determining what value is considered or acceptable. In different fields of study, the acceptable values can vary greatly. In engineering studies and experimental studies, *Adj. R-Squared* values above 0.80 or higher

are expected, but in behavior studies a much lower value is often attained. When conducting experiments, as was done in this research, the experiment is designed using randomization to reduce the variance which should inherintly lead to a better fit model with a high *Adj. R-Squared* value.

In the TPS One year, the *Adj. R-Squared* values are much lower than expected for an experiment design. This value is probably lower than expected due to the fact that the TPS one year model represents a snapshot at the end of one year. In addition, since there are several random distributions providing inputs to the model each month, there is a certain amount of variance in the system that may cause problems when trying to fit a polynomial equation. This problem is also present in the TPS 5 year and 10 year model, as well as in the CPS 1 year, 5 year, and 10 year models discussed later in this section.

It is important to note that the TPS one year regression model presented in this section is based on the illustrative example and should not be applied to any other situation. For this example, this model could be used to determine the significant factors that influence the level of TPS at the end of one year and to predict an expected response.

The plot of the predicted versus actual data points is shown in Figure 16: Predicted vs. Actual -TPS (1 year).

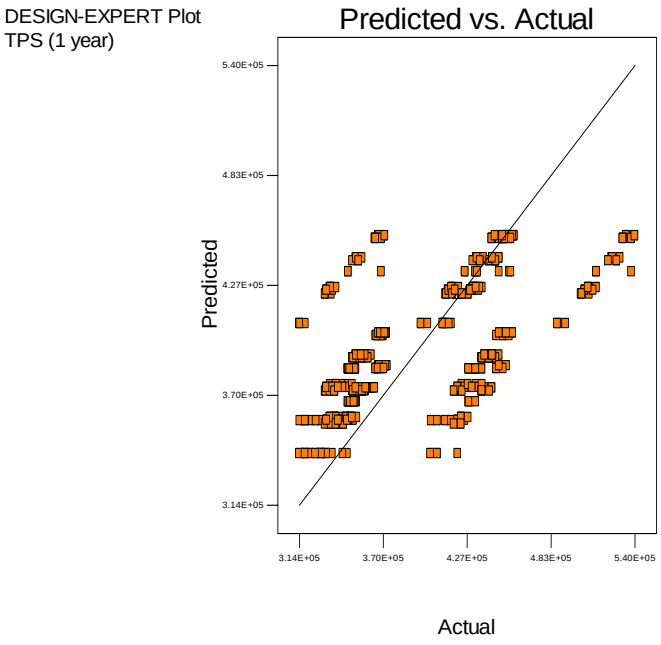


Figure 16: Predicted vs. Actual -TPS (1 year)

5.6.2. TPS: Five Year Model

The resulting coded TPS five year model is shown in equation 5.4:

$$\begin{aligned} TPS\ (5\ year) \quad = \quad & 604862.1646 \\ & 178254.5854 \quad * B \\ & -42102.87873 \quad * E \\ & -64911.13757 \quad * F \\ & 78835.57262 \quad * B^2 \end{aligned} \tag{5.4}$$

This equation shows the degree of significance for each factor in the five year TPS model. Specifically, it shows the same factors are significant at five years as were at one year, and that their magnitude of significance is similar, with B once again having the largest impact on the response. The F value for each of the factors in this model, shown in Table 6, shows the degree to which each factor contributes to explaining the error in the model. The lack of fit is also shown to be not significant.

Table 6: TPS (Five Year) Results

Source	F Value	Prob > F	
Model	142.349	< 0.0001	significant
B	410.249	< 0.0001	
E	27.3039	< 0.0001	
F	52.5182	< 0.0001	
B^2	23.8175	< 0.0001	
Lack of Fit	0.07082	1.0000	not significant

The actual model for TPS at the end of five years is shown in equation 5.4:

$$\begin{aligned} \textit{TPS (5 year)} = {} & \textit{677649.1476} \\ & \textit{-3273235.877} * \textit{prob threshold of non-local actions} \\ & \textit{-5087.961175} * \textit{Coalition financial support for reconstruction actions} \\ & \textit{-3123.731356} * \textit{Coalition financial support for military actions} \\ & \textit{64355569.48} * (\textit{prob threshold of non-local actions})^2 \end{aligned} \tag{5.5}$$

This model yields an *R-Squared* = 0.5451 and an *Adj R-Squared* = 0.5413. The plot of the predicted versus actual data points is shown in Figure 17.

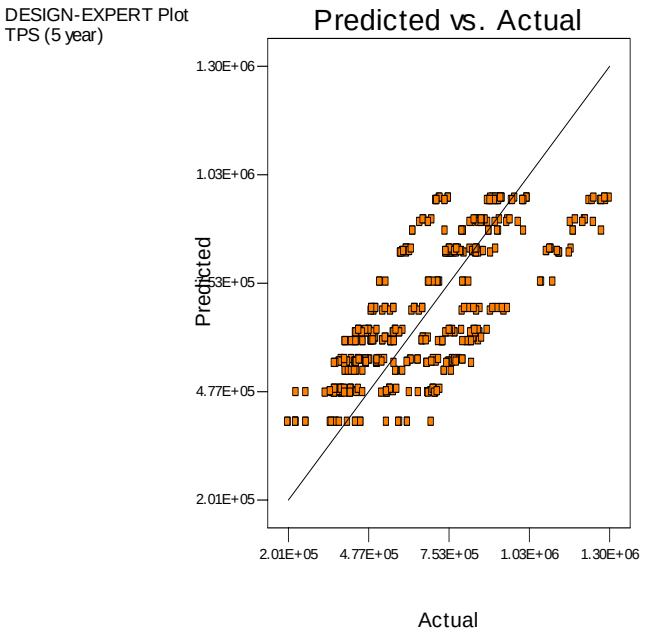


Figure 17: Predicted vs. Actual -TPS (5 year)

5.6.3. TPS: 10 Year Model

The resulting coded TPS 10 year model is shown in equation 5.5:

$$\begin{aligned} TPS\ (10\ year) \;=\; & 858807.4 \\ & 430051.1 \;*B \\ & -84052.6 \;*E \\ & -134744 \;*F \\ & 127990.7 \;*B^2 \end{aligned} \qquad (5.6)$$

This equation shows the degree of significance for each factor in the 10 year TPS model. Specifically, it shows the same factors are significant at 10 years as were at year 1 and year 5. Factor B is still much larger than the other factors as its coefficient shows and should have the most impact on the response. The F value for each of the factors in this model are shown in Table 7.

Table 7: TPS (10 Year) Results

Source	F Value	Prob > F	
Model	449.243	< 0.0001	significant
B	1403.88	< 0.0001	
E	63.97761	< 0.0001	
F	133.0505	< 0.0001	
B^2	36.90907	< 0.0001	
Lack of Fit	0.263755	1.0000	not significant

The actual model for TPS at the end of 10 years is shown in equation (5.7).

$$\begin{aligned} \textit{TPS (10 year)} = {} & \textit{771589.2} \\ & \textit{-1295515} && \textit{* prob threshold of non-local actions} \\ & \textit{-10157.4} && \textit{* Coalition financial support for reconstruction actions} \\ & \textit{-6484.33} && \textit{* Coalition financial support for military actions} \\ & \textit{1.04E+08} && \textit{* (prob threshold of non-local actions)}^2 \end{aligned} \tag{5.7}$$

This model yields an *R-Squared* = 0.7909 and an *Adj R-Squared* = 0.7892. The *R-Squared* value of .79 is higher than the *R-Squared* value for both the 1year and 5 year models which have *R-Squared* values of .35 and .54 respectively. These values indicate that the 10 year model explains more variance than the 1 year or 5 year model. They also indicate that the data is more predictive as the time period examined increases. This could be due to the nature of the notional data or it could be an indicator that the simulation needed a warm-up period. Either way, the 10 year model is the most explanatory of the three TPS models.

The predicted versus actual plot for the TPS 10 year model shown in Figure 18: Predicted vs. Actual -TPS (10 year) also shows the increase in the *R-Squared* values since the clustering of the actual data points around the fitted regressionline is tighter than

those fit for the 1 year and 5 year TPS models (shown in Figure 16 and Figure 17) indicating the model is able to explain more variance.

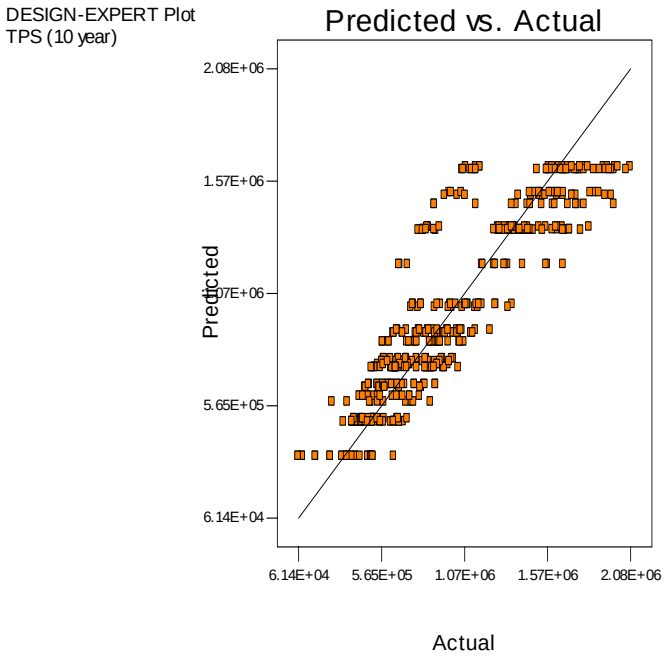


Figure 18: Predicted vs. Actual -TPS (10 year)

In interpreting the results from all three of these TPS models, it is interesting to note that they are all very similar in terms of the factors that are significant and the order in which they able to predict the response variable. Out of the three different factors that have a statistical influence on popular support for KAOS, one is much more significant than the others. Since B, which represents the probability threshold of a non-local terrorist action, is the most significant by a large amount, it is expected that it will have the most impact on the response and may even make the others almost insignificant.

These models imply that whether a decision maker in this notional example is intersted in the resulting effects of policies or plans in the short-term, mid-term ,or long-term, the best place to focus efforts is on the probability threshold that the terrorists will

actually conduct a non-local action. If the Control Coalition focuses efforts on any of the other factors, the model shows that they will have some impact on the popular support level for KAOS, but not nearly as much as if Conrol is able to reduce KAOS's probability threshold of a non-local attack. Actions which lower the rate of attacks have the best results in the scenario.

It was assumed for this example that KAOS needs popular support levels to reach 1.5 million people in order to gain dominance. While popular support for KAOS over the 10 years is increasing, it does not reach the necessary threshold (see Figure 14), so the Control Coaltion has achieved the desired effect of preventing world domination.

5.6.4. CPS: One Year Model

Using the same criteria as was used for all the TPS models discussed above, a regression model was built to fit the results of the CPS at the end of one year. The resulting model is shown in equation (5.8:

$$\begin{aligned} CPS\ (1\ year) \quad = \quad & 212282304.33 \\ & 9911471.75 \quad * F \\ & 7614391.67 \quad * F^2 \end{aligned} \tag{5.8}$$

This equation shows that only one of the six factors tested, *Coalition financial support for military actions*, is significant in predicting the response variable, CPS, at the end of one year. This model is much more parsimonious than the TPS models as it has only one term. However, like the TPS models, this model also has a square term. The F-values for this model are shown in Table 8 which shows the main effect, Coalition financial support for military actions, explains more of the model error than the second order effect, (Coalition financial support for military actions)^2.

Table 8: CPS (One Year) Results

Source	F Value	Prob > F	
Model	66.82	< 0.0001	significant
F	106.98	< 0.0001	
F^2	20.13	< 0.0001	
Lack of Fit	0.263755	1.0000	not significant

The actual model for PS at the end of one year is shown in equation 5.8:

$$\begin{aligned} \textit{CPS (1 year)} = {} & \textit{204328787.9} \\ & \textit{490291.1067} \ * \textit{Coalition financial support for military actions} \\ & * \textit{Coalition financial support for military actions}^2 \end{aligned} \tag{5.9}$$

This CPS 1 year model has an *R-Squared* = 0.2189 and an *Adj R-Squared* = 0.2156. These values are lower than any of the three TPS models examined in chapter. This indicates that this model is less predictive and can explain a smaller percent of the variance in the model. This could be due to notional data set or the randomness used to generate monthly rates for several parameters that directly influence CPS. Since these functions were designed for this illustration with a fairly large range of values, this may be part of the reason for the low *R-Squared* values. Even though the values are low, the difference between the *R-Squared* and *Adjusted R-Squared* is small which indicates the model is parsimonious and does not contain extra or unnecessary variables.

The plot of the predicted versus actual data points is shown in Figure 19.

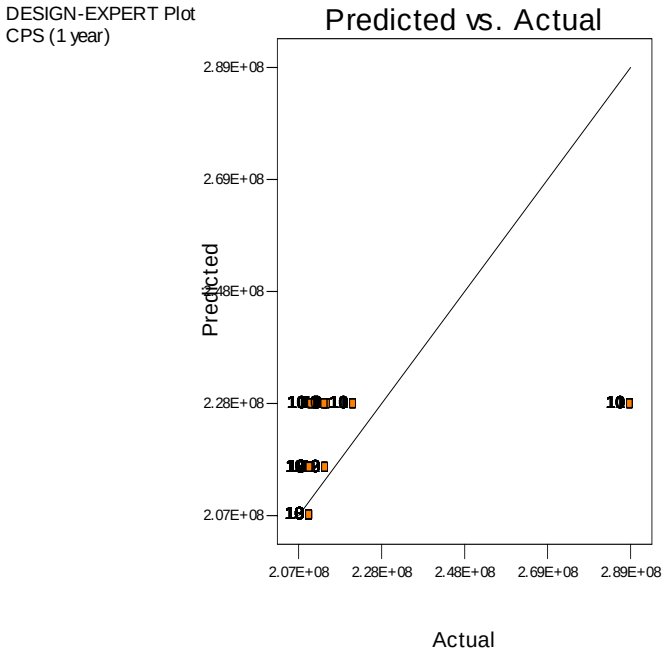


Figure 19: Predicted vs. Actual -CPS (1 year)

As expected, Figure 19 does not appear to fit as well as the ones for the TPS models, however, this is probably due to the nature of the data for the factor of significance. The Coalition military spending factor was a constant value with changes only when a non-local terrrorist action occurred. This leads to fairly clustered data points around the three levels it was varied.

5.6.5. CPS: Five Year Model

The resulting coded CPS model at the end of five years is shown in equation 5.9:

$$\begin{aligned} CPS\ (5\ year) \quad = \quad & 218969494.26 \\ & 28149100.29 \quad * F \\ & 19221515.13 \quad * F^2 \end{aligned} \tag{5.10}$$

This model is also a quadratic equation with only one factor of significance. The F-values for this model are shown in Table 9 which shows that as in the CPS one year model coded with -1, 0 , and 1 for the three levels, the main effect, *Coalition financial*

support for military actions, is explains more model error than the second order effect, (*Coalition financial support for military actions)*^{2}.

Table 9: CPS (Five Year) Results

Source	F Value	Prob > F	
Model	99.61	< 0.0001	Significant
F	165.56	< 0.0001	
F^2	24.61	< 0.0001	
Lack of Fit	6.29017E-07	1.0000	not significant

The actual model for PS at the end of one year is shown in equation (3.1.

$$\begin{aligned} CPS\ (5\ year) = {} & 214555061.14 \\ & -1024203.01 \ * \text{Coalition financial support for military actions} \\ & 44513.99 \ * \text{Coalition financial support for military actions}^2 \end{aligned} \quad (5.11)$$

The model has an *R-Squared* = 0.2946 and an *Adj R-Squared* = 0.2916. The plot of the predicted versus actual data points is shown in Figure 20.

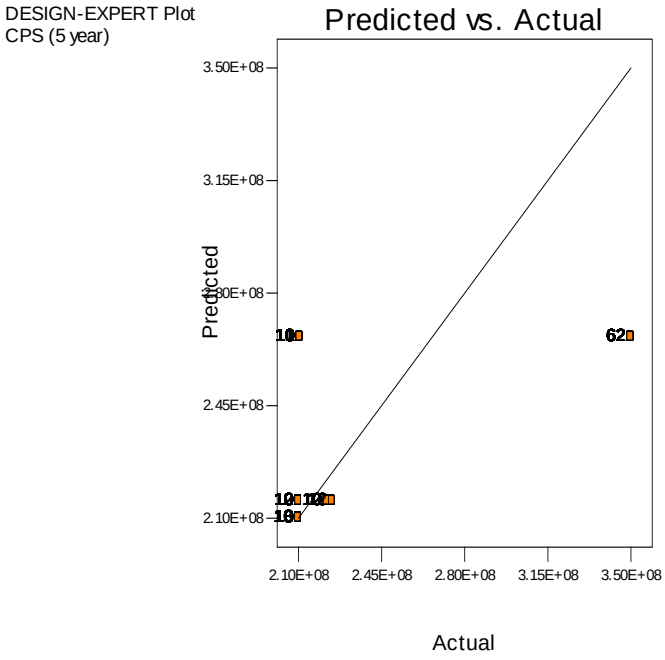


Figure 20: Predicted vs. Actual -CPS (5 year)

5.6.6. CPS: 10 Year Model

The resulting coded CPS model at the end of 10 years is shown in equation 5.11:

$$\begin{aligned} CPS\ (10\ year) \quad = \quad & 214569240.1 \\ & 15606067.94 \quad * F \\ & 11051833.86 \quad * F^2 \end{aligned} \tag{5.12}$$

This model is also a quadratic equation with only one factor of significance. The F-values for this model are shown in Table 10: CPS (10 Year) Results which shows that as in the CPS one year and five year models, the main effect, *Coalition financial support for military actions*, explains more model error than the second order effect, (*Coalition financial support for military actions)*^{2}.

Table 10: CPS (10 Year) Results

Source	F Value	Prob > F	
Model	48.65	< 0.0001	Significant
F	79.99	< 0.0001	
F^2	12.79	< 0.0001	
Lack of Fit	6.21955E-07	1.0000	not significant

The actual model for PS at the end of one year is shown in equation 5.12:

$$\begin{aligned} \textit{CPS (10 year)} = {} & \textit{212775415.6} \\ & \textit{-616745.5511} \ \textit{* Coalition financial support for military actions} \\ & \textit{25594.30029} \ \textit{* Coalition financial support for military actions}^2 \end{aligned} \tag{5.13}$$

The model has an *R-Squared* = 0.1694 and an *Adj R-Squared* = 0.1659. Recall that the CPS (1 year) *R-squared* = 0.21 and the CPS (5 year) *R-squared* = 0.290. Based on these values, the 10 year model explains a smaller proportion of the variance than the other two models. Upon re-examinng the data and running several regression models for additional time periods not already regressed, it is apparent that the month chosen causes a large variation in *R-Squared* values as well as the shape of the model. For example, some of the time periods examined give a positive quadratic equation whereas other show a negative quadratic fit. This seems to imply that the model is sensitive to small changes, for a given year's results, indicating that the interaction of divese behavioral elements is critical in this scenario. There are also strong indications of a horizon effect, often found in other settings,in this planning horizon. This should be further investigated.

The plot of the predicted versus actual data points is shown in Figure 21.

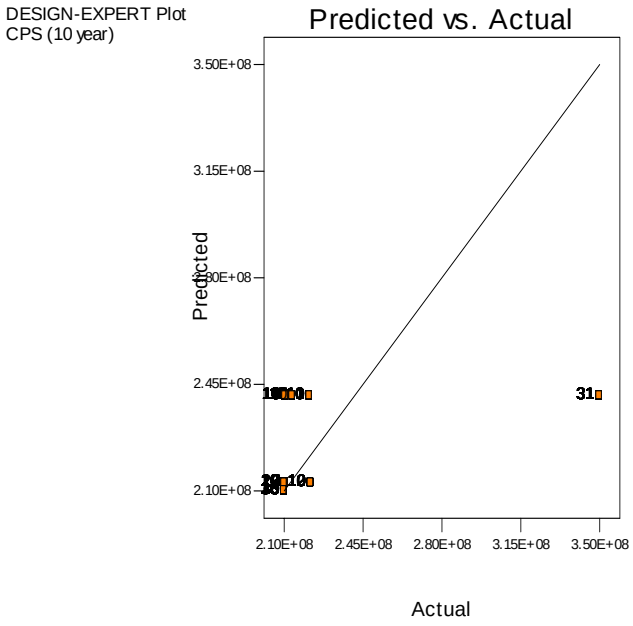


Figure 21: Predicted vs. Actual -CPS (10 year)

In interpreting these three models, it is clear that only one factor is significant in repredicting the response. It is also noted that all of the functions that were fit to the data were quadratic as was the case in the TPS models. It is possible this is a result of the type of notional data used, but it may be an occurrence that will repeat even if real data sets are obtained and used. Further researh is needed to say which is true.

It is interesting to note that in all three of the example models the main factor in the equations has a negative coefficient and the square term has a positive coefficient. This seems counterintuitive. The model assumes that as military actions, which in the model are driven by military spending, increase, the level of support generated from each action increase in a exponential manner. This means in the example that when spending is low, only a small amount of people will start supporting the Coaltion each month. This low trickle of support could be masked or dampened in the model output by other factors

in the model that are driving popular support down at the same time. This would explain why the only input to CPS that is positive would have a negative coefficient. Further testing and analysis is needed to determine whether this is the case or whether the noise in the model is the culprit.

5.7. Summary

In this chapter, a notional scenario was created with notional data in order to illustrate how the general form of the transnational terrorists' center of gravity interactions system dynamics model could be applied to a specific situation. The results of the notional simulation were then discussed and analyzed.

The results showed that in this notional example popular support for the terrorists is increasing over the 120 month time period examined and Coalition popular support is remaining constant. This means that the specific courses of action examined in the experiment, *% of TT who donate, probability threshold of non-local action, persons from TPS, average casualties, Coalition financial support for reconstruction actions,* and *Coalition financial support for military actions,* are not successful in causing a decrease in popular support for the terrorists over the 120 months. There are, however, time steps where the terrorists support level decreased before recovering and resuming an increasing pattern. More effort should be aimed at COAs that increase the number and frequency of these downturns in support for the terrorists. Since the TPS short, mid, and long-term models showed that the probability threshold of non-local action is the most significant factor, COAs should be aimed at increasing this threshold and thereby reducing the terrorists propensity for using non-local actions. Concentrating efforts on this threshold factor should then have the greatest chance of decreasing support for the terrorists.

Regarding the level of Coalition popular support in this notional illustration, there was only one factor, *Coalition financial support for military actions*, that was significant. This implies that the amount of funds spent on the conflict should impact the level of CPS. However, the trend of CPS over the 120 months simulated is a constant linear function which means that CPS is fairly resistant to the factors and their various levels used in this experiment. This may be due to the nature of the notional data, but it may indicate that the illustrative Control Coalition popular is steady, and while it may change often in the short term, over time it is robust over the long haul.

This illustration was notional which can create problems in analysis. A weakness of using notional data is that the results do not provide real insight to a decision maker. Additionally, the results from this illustration cannot be applied to any other situation or scenario. However, the strength of this illustration is in its ability to demonstrate how the transnational terrorists' COG interaction model could be used to conduct analysis aimed at providing a decision maker with alternative COAs for achieving the desired effect or effects. If the relationship and node data is available, the analysis techniques used in this illustrative example could be applied to a specific transnational terrorist group of interest and the model could then be used to provide critical information for decision makers in making effects based decisions. As a purpose of modeling is insight, even such a notional example may help to create requirements for the necessary input data

6. Conclusions and Future Research

6.1. Conclusions about the General Model and Its Application

This thesis effort offers a first cut at modeling transnational terrorists center of gravity. It identified the transnational terrorists' center of gravity (COG) and the key elements of influence, and used these to develop a general model for simulating transnational terrorist groups' COG interactions. The open source literature on COGs, COG models, and system dynamics was reviewed to determine the key factors and the COG for transnational terrorist groups and to decide the best method for organizing, displaying and modeling their interactions. Once the COG and key elements were identified, an influence diagram-like approach was used to develop four influence sub-models, one for each component of popular support. These sub-models were designed to display the key elements of value and to show their relationship to popular support and to each other. These qualitative influence sub-models were then turned into a general system dynamics model where quantitative measures were applied to capture the nature of the interactions between popular support and the key elements of value. The specific elements of value chosen for inclusion were based on the illustrative example used for this research. The key elements selected for inclusion in any model will be situation dependent and this determination will need to be made for each new scenario. In addition, this research effort used system dynamics techniques once the key elements of value were collected, organized, and displayed, but other methods, such as SIAM or CAESAR, might have been used.

The resulting general model was then applied to a notional scenario to illustrate how such a COG model could be utilized to provide insight about potential strategic courses of actions. An experiment was designed to identify the key drivers of popular support, for the terrorists and the U.S. and its Partners as well. The statistical significance of these factors was tested and notional implications for policy were inferred. The running of the experiment demonstrated that the general model could be simulated and could generate results for use in analysis.

The model developed in this research demonstrates how an analyst can model complex networks, especially of human behavior, by first identifying the COG and its influential elements, such as financial support, media attention, and military operations, and then quantifying the effect of each factor over its direct connections to other factors. This allows for better understanding of the COG and how best to influence it towards a desired effect. The use of influence diagrams provided a way to easily display these elements and the direction or strength of influence. Once this is done, applying system dynamics techniques provides decision makers insight into the effects of strategic policy and alternative courses of action.

In order for the general model to be realistically implemented, accurate data sets need to available to the analyst. Since the illustration used in this research was based on notional data, the results are not useful in themselves. However, if real data had been available and used, then strategic policies and plans could be tested against the model and their significance in influencing the transnational terrorist group of interest could be analyzed. The model could also highlight the key factors which have the greatest impact in producing the desired behavior in the system and provide decision makers a vector of

where to focus weight of effort. In cases where the data is not available, either due to classification or a real absence of data, an intelligence requirement could and should be generated to collect the missing information highlighted by the general model.

This research assumed that all transnational terrorist groups have the same COG and key elements of value, or influence. Since this, of course, may not always true, consideration needs to be given to which of the elements of value identified in this thesis apply to the specific group being modeled, and what additional factors may be needed. Once this is done, the same methodology as demonstrated in this research could then be applied.

6.2. Areas of Future Research

A fist step in future research would be to conduct verification, validation, and analysis on the model developed in this research. This would provide insight into whether the key elements chosen were appropriate and whether additional elements need to be added in order to more accurately represent the transnational terrorist groups' COG interactions. By adding some elements and removing others, the model could be tailored for any situation of interest. This flexibility of the model makes the model applicable across a broad spectrum of scenario's since one can pick and choose the key elements as warranted.

While the focus of this research was the strategic level of warfare, this approach could be expanded to model terrorists operational COGs. This would add a higher level of fidelity to the model and would provide decision makers insight into effects for the lower levels of planning. This extension would involve identification of the operational level COGs and their associated key elements of influence, and may lead to the need to

build multiple sub-models since there may be multiple COGs at this level. It would also require the appropriate data sets be available, and if unavailable, would highlight the elements where information collected should be focused.

Another area for further research is tailoring the model to fit a specific type of transnational terrorist group, such as ideological or political. This would involve reviewing and possibly modifying the key elements of influence, but would result in a model designed to meet a specific need.

In addition, a great deal of further work is required in developing the specific relations represented in the model. This may well prove to be a continuing effort, as information on terrorists is gained and as they evolve in their own tactics and techniques.

The gaps in the source documentation used to support the existence and strength of influences need to be filled. This information may be found in sources unavailable at this point due to time or classification constraints, or it may be an issue for which collection needs to be focused. Further research is needed to fill these information gaps.

The model developed in this research could be used in analysis of effects-based operations. Since the item of interest in both the model and effects-based operations is effects, the model should be capable of providing insight into whether the desired effect is achieved and would highlight any unintended effects as well.

Given real data sets, the results of the model could be further analyzed to include in-depth analysis of the many cause and effect relationships and the behavior they generate. Since this behavior is often a result of interactions, secondary and tertiary effects should be expected and further research could test this hypothesis. While a great deal of work remains to be done, this effort represents a first step on a long road.

Appendix A: Centers of Gravity in Literature

Table 11: Traditional Centers of Gravity (by source)

Combating Terrorism in a Globalized World	Tomlin	AFP 3-20	Schweitzer	Haberkem	Warden	Eikmeier
Leadership	Culture	Legitimacy	Ideology	Ideology	Leadership	A Military/ Security Capability
Legitimacy of Ideology	Ethnicity		*Terrorist Cells	*Leadership	Communications & Financing	An Economic/ Industrial Capability
Financial Support	Religion		*Leadership	*Military Capability	Training Camps	
Sanctuaries	Ideology		*Financial Support	*Infrastructure	Population	
C2 Network	Network Structure		*State Sponsorship	*Finance	Members	
	Financial Support		*Network			

* These COGs are listed by the sources as decisive points that are critical to the main COG, ideology for Schweitzer and Haberkem.

Table 12: Terrorist Centers of Gravity (by source)

Cragin and Daly	Choudhry
Ideology	Hearts and Minds of Population
Leadership	
Recruitment Pools	
Publicity	

Table 13: Transnational Terrorist Centers of Gravity (by source)

Marion and Uhl-Bien	Krebs	Pipes	Bliss	Vickers
Complexity of the Network	Massive Redundant Network	Ideology	Leadership	Terrorist Organization and Leadership
			Extremist Ideology	Sanctuary
				Popular Appeal
				Trans-national Networks

Table 14: Insurgencts Centers of Gravity (by source)

Margulies	Krepinevich	FMI 3-07.22	Clawson	Eland	Shreves	Clausewitz	Donnelly, Serchuk
U.S. Will to Fight	Nation's Target Population	Public Support for Insugents	US Public Opinion	Sanctuary	Popular Support	Leaders	U.S. Public Opinion
	External Supporting Power's Population	U.S. Public Support	Local Pubic Opinion	Source of Arms and Supplies		Public Opinion	
				Support of Significant Part of Population			

Appendix B: Influence Submodels

The TTAG represents the segment of the global population that consists of those who are similar to the terrorists in either their culture, beliefs, perceived oppression, and, possibly, religion and believe they are disfranchised with their governments or society in general. This is the population from which the terrorist group draws its principal support and followers. However, membership in the TTAG population does **not** imply membership in the terrorist group; it only means that one is in the population segment that is the terrorist group's principal supplier.

TTAG Support Influence Sub-model

The TTAG support influence sub-model (see Figure 22) is an influence-like diagram displaying several key elements of value that affect the overall level of TTAG support. It consists of four population groups: TTAG active supporters, TTAG passive supporters, TTAG uncommitted population, and US/Partners' supporters.

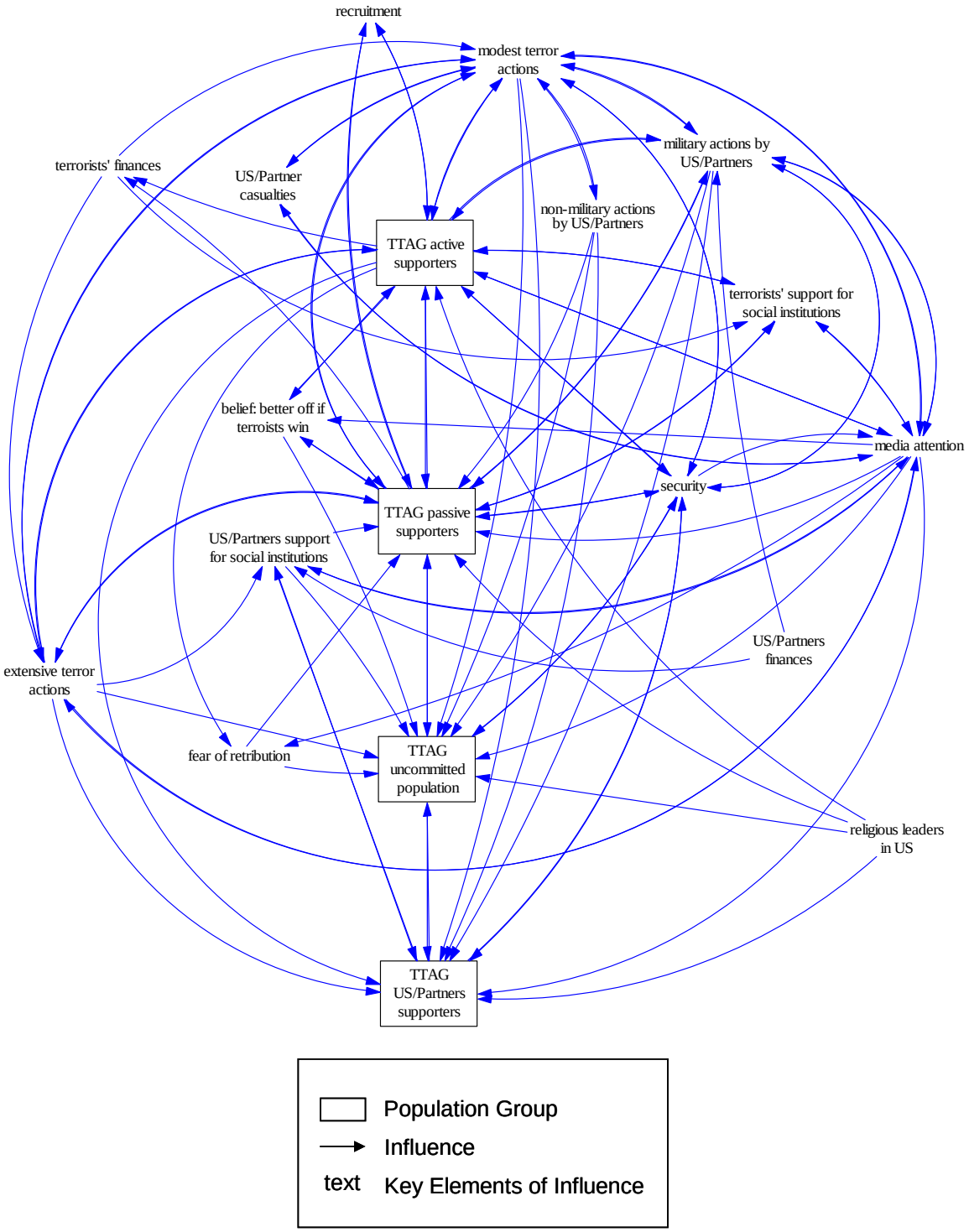


Figure 22: TTAG Support Influence Sub-model

According to AFP 3-20, active and passive support can be in the form of ideological, political, economic support or sanctuary. APF 3-20 also provides definitions

and examples of both types of supporters. Active supporters usually agree with the group's ideology and are those who provide money, information, safe houses, medial services, food, weapons, and safe passage. Examples of active supporters are states, religious centers, schools, wealthy individuals, businesses, charities, Diasporas, and the anti-Western community (AFP 3-20 1990: III). Since the strategic COG in this research is popular support, the focus is on groups that contribute to or affect the level of popular support. For this reason, the active operators of the terrorist groups, the ones who actually carry-out the attacks, are included in the "active supporters" group since they are obviously for the terrorists and count towards the level of popular support within the TTAG. Therefore, all individuals matching the definition of "action supporter" just outlined who are from the Transnational Terrorist Affinity Group (TTAG) are considered to be members of the TTAG active supporters group.

Passive supporters are those who "are sympathetic to the terrorist's cause, but either will not or cannot assume an active role" (AFP 3-20 1990: III). Often their support is a result of blackmail or intimidation. "Passive support may be unwitting; for example, contributions to 'charitable' causes or other ruses" (AFP 3-20 1990: III). Individuals from the TTAG population who passively support the terrorists are modeled as members of the TTAG passive supporters group.

The uncommitted population within the TTAG includes those who are not supporting either the terrorists or the U.S. and its Partners; they are sitting on the fence. According to Krepinevich (2004: 4), the majority of the population is uncommitted and provides support to the terrorists only when coerced or when it is clear who will or has won.

The influence between the active and passive supporters goes both ways. They both influence each other. The active supporters influence the passive supporters through recruiting activities and terror actions (Cragin and Daly 2004: 35), and by playing on their shared culture or affinity, while the passive supporters affect the active supporters by providing financial aid, public displays of support, and minor logistical support (AFP 3-20 1990: III).

The last group that needs to be defined is US/Partners' supporters. This group represents those in the TTAG who support U.S. and its Partner countries' war effort.

While there are more layers of elements that influence the level of support from within the TTAG than are shown here, these key strategic elements of influence were chosen based on the strategic scope of this research and the high level of fidelity the model is intended to represent. In order to ensure the influences in the model are understandable, the key elements chosen are defined next.

Key Elements of Influence

Modest terror actions are defined as those actions carried out by the terrorists to further their cause through the use of fear. These attacks can be directed at any group or person the terrorists decide may benefit their cause. Often the attacks are directed at opposition forces or opposition countries populations and infrastructure, but are not limited to them. Examples of these actions are bombings, kidnapping, and assassinations. According to the Air Force Studies and Analysis Agency's report, *FY04 Capability Review and Risk Assessment (CRRA) Analytic Methodology*, modest terror attacks refer to the number of friendly casualties sustained in an attack and are defined as "tens of citizens/troops killed and citizens overseas attacked/injured" (2003: 20). Extensive terror

actions are characterized by “thousands to tens of thousands of citizens/troops killed/injured and citizens oversees killed/taken hostage.” (AFSAA, 2003: 20) Extensive terror actions are by definition larger in scale than a modest terror action. The attack on September 11 on the World Trade Center is an example of an extensive terror action. It had a far greater impact than a suicide bombing that might, in general, only kill a few innocent civilians or troops. Additionally, an extensive act will get far more media attention than a small scale terror attack. A key assassination could also be considered an extensive act. (The cause of specific key assassinations has not been modeled here, but could be added if desired.)

Since there is such a distinction between modest and extensive attacks in terms of number of casualties and damage caused and their impact can be very different on the various groups of interest, they are identified separately in this model. Both of these elements of value affect the US/Partner casualties which is defined as the number of U.S. and Partner troops and civilians that are wounded or killed as a result of the conflict. It is through these effects, the sub-models interact.

Terrorists’ support for social institutions represents all actions taken to help the populations within the TTAG, such as donations to Universities or religious education centers, hospitals, or schools. *Fear of retribution* represents the fear people in the TTAG have that the terrorists will harm them or their families if they do not support the terrorists or if they support the U.S. and its Partners. The element *belief: better off if terrorists win* represents the perception of the members of the TTAG that they will be better off if the terrorists win than if the U.S. and its Partners win.

Security is defined as the level of security felt by the population in the areas affected by military actions. For example, in terms of the current conflict in Iraq, security would refer to the level of security inside Iraq and on its borders. The geographic area could be much broader, depending on each specific conflict. *Media attention* is defined as the amount of attention, positive or negative, given to the terrorists and activities surrounding them by the media. This attention includes reporting on their modest and extensive terror actions and their support for social institutions, as well as coverage of U.S./Partners' reactions to or actions to prevent terror actions. The U.S./Partners' actions include, military actions, non-military actions, and support for social institutions. Military actions are generally assumed to be done in response to the actions of the terrorists, as are non-military actions, such as economic sanctions, but also includes actions to establish and provide security and to train indigenous forces. *U.S./Partners' support for social institutions* includes financial aid and security to groups such as the Red Cross or Doctors Without Borders, and includes humanitarian actions by the military reconstruction teams or troops such as digging wells, re-building schools, or passing out water to villages.

Terrorist finances are defined as the total amount of funds they have access to for planning and conducting operations, supporting group members and their families, funding social institutions, and many other activities. This money may come from a variety of sources, to include donations from individuals, from nation states, from front businesses, or from involvement in the drug trade. *US/Partners finances* represents the amount of funds available or allocated for use in fighting the GWOT. This money would

be divided into separate funds, such as one for support of military actions and one for support of reconstruction actions.

Religious leaders in the U.S. represents the negative public statements made by several key religious leaders in the U.S. which may be seen by the members of the TTAG as views shared by the U.S. government. In many Islamic nations, the government is not separate from the church (Anonymous, 2004: 3-4); therefore, a less worldly Islamist might believe that the U.S. religious leaders are speaking for, and with the support of, the government, even though that is often not the case in a nation that values the separation of church and state.

Influences

All of the elements displayed in Figure 22 have an affect on the level of popular support for the terrorists from within the TTAG. The specific relationships between the elements and popular support are dependent on the specific situation being modeled. The relationships assumed in this research for this sub-model were discussed in Chapter 3, but they can and will change according to the various scenarios for which this model is applied.

All of the elements that affect popular support for the terrorists from within the TTAG are not modeled; only the key elements of influence fitting the strategic scope of this research were included. Table 15 through Table 20 list all the relationships in the TTAG support influence diagram that were assumed for this research along with sources used to determine their existence.

Table 15: Key Elements of Influence and TTAG Active Supporters

From	To	Source
TTAG passive supporters	TTAG active supporters	Margulies 2002: 8-10
modest terror actions		
military actions by US/Partners		Margulies 2002:8; Russell, 2003: np
extensive modest terror actions		St. John 2004: 1-4
terrorists' support for social institutions		
media attention		Chappel 2002: 6; *Psychology of Terror* 2004: 9
security		Eland 2004: 1-2; Krepinevich 2004: 5
belief: better off if the terrorists win		Krepinevich 2004: 1
recruitment		
religious leaders in US		Curtis 2004: 1; Nye 2004a:16-20
TTAG active supporters	extensive modest terror actions	
	modest terror actions	Brookings Institution, 2005:14
	military actions by US/Partners	
	terrorists' support for social institutions	
	media attention	
	security	
	belief: better off if terrorists win	Krepinevich 2004: 1

Table 16: Key Elements of Influence and TTAG Passive Supporters

From	To	Source
modest terror actions	TTAG passive supporters	Margulies 2002: 8-10; *Combating Terrorism in a Globalized World* 2002: 16
TTAG active supporters		
TTAG uncommitted population		
military reactions by US/Partners		Kohn 2004: 3; Gorenberg 2004: 2-3; Russell, 2003: np
non-military actions by US/Partners		
US/Partners' support for social institutions		
terrorists' support for social institutions		Cragin, Daly 2004: 35-36
media attention		Chappel 2002: 6
security		Shreves 2004: 6
belief: better off if the terrorists win		Krepinevich 2004: 1
fear of retribution		Krepinevich 2004: 5
extensive terror actions		
recruitment		
religious leaders in U.S.		Curtis 2004: 1
TTAG passive supporters	modest terror actions	
	catastrophic modest terror actions	
	military actions by US/Partners	
	security	
	terrorists' support for social institutions	

Table 17: Key Elements of Influence on TTAG Uncommitted Population

From	To	Source
fear of retribution	TTAG uncommitted population	Krepinevich 2004: 5-6
modest terror actions		Margulies 2002: 8-10; *Combating Terrorism in a Globalized World* 2002: 16
extensive modest terror actions		
religious leaders in U.S.		Curtis 2004: 1
security		Krepinevich 2004: 4-5; Shreves 2004: 6
media attention		Chappel 2004: 8
non-military actions by US/Partners		
military reactions by US/Partners		Cordesman 2004: 3; Gorenberg 2004: 2-3
US partners' support for social institutions		Cragin, Chalk 2003: x; Shreves 2004: 7-8
TTAG passive supporters		
TTAG US/Partners' supporters		
terrorists' support for social institutions		Cragin, Daly 2004: 35-36

Table 18: Key Elements of Influence on TTAG US/Partners' Supporters

From	To	Source
TTAG uncommitted population	TTAG US/Partners' supporters	Krepinevich 2004: 5-6
modest terror actions		Margulies 2002: 8-10; *Combating Terrorism in a Globalized World* 2002: 16
non-military actions by US/Partners		
military actions by US/Partners		
security		
media attention		Wong 2000: 65-69
religious leaders in U.S.		Anonymous, 2004: 3-4
catastrophic modest terror actions		
TTAG active supporters		

Table 19: Media Attention Influence within TTAG

media attention	modest terror actions	*Psychology of Terror* 2004: 9
	belief: better off if terrorists win	
	US/Partners support for social institutions	
	military actions by US/Partners	Wong 2000: 65-69
	terrorists' support for social institutions	
	fear of retribution	
	extensive modest terror actions	
US partners' support for social institutions	media attention	
non-military actions by US/Partners		
terrorists' support for social institutions		Cragin, Daly 2004: 35-36

Table 20: TTAG Key Elements of Influence

From	To	Source
security	military actions by US/Partners	
	modest terror actions	
	media attention	
military reactions by US/Partners	modest terror actions	*Psychology of Terror* 2004: 7, FMI 3-07.22 2004: 2-66
	security	
TTAG uncommitted population	security	
TTAG US/Partners' supporters		
	US/Partners support for social institutions	
non-military actions by US/Partners	modest terror actions	Klevans, 2003:np
US/Partners finances	US support for social institutions	
	non-military actions by US/Partners	
terrorists finances	modest terror actions	*Combating Terrorism in a Globalized World* 2002: 47
	extensive terror actions	*Combating Terrorism in a Globalized World* 2002: 47
	terrorists' support for social institutions	

U.S. Resolve Influence Sub-model

This sub-model is important because it represents the impact of several key factors on the overall level of resolve in continuing the war on terrorism. The elements in this sub-model that did not appear in Figure 23 are defined next.

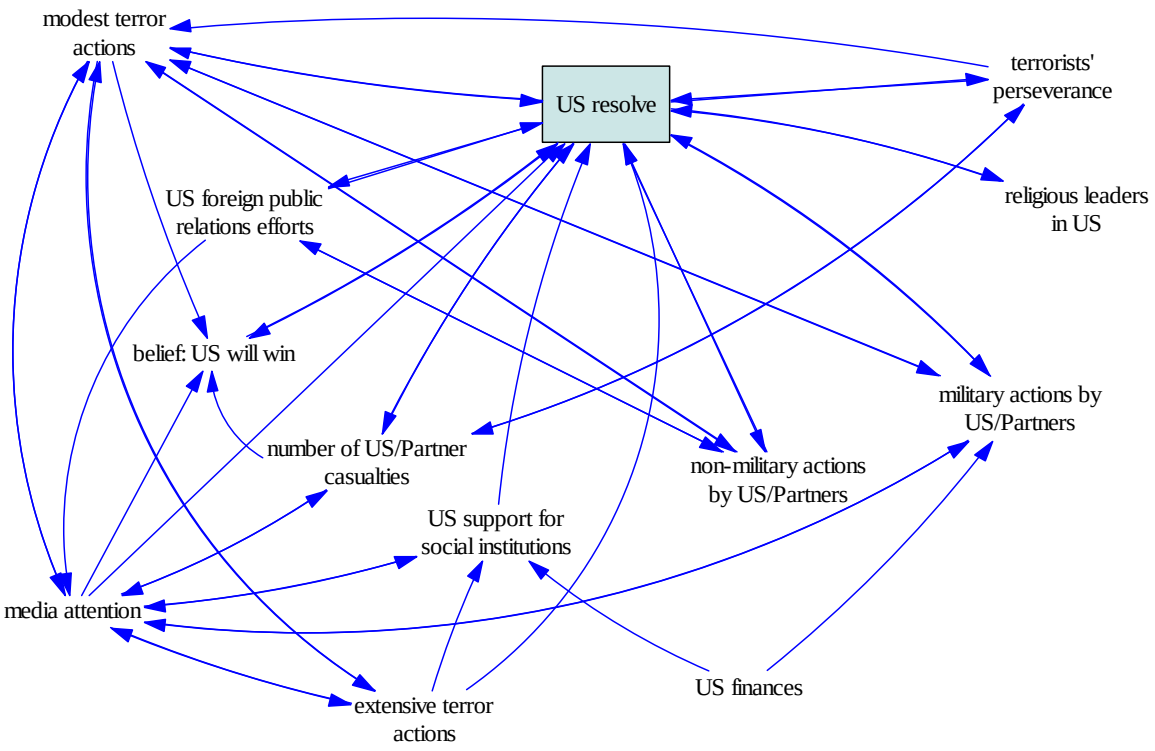


Figure 23: U.S. Resolve Influence Sub-model

Key Elements of Value

The terms in this sub-model that are common to other sub-models, e.g. the TTAG support influence model, are identically worded, and represent the same element. For example, *military actions by U.S./Partners* is the same effecter variable that was used in the TTAG support influence sub-model. The new elements in this sub-model are *US foreign relations efforts*, the *belief that the US will win*, and the *terrorists' perseverance*. The *US foreign public relations efforts* represents the actions by the U.S. that are done to affect relations between the U.S. and foreign countries. An integral component of this is strategic communications (Gjelten, 2005: np). This includes attempts at improving relations with our Partners as well as the countries who are not currently supporting the U.S./Partners' war efforts. The *belief that the US will win* captures the perception of the

U.S. citizens on how well the war is going. The last element to be defined is *terrorists' perseverance*. This refers to the persistence of the terrorists; their continued level of terror attacks over time. For example, if the rate of attacks decreased over the period of one year, then their persistence could be supposed to be decreasing.

Influences

All of the elements displayed in Figure B.2 have an affect on the level of the U.S. resolve in fighting, and the level of U.S. resolve, in turn, influences most of these elements as well. The specific relationships between the elements are dependent on the specific situation being modeled. The relationships assumed in this research were discussed in Chapter 3, but they can and will change according to the various scenarios for which this model is applied.

As in the TTAG support influence sub-model, all of the elements that affect U.S. resolve are not modeled; thus only the key elements of influence fitting the scope of this research are included. The documentation for the relationships assumed for this research is shown in Table 21 and Table 22.

Table 21: US Resolve Key Elements of Influence

From	To	Source
media attention	belief: US will win	Williams, 2004:np; Voeten and Brewer, 2004: 18-21; Wong, 2002: 65-69
	US support for social institutions	
	modest terror actions	*Psychology of Terror*, 2004: 9
	number of US/Partner casualties	
	extensive terror actions	Wong, 2002:65-69
US/Partners' support for social institutions	media attention	
number of US/Partner casualties		
military actions by US/Partners		
modest terror actions		*Psychology of Terror*, 2004: 9
non-military actions by US/Partners	US foreign public relations efforts	
US foreign public relations efforts	non-military actions by US/Partners	
US resolve	military actions by US/Partners	
number of US/Partner casualties	belief: US will win	Voeten and Brewer, 2004: 19-21
	US partner's resolve	Margulies 2002: 5
modest terror actions	belief: US will win	
	non-military actions by US/Partners	
	military actions by US/Partners	Shreves, 2004: 5-7; Gorenberg, 2004: 2
	terrorists' perseverance	Wong, 2002: 65
terrorists' perseverance	number of US/Partner casualties	
	modest terror actions	Wong, 2002:65-69
US Resolve	religious leaders in US	Anonymous, 2004: 3-4
military actions by US/Partners	modest terror actions	Wong, 2002:66; Shreves, 2004: 5-7; Gorenberg, 2004: 2
US finances	US support for social institutions	
	military actions by US/Partners	

Table 22: Key Elements of influence on US Resolve

From	To	Source
US foreign public relations efforts	US resolve	Voeten and Brewer, 2004: 18
belief: US will win		Krepinevich, 2004: 1; Voeten and Brewer, 2004: 25
media attention		Voeten and Brewer, 2004: 18-19; Wong, 2002: 65-69
number of US/Partner casualties		Cordesman, 2004: 3; Margulies, 2002: 5; Voeten and Brewer, 2004: 4; Nincic, 1995: np
US and partners' support for social institutions		
non-military actions by US/Partners		
terrorists' perseverance		Wong, 2002: 65-69
military actions by US/Partners		Cordesman 2004: 2-3; Shreves 2004: 5; *Combatting Terrorism in a Globalized World* 2002: 34
modest terror actions		Wong, 2002: 65
religious leaders in US		Anonymous, 2004: 3-4
extensive terror actions		

Non-TTAG Influence Sub-model

The Non-TTAG is comprised of those individuals not in the terrorist target affinity group population. This does not mean that the Non-TTAG cannot contain active or passive supporters of the terrorists; it simply means this segment of the population is not the principal "local support" group for the transnational terrorists. The Non-TTAG influence diagram (see Figure 24) is very similar to the TTAG influence diagram since all of the same elements of influence affect the overall level of support for the terrorists from the Non-TTAG as in the TTAG; however the base populations' being modeled are different which results in a difference in the nature of the relationships. If the transnational terrorist group of interest was an Islamic group, for example, then the

TTAG might be the global Muslim population, regardless of where they lived, or worked, and the Non-TTAG would consist of the remaining global population.

The diagram structures are the same, but the relationships may vary due to the different population being modeled; however, there is the possibility that some of the relationships will be similar depending on the particular transnational terrorist group being examined. Due to the identical structure, no new elements of influence need to be defined, although the four new population groups need to be defined.

In the Non-TTAG influence sub-model, the four population groups are Non-TTAG active supporters, Non-TTAG passive supporters, Non-TTAG uncommitted population, and Non-TTAG US/Partners' supporters. The active and passive groups are defined in the same manner as in the TTAG sub-model, where active members actually carry out the attacks, and passive supporters provide various forms of support but stop short of conducting attacks themselves for the terrorist group being modeled. The only difference is that the people in these groups come from the Non-TTAG population. They support the terrorist group, but are not from their target affinity group. The Non-TTAG uncommitted population is comprised of those in the Non-TTAG who are not for the terrorists, nor are they for the U.S. and its Partners. The last population group in the diagram is the US/Partners' supporters level. This group represents all the people in the Non-TTAG who support the conflict efforts by the U.S. and its Partners. These are not restricted to U.S. or Partner countries' citizens, as they may be from neutral nation states.

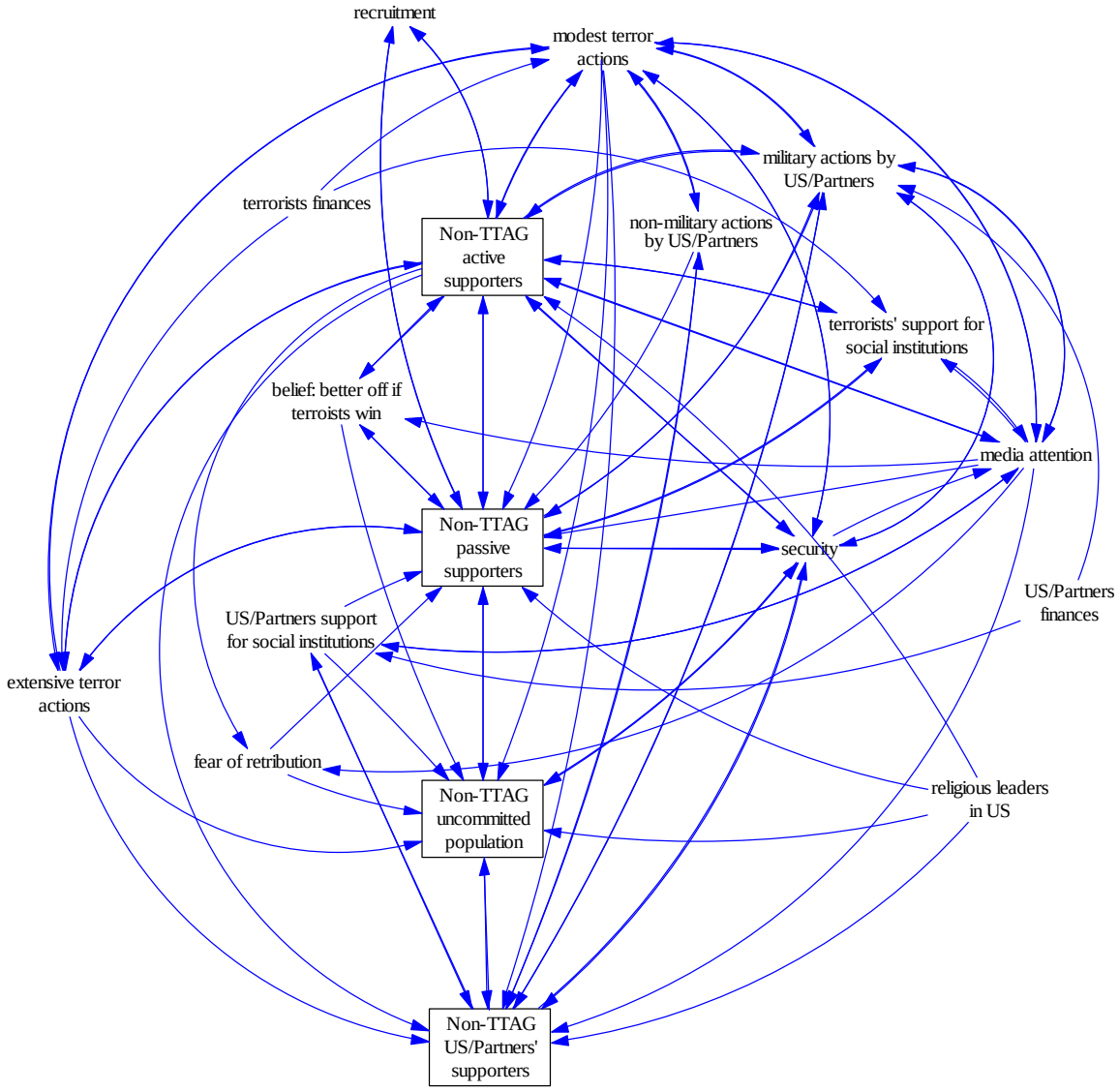


Figure 24: Non-TTAG Support Influence Sub-model

As in the other influence sub-models, there are additional key elements of influence not shown. The elements included were chosen for the strategic scope of this research as well as the desire to present a generic model that could be used to model all transnational terrorist groups. For a specific group, key elements could be added or removed in order to more accurately represent the group of interest.

Influences

The majority of the influences in the Non-TTAG diagram are the same in nature as in the TTAG, only the degree of influence in different. There are, however, a few influences that should be discussed to demonstrate their different impacts.

In the TTAG, fear of retribution has a significant influence on members of the passive and uncommitted groups. While this influence still exists in the Non-TTAG, the nature of this influence may be different. If most of the fighting for the conflict of interest is located in the Middle East, for example, then a person in the passive or uncommitted group in Ireland may not have the same level of fear of retribution as someone living in the Middle East. This is not to say the fear does not exist if one is geographically separated from the fighting, but the amount and type of fear is different. With the global nature of transnational terrorist groups and their demonstrated capability to conduct attacks around the world, no one should feel they are untouchable. A person in Ireland may be afraid of a nuclear weapon attack by the terrorists, but may not be fearful of being kidnapped by the terrorists while driving to work. Of course, this is not to say that a person in Ireland is more afraid an extensive attack than of being kidnapped by a terrorist, but demonstrates the manner in which the relationships may be different in the Non-TTAG and TTAG.

Another influence relationship that is slightly different is that of negative statements made by religious leaders in the U.S. about the terrorists and the four Non-TTAG population groups. Some parts of the Non-TTAG may not be affected at all by these statements while others may be. If the Non-TTAG level of support for the U.S. and

its Partners or for the terrorists is not impacted by these religious leaders' statements, then this variable should be set to zero or left out.

While the presence of influences exists for extensive terror actions to the four population groups in the Non-TTAG just as in the TTAG, the relationships themselves are different. In the Non-TTAG, the impact of an extensive terror action is hypothesized to draw fewer recruits to the active and passive groups and will most likely cause a larger portion of the group to move to US/Partners' supporters than in the TTAG. This was the case in Ireland after the attacks on September 11th when their support for the U.S. increased dramatically (Popular Opposition to War in Iraq, 2005: np).

The belief that they are better off if the terrorists win may be much lower for some people in the Non-TTAG than for those in the TTAG, but it also may be higher for some. For example, if all Muslim's form the TTAG, then a non-Muslim living in the current geographic area of fighting may be concerned about this effecter variable; however, if persons in the Non-TTAG living outside the current geographic area of conflict may not be concerned about this at all.

Media attention has been modeled, for the most part, the same in terms of influence for the Non-TTAG as in the TTAG. The active supporters and passive supporters are still motivated by negative media attention while the uncommitted and US/Partners' supporters are still influenced by the media in terms of fear of retribution and the belief that they are better off if the terrorists win. Media attention also influences the way military actions by the US are viewed which in turn affects the active and passive supporters in the Non-TTAG.

Terrorists' support for social institutions may or may not play an influential role in the Non-TTAG. The terrorists may focus more of their social support efforts at the TTAG population since this is the affinity group from which they are trying to recruit and draw support, but this assumption may not always be true. It is feasible that a transnational terrorist group may provide financial support to a group that is very different from them in an attempt to garner wider global popular support.

Non-military actions by US/Partners will definitely impact the Non-TTAG population groups. If economic sanctions cause starvation of any members of the Non-TTAG, then there is a clear influence. This is believed to drive at least a few people to passive or active supporters because of their anger and belief that the U.S. and Partners caused their problem, whether it is true or not.

Security is the last effecter element discussed in this section. The level of security for the Non-TTAG population influences the amount of media attention. The lower the security is, the easier it is for active supporters to conduct modest terror actions which impact the level of security. Thus, the security level feeds back in to influence itself. Additionally, the level of security affects and is affected by military actions by US/Partners. As military actions increase, the level of security should increase, but as the level of security decreases the numbers of military actions by US/Partners often increase as they attempt to regain an acceptable level of security.

Table 23 through Table 28 list all the relationships in the TTAG support influence diagram along with sources used to determine their existence.

Table 23: Key Elements of Influence and Non-TTAG Active Supporters

From	To	Source
TTAG passive supporters	Non-TTAG active supporters	Margulies 2002: 8-10
modest terror actions		Margulies 2002:8;Popular Opposition to War in Iraq, 2005:np
military actions by US/Partners		St. John 2004: 1-4
extensive modest terror actions		
terrorists' support for social institutions		Chappel 2002: 6; *Psychology of Terror* 2004: 9
media attention		Eland 2004: 1-2; Krepinevich 2004: 5
security		Krepinevich 2004: 1
belief: better off if the terrorists win		Cragin, Daly 2004: 57, Schweitzer 2003: 6
recruitment		Curtis 2004: 1; Nye 2004a:16-20
religious leaders in US		Margulies 2002: 8-10
Non-TTAG active supporters	extensive modest terror actions	
	modest terror actions	Brookings Institution, 2005:14
	military actions by US/Partners	
	terrorists' support for social institutions	
	media attention	
	security	
	belief: better off if terrorists win	Krepinevich 2004: 1

Table 24: Key Elements of Influence and Non-TTAG Passive Supporters

From	To	Source
modest terror actions	Non-TTAG passive supporters	Margulies 2002: 8-10; *Combatting Terrorism in a Globalized World* 2002: 16
TTAG active supporters		
TTAG uncommitted population		
military reactions by US/Partners		Kohn 2004: 3; Gorenberg 2004: 2-3;Popular Opposition to War in Iraq, 2005:np
non-military actions by US/Partners		
US/Partners' support for social institutions		Russell, 2003:np
terrorists' support for social institutions		Cragin, Daly 2004: 35-36
media attention		Chappel 2002: 6
security		Shreves 2004: 6
belief: better off if the terrorists win		Krepinevich 2004: 1
fear of retribution		Krepinevich 2004: 5
extensive modest terror actions		Curtis 2004: 1
recruitment		Margulies 2002: 8-10; *Combatting Terrorism in a Globalized World* 2002: 16
religious leaders in U.S.		
Non-TTAG passive supporters	modest terror actions	
	catastrophic modest terror actions	
	military actions by US/Partners	
	security	
	terrorists' support for social institutions	

Table 25: Key Elements of Influence on Non-TTAG Uncommitted Population

From	To	Source
fear of retribution	Non-TTAG uncommitted population	Krepinevich 2004: 5-6
modest terror actions		Margulies 2002: 8-10; *Combating Terrorism in a Globalized World* 2002: 16
extensive modest terror actions		
religious leaders in U.S.		Curtis 2004: 1
security		Krepinevich 2004: 4-5; Shreves 2004: 6
media attention		Chappel 2004: 8
non-military actions by US/Partners		
military reactions by US/Partners		Cordesman 2004: 3; Gorenberg 2004: 2-3
US partners' support for social institutions		Cragin, Chalk 2003: x; Shreves 2004: 7-8
Non-TTAG passive supporters		
Non-TTAG US/Partners' supporters		
terrorists' support for social institutions		Cragin, Daly 2004: 35-36

Table 26: Key Elements of Influence on Non-TTAG US/Partners' Supporters

From	To	Source
Non-TTAG uncommitted population	TTAG US/Partners' supporters	Krepinevich 2004: 5-6
modest terror actions		Margulies 2002: 8-10; Combating Terrorism in a Globalized World 2002: 16
non-military actions by US/Partners		
military actions by US/Partners		
security		
media attention		
religious leaders in U.S.		Anonymous, 2004: 3-4
extensive terror actions		Popular Opposition to War in Iraq, 2005:np
Non-TTAG active supporters		

Table 27: Media Attention Influence within Non-TTAG

media attention	modest terror actions	*Psychology of Terror* 2004: 9
	belief: better off if terrorists win	
	US/Partners support for social institutions	
	military actions by US/Partners	
	terrorists' support for social institutions	
	fear of retribution	
	extensive modest terror actions	
US partners' support for social institutions	media attention	
non-military actions by US/Partners		
terrorists' support for social institutions		Cragin, Daly 2004: 35-36

Table 28: Non-TTAG Key Elements of Influence

From	To	Source
security	military actions by US/Partners	
	modest terror actions	
	media attention	
military reactions by US/Partners	modest terror actions	*Psychology of Terror* 2004: 7, FMI 3-07.22 2004: 2-66
	security	
Non-TTAG uncommitted population	security	
Non-TTAG US/Partners' supporters		
	US/Partners support for social institutions	
non-military actions by US/Partners	modest terror actions	Klevans, 2003:np
US/Partners finances	US support for social institutions	
	non-military actions by US/Partners	
terrorists finances	modest terror actions	*Combating Terrorism in a Globalized World* 2002: 47
	extensive terror actions	*Combating Terrorism in a Globalized World* 2002: 47
	terrorists' support for social institutions	

US Partners' Resolve Influence Sub-model

The US Partners' Resolve Influence Sub-model (see Figure 25) has the same structure as the US resolve diagram (see Figure 23). All of the elements are also the same, but some will have different influences than in US resolve. The different affects of these relationships will be discussed next.

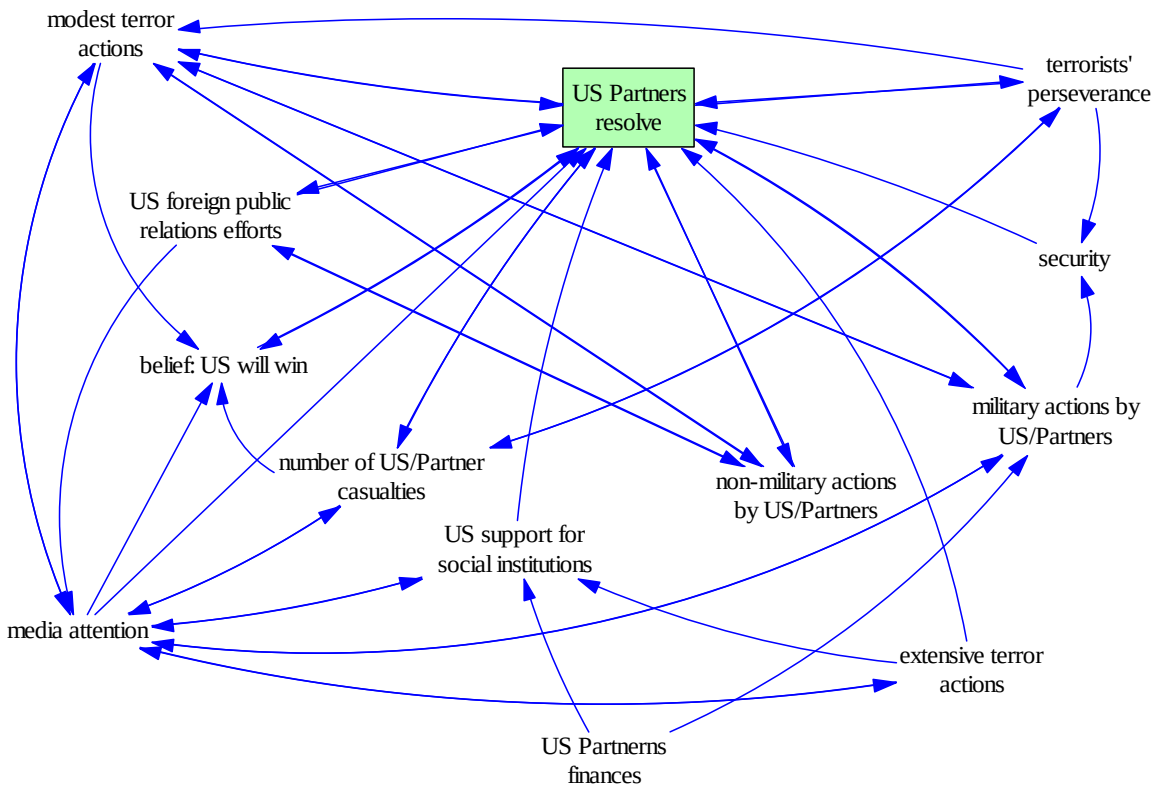


Figure 25: US Partners' Resolve Influence Sub-model

Influences

As in US resolve, the number of US/Partners casualties will have an impact on the level of US Partners' resolve for fighting the war on terrorism. If the number of casualties gets too high, the resolve may eventually erode. Conversely, the level of resolve affects the amount of military actions by US/Partners which affects the number of casualties. Additionally, military actions influence the level of security in the region of fighting and the amount of media attention. The media reports on the number of casualties and the amount of fighting, so as these events increase, the amount of media attention increases.

Media attention also directly influences the level of US Partners resolve. If the public constantly sees conflicting or negative reports, then their resolve may decay.

Extensive terror actions also are affected by the media. The terrorists know that an extensive attack will get lots of press, so they plan and conduct these types of attacks with that purpose in mind; thus, a reciprocal influence exists between media and extensive terror actions.

Statements made by religious leaders in the US can have an impact on the US Partners' resolve. Popular support might be driven down if their public strongly disagrees with these statements, driving a wedge between the U.S. and its Partner countries.

Modest terror actions has the same type influences as in the US resolve diagram, as does terrorists' perseverance, non-military actions, security, US support for social institutions, and US Partners finances; the exact weight of influences are what is different. For their more detailed description see the US resolve influence diagram section.

As in the other influence sub-models, all of the elements that affect U.S. Partners' resolve were not modeled. Only the key elements of influence fitting the strategic cope of this research were included. In order to improve the flow of the presentation, the supporting sources for the influences in Figure 25 are shown in Table 29 and Table 30.

Table 29: US Partners' Resolve Key Elements of Influence

From	To	Source
media attention	belief: US will win	Williams, 2004:np; Voeten and Brewer, 2004: 18-21; Wong, 2002: 65-69
	US support for social institutions	
	modest terror actions	*Psychology of Terror*, 2004: 9
	number of US/Partner casualties	
	extensive terror actions	Wong, 2002:65-69
US/Partners' support for social institutions	media attention	
number of US/Partner casualties		
military actions by US/Partners		
modest terror actions		*Psychology of Terror*, 2004: 9
non-military actions by US/Partners	US foreign public relations efforts	
US foreign public relations efforts	non-military actions by US/Partners	
US Partners' resolve	military actions by US/Partners	
number of US/Partner casualties	belief: US will win	Voeten and Brewer, 2004: 19-21
	US partner's resolve	Margulies 2002: 5
modest terror actions	belief: US will win	
	non-military actions by US/Partners	
	military actions by US/Partners	Shreves, 2004: 5-7; Gorenberg, 2004: 2
	terrorists' perseverance	Wong, 2002: 65
terrorists' perseverance	number of US/Partner casualties	
	modest terror actions	Wong, 2002:65-69
US Resolve	religious leaders in US	Anonymous, 2004: 3-4
military actions by US/Partners	modest terror actions	Wong, 2002:66; Shreves, 2004: 5-7; Gorenberg, 2004: 2
US Partners' finances	US support for social institutions	
	military actions by US/Partners	

Table 30: Key Elements of influence on US Partners' Resolve

From	To	Source
US foreign public relations efforts	US Partners' resolve	Voeten and Brewer, 2004: 18
belief: US will win		Krepinevich, 2004: 1; Voeten and Brewer, 2004: 25
media attention		Voeten and Brewer, 2004: 18-19; Wong, 2002: 65-69
number of US/Partner casualties		Cordesman, 2004: 3; Margulies, 2002: 5; Voeten and Brewer, 2004: 4; Nincic, 1995: np
US and partners' support for social institutions		
non-military actions by US/Partners		
terrorists' perseverance		Wong, 2002: 65-69
military actions by US/Partners		Cordesman 2004: 2-3; Shreves 2004: 5; *Combatting Terrorism in a Globalized World* 2002: 34
modest terror actions		Wong, 2002: 65
religious leaders in US		Anonymous, 2004: 3-4
extensive terror actions		

Appendix C: General Functions for Transnational Terrorists's Systems Dynamics Model

Variable		Function
TT	=	*TT gain in support – TT loss in support*
NT	=	*NT gain in support – NT loss in support*
TT gain in support	=	*f(TPS, non-local terrorist actions)*
TT loss of support	=	*f(local terrorist actions, CPS, Coalition military actions)*
NT gain in support	=	*f(local terrorist actions)*
NT loss of support	=	*f(CPS, Coalition military actions, Coalition financial support for reconstruction)*
TPS	=	*f(TT, NT)*
CPS	=	*f(Coalition military actions, negative media for Coalition, Coalition casualties)*
terrorist finances	=	*f(TT, NT)*
local terrorist actions	=	*f(terrorist finances)*
non-local terrorists actions	=	*f(terrorist finances)*
total Coalition financial support	=	*f(Coalition financial support for reconstruction actions, Coalition financial support for military actions)*
Coalition financial support for military actions	=	*f(non-local terrorist actions)*
force level	=	*f(Coalition financial support for military actions)*
Coalition military actions	=	*f(force level)*
negative media for Coalition	=	*f(Coalition casualties)*

Appendix D: Vensim text Code for Notional Illustration

```
"# CPS persons per non-local action"=
        200000
        ~       persons/action
        ~               |

"# dollars per NT person" = 1e-007
        ~       Billions of Dollars/persons
        ~               |

"# dollars per TT person" = 1e-006
        ~       Billions of Dollars/persons
        ~               |

"# forces needed for one Coalition military action"=
        INTEGER (RANDOM EXPONENTIAL(500, 10000, 0, 1, "random seed for #
mil troops"))
        ~       persons/actions
        ~               |

"# neg media reports per casualty"=
        INTEGER ( RANDOM UNIFORM ( 1, 3, random seed for neg media reports ))
        ~       Dmnl
        ~               |

"# NT persons per local action"=
        1
        ~       persons/actions
        ~               |

"# NT persons per non-local action"=
        10000
        ~       persons/actions
        ~               |

"# NT persons per CPS"=
        IF THEN ELSE ( "Coalition popular support (CPS)" < 250000, 0, IF THEN
ELSE ( "Coalition popular support (CPS)"\
                >= 250000 :AND: "Coalition popular support (CPS)" < 1e+006, 1e-009,
IF THEN ELSE (\
```

"Coalition popular support (CPS)" <= 1e+007 :AND: "Coalition popular support (CPS)"\
"Coalition popular support (CPS)" > 1e+008, 1e-008, IF THEN ELSE ("Coalition popular support (CPS)" <= 1e+008 :AND:\
"Coalition popular support (CPS)" > 1e+009, 1e-007, 1e-006))))
~ Dmnl
~ |

"# of NT supporters who donate money" = IF THEN ELSE ("Non-TTAG in support of terrorist group (NT)"\
> 0, "% of NT who donate" * "Non-TTAG in support of terrorist group (NT)" / "conversion to persons/month"\
, 0)
~ persons/Month
~ |

"# of TT supporters who donate money" = IF THEN ELSE ("TTAG in support of terrorist group (TT)"\
> 0, "% of TT who donate" * "TTAG in support of terrorist group (TT)" , 0)
~ persons/Month
~ |

"# persons in Coalition population" = INITIAL(3.5e+008)
~ persons/Month [0,?]
~ |

"# persons in global population" = 6.4e+009
~ persons/Month
~ |

"# persons in NT support group"=
"Non-TTAG in support of terrorist group (NT)"/conversion to persons per month
~ persons/Month
~ |

"# persons in TT support group"=
"TTAG in support of terrorist group (TT)"/conversion to persons per month 0
~ persons/Month
~ |

"# persons per casualties"=
IF THEN ELSE(Coalition casualties<1050,10, IF THEN ELSE(Coalition casualties>=1050:AND:\
Coalition casualties<1700, 15, 25))

~ persons/actions
~ |

"# persons per Coalition financial support for reconstruction"=
IF THEN ELSE (Coalition financial support for reconstruction actions in billions per month\
< 1,
10, IF THEN ELSE (Coalition financial support for reconstruction actions in billions per month\
>= 1 :AND: Coalition financial support for reconstruction actions in billions per month\
< 2, 50, 100))
~ persons/Billions of Dollars
~ |

"# persons per Coalition military action to CPS"=
IF THEN ELSE(Coalition military actions<20, 1000, IF THEN ELSE(Coalition military actions\
>=20:AND:Coalition military actions<40, 5000, IF THEN ELSE(Coalition military actions\
>=40:AND:Coalition military actions<70, 10000, IF THEN ELSE(Coalition military actions\
>=70:AND:Coalition military actions<100, 50000, IF THEN ELSE(Coalition military actions\
>=100:AND:Coalition military actions<150, 100000, IF THEN ELSE(Coalition military actions\
>=150:AND:Coalition military actions<200, 500000, 750000))))))
~ persons/actions
~ |

"# persons per Coalition military action to NT loss of support"=
5
~ persons/actions
~ |

"# persons per Coalition military action to TT loss of support"=
10
~ persons/actions
~ |

"# persons per force level" = 0.004
~ Dmnl
~ |

"# persons per month in NT support group" = "Non-TTAG in support of terrorist group (NT)"\
	/ conversion to persons per month
	~	persons/Month
	~		|

"# persons per month in TT support group" = "TTAG in support of terrorist group (TT)"\
	/ conversion to persons per month 0
	~	persons/Month
	~		|

"# persons per neg media for Coalition"=
	5
	~	persons/actions
	~		|

"# persons per total billions in Coalition financial support"=
	1
	~	persons/Billions of Dollars
	~		|

"# soldiers per billion dollars/month"=
	10000
	~	persons/Billions of Dollars
	~		|

"# TT persons per non-local action"=
	100000
	~	persons/actions
	~		|

"# TT persons per CPS"=
	1e-005
	~	Dmnl
	~		|

"% initial CPS support" = 0.6
	~	Dmnl
	~		|

"% of NT who donate" = 0.1
	~	Dmnl
	~		|

"% of TT who donate"=

0.2
~ 1/Month
~ |

amount of money in billions per support persons = ("# dollars per NT person" * "# of NT supporters who donate money"\
+ "# dollars per TT person" * "# of TT supporters who donate money") * 1e+009
~ Billions of Dollars/Month [0,?]
~ |

average casualties per month=
1050
~ actions/Month [500,1050,1700]
~ |

average initial financial support for Coalition military actions per month=
23.75
~ Dmnl [0,?]
~ |

average initial financial support for Coalition reconstruction actions per month=
1.25
~ Billions of Dollars/Month [0,?]
~ |

Coalition casualties=
INTEGER (RANDOM POISSON (0, 2500, average casualties per month , 0, 1, random seed for casualty parameter\
))
~ actions/Month [0,?]
~ |

Coalition financial support for military actions=
IF THEN ELSE("non-local terrorist actions"=1, average initial financial support for Coalition military actions per month
+"effect of non-local action on Coalition military financing", average initial financial support for Coalition military actions per month\
)
~ Dmnl
~ |

Coalition financial support for reconstruction actions in billions per month=
average initial financial support for Coalition reconstruction actions per month
~ Billions of Dollars/Month

~ |

Coalition military actions=
INTEGER(force level / "# forces needed for one Coalition military action")
~ actions/Month
~ |

"Coalition popular support (CPS)"=
IF THEN ELSE ("initial # Coalition supporters" - effect of casualties on CPS + effect of Coalition military actions on CPS
- effect of TPS on CPS - effect of force level on CPS - effect of negative media on CPS\
-effect of total Coalition financial support on CPS-"effect of non-local terrorist actions on CPS"
< 0, 0, IF THEN ELSE ("initial # Coalition supporters"
- effect of casualties on CPS + effect of Coalition military actions on CPS - effect of TPS on CPS\
- effect of force level on CPS
- effect of negative media on CPS-effect of total Coalition financial support on CPS\
-"effect of non-local terrorist actions on CPS" >= "# persons in Coalition population"\
,
"# persons in Coalition population" , "initial # Coalition supporters" - effect of casualties on CPS
+ effect of Coalition military actions on CPS - effect of TPS on CPS - effect of force level on CPS\
- effect of negative media on CPS-effect of total Coalition financial support on CPS\
-"effect of non-local terrorist actions on CPS"))
~ persons/Month
~ |

conversion to persons per month = 1
~ Month
~ |

conversion to persons per month 0=
1
~ Month
~ |

"conversion to persons/month" = 1
~ Month
~ |

effect of casualties on CPS = "# persons per casualties" * Coalition casualties
	~	persons/Month
	~		|

effect of Coalition financial support for reconstruction on NT loss of support=
	"# persons per Coalition financial support for reconstruction"*Coalition financial support for reconstruction actions in billions per month
	~	persons/Month
	~		|

effect of Coalition military actions on CPS = "# persons per Coalition military action to CPS"\
		* Coalition military actions
	~	persons/Month
	~		|

effect of Coalition military actions on NT loss of support = "# persons per Coalition military action to NT loss of support"\
		* Coalition military actions
	~	persons/Month
	~		|

effect of Coalition military actions on TT loss of support = "# persons per Coalition military action to TT loss of support"\
		* Coalition military actions
	~	persons/Month
	~		|

effect of CPS on NT loss of support = IF THEN ELSE ("Coalition popular support (CPS)"\
		<= 0, 0, "# NT persons per CPS" * "Coalition popular support (CPS)")
	~	persons/Month
	~		|

effect of CPS on TT loss of support = IF THEN ELSE ("Coalition popular support (CPS)"\
		<= 0, 0, "# TT persons per CPS" * "Coalition popular support (CPS)")
	~	persons/Month [0,?]
	~		|

effect of finances on local actions = IF THEN ELSE (terrorist finances < 5000, 10, IF THEN ELSE\
		(terrorist finances >= 5000 :AND: terrorist finances < 100000, 100, IF THEN ELSE \

```
                ( terrorist finances >= 100000 :AND: terrorist finances < 1e+006, 1000, IF
THEN ELSE\
                 ( terrorist finances >= 1e+006 :AND: terrorist finances < 5e+008, 2000,
IF THEN ELSE\
                 ( terrorist finances >= 5e+008 :AND: terrorist finances < 1e+009, 3000,
4000) ) ) \
                ) )
        ~       actions/Month
        ~               |

"effect of finances on non-local actions"=
        IF THEN ELSE ( terrorist finances < 500000, 0, IF THEN ELSE ( RANDOM
UNIFORM ( 0, 1,\
                 "random seed for effect of finances on non-local actions") > "probability
threshold for occurrence of non-local actions"\
                 , 1, 0) )
        ~       actions
        ~               |

effect of force level on CPS = force level * "# persons per force level"
        ~       persons/Month
        ~               |

effect of local actions on TT loss of support=
        local terrorist actions*TT persons per local terrorist action
        ~       persons/Month
        ~               |

effect of local actionso n NT gain in support=
        "# NT perosns per local action"*local terrorist actions
        ~       persons/Month
        ~               |

effect of negative media on CPS=
        negative media for Coalition * "# persons per neg media for Coaltion"
        ~       persons/Month
        ~               |

"effect of non-local action on Coalition military financing"=
        RANDOM UNIFORM(2, 10, "random seed for non-local action on Coalition
military financing"\
                )
        ~       Billions of Dollars/Month [0,?]
        ~               |
```

```
"effect of non-local actions on NT loss of support"=
        "# NT persons per non-local action"*"non-local terrorist actions"
        ~       persons/Month
        ~               |

"effect of non-local actions on TT loss of support" = "# TT persons per non-local action"\
                * "non-local terrorist actions"
        ~       persons/Month
        ~               |

"effect of non-local terrorist actions on CPS"=
        "non-local terrorist actions"*"# CPS persons per non-local action"
        ~       persons/Month
        ~               |

effect of total Coalition financial support on CPS=
        "# persons per total billions in Coalition financial support"*total Coalition
financial support
        ~       persons/Month
        ~               |

effect of TPS on CPS = "popular support for the terrorists (TPS)" * TPS to CPS rate
        ~       persons/Month [0,?]
        ~               |

effect of TPS on local actions=
        IF THEN ELSE ( "popular support for the terrorists (TPS)" < 200000, 0, IF
THEN ELSE \
                ( "popular support for the terrorists (TPS)"
         >= 200000 :AND: "popular support for the terrorists (TPS)" < 300000, 1.2, IF
THEN ELSE\
                 ( "popular support for the terrorists (TPS)"
         >= 300000 :AND: "popular support for the terrorists (TPS)" > 400000, 1.3, IF
THEN ELSE\
                 ( "popular support for the terrorists (TPS)"
         >= 400000 :AND: "popular support for the terrorists (TPS)" < 500000, 1.35, IF
THEN ELSE\
                ("popular support for the terrorists (TPS)">=500000:AND:"popular
support for the terrorists (TPS)"\
                <1e+009, 1.75, 2)) ) ) )
        ~       Dmnl
        ~               |

effect of TPS on TT gain in support = persons from TPS * "popular support for the
terrorists (TPS)"
```

~ persons/Month
~ |

force level=
"# soldiers per billion dollars/month" *Coalition financial support for military actions
~ persons/Month
~ |

"initial # Coalition supporters" = INITIAL("% initial CPS support" * "# persons in Coalition population"\
)
~ persons/Month [0,?]
~ |

"initial # Non-TTAG supporters" = INITIAL(320000 * 0.1)
~ persons
~ |

"initial # TTAG supporters" = INITIAL(320000)
~ persons/Month
~ |

initial terrorist finances in billions of dollars per month= INITIAL(
2.5/12)
~ Billions of Dollars/Month
~ |

local terrorist actions=
IF THEN ELSE (effect of TPS on local actions = 0, INTEGER(RANDOM POISSON (0, 3500,\
effect of finances on local actions
, 0, 1, 0)) , INTEGER(RANDOM POISSON (0, 3500, effect of finances on local actions\
, 0, 1, 0) * effect of TPS on local actions
))
~ actions/Month
~ |

negative media for Coalition = Coalition casualties * "# neg media reports per casualty"
~ actions/Month
~ |

"non-local terrorist actions"=

```
        IF THEN ELSE ( RANDOM UNIFORM ( 0, 1, "random seed for non-local
actions") < "effect of finances on non-local actions"\
                , PULSE ( Time , 1) , 0)
        ~       actions/Month
        ~               |

"Non-TTAG in support of terrorist group (NT)"= INTEG (
         IF THEN ELSE ( MAX(0, "Non-TTAG in support of terrorist group (NT)") = 0,
IF THEN ELSE\
                (NT gain in support-NT loss of support
         > 0, MAX(NT gain in support-NT loss of support,"Non-TTAG in support of
terrorist group (NT)"\
                ), -1*"Non-TTAG in support of terrorist group (NT)"
        ),NT gain in support-NT loss of support )


        ,
                "initial # Non-TTAG supporters")
        ~       persons [0,?,5.2e+009]
        ~               |

NT gain in support=
        INTEGER(effect of local actions on NT gain in support)
        ~       persons/Month
        ~               |

NT loss of support=
        INTEGER(effect of Coalition financial support for reconstruction on NT loss of
support\
                +effect of Coalition military actions on NT loss of support
        +effect of CPS on NT loss of support+"effect of non-local actions on NT loss of
support"\
                )
        ~       persons/Month
        ~               |

persons from TPS=
        0.001
        ~       Dmnl [1e-005,0.0001,0.001]
        ~               |

"popular support for the terrorists (TPS)" = IF THEN ELSE ( "# persons in TT support
group"\
                 + "# persons in NT support group" >= "# persons in global population" ,
"# persons in global population"\
```

, IF THEN ELSE ("# persons in NT support group" + "# persons in TT support group"\
< "# persons in global population" :AND: "# persons in NT support group" + "# persons in TT support group"\
> 0, "# persons in NT support group" + "# persons in TT support group" , 0))
~ persons/Month [0,?,6.4e+009]
~ |

"probability threshold for occurrence of non-local actions"=
0.9
~ Dmnl
~ |

"random seed for # mil troops"=
0
~ Dmnl
~ |

random seed for casualty parameter=
0
~ Dmnl
~ |

"random seed for effect of finances on non-local actions"=
4
~
~ |

random seed for neg media reports=
1
~ Dmnl
~ |

"random seed for non-local action on Coalition military financing"=
0
~
~ |

"random seed for non-local actions"=
4
~ Dmnl
~ |

terrorist finances = initial terrorist finances in billions of dollars per month + amount of money in billions per support persons
	~	Billions of Dollars/Month
	~		|

total Coalition financial support=
	Coalition financial support for military actions+Coalition financial support for reconstruction actions in billions per month
	~	Billions of Dollars/Month
	~		|

TPS to CPS rate=
	IF THEN ELSE ("popular support for the terrorists (TPS)" < 1e+008, 1e-010, IF THEN ELSE\
		("popular support for the terrorists (TPS)" >= 1e+008 :AND: "popular support for the terrorists (TPS)"\
		< 8e+008, 1e-009, 1e-008))
	~	Dmnl
	~		|

TT gain in support=
	INTEGER("effect of non-local actions on TT loss of support" + effect of TPS on TT gain in support\
		)
	~	persons/Month
	~		|

TT loss of support=
	INTEGER(effect of Coalition military actions on TT loss of support+effect of CPS on TT loss of support\
		+effect of local actions on TT loss of support)
	~	persons/Month
	~		|

TT persons per local terrorist action=
	0.01
	~
	~		|

"TTAG in support of terrorist group (TT)"= INTEG (
	IF THEN ELSE (MAX(0, "TTAG in support of terrorist group (TT)") = 0, IF THEN ELSE(\
		TT gain in support-TT loss of support
	> 0, MAX(TT gain in support-TT loss of support,"TTAG in support of terrorist group (TT)"\

```
        ), -1*"TTAG in support of terrorist group (TT)"
    ),TT gain in support-TT loss of support ),
        "initial # TTAG supporters")
    ~   persons
    ~       |

********************************************************
    .Control
********************************************************~
        Simulation Control Parameters
    |

FINAL TIME  = 120
    ~   Month
    ~   The final time for the simulation.
    |

INITIAL TIME  = 0
    ~   Month
    ~   The initial time for the simulation.
    |

SAVEPER  =
   TIME STEP
    ~   Month [0,?]
    ~   The frequency with which output is stored.
    |

TIME STEP  = 1
    ~   Month [0,?]
    ~   The time step for the simulation.
    |

\\\---/// Sketch information - do not modify anything except names
V300  Do not put anything below this section - it will be ignored
*View 1
$192-192-192,0,Times New Roman|12||0-0-0|0-0-0|0-0-255|-1--1--1|-1--1--1|96,96,75
10,1,Coalition casualties,611,1340,60,11,8,3,0,0,0,0,0,0
10,2,"Coalition popular support (CPS)",579,932,57,57,2,3,0,0,0,0,0,0
10,3,negative media for Coalition,356,1270,58,19,8,3,0,0,0,0,0,0
1,4,1,3,1,0,43,0,2,64,0,-1--1--1,|12||0-0-0,1|(478,1342)|
10,5,"# persons per casulties",630,1275,44,19,8,3,0,0,0,0,0,0
10,6,effect of casualties on CPS,618,1125,58,19,8,3,0,0,0,0,0,0
1,7,6,2,1,0,45,0,2,64,0,-1--1--1,|12||0-0-0,1|(611,1051)|
10,8,effect of negative media on CPS,499,1194,54,19,8,3,0,0,0,0,0,0
```

1,9,3,8,1,0,0,0,0,64,0,-1--1--1,,1|(419,1214)|
1,10,8,2,1,0,45,0,2,64,0,-1--1--1,|12||0-0-0,1|(567,1037)|
10,11,"initial # Coalition supporters",430,985,53,19,8,3,0,0,0,0,0,0
1,12,11,2,1,0,43,0,2,64,0,-1--1--1,|12||0-0-0,1|(499,979)|
10,13,"# persons in Coalition population",344,1049,64,19,8,3,0,0,-1,0,0,0
1,14,13,11,1,0,0,0,0,64,1,-1--1--1,,1|(359,1013)|
10,15,force level,754,1313,33,11,8,3,0,0,0,0,0,0
10,16,"# persons per force level",792,1240,44,19,8,3,0,0,0,0,0,0
10,17,effect of force level on CPS,758,1159,61,19,8,3,0,0,0,0,0,0
1,18,15,17,1,0,0,0,0,64,0,-1--1--1,,1|(735,1244)|
1,19,16,17,1,0,0,0,0,64,0,-1--1--1,,1|(760,1202)|
1,20,17,2,1,0,45,0,2,64,0,-1--1--1,|12||0-0-0,1|(679,1080)|
10,21,"# soldiers per billion dollars/month",854,1400,64,19,8,3,0,0,0,0,0,0
1,22,21,15,1,0,0,0,0,64,0,-1--1--1,,1|(769,1369)|
10,23,Coalition military actions,926,1166,54,19,8,3,0,0,0,0,0,0
10,24,effect of Coalition military actions on CPS,724,1022,74,19,8,3,0,0,0,0,0,0
10,25,"# persons per Coalition military action to CPS",935,1075,74,19,8,3,0,0,0,0,0,0
1,26,25,24,1,0,0,0,0,64,0,-1--1--1,,1|(804,1082)|
1,27,24,2,1,0,43,0,2,64,0,-1--1--1,|12||0-0-0,1|(662,963)|
10,28,Coalition financial support for reconstruction actions in billions per
month,145,1049,100,28,8,3,0,0,0,0,0,0
10,29,total Coalition financial support,135,1363,63,21,8,3,0,0,0,0,0,0
10,30,effect of Coalition fincancial support for reconstruction on NT loss of
support,256,945,92,28,8,3,0,0,0,0,0,0
10,31,"# persons per Coalition financial support for
reconstruction",132,871,74,28,8,3,0,0,0,0,0,0
1,32,31,30,1,0,0,0,0,64,0,-1--1--1,,1|(188,881)|
1,33,30,62,1,0,45,0,2,64,0,-1--1--1,|12||0-0-0,1|(289,921)|
10,34,"TTAG in support of terrorist group (TT)",932,602,61,36,3,3,0,0,0,0,0,0
12,35,48,1118,598,10,8,0,3,0,0,-1,0,0,0
1,36,38,35,4,0,0,22,0,0,0,-1--1--1,,1|(1085,599)|
1,37,38,34,100,0,0,22,0,0,0,-1--1--1,,1|(1022,599)|
11,38,48,1057,599,6,8,34,3,0,0,1,0,0,0
10,39,TT loss of support,1057,618,58,11,40,3,0,0,-1,0,0,0
10,40,"# persons per Coalition military action to TT loss of
support",921,1000,75,28,8,3,0,0,0,0,0,0
10,41,effect of Coalition military actions on TT loss of
support,1015,910,81,28,8,3,0,0,0,0,0,0
1,42,40,41,1,0,0,0,0,64,0,-1--1--1,,1|(954,903)|
1,43,41,39,1,0,0,0,0,64,0,-1--1--1,,1|(1078,835)|
10,44,"# TT persons per CPS",831,904,56,19,8,3,0,0,0,0,0,0
10,45,effect of CPS on TT loss of support,986,783,65,19,8,3,0,0,0,0,0,0
1,46,44,45,1,0,0,0,0,64,0,-1--1--1,,1|(899,847)|
1,47,2,45,1,0,0,0,0,64,0,-1--1--1,,1|(803,881)|
1,48,45,39,1,0,0,0,0,64,0,-1--1--1,,1|(1033,725)|

12,49,48,707,603,10,8,0,3,0,0,-1,0,0,0
1,50,52,49,36,0,0,22,2,0,0,-1--1--1,|12||0-0-0,1|(744,602)|
1,51,52,34,68,0,0,22,2,0,0,-1--1--1,|12||0-0-0,1|(827,602)|
11,52,48,777,602,6,8,34,3,0,0,1,0,0,0
10,53,TT gain in support,777,621,57,11,40,3,0,0,-1,0,0,0
10,54,"popular support for the terrorists (TPS)",751,431,56,56,2,3,0,0,0,1,0,0
10,55,"Non-TTAG in support of terrorist group (NT)",396,599,65,36,3,3,0,0,0,0,0,0
10,56,"initial # Non-TTAG supporters",302,686,63,19,8,3,0,0,0,0,0,0
1,57,56,55,0,0,0,0,0,64,1,-1--1--1,,1|(334,655)|
12,58,48,619,596,10,8,0,3,0,0,-1,0,0,0
1,59,61,58,4,0,0,22,0,0,0,-1--1--1,,1|(574,596)|
1,60,61,55,100,0,0,22,0,0,0,-1--1--1,,1|(494,596)|
11,61,48,533,596,6,8,34,3,0,0,1,0,0,0
10,62,NT loss of support,533,615,59,11,40,3,0,0,-1,0,0,0
12,63,48,160,598,10,8,0,3,0,0,-1,0,0,0
1,64,66,63,36,0,0,22,2,0,0,-1--1--1,|12||0-0-0,1|(200,598)|
1,65,66,55,68,0,0,22,2,0,0,-1--1--1,|12||0-0-0,1|(286,598)|
11,66,48,236,598,6,8,34,3,0,0,1,0,0,0
10,67,NT gain in support,236,617,59,11,40,3,0,0,-1,0,0,0
10,68,conversion to persons per month 0,995,308,49,29,8,3,0,0,0,0,0,0
10,69,"# persons in TT support group",885,234,50,19,8,3,0,0,0,0,0,0
1,70,69,54,1,0,0,0,0,64,0,-1--1--1,,1|(807,302)|
10,71,conversion to persons per month,605,361,59,19,8,3,0,0,0,0,0,0
10,72,"# persons in NT support group",613,443,52,19,8,3,0,0,0,0,0,0
1,73,72,54,1,0,0,0,0,64,0,-1--1--1,,1|(686,405)|
10,74,"# NT persons per CPS",328,810,57,19,8,3,0,0,0,0,0,0
10,75,effect of CPS on NT loss of support,395,740,67,19,8,3,0,0,0,0,0,0
1,76,74,75,1,0,0,0,0,64,0,-1--1--1,,1|(352,795)|
1,77,75,62,1,0,0,0,0,64,0,-1--1--1,,1|(431,699)|
1,78,2,75,1,0,0,0,0,64,0,-1--1--1,,1|(489,818)|
10,79,"# persons per Coalition military action to NT loss of
support",742,840,78,32,8,3,0,0,0,0,0,0
10,80,effect of Coalition military actions on NT loss of
support,560,768,81,28,8,3,0,0,0,0,0,0
1,81,79,80,1,0,0,0,0,64,0,-1--1--1,,1|(675,758)|
1,82,80,62,1,0,0,0,0,64,0,-1--1--1,,1|(561,691)|
10,83,"# persons in global population",733,323,60,19,8,3,0,0,0,0,0,0
1,84,15,23,1,0,0,0,0,64,0,-1--1--1,,1|(839,1265)|
10,85,"# forces needed for one Coalition military action",961,1261,76,19,8,3,0,0,0,0,0,0
1,86,85,23,1,0,0,0,0,64,0,-1--1--1,,1|(966,1237)|
1,87,2,74,1,0,0,0,0,0,0,-1--1--1,,1|(447,894)|
1,88,13,2,1,0,0,0,0,64,0,-1--1--1,,1|(440,1042)|
10,89,"non-local terrorist actions",397,304,57,19,8,3,0,0,0,0,0,0
10,90,effect of local actionso n NT gain in support,115,422,77,19,8,3,0,0,0,0,0,0
10,91,"# NT perosns per local action",81,523,63,29,8,3,0,0,0,0,0,0

1,92,91,90,1,0,0,0,0,64,0,-1--1--1,,1|(92,500)|
1,93,90,66,1,0,0,0,0,64,0,-1--1--1,,1|(200,487)|
10,94,"effect of non-local actions on TT loss of support",680,237,82,19,8,3,0,0,0,0,0,0
10,95,"# TT perosns per non-local action",832,180,56,19,8,3,0,0,0,0,0,0
1,96,95,94,1,0,0,0,0,64,0,-1--1--1,,1|(732,179)|
1,97,89,94,1,0,0,0,0,64,0,-1--1--1,,1|(569,254)|
1,98,94,53,1,0,0,0,0,64,0,-1--1--1,,1|(809,364)|
10,99,"effect of finances on non-local actions",273,179,64,19,8,3,0,0,0,0,0,0
1,100,99,89,1,0,0,0,0,64,0,-1--1--1,,1|(328,218)|
10,101,Time,236,114,26,11,8,2,0,3,-1,0,0,0,128-128-128,0-0-0,|12||128-128-128
1,102,101,89,1,0,0,0,0,0,0,-1--1--1,,1|(307,199)|
10,103,effect of TPS on TT gain in support,915,484,64,19,8,3,0,0,0,0,0,0
1,104,103,52,1,0,0,0,0,64,0,-1--1--1,,1|(892,524)|
10,105,persons from TPS,911,356,51,19,8,3,0,0,0,0,0,0
1,106,105,103,1,0,0,0,0,64,0,-1--1--1,,1|(903,399)|
1,107,54,103,1,0,0,0,0,64,0,-1--1--1,,1|(837,425)|
1,108,83,54,1,0,0,0,0,64,0,-1--1--1,,1|(719,361)|
10,109,terrorist finances,487,162,52,11,8,3,0,0,0,0,0,0
10,110,"# dollars per NT person",103,88,54,19,8,3,0,0,0,0,0,0
10,111,amount of money in billions per support persons,250,83,62,28,8,3,0,0,0,0,0,0
1,112,110,111,1,0,0,0,0,64,0,-1--1--1,,1|(203,123)|
1,113,111,109,1,0,0,0,0,64,0,-1--1--1,,1|(340,151)|
10,114,initial terrorist finances in billions of dollars per
month,582,107,78,28,8,3,0,0,0,0,0,0
1,115,114,109,1,0,0,0,0,64,0,-1--1--1,,1|(492,124)|
10,116,"# of NT supporters who donate money",100,159,62,19,8,3,0,0,0,0,0,0
1,117,116,111,1,0,0,0,0,64,0,-1--1--1,,1|(190,147)|
1,118,109,99,1,0,0,0,0,64,0,-1--1--1,,1|(423,196)|
1,119,55,116,1,0,0,0,2,0,0,-1--1--1,|12||0-0-0,1|(214,431)|
1,120,109,121,1,0,0,0,0,64,0,-1--1--1,,1|(630,179)|
10,121,effect of finances on local actions,648,170,64,19,8,3,0,0,0,0,0,0
10,122,"probability threshold for occurrence of non-local
actions",237,328,76,28,8,3,0,0,0,0,0,0
1,123,122,99,1,0,0,0,0,64,0,-1--1--1,,1|(297,250)|
10,124,"% of NT who donate",71,292,45,19,8,3,0,0,0,0,0,0
1,125,124,116,1,0,0,0,0,64,0,-1--1--1,,1|(77,230)|
10,126,"# of TT supporters who donate money",816,116,61,19,8,3,0,0,0,0,0,0
10,127,"% of TT who donate",980,116,43,19,8,3,0,0,0,0,0,0
1,128,127,126,1,0,0,0,0,64,0,-1--1--1,,1|(905,79)|
1,129,34,126,1,0,0,0,0,64,0,-1--1--1,,1|(1020,309)|
1,130,126,111,1,0,0,0,0,64,0,-1--1--1,,1|(602,70)|
10,131,"# dollars per TT person",402,117,47,19,8,3,0,0,0,0,0,0
1,132,131,111,1,0,0,0,0,64,0,-1--1--1,,1|(358,106)|
10,133,"# neg media reports per casualty",322,1338,64,19,8,3,0,0,0,0,0,0
1,134,133,3,1,0,0,0,0,64,0,-1--1--1,,1|(326,1273)|

10,135,"conversion to persons/month",59,355,47,19,8,3,0,0,0,0,0,0
1,136,135,116,1,0,0,0,0,64,0,-1--1--1,,1|(22,241)|
10,137,effect of TPS on CPS,694,706,53,19,8,3,0,0,0,0,0,0
1,138,137,2,1,0,0,0,0,64,0,-1--1--1,,1|(644,840)|
10,139,TPS to CPS rate,728,540,54,11,8,3,0,0,0,0,0,0
1,140,139,137,1,0,0,0,0,64,0,-1--1--1,,1|(677,609)|
1,141,54,137,1,0,0,0,0,64,0,-1--1--1,,1|(648,577)|
1,142,54,139,1,0,0,0,0,64,0,-1--1--1,,1|(724,494)|
10,143,average casualties per month,549,1391,57,19,8,3,0,0,0,0,0,0
1,144,143,1,1,0,0,0,0,64,0,-1--1--1,,1|(608,1348)|
1,145,23,24,1,0,0,0,0,64,0,-1--1--1,,1|(820,1119)|
1,146,23,41,1,0,0,0,0,64,0,-1--1--1,,1|(1033,1058)|
1,147,23,80,1,0,0,0,0,64,0,-1--1--1,,1|(751,976)|
10,148,"% initial CPS support",456,866,43,19,8,3,0,0,0,0,0,0
1,149,148,11,1,0,0,0,0,64,1,-1--1--1,,1|(420,922)|
10,150,Time,1029,1593,26,11,8,2,0,3,-1,0,0,0,255-255-255,0-0-0,|12||128-128-128
1,151,89,158,1,0,0,0,0,64,0,-1--1--1,,1|(74,686)|
1,152,5,6,0,0,0,0,0,0,0,-1--1--1,,1|(624,1206)|
1,153,1,6,1,0,0,0,0,0,0,-1--1--1,,1|(569,1221)|
1,154,55,72,1,0,0,0,0,64,0,-1--1--1,,1|(560,530)|
1,155,71,72,1,0,0,0,0,64,0,-1--1--1,,1|(566,390)|
1,156,34,69,1,0,0,0,0,64,0,-1--1--1,,1|(993,401)|
1,157,68,69,1,0,0,0,0,64,0,-1--1--1,,1|(961,239)|
10,158,Coalition financial support for military actions,698,1504,60,28,8,3,0,0,0,0,0,0
10,159,random seed for casualty paramater,644,1426,60,19,8,3,0,0,0,0,0,0
1,160,159,1,1,0,0,0,0,64,0,-1--1--1,,1|(632,1356)|
10,161,"random seed for effect of finances on non-local
actions",204,253,80,28,8,3,0,0,0,0,0,0
1,162,161,99,1,0,0,0,0,0,0,-1--1--1,,1|(229,231)|
10,163,"random seed for # mil troops",908,1332,61,19,8,3,0,0,0,0,0,0
1,164,163,85,1,0,0,0,0,64,0,-1--1--1,,1|(989,1303)|
10,165,random seed for neg media reports,406,1407,66,19,8,3,0,0,0,0,0,0
1,166,165,133,1,0,0,0,0,64,0,-1--1--1,,1|(330,1365)|
10,167,"random seed for non-local actions",451,236,54,19,8,3,0,0,-1,0,0,0
1,168,167,89,1,0,0,0,0,0,0,-1--1--1,,1|(445,248)|
1,169,28,30,1,0,0,0,0,64,0,-1--1--1,,1|(193,985)|
1,170,28,31,1,0,0,0,0,64,0,-1--1--1,,1|(123,915)|
1,171,158,15,0,0,0,0,0,64,0,-1--1--1,,1|(726,1407)|
1,172,28,29,1,0,0,0,0,64,0,-1--1--1,,1|(91,1129)|
1,173,158,29,1,0,0,0,0,64,0,-1--1--1,,1|(399,1484)|
10,174,average initial financial support for Coalition military actions per
month,188,1477,96,28,8,3,0,0,0,0,0,0
1,175,174,158,1,0,0,0,0,64,0,-1--1--1,,1|(500,1531)|
10,176,average initial financial support for Coalition reconstruction actions per
month,203,1127,96,28,8,3,0,0,0,0,0,0

1,177,176,28,1,0,0,0,0,64,0,-1--1--1,,1|(158,1084)|
10,178,"effect of non-local action on Coalition military
financing",881,1473,79,28,8,3,0,0,-1,0,0,0
10,179,"random seed for non-local action on Coalition military
financing",1038,1402,87,33,8,3,0,0,-1,0,0,0
1,180,179,178,1,0,0,0,0,0,0,-1--1--1,,1|(931,1402)|
1,181,178,158,1,0,0,0,0,64,0,-1--1--1,,1|(751,1457)|
10,182,"effect of non-local terrorist actions on CPS",167,766,77,19,8,3,0,0,0,0,0,0
10,183,"# CPS persons per non-local action",139,678,61,19,8,3,0,0,0,0,0,0
1,184,89,182,1,0,0,0,0,64,0,-1--1--1,,1|(263,475)|
1,185,183,182,1,0,0,0,0,64,0,-1--1--1,,1|(149,731)|
1,186,182,2,1,0,0,0,0,64,0,-1--1--1,,1|(350,922)|
10,187,effect of total Coalition fincancial support on CPS,447,1117,83,19,8,3,0,0,0,0,0,0
10,188,"# persons per total billions in Coalition financial
support",243,1217,72,30,8,3,0,0,0,0,0,0
1,189,188,187,1,0,0,0,0,64,0,-1--1--1,,1|(295,1174)|
1,190,29,187,1,0,0,0,0,64,0,-1--1--1,,1|(277,1263)|
1,191,187,2,1,0,0,0,0,64,0,-1--1--1,,1|(536,1008)|
1,192,1,5,1,0,0,0,0,0,0,-1--1--1,,1|(632,1309)|
10,193,effect of local actions on TT loss of support,887,693,77,19,8,3,0,0,0,0,0,0
10,194,local terrorist actions,474,426,42,19,8,3,0,0,0,0,0,0
1,195,194,193,1,0,0,0,0,64,0,-1--1--1,,1|(666,603)|
10,196,effect of TPS on local actions,595,298,53,19,8,3,0,0,-1,0,0,0
1,197,196,194,1,0,0,0,0,0,0,-1--1--1,,1|(529,354)|
1,198,193,39,1,0,0,0,0,64,0,-1--1--1,,1|(982,666)|
1,199,121,194,1,0,0,0,0,64,0,-1--1--1,,1|(532,281)|
10,200,TT persons per local terrorist action,798,772,66,19,8,3,0,0,0,0,0,0
1,201,200,193,1,0,0,0,0,64,0,-1--1--1,,1|(839,753)|
1,202,54,196,1,0,0,0,0,64,0,-1--1--1,,1|(675,353)|
1,203,194,90,1,0,0,0,0,64,0,-1--1--1,,1|(290,377)|
10,204,"initial # TTAG supporters",1087,510,46,19,8,3,0,0,0,0,0,0
1,205,204,34,0,0,0,0,0,64,1,-1--1--1,,1|(1029,543)|
10,206,"effect of non-local actions on NT loss of support",449,515,82,19,8,3,0,0,0,0,0,0
10,207,"# NT perosns per non-local action",354,446,57,19,8,3,0,0,0,0,0,0
1,208,207,206,1,0,0,0,0,64,0,-1--1--1,,1|(360,504)|
1,209,89,206,1,0,0,0,0,64,0,-1--1--1,,1|(408,405)|
1,210,206,62,1,0,0,0,0,64,0,-1--1--1,,1|(486,532)|
10,211,"# persons per neg media for Coaltion",486,1298,59,19,8,3,0,0,0,0,0,0
1,212,211,8,1,0,0,0,0,64,0,-1--1--1,,1|(447,1252)|
1,213,23,25,1,0,0,0,0,64,0,-1--1--1,,1|(940,1118)|

Appendix E: Design of Experiment Matrix

Row	% TT who donate (A)	probability threshold of non-local action occurrence (B)	persons from TPS (C)	average casualties per month (D)	Coalition financial support for reconstruction in billions per month (E)	Coalition financial support for military actions in billions (F)
1	0.2	0.94	0.00001	1050	17.8	23.75
2	0.5	0.97	0.001	1050	17.8	23.75
3	0.5	0.94	0.0001	1050	17.8	47.5
4	0.5	0.97	0.001	1700	1.25	23.75
5	0.5	0.94	0.00001	1700	1.25	5.94
6	0.8	0.94	0.001	500	17.8	47.5
7	0.8	0.94	0.0001	1050	17.8	5.94
8	0.5	0.97	0.00001	1700	2.5	5.94
9	0.2	0.9	0.001	1700	1.25	5.94
10	0.8	0.94	0.001	1700	1.25	5.94
11	0.5	0.94	0.00001	1050	2.5	23.75
12	0.2	0.97	0.0001	500	1.25	47.5
13	0.8	0.94	0.0001	500	1.25	5.94
14	0.5	0.94	0.00001	500	17.8	5.94
15	0.5	0.9	0.00001	1050	2.5	47.5
16	0.2	0.97	0.00001	1050	1.25	47.5
17	0.8	0.97	0.0001	500	2.5	5.94
18	0.5	0.9	0.001	500	17.8	47.5
19	0.5	0.94	0.001	1700	2.5	47.5
20	0.8	0.94	0.0001	1700	2.5	23.75
21	0.8	0.94	0.001	1050	1.25	23.75
22	0.8	0.97	0.0001	500	17.8	47.5
23	0.8	0.9	0.0001	1050	17.8	23.75
24	0.2	0.94	0.0001	1700	1.25	47.5
25	0.8	0.97	0.00001	1050	17.8	5.94
26	0.8	0.97	0.0001	1700	1.25	23.75

Row	% TT who donate (A)	probability threshold of non-local action occurrence (B)	persons from TPS (C)	average casualties per month (D)	Coalition financial support for reconstruction in billions per month (E)	Coalition financial support for military actions in billions (F)
27	0.2	0.94	0.001	1050	1.25	5.94
28	0.5	0.9	0.001	1700	2.5	5.94
29	0.2	0.97	0.001	1700	17.8	47.5
30	0.2	0.9	0.0001	1700	17.8	23.75
31	0.8	0.97	0.001	1050	1.25	5.94
32	0.8	0.97	0.001	1700	17.8	23.75
33	0.5	0.97	0.00001	1700	17.8	47.5
34	0.5	0.97	0.0001	1050	1.25	5.94
35	0.5	0.9	0.001	1700	2.5	23.75
36	0.2	0.94	0.001	1700	2.5	23.75
37	0.5	0.97	0.00001	500	2.5	47.5
38	0.5	0.97	0.0001	500	2.5	23.75
39	0.2	0.97	0.001	1050	2.5	5.94
40	0.8	0.94	0.00001	500	1.25	23.75
41	0.5	0.94	0.001	500	2.5	23.75
42	0.2	0.97	0.001	500	1.25	23.75
43	0.8	0.9	0.001	500	17.8	23.75
44	0.8	0.9	0.001	1700	1.25	47.5
45	0.5	0.97	0.0001	1700	2.5	47.5
46	0.8	0.97	0.00001	1050	2.5	23.75
47	0.5	0.9	0.00001	500	17.8	23.75
48	0.8	0.9	0.001	1050	2.5	23.75
49	0.2	0.94	0.001	1700	17.8	5.94
50	0.5	0.94	0.001	1050	17.8	5.94
51	0.8	0.97	0.001	1050	17.8	47.5
52	0.5	0.9	0.00001	1050	1.25	5.94
53	0.5	0.9	0.0001	1700	1.25	47.5
54	0.8	0.94	0.00001	1050	2.5	47.5
55	0.8	0.97	0.001	500	2.5	47.5
56	0.8	0.94	0.00001	1700	17.8	5.94

Row	% TT who donate (A)	probability threshold of non-local action occurrence (B)	persons from TPS (C)	average casualties per month (D)	Coalition financial support for reconstruction in billions per month (E)	Coalition financial support for military actions in billions (F)
57	0.2	0.9	0.00001	1700	2.5	47.5
58	0.5	0.97	0.001	500	17.8	5.94
59	0.5	0.97	0.00001	500	1.25	23.75
60	0.2	0.97	0.00001	1700	17.8	23.75
61	0.8	0.9	0.00001	500	2.5	5.94
62	0.2	0.94	0.00001	1700	1.25	23.75
63	0.8	0.97	0.00001	1700	1.25	47.5
64	0.2	0.94	0.0001	500	17.8	23.75
65	0.2	0.94	0.0001	1050	2.5	23.75
66	0.2	0.94	0.00001	500	2.5	47.5
67	0.2	0.9	0.001	1050	17.8	5.94
68	0.5	0.94	0.0001	1700	17.8	23.75
69	0.2	0.97	0.00001	500	17.8	47.5
70	0.2	0.97	0.00001	500	1.25	5.94
71	0.5	0.9	0.001	500	1.25	5.94
72	0.2	0.9	0.00001	500	1.25	47.5
73	0.5	0.97	0.001	1050	1.25	47.5
74	0.2	0.9	0.00001	500	2.5	23.75
75	0.2	0.9	0.00001	1050	2.5	5.94
76	0.2	0.97	0.0001	1050	17.8	5.94
77	0.2	0.94	0.0001	1700	2.5	5.94
78	0.8	0.9	0.00001	1050	17.8	47.5
79	0.5	0.9	0.0001	1050	2.5	5.94
80	0.2	0.9	0.001	1050	1.25	23.75
81	0.5	0.94	0.0001	1050	1.25	23.75
82	0.8	0.97	0.0001	1050	2.5	47.5
83	0.8	0.9	0.00001	1700	1.25	23.75
84	0.8	0.9	0.0001	1700	2.5	5.94
85	0.2	0.9	0.0001	500	17.8	5.94
86	0.2	0.97	0.0001	1700	2.5	23.75

Row	% TT who donate (A)	probability threshold of non-local action occurrence (B)	persons from TPS (C)	average casualties per month (D)	Coalition financial support for reconstruction in billions per month (E)	Coalition financial support for military actions in billions (F)
87	0.8	0.9	0.0001	1700	17.8	47.5
88	0.5	0.9	0.0001	1700	17.8	5.94
89	0.8	0.9	0.0001	1050	1.25	5.94
90	0.2	0.9	0.001	1050	2.5	47.5
91	0.8	0.94	0.001	500	2.5	5.94
92	0.5	0.94	0.001	500	1.25	47.5
93	0.8	0.9	0.0001	500	2.5	47.5
94	0.2	0.9	0.001	500	2.5	5.94
95	0.5	0.9	0.0001	500	1.25	23.75
96	0.2	0.9	0.0001	1050	1.25	47.5

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Vita

Capt Cheryl Hetherington was born in Warren, Ohio. She graduated from Maplewood High School in 1990. She then attended Youngstown State University and graduated in 1994 with a Bacheler's of Science Degree in Secondary Education with a concentration in Mathematics.

After teaching high school Mathematics for two years and working in the manufacturing industry for three years, Capt Cheryl Hetherington attended Officer Training School in Maxwell AFB, Alabama in 1999. Her first assignement was attending the Intelligence Officer Training Course. After completion, she was assigned to the Twelfth Air Force, 612th Air Intelligence Squadron. In 2003, she was selected to attend the Air Force Institute of Technology's Graduate of Operations Research program. After her completion of the program, Capt Cheryl Hetherington will be asigned to Headquarters Air Force Materiel Command, Plans and Programs Division in Dayton, OH

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14. ABSTRACT

Since the September 11th terrorist attack, there has been an increased emphasis on understanding and modeling terrorists groups. While several efforts have focused on identifying transnational terrorists' centers of gravity (COGs), most of these efforts have proposed COGs using a traditional nation-state paradigm. In today's "global village", terrorist groups are no longer limited by locality and national boundaries. With the increasing threats from transnational terrorist groups, new paradigms and models are necessary to properly analyze today's, and tomorrow's, conflict. Analysis should be based on the identified and quantified transnational terrorists' COGs and their associated interactions. Unfortunately, not all of the transnational terrorists' COGs and their interconnected cause and effect relationships are fully known or understood. This research effort suggests a single COG, Public Support as the transnational terrorists' key driver. An influence diagram-like approach was used to collect, organize, and display the COG and its key elements of value. These qualitative influence diagrams serve as a basis to develop a system dynamics model where quantitative measures were applied to the interactions. A prototype model capable of capturing and utilizing time-persistent and higher order effects that provides insight to decision makers regarding alternative strategic policies and courses of action (COA) against transnational groups has been developed and illustrated against a notional transnational terrorist group.

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