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THE EFFECTS OF MILITARY TACTICS, TECHNIQUES AND PROCEDURES ON PEACE SUPPORT ELECTION OPERATIONS IN REPRESENTATIVE IRAQI TOWNS

by

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December 2005

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The complexity of Peace Support Operations (PSO) requires that a wide variety of aspects and possible effects be considered. Unlike traditional analysis of combat operations, the analysis of PSO aims at avoiding conflict situations, where losses or injuries are to be minimized for all participants involved.

Election scenarios in a homogeneous (Sunni) and a heterogeneous (Sunni, Shiite/Kurd) populated representative Iraqi town are developed to evaluate and gain insights on the proposed military tactics, techniques and procedures for the PSO, which may affect the outcome of the election.

An agent-based modeling platform designed specifically for PSO is used to model the evolving behavior of civilian individuals and their influences on the emerging behavior of groups. An efficient experimental design, with excellent space filling and orthogonality properties, is employed to gather data from the simulation over a broad variety of scenarios. The voter participation rates, escalation among civilians, and civilian-military interactions are the primary measures of effectiveness.

The results indicate that several military measures contribute to a successful election. These include the execution of security control regions, the deployment of election booths intended to calm the crowd and encourage voter participation, and attempts to quell unrest by seeking the cooperation of civilian leaders. Factors such as soldiers' rules of engagement, civilian fear and anger personalities and their variability also play important roles in the escalation or de-escalation of civilian behavior.

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THE EFFECTS OF MILITARY TACTICS, TECHNIQUES AND PROCEDURES ON PEACE SUPPORT ELECTION OPERATIONS IN REPRESENTATIVE IRAQI TOWNS

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ABSTRACT

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EXECUTIVE SUMMARY

The purpose of this thesis is to develop an election scenario to evaluate and gain insight on the proposed military tactics, techniques and procedures which may affect the outcome of peacekeeping operations in a homogeneous (Sunni) and a heterogeneous (Sunni, Shiite/Kurd) populated Iraqi town. The proposed multiple security control regions with manned checkpoints aim to provide a secure and safe environment for both the soldiers and Iraqi voters. The proposed election booths are deployed to encourage voter participation and deter escalation of civilian's aggression. The possibilities of enlisting the cooperation and leveraging the influence of leaders of two potential hostile civilian groups are studied to identify their impacts on the election outcomes. In addition, different levels and variability in civilian fear, anger, and other emotional states are explored to determine their roles in the escalation or de-escalation processes. The voter participation rates, escalation among civilians, and civilian-military interactions are the primary measures of effectiveness.

Based on the October 15, 2005 referendum results, abstractions of the representative Iraqi towns, such as Anbar and Tamin, are built and modeled in the simulation. The basic model reflects the town and polling center layout, multiple civilian groups and its civilian personalities. Peacekeeping operations revolve around non-use of force, except in self-defense. Hence, a non-attrition agent-based simulation software called PAX, which features social psychological and Rules of Engagement (ROE) models for peace support operations, is used to conduct the simulation. An efficient experimental design, with excellent space filling and orthogonality properties, allows data to be collected for a broad variety of scenarios while keeping the required number of simulation runs to a manageable size. Graphical and statistical techniques are used to characterize the simulation outputs, allowing key factors that have significant impact on the success of peacekeeping operations to be identified.

One scenario is based on an Iraqi town with a homogeneous (Sunni) population, modeled after towns in the Anbar province where voter participation was low and violence was high during the October 2005 election. The results for this scenario show that the deployment of election booths contributes to significant improvement to the average voting participation. While there is also an increase in civilian escalation, this is considered non-alarming and controllable. Observations made from the simulation runs indicate that the election booths manage to attract the hostile civilians. While soldiers at the election booths attempt to calm and pacify the hostile civilians, opportunities are created for elective motivated civilians to proceed to the poll center and cast their votes. Increasing the elective motivation of some Sunni registered voters has a significant positive impact on the average voter participation, and also reduces civilian escalation in the election. The election operations are more successful if the readiness for aggression of the Sunni bystanders and fearful voters can be reduced. The analysis results also indicate that attempts to enlist the cooperation of civilian leaders to deescalate the situation should focus on leaders of hostile registered voters.

The second scenario is based on an Iraqi town with a heterogeneous (Sunni, Shiite/Kurd) population, modeled after towns in the Tamin province where voter participation was higher and less violence occurred during the October 2005 election. In this scenario, the deployment of Election Booths has little impact on the average voter participation. However, maximizing the elective motivation of Shiite/Kurd Voter leads to a substantive improvement in both the average voter participation and civilian escalation in the election. Minimizing the readiness for aggression of the Sunni voters and Shiite/Kurd voters is also beneficial. In this scenario, there is no sufficient statistical evidence to suggest that the military should focus on the leadership of a hostile registered voters or hostile unregistered voters.

The analysis also concludes that small variability among civilian personalities is associated with higher voter participation and lower civilian

escalation in both scenarios. Two ROE sets are identified for soldiers within the control area, and one ROE set is identified for soldiers within the poll area. By executing these ROEs, soldiers contribute to higher voter participation and lower civilian escalation in both the homogeneous and heterogeneous scenarios. These common ROEs suggest that the effort required in training the ill-equipped Iraqi forces can now be streamlined, hence reducing the length of their learning curve.

In general, the modeling and analysis approaches established in this thesis seek to develop a basis for future studies on other Iraq cities or other nations that face similar election situations. The results and insights gained may act as possible guidelines for decision makers in preparing the Iraqi forces for the upcoming elections, specifically in the area of reducing civilian escalation and improving voter participation.

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I. INTRODUCTION

A. BACKGROUND

On May 1, 2003, U.S. President George W. Bush declared the end of major combat operations terminating the Ba'ath Party's rule [Teimourian, 2003] and removing Iraqi President Saddam Hussein from office. On October 16, 2003, the U.N. Security Council authorized a multinational force [Multi-National Force, 2005a] in Iraq to take all necessary measures to contribute to the maintenance of security and stability in Iraq. Until the time when local police can be organized for securing public order, occupying armed forces may have to be deployed in this role [Human Rights Watch, 2005]. “Since then, this multinational force has engaged in a mix of lower-combat, lower-risk peacekeeping and higher-combat, higher-risk peace enforcement. This distinction is important because such a mix will see more troops killed in Iraq than would occur from keeping the peace alone.” [Burgess, 2003]. The 2,000 mark in U.S. military deaths is approaching at a time when Iraqi and U.S. officials are congratulating themselves that the October 15, 2005 constitutional referendum and the start of Saddam Hussein's trial four days later passed without major bloodshed and destruction [Hamza, 2005a]. President Bush outlined his five-point plan to return Iraq to self-rule and to rebuild its institutions in a speech to U.S. military Central Command personnel at MacDill Air Force Base in Tampa, Florida on June 16 2004. Listing the points, the president said: “We're handing over authority to a sovereign Iraqi government. We're encouraging more international support for Iraq's political transition. We're helping Iraqis take responsibility for their own security. We're continuing to rebuild Iraq's infrastructure, and we're helping Iraq move to free elections.” [CPA, 2005a].

Soon after, the transfer of sovereignty from the coalition to an interim Iraqi government occurred on June 28, 2004. Controversially, the coalition forces are currently an official occupying power. Under the United Nations command, Coalition troops can remain in control of the country indefinitely despite the transfer of sovereignty. Since Iraqi forces are currently considered ill-equipped to

police and secure the country, it is expected that coalition troops will remain in the country for many years to come [Pollack, 2004]. The “reconstruction and democratization of Iraq” has been a major stated goal of the Bush administration since declaring the “end of major combat operations” in the 2003 Iraq war [Pollack, 2004]. The first major step will be Iraqi self-governance. Hence, a successful election is desired and viewed as a positive transition milestone from military to full civil control. Most importantly, it is a prerequisite for establishing a long-standing and self-sustaining peace in Iraq. On January 30, 2005, the Iraqi people chose representatives for the newly formed 275-member Iraqi National Assembly in legislative elections. Following the ratification of the constitution of Iraq on October 15, 2005, a general election was called for December 15, 2005, to elect a permanent 275-member Iraqi National Assembly. Still, terrorists attack civilian targets and insurgents battle against coalition forces and newly formed Iraqi institutions in some pockets of the country, and so hamper the emergence of post-war stability. Although some progress is being made, crime and infrastructure problems continue to plague the country, also contributing to anti-occupation sentiments. A 2005 poll by British intelligence reported that 45% of Iraqis support attacks against coalition forces, rising to 65% in some areas, and that 82% are “strongly opposed” to the presence of foreign troops. Demands for U.S. withdrawal have also been signed on by one third of Iraq's Parliament [Rayment, 2005].

Facing this heightened aggression and civilian fear, can the coalition forces effectively train the ill-equipped Iraqi forces to uphold their own country’s law and order while not raising the fear of this war-torn society from going towards a civil war? Can the coalition forces expedite the “reconstruction and democratization of Iraq” process to cushion the anti-occupation sentiments and eliminate those intimidating insurgency threats?

B. PURPOSE

The purpose of this thesis is to develop an election scenario to evaluate and gain insight on the proposed military tactics, techniques and procedures

which may affect the outcome of peacekeeping operations in a homogeneous (Sunni) and a heterogeneous (Sunni, Shiite/Kurd) populated representative Iraqi town.

The analysis of this thesis seeks to explore factors such as soldier's rules of engagement (ROE), civilian personalities and attention of civilian leadership. These factors can potentially cause civilian behavior to escalate or weaken during an election day proceeding. We will also seek to identify other significant factors that most accurately achieve the lowest level of civilian readiness for aggression. The goal of this thesis is to gain knowledge and to contribute guidelines, specifically in the area of reducing civilian escalation and improving voter participation, in order for decision makers to conduct successful elections.

United Nations (U.N.) Secretary-General Kofi Annan said in his message to the Iraqi people on National Constitution Day (13 October 2005), "At this critical moment in Iraq's history, every vote counts. Whatever the outcome, the United Nations will continue to do all it can to help you succeed on whichever path you choose for building a stable, unified and prosperous Iraq." [UN, 2005].

C. SCOPE AND METHODOLOGY

This thesis focuses primarily on the effects of military tactics, techniques and procedures executed during an election day in a representative Iraqi town, particularly in a homogeneous (Sunni) and a heterogeneous (Sunni, Shiite/Kurd) populated town. In each of the population scenarios, a study is conducted. Areas that are examined include the presence of multiple civilian groups, the effect of providing the civilians with physical and psychological securities (particularly the execution of security control regions), media booths used to promote "elective motivation", and the importance of and attention to civilian group leadership.

Based on the October 15, 2005 constitution referendum results, an abstraction of the representative Iraqi town was built and modeled in an agent-based simulation platform. This model reflects the town's structural and polling center layout, multiple civilian groups and its civilian personalities. "Peacekeeping

revolves around non-use of force, except in self-defense" [Burgess, 2003]. Hence, PAX is used to conduct the simulation. PAX is a non-attrition agent-based simulation platform, developed for the German armed forces that features social psychological and ROE model for peace support operations [Schwarz, 2005].

To explore the performance of the simulation both broadly and efficiently, Design of Experiment (DOE) using Nearly Orthogonal Latin Hypercube (NOLH) designs are used. These designs have excellent space filling and near orthogonality properties, and reduce the required number of simulation runs to a manageable number. The simulation output data are analyzed using a JMP 5.1 statistical package [SAS, 2005] where regression trees and linear regression models are built.

D. RESEARCH QUESTIONS

This thesis aims to derive conclusions and insights that can provide guidance for decision-makers in conducting successful elections. The following questions are what this thesis seeks to answer. Given a homogeneous (Sunni) or heterogeneous (Sunni, Shiite/Kurd) population scenario and in the presence of multiple civilian group interactions:

- What and how can physical security help to provide a secure and safe environment for both the soldiers and different groups of civilian voters?
- How can the psychological security that encourages voter participation and deters escalation of civilian aggression be increased?
- What is the expected voter participation and civilian escalation?
- What military ROE should be employed at different military control regions in order to reduce aggressive actions among civilians and peacekeeping personnel?
- What are the factors that have the greatest influence on voter participation and civilian escalation?
- What type of ROE set can best achieve highest voter participation and lowest civilian escalation?

- For which civilian group that possesses high potential of escalating conflicts during the election should the military seek to enlist the cooperation of the leadership?
- Is the deployment of "Elective Motivation" promoting booths important?
- How can the variability of civilian personalities affect the election results?
- Are there any common ROE set(s) or significant factor(s) that best suit or represent both homogeneous and heterogeneous population scenarios?

E. THESIS ORGANIZATION

This document is organized into six chapters. Chapter I provides the introduction to and background for the post-war situation in Iraq, as well as the purpose of this research work. Chapter II looks at the problem in detail and attempts to highlight some of the key distinctions between homogeneous and heterogeneous populations. A hybrid model is derived for this research. Chapter III introduces PAX and describes how the hybrid model is built using this agent-based software package. Chapter IV describes the efficient experimental design used to explore the scenario and presents the results and analysis of the experiment. Chapter V summarizes of the results and provides detailed comparisons between the homogeneous and heterogeneous population scenarios. Chapter VI is devoted to conclusions and recommendations for future studies.

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II. PROBLEM DEFINITION AND ASSUMPTION

A. CHAPTER OVERVIEW

Peacekeeping operations can be multi-dimensional, especially in the efforts to coordinate political, military, and development operations at the strategic, operational, and tactical levels [Jablonsky and McCallum, 1999].

This thesis focuses primarily on the small military forces deployed at the tactical operation level during an election day. They are armed only for self-defense, deployed in a representative Iraqi town conducting peace-building efforts with the civilian voters. Among the civilian voters, there is also a fraction of hostilities.

The post-war situation in Iraq is addressed first since it highlights potential problems that can further deteriorate the already war-torn country. Some of the problems will be focused on by the proposed military tactics, techniques and procedures discussed in Chapter III.

A set of non-traditional measures of effectiveness is listed. These will be used to evaluate the success of the proposed military measures in this non-combat peacekeeping mission.

B. UNDERSTANDING IRAQ

1. Iraq Demographics

Iraq is divided into 18 governorates or provinces with a pictorial representation as shown in 0 [BBC, 2005a]. Iraq has a population of about 27 million people with two large ethnic groups, namely Arabs (75-80%) and Kurds (15-25%). The Arabs are subdivided into Shiite Arabs and Sunni Arabs. Other distinct groups are Turkomans, Assyrians, Iranians, Lurs, and Armenians (5%).

The predominant religion in Iraq is Muslim, comprising 95-97% of the population, while Christians, Yezidi and others represent the remaining 3-5%. Most (60%) Iraqi Muslims are members of the Shiites, but there is a large Sunni

Muslim population as well, made up of both Arabs and Kurds. Small communities of Christians, Jews, Bahá'ís, Mandaeans, and Yezidis also exist [CIA, 2005].

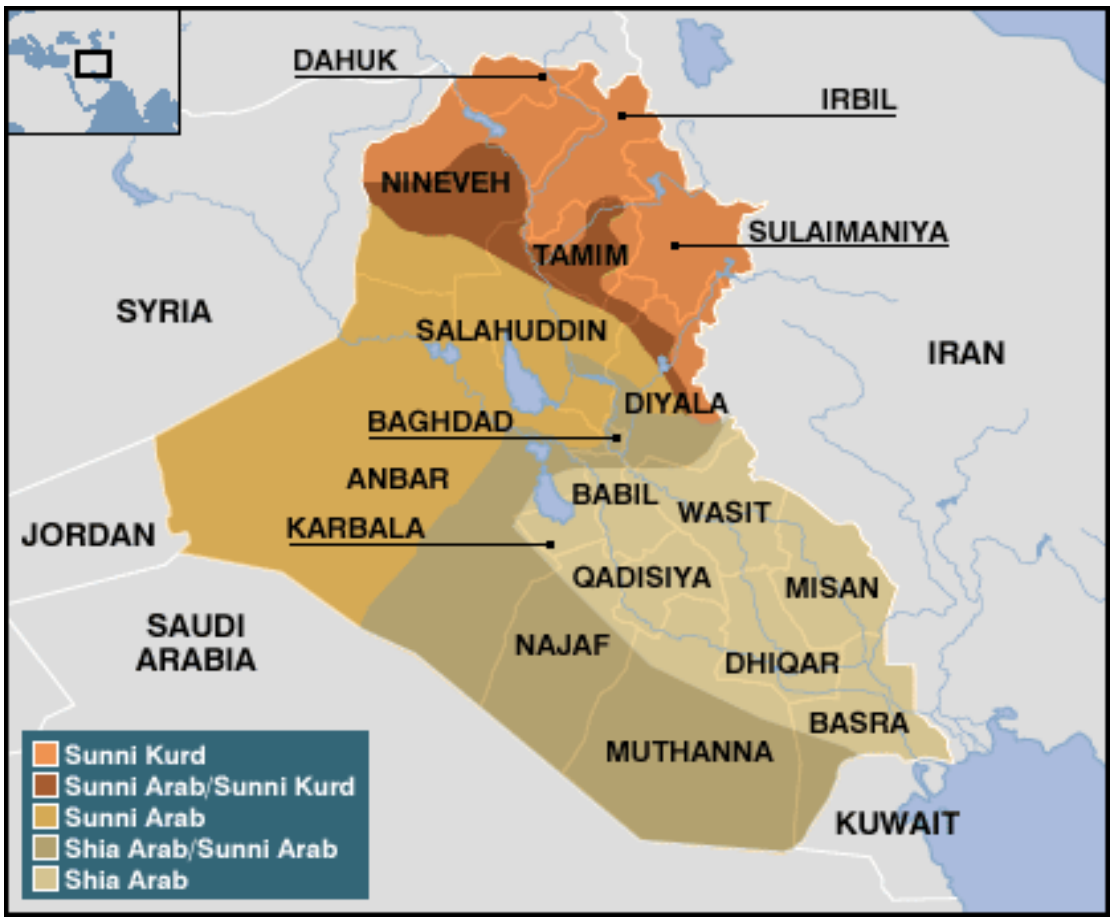


Figure 1 18 Iraq Governorates and Main Ethnic Group Locations (From: CIA, 2005)

Ethnic differences can impact lives in ways that both alienate and bring people together. As with many countries in Africa and the Middle East, Iraq's borders were not decided by the people of the region, but by outside forces. Over time, this reality has presented a challenge for a united Iraq, as each ethnic group claims a cultural connection to the tract of land that they consider to be their homeland. The differences among these groups vary from slight to severe, and competing interests threaten to complicate the formation of Iraq's post-Saddam government. Both the Shiites and the Kurds were excluded from power during the regime of Saddam Hussein, dominated by members of the Sunni Arab

minority. Both the Shiite and Sunni sects are comprised of ethnic Arabs, but their religious differences have shaped them into separate cultures. Kurds share ethnic ties with Iranians and the desire to form their own independent state. This is evident in their several failed attempts to negotiate a territorial agreement with Iraq [Crabb, 2003].

The three major ethnic groups, namely Shiite Arabs, Sunni Arabs and Kurds, are regarded to be the main influences contributing to the evolution of modern Iraq. They will be addressed in this thesis.

2. Homogeneous Population Hierarchy

From 0, it is evident that the provinces in Iraq can be represented by two main types of populations, namely homogeneous and heterogeneous. The latter will be discussed in next section.

In a homogeneous population group, it is distinctively illustrated that the three major ethnic groups (Sunni, Shiite and Kurd) each have their majority residing in different regions of the country, namely in the western, southern and northern parts of Iraq. In the western region, the Sunni majority reside in provinces like Anbar and Salahudin with capitals at Ramadi and Tikrit. In the southern region, the Shiite majority reside in provinces like Dhi Qar and Muthanna with capitals at Nasiriyah and Samawa. In the northern region, the Kurd majority reside in provinces like Arbil and Douhuk with capitals at Arbil and Douhuk.

In October 2005, the constitution referendum results reflected overwhelming support from both the Shiite and Kurd populations. Shiite Arabs, who account for about 60% of Iraq's population, overwhelmingly favored passage of the constitution. Kurds, who make up about 20% of the population, also strongly embraced the charter, which grants far-reaching autonomy to their region in northern Iraq. Sunni Arabs who came close to defeating the charter will now try to amend it after electing a new legislature in December [Anderson, Cannistra and Tobey, 2005]. These results indicated that provinces with Shiites and Kurds as the majority had no difficulty dealing with voter participation and

civilian escalation. However, some fear Shiite and Kurd victories, which came despite a large turnout by Sunni Arabs in an effort to defeat the constitutional referendum, could enrage many members of the minority and fuel their support for the insurgency.

Therefore, in a homogeneous population scenario, this thesis shall focus its research on Sunni majority population scenarios where most of the violence has taken place and extreme sides of the voter participation have occurred. A typical voter hierarchy of a homogeneous (Sunni) population is illustrated in Figure 2 Here, “majority” and “minority” refer to the sizes of the civilian groups.

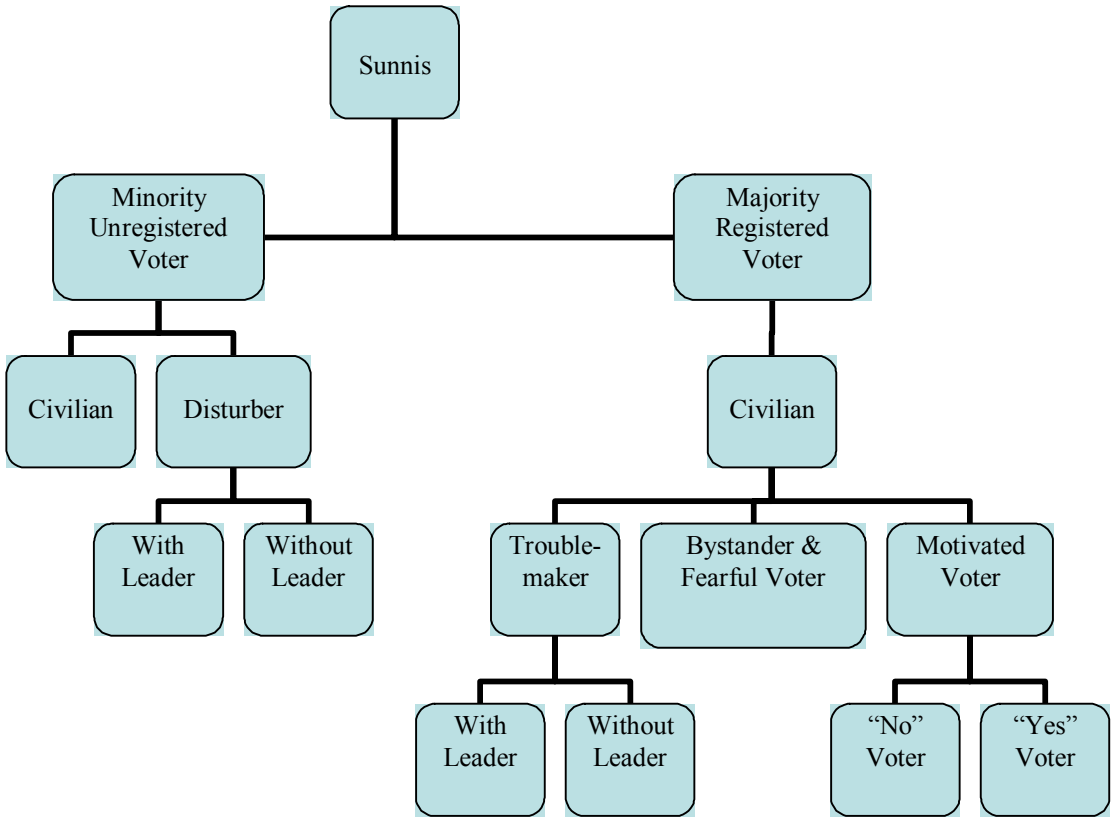


Figure 2 Voter Hierarchy in Homogeneous Population (Sunni)

In a typical election scenario, there are unregistered and registered voter groups. The unregistered voter group consists of a small portion of civilians and a fraction of hostile individuals. In this thesis, the hostile individuals are referred to as the “disturbers” whom are the insurgents. These groups of insurgents may or may not have any leadership.

In the registered voter group, there are motivated and unmotivated voters. This is where the majority of the population belongs. Among the motivated voter group, there are a mixture of “Yes” and “No” voters. The “Yes” voters supported Iraq’s new political system and the “No” voters believed the Shiite-dominated government will further deprive them of their fair share in the country's vast oil wealth [Keath, 2005a].

Among the unmotivated registered voter group, there are several types of voters. “Bystander and fearful” voters are those who stay away from the election. Some may perceive that their votes will not have any significant impact on the election result, while others may fear becoming victims of the more intimidating insurgency threats. Within this unmotivated voter group, there is also a small group who may support the Sunni-led insurgency. In this thesis, this minority group is referred to as the “trouble-maker” group. They belong to the registered voter group and are allowed to enter the polling center, but once inside they may turn hostile and instigate conflicts among the civilians and soldiers. These groups of trouble-makers may or may not have any leadership.

3. Heterogeneous Population Hierarchy

In a heterogeneous population scenario, we will see a mixture of Sunni, Shiite and Kurd populations. As shown in Figure 1, provinces like Kirkuk, Baqouba, Nineveh, Tamin, and Diyala are places where heterogeneous populations reside. Some of these mixed areas are primarily Sunni, some are primarily Kurd, some are primarily Shiite population, and some have approximately equal proportions of Shiites, Kurds and Sunnis.

In October 2005, the constitution referendum results indicated that Sunni Arabs voted in surprisingly high numbers on Iraq’s new constitution, many of them hoping to defeat it in an intense competition with Shiites and Kurds over the shape of the nation's young democracy after decades of dictatorship [Keath, 2005b]. These results also indicated that the voting turnout rate was high in the mixed areas. With this increase in voter participation, it suggests an expected increase in the civilian interactions that may contribute significant increase in the conflicts between the civilian groups who turn up at the polling center.

Therefore, in a heterogeneous population scenario, this thesis shall focus its research on scenarios with equally large Sunni and Shiite/Kurd populations where we have large numbers of Sunni and Shiite/Kurd motivated voters coming forward to cast their votes. A typical voter hierarchy of a heterogeneous Sunni and Shiite/Kurd population hierarchy is illustrated in Figure 3.

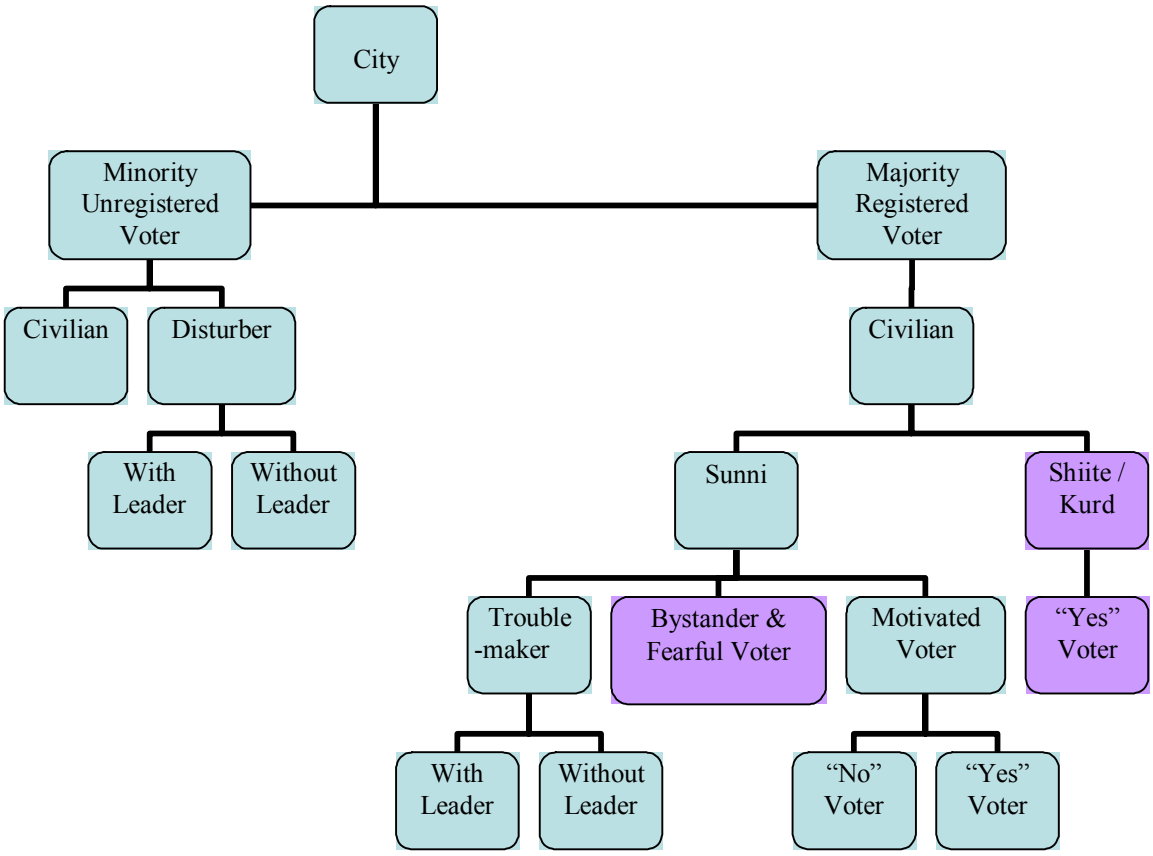


Figure 3 Voter Hierarchy in Heterogeneous Population (Sunni, Shiite/Kurd)

The hierarchy in a typical heterogeneous election population scenario is similar to the homogeneous population hierarchy except for two differences. First, in a mixed population scenario, there is an addition of the Shiite/Kurd registered voter group. As the October 2005 referendum results indicated, there was a large turnout from both Shiite and Kurd groups. This thesis will model Shiites and Kurds as one "Yes" voter group for the heterogeneous scenario. Secondly, the Sunni bystander and fearful voter group constitute the minority of the registered Sunni voter group since the results indicated large turnout by the Sunni.

4. Politics in Iraq

Iraq's economy is dominated by the oil sector, which has traditionally provided about 95% of foreign exchange earnings. Many Sunnis have said they were concerned that the charter would divide the nation on sectarian lines by permitting the formation of autonomous regions. They also said it would deprive them of oil revenue by ceding control of the oil-rich north to the Kurds and the southern oil fields to the majority Shiite Muslims, leaving Sunnis relegated to the resource-poor center [Alexander, 2005].

Many believe that the divisions of ethnic and sectarian lines in the Iraqi society have fueled a violent Sunni-led insurgency against the government and U.S. occupation forces [Anderson, Cannistra and Tobey, 2005]. These sectarian line frictions among the ethnic groups suggest that it should be solved at a national level and thus it will not be studied in this thesis.

5. Insurgents and Non-Violent Groups in Iraq

With the grim milestone of the 2,000th U.S. military death looming in Iraq, many wonder about the direction of the insurgency that killed most of them. Experts think the country's increasingly regional-oriented politics will fuel the insurgency and even spread it further inside Iraq. Others put forward a simple, disquieting scenario: So long as U.S. and other foreign troops remain in Iraq, the insurgency will continue. Maj. Gen. Rick Lynch, U.S. military spokesman in Iraq, said troops captured more than 300 foreign fighters and killed 100 members of al-Qaeda in Iraq during the past six months. Other successes include the detention of 600 insurgents two weeks before the referendum, said Maj. Gen. William G. Webster, commander of U.S. forces in Baghdad. However, “The insurgents are still there,” Lynch cautioned. “They still want to derail the democratic process. They still want to discredit the Iraqi government, so operations continue.” [Hamza, 2005a].

Polls indicate that the greatest support for the insurgency is in the al-Anbar province, a vast area extending from the Syrian border to the western outskirts of Baghdad. This is attributed to a number of reasons, including the lack of the employment opportunities of the old regime, tribal customs, suspicion of

outsiders, and the religious conservatism of the area. Coalition “counter-insurgency” operations have suffered heavy casualties in the province. In this thesis, we refer to this group of insurgents as the disturbers.

Apart from the armed insurgency, there are important non-violent groups that resist the foreign occupation through other means. The National Foundation Congress that was set up by Sheikh Jawad al-Khalisi includes a broad range of religious, ethnic, and political currents united by their opposition to the occupation. Although it does not reject armed insurgency, which it regards as any nation's right, it favors non-violent politics and criticizes the formation of militias. The General Union of Oil Employees (GUOE) opposes the occupation and calls for immediate withdrawal of the foreign troops but was neutral on participation in the election. Whereas the GUOE wants all foreign troops out immediately, both the Iraqi Federation of Trade Unions (IFTU) and the Workers Councils call for replacement of US and British forces with neutral forces from the U.N., the Arab League and other nations as a transition [Bruskin, Guillen, Mason, Muehlenkamp, Wohlforth, 2005].

In this thesis, civilians belonging to these non-violent groups that might create public disturbances during the election process are called trouble-makers.

These heightened insurgency threats and dynamics among the multiple civilian groups suggest that the presence of the insurgents and non-violent groups plays an important role in the election process and outcomes. Counter-insurgencies measures should continue to be identified and implemented. Leaders of the different groups may be able to exert considerable influences over their followers. Military measures should further exploit this leadership influence to reach another level of cooperation during elections.

Therefore, this thesis shall focus on the existence of these disturber and trouble-maker groups in the election scenario as well as the leverage of their group’s leadership.

6. Iraq Election Results

This section summarizes the recent Iraq election results and discusses the different election participation and responses that were demonstrated by the Shiite, Kurd and Sunni groups; especially their responses over the reversal decision on the election rule.

The multinational force invasion of Iraq in 2003 overthrew Saddam's administration and installed an interim government, which represented all Iraq's ethnic and religious communities. On January 30, 2005, the Iraqi people chose representatives for the newly-formed 275-member Iraqi National Assembly in legislative elections. Following the ratification of the constitution of Iraq on October 15, 2005, a general election was called for December 15, 2005 to elect a permanent 275-member Iraqi National Assembly. The following sections summarize the three elections.

a. Legislative Election – January 2005

On January 30, 2005, a historic election gave Iraq its first democratically elected government in decades. Though it marked a major morale success over the insurgency, the victory was rapidly overshadowed by relentless and aggressive post-election insurgency threats.

The provisional results released on February 13 are presented in Table 1. They show that the United Iraqi Alliance, tacitly backed by Shiite leader Grand Ayatollah Ali al-Sistani, led with 48% of the vote. The Democratic Patriotic Alliance of Kurdistan was in second place with 26% of the vote. Prime Minister Ayad Allawi's party, the Iraqi List, came in third with 14%. The most prominent party excluded was the secular, but predominantly Sunni, Independent Democrats Movement led by former exile Adnan Pachachi [IEC, 2005 and BBC, 2005b, and Wikipedia, 2005].

Summary of the January 2005 Legislative Election Results	Votes	%	Seats	Leaders
United Iraqi Alliance	4,075,292	48.19%	140	Abdul Aziz al-Hakim, Ibrahim al-Jaafari, Hussain al-Shahristani, Ahmed Chalabi
Democratic Patriotic Alliance of Kurdistan	2,175,551	25.73%	75	Jalal Talabani, Masoud Barzani
Iraqi List	1,168,943	13.82%	40	Iyad Allawi
The Iraqis	150,680	1.78%	5	Ghazi al Yawer
Iraqi Turkmen Front	93,480	1.11%	3	Farok Abdullah Abdurrahman
National Independent Cadres and Elites	69,938	0.83%	3	Fatah al Sheikh
People's Union	69,920	0.83%	2	Hamid Majid Mousa
Islamic Group of Kurdistan	60,592	0.72%	2	Ali Abd al Aziz
Islamic Action Organization In Iraq - Central Command	43,205	0.51%	2	
National Democratic Alliance	36,795	0.44%	1	
National Rafidain List	36,255	0.43%	1	Yonadem Kana
Reconciliation and Liberation Bloc	30,796	0.36%	1	Mishaan Jibouri
Iraq Assembly of National Unity	23,686	0.28%	0	Dr. Nehro Mohammed
Assembly of Independent Democrats	23,302	0.28%	0	Adnan Pachachi
Iraqi Islamic Party	21,342	0.25%	0	Mohsen Abdel Hamid
Islamic Dawa Movement	19,373	0.23%	0	Adil Abd Al Raheem
Iraqi National Gathering	18,862	0.22%	0	Hussein al-Jibouri
Iraqi Republican Assembly	15,452	0.18%	0	Sa'ad Al-Janabi
Constitutional Monarchy - Al-Sharif Ali bin Al-Hussein	13,740	0.16%	0	Sharif Ali bin Al-Hussein
Others	309,062	3.65%	0	
Total	8,456,266	100	275	
Invalid-votes	94,305			

Table 1 Legislative Election Results – January 2005

The results clearly indicated a decisive victory for the Shiite and Kurd population. Areas with mixed populations saw the vast majority of voters supported Shiite or Kurdish parties. One challenge to the legitimacy of the election was the low Arab Sunni turnout, which was as low as 2% in the province of Anbar. In another example, the largest Arab Sunni party, The Iraqis, obtained only 1.78% of the vote. Major Arab Sunni parties, such as the Iraqi Islamic Party,

the Association of Muslim Scholars, and some smaller groups such as the Worker-Communist Party of Iraq, boycotted the elections. The boycott was largely a product of the threatened violence, which centered in the Arab Sunni areas. The Arab Sunni party leaders felt that it would be impossible to hold fair elections in their areas. The major Arab Sunni groups called for elections to be postponed until the safety of voters could be guaranteed. This call for a delay was supported by some in the west, but any such scheme was strongly opposed by the Shiite parties. Resolving the issue of Sunni underrepresentation in the National Assembly, major party leaders had assured the Arab Sunnis that they would have input into drafting of the new constitution and at least one of the major government positions will go to an Arab Sunni [IEC, 2005 and BBC, 2005b and Wikipedia, 2005].

b. Constitution Referendum – October 2005

Shortly before the referendum was to take place, Iraq's Shiite-led parliament changed the electoral law so that two-thirds of the registered voters would have to reject the referendum for it to fail. This had led to many Sunni Arab leaders threatening to boycott the election. Under U.S. and U.N. pressure, Iraq's Shiite-led parliament reversed its last-minute electoral law changes. The final rule said that, for the referendum to fail, two-thirds of those casting ballots had to vote "no" instead of two-thirds of the registered voters. This reversal had gained wide support and satisfaction from many Sunni Arab leaders and they had mobilized followers to defeat the charter at the polls.

On October 15, 2005, more than 63% of eligible Iraqis came out across the country to vote on whether to accept or reject the new constitution. U.N. Commission officials released the final results on October 25, which indicated that the constitution had been approved. Overall, 79% of voters backed the charter and 21% opposed it. Of 18 governorates, two recorded "No" votes greater than two thirds – one province short of a veto. The new constitution had an overwhelming support among the Shiite and Kurd communities, as well as among a sizeable minority of the Sunni Arabs of Western Iraq.

Refer to Figure 4for the results in pictorial representation [Anderson, Cannistra and Tobey, 2005] and Table 2 for the tabulated statistics [Alexander, 2005 and IEC, 2005 and AP, 2005].

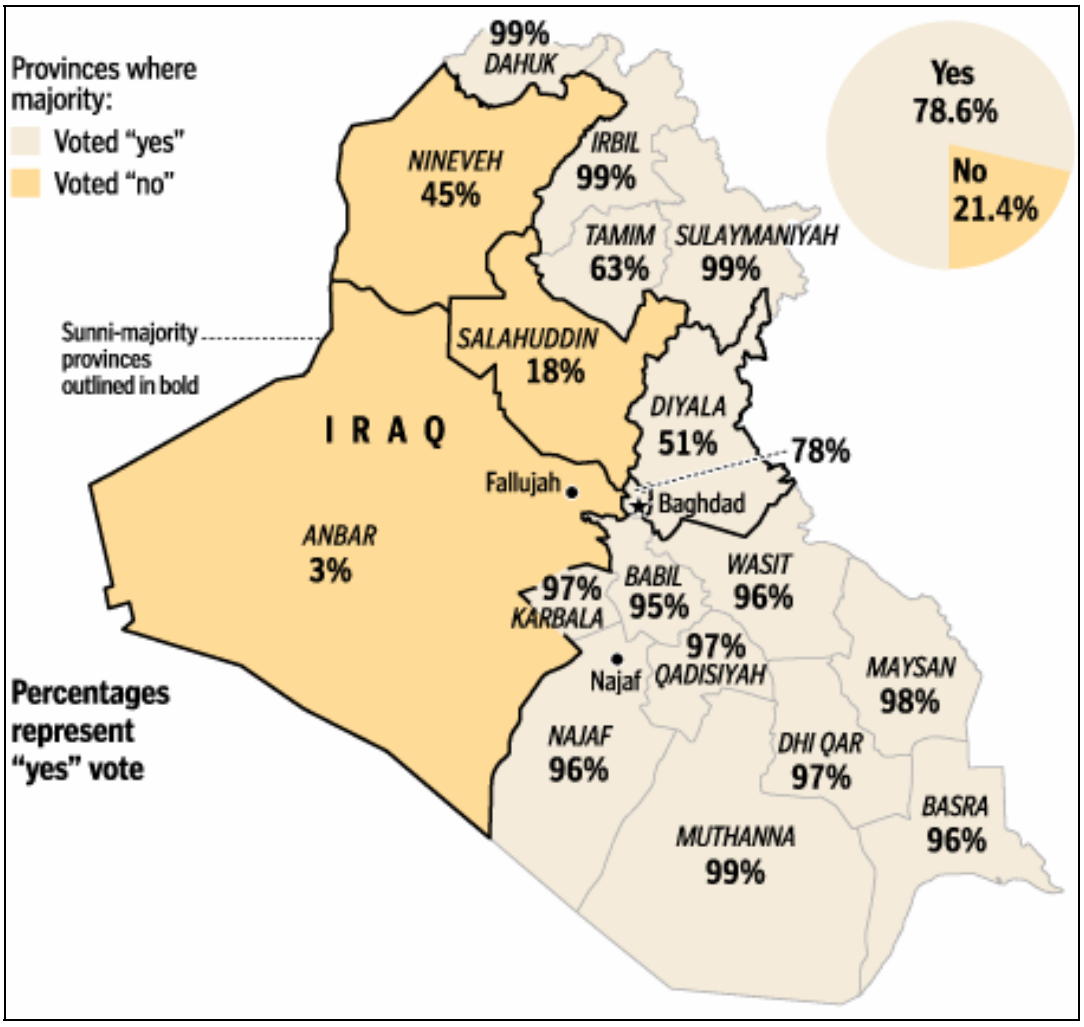


Figure 4 Constitution Referendum Results – October 2005 (From: Anderson, Cannistra and Tobey, 2005_

The results again showed overwhelming support from the Shiite and Kurd groups, with the charter favored by more than 90% of those voting in most of their provinces. There is an improvement in Sunni's voter participation when compared with the January results. Many Sunni Arabs had hoped to defeat the constitution by rallying two-thirds of the voters in three of Iraq's 18 provinces to vote against it -- a veto provision designed to protect Iraq's minorities. They came close, winning solid majorities against the constitution in three provinces

(Anbar 96%, Salahuddin 81% and Nineveh 55%), but in Nineveh they fell short of the two-thirds threshold necessary for defeat in Nineveh by 10%.

Provinces	Capital	Demographics	% Yes	% No	Votes Cast	Jan % Turnout	Oct % Turnout
Al-Anbar	Ramadi	Sunni Majority	3.04	96.96	259,919		32
Arbil	Arbil	Kurd Majority	99.13	0.64	830,570		90
Babil	Hilla	Shiite Majority	94.56	5.44	543,779	71	72
Baghdad	Baghdad	Mix	77.7	22.3	2,120,615		56
Basra	Basra	Shiite Majority	96.02	3.98	691,024	48	63
Dhi Qar	Nasiriyah	Shiite Majority	97.15	2.85	462,710	67	54
Diyala	Baqouba	Mix	51.27	48.73	476,980	34	66
Douhuk	Douhuk	Kurd Majority	99.13	0.87	389,198	89	85
Karbala	Karbala	Shiite Majority	96.58	3.42	264,674	73	58
Tamin	Kirkuk	Mix	62.91	37.09	542,688		79
Maysan	Amara	Shiite Majority	97.79	2.21	254,067	59	57
Muthanna	Samawa	Shiite Majority	98.65	1.35	185,710	61	58
Najaf	Najaf	Shiite Majority	95.82	4.18	299,420	73	56
Nineveh	Mosul	Mix	44.92	55.08	718,758		58
Qadisyah	Diwaniyah	Shiite Majority	96.74	3.26	297,176	69	56
Salahudin	Tikrit	Mix	18.25	81.75	510,152		88
Sulemaniyah	Sulemaniyah	Kurd Majority	98.96	1.04	723,723	80	75
Wasit	Kut	Shiite Majority	95.7	4.3	280,128	66	54
Total:			78.59	21.41	9,852,291		

Table 2 Constitution Referendum Results – October 2005

Under the terms of the constitution, the country will conduct fresh nationwide parliamentary elections on December 15, 2005 to elect a new permanent government.

c. General Election – December 2005

The January 2005 election treated all of Iraq as a single constituency, with representation in the Assembly proportional to the nationwide vote. In contrast, in the December 2005 elections each governorate of Iraq will be apportioned a number of Assembly seats in proportion to its population, and the makeup of each governorate's delegation to the assembly will be proportional to the votes cast in that governorate.

Despite the improved turnout by the Sunni minority who had boycotted in the January election, wide voter participation is still desired. Below is a statement from the U.N. by Special Representative of the Secretary General in Iraq (SRSG) Ashraf Qazi, on the announcement of the final results of the referendum – Baghdad, 25 October: “The results of the referendum have indicated the degree of political polarization in Iraq. This poses an ongoing challenge for all Iraqis and underscores the importance of an inclusive national dialogue. Accordingly, it is essential that all of Iraq’s communities fully participate in the December elections to ensure their full representation in the Government, the Council of Representatives and the Constitutional Review Commission which will be established for the express purpose of further broadening the national base of support for the fundamental law of the land, i.e. the Constitution.” [SRSG, 2005]

7. Iraqi Needs

To address and define the problem of an election scenario that has issues such as poor voter participation and heightened civilian escalation, this thesis seek to first identify the needs of the civilian voters involved in the election.

A series of several polls have been conducted to ascertain the position of the Iraqi public on the insurgency and the coalition occupation. According to Christian Peck of Zogby International, all of the polls seem to consistently find the following [Peck, 2005]:

- A large minority, if not a majority, of Sunni Arabs consider armed attacks on U.S. forces legitimate and justified resistance.
- The greatest support for resistance is in the al-Anbar province.

- The majority of Iraqis disapprove of the presence of coalition forces.
- A majority of both Sunnis and Shiites want an end to the occupation as soon as possible, although Sunnis are opposed to the occupation in somewhat greater margins.

These needs can also be heard from the "cries and voices" interviewed from the Iraqi public:

- "The latest death toll for yesterday's three car bomb attacks was 17 dead and 10 wounded, most of the casualties were policemen guarding the hotels and passers by as well as some worshippers who were stepping out of the nearby mosque." Kamal said [Wagner, 2005].
- "Why should I care? Nothing has changed since we have elected this government: no security, no electricity, no water," said Saad Ibrahim, a Shiite resident of Baghdad's Karrada district who passed on voting. "The constitution will not change that. The main issue is not getting this constitution passed, but how to stop terrorism." [Keath, 2005a]
- "There is no doubt that America has interfered in the process, since they and the Shiite government are supervising the whole operation, and since both want this draft to pass." al-Kubaisi said [Keath, 2005a].
- "Whatever happens or will happen in politics has nothing to do with the will of the people. It comes from the political elite who run Iraq along with the Americans out of the Green Zone in Baghdad," said Zuhair Qassam al-Khashab, a mathematics professor in Mosul who voted "no" [Keath, 2005a].

From feedback like that above, the general desires from the heart of many Iraqis seem to be a secure and safe environment without worry of terrorism. They also express the need for freedom in a political system that will maintain their own self-ruled government.

C. PROBLEM DEFINITION

Understanding the post war Iraq situation and the needs of the Iraqi, one may immediately grasp the complexity of an election support operation in this

multi-dimensional peacekeeping mission. The simulation model used in this research tries to capture some, but not all, of the following characteristics in the Iraqi election scenario.

1. Insurgency Built-up

Widespread violent insurgencies began shortly after the invasion of Iraq in 2003. These insurgencies grew rapidly and relentlessly during the period between the occupation and the establishment of a new sovereign Iraqi government. “The foreign contingent, said by U.S. officials to be mostly Arabs, is widely blamed for dozens of those devastating suicide bombings targeting Shiite Muslims and Iraqi security forces. These domestic rebels are mostly aided by foreign fighters brought into Iraq by leaders like al-Qaeda or Iraq's Jordanian-born Abu Musab al-Zarqawi to participate in a self-styled ‘holy war’” [Hamza, 2005a].

2. Uncontrollable Multiple Ethnic Groups Dynamics

With the fall of Saddam’s regime, there is an emergence of new political groups with new leaders, bringing different group dynamics onto the political table. Energized by the adoption of a new constitution, which passed over Sunni objections, key Sunni political parties said this week that they are forming a coalition to ensure they have a voice in Iraq's new parliament, to be elected in December 2005. Many of the old Sunni leaders are gone, entangled in the insurgency, or in jail. These new leaders are hoping that they can begin to reverse a political posture that was damaged in part by the January boycott [Carroll, 2005].

3. Heightened Aggression and Civilian Fear

Insurgent tactics vary widely, as do their targets. Jihadist elements of the insurgency favor the use of car bombs, kidnappings, hostage-taking, shootings and other types of attacks to target Iraqi “collaborators” and U.S. forces with little regard for civilian casualties [GlobalSecurityOrg, 2005]. These attacks have inevitably created a tremendous amount of unease and terror in the Iraqi public.

4. Low Voter Participation

A successful election is a prerequisite to establishing long-standing and self-sustaining peace. From the January and October 2005 election results, there are still provinces with poor turnout at as low as 32%, like Anbar (32%), Dhi Qar (54%) and Wasit (54%). Therefore, strategies and measures to encourage civilians to come forward and cast their votes remains a great challenge for the U.N and the interim government.

5. Heightened Anti-Occupation Sentiments

Polls conducted in June 2005 suggest anti-occupation sentiment has increased. Most alarming to U.S. policymakers is the rising support for the insurgency. As mentioned earlier, a 2005 poll by British intelligence found that 45% of Iraqis support attacks against coalition forces, rising to 65% in some areas, and that 82% are “strongly opposed” to the presence of foreign troops. Demands for U.S. withdrawal have also been signed on by one third of Iraq's Parliament [Rayment, 2005].

6. Unprepared Iraqi Forces

The public has mixed opinions about the growing efficiency and number—200,000 at present—of Iraq's security forces. “I am extremely pleased with the role 2nd Marine Division and our partners in the Iraqi security forces played in helping to provide a safe and secure environment for the citizens of al-Anbar to go to the polls,” said 2nd Marine Division Commanding General, Maj. Gen. Richard A. Huck. “Together we provided security for 139 polling sites, allowing every citizen the opportunity to vote.” [Multi-National Force, 2005b]. But some U.S. commanders say the Iraqis need 18 months to two years before they will be able to fight the insurgency unaided [Hamza, 2005a].

D. ASSUMPTIONS

The following are the assumptions for the scenarios studied in this thesis research:

- The election process will be completed within a single day.
- The scenario focuses primarily on the admission and crowd control aspects of the election organization. The pre-election tasks such as logistic support operations (i.e., setup, escort), contingency support for conflict resolutions (i.e., bombing, sniper attack), and post-election support operations will not be studied.
- There is no distinction between gender and age among the civilian voters. The individual civilian's personality and behavior will be represented by the group's average that the individual civilian belonged to. A variance factor will be used in the model to give variations to the civilian's fear, anger and RFA levels within each group.
- The October 2005 referendum result in the representative town is used as a basis for defining the population groups, sizes and civilian personalities.
- There is no differentiation of "Yes" and "No" votes. Civilians with either of these two elective motivations will be modeled as voters with high elective motivation.

E. MEASURES OF EFFECTIVENESS

Peacekeeping missions are, by nature, different from conventional combat operations. Hence, the following are the non-traditional set of measure of effectiveness (MOE) used to evaluate the success of the proposed peacekeeping measures:

1. Percentage of Votes

This measures the voter participation, in percent (i.e., the number of votes cast divided by the total number of registered voters) at the end of the election. It is a direct indication of the public voter participation. A good turnout can reflect the overall performance of the peacekeeping force that is organizing the election support operation both inside and outside the polling center.

2. Average Aggregated Civilian Escalation

This measure is the total average amount of civilian aggressiveness accumulated during the election process. It is measured as a function of the number of attacks and the number of threatening actions performed by the civilians, where attacks are weighted with higher severity than threatening actions. These attacks and threatening actions are performed by the civilians

against soldiers, volunteers and/or other civilians. The level of civilian escalation can reflect the peacekeeping force's ability to manage their tactics, techniques and procedures (like rules of engagement) in dealing with conflict resolutions.

3. Average Civilian Fear

This measure the average amount of civilian fear present at the end of the election process. A very high fear level indicates that the civilians are staying away from the election, but even moderate levels of fear may indicate long-term effects on the civilians for the future election process. This reflects the inability of the peacekeeping force to provide them with a safe and secure environment.

4. Average Civilian Anger

This measure is the average amount of civilian anger present at the end of the election process. Higher anger levels indicate that the civilians are getting more agitated and will be more inclined toward aggressive behaviors. This reflects the inability of the peacekeeping force to reduce the intensity of hostility in the election environment. Similar to the measure for average civilian fear, civilian anger at the end of the simulation will be measured to further study the possible long-term effect of this election process on the civilians.

5. Average Civilian Readiness for Aggression

This measures the likelihood a civilian will act aggressively. The level of civilian escalation increases with the level of readiness for aggression. The ability of the peacekeeping force to deal with and resolve conflicts also contributes to the level of civilian readiness for aggression. This measure reflects the short-term success of the election process.

6. Number of Performed Actions by Civilians or Soldiers

There are several hostile actions that the civilians can exhibit during an election process. They can threaten and attack either peacekeeping forces or other civilians. Therefore, the measures of the number and type of these hostile actions will indicate the expected degree of conflict and severity of the situation that the military is required to handle during the election process.

As this is a non-combat based operation where soldiers are armed for self-defense only, they can counter the civilians' hostilities by pacifying,

threatening or defending against them. Note that, soldier will only “attack” as a defensive measure in response to civilian actions, according to the specific rules of engagement. Therefore, the measures of the number and type of these engagement actions executed will indicate the expected amount of soldier’s effort required to counter them during the election process.

In the detailed analysis for civilian escalation and voter participation, these MOEs can be further categorized according to individuals, groups, and areas of concern. Additional measures, such as the proportion of civilians who vote in each group, or the proportion of civilian with leading fear and anger in each group, can also be derived for better measures of effectiveness.

III. BUILDING THE MODEL

A. CHAPTER OVERVIEW

This chapter attempts to address the problems defined in Chapter II. After a brief discussion of several military tactics, techniques and procedures that could be used to support the ongoing peacekeeping efforts in Iraq, a brief overview of an agent-based modeling platform called PAX is provided. We then describe eight separate hybrid scenarios (chosen to cover the critical areas of concern in both the homogeneous and heterogeneous population hierarchy) that are investigated in detail in subsequent chapters. Model assumptions and limitations are also discussed.

B. PROPOSED MILITARY TACTICS, TECHNIQUES AND PROCEDURES

1. Secure and Safe Environment

Enhancing security and safeguarding peace for all Iraqi citizens will enable citizens to participate fully in the election process. Achieving a secure and safe environment is the immediate priority measure proposed in this thesis. This thesis focuses primarily on enforcing physical and psychological security inside and outside the polling center in order to ease the fear of the civilians.

a. Physical Security

Two layers of a security control region, namely the polling area and control area, are proposed for implementation. Each control region has one entrance and one exit guarded by the admission control soldiers.

This implementation aims at providing physical separation between motivated voters and civilians who might either instigate conflicts or attempt to influence voter's decisions outside the polling center. The layers of controlled regions within the operation area surrounding the polling center should be identified and cordoned off from the public. There should be a limited number of entrances and exits leading in and out of these controlled regions. The admission control soldiers should be placed at each polling center's entrances and exits to inspect every voter. These different layers of controlled regions seek to channel

voter movement within the polling center and have the flexibility of withholding them at designated areas to minimize any undesired crowd dynamic. Physical barricades such as barbed wire, armed soldiers, low and high walls should be set up along the perimeter of these controlled regions. These barricades also serve to restrict and minimize unnecessary voter interactions inside these controlled regions.

The concern for physical security was demonstrated during the October 2005 referendum election. Hundreds of Iraqi police and army troops fanned out across Baghdad, setting up checkpoints and fortifying polling stations with barbed wire and blast barriers two days ahead of a historic constitutional referendum. Iraqi polices were aided by Iraqi soldiers forming a ring around polling centers, while U.S. and other coalition troops formed a wider ring, according to Lynch [Hamza, 2005b].

b. Psychological Security

The relentless and ongoing insurgency threats instilled fear among the general public before the previous elections, especially in the western part of Iraq. According to Associated Press, in the Anbar province, “streets and polling stations in towns were largely empty as residents remained hunkered in their homes, fearing insurgent violence or so embittered they refused to vote.” [Keath, 2005b]. Apparently, it created some psychological barriers in the civilians, which affected their voting participation in the election. To overcome this psychological barrier, we consider possible means of promoting voter participation and further enhancing the security in the election environment.

The setup of election booths outside the polling center aim at promoting elective motivation. These election booths should be manned by non-military agencies such as U.N. volunteers, Iraqi civilian volunteers, Iraqi police or other neutral forces. Their primary role is to encourage civilians to come forward and cast their election votes. Therefore, armed military forces defending and threatening actions are not encouraged at these booths. There are several ways to attract a civilian’s attention, such as distributing tangible incentive benefits like “goodie” bags packed with pro-election pamphlets, food, drink, etc. This measure

aims at encouraging voter participation and promoting harmonized election sentiment outside the polling center.

Different sets of ROE for the peacekeeping forces may result in different treatment of some or all of the civilians. This treatment has direct influence over the ensuing civilian behavior. Therefore, in addition to the election booth, proposed psychological security measures include specifying appropriate ROEs for peacekeeping forces stationed in different areas of the polling center. For example, a more aggressive ROE might be used outside the polling center where there are more civilian interactions. A less aggressive ROE might be more appropriate inside the polling center where there are more motivated voters. In Chapter IV, a total of six ROE sets will be analyzed.

2. Distribution of Crowd Effect

According to French sociologist Gustave Le Bon, “contagion theory says that crowds exert a hypnotic influence over their members. Shielded by the anonymity of a crowd, people abandon personal responsibility and surrender to the contagious emotions of the crowd. A crowd thus assumes a life of its own, stirring up emotions and driving people toward irrational, perhaps violent action. In another view, convergence theory holds that crowd behavior is not a product of the crowd itself, but is carried into the crowd by particular individuals. Thus, crowds amount to a convergence of like-minded individuals. In other words, while contagion theory states that crowds cause people to act in a certain way, convergence theory says the opposite that people who wish to act in a certain way come together to form crowds.” [Bon, 1895].

Therefore, the peacekeeping force must prevent such crowds from forming within the area of operation. Measures such as the deployment of mobile peacekeeping forces inside and outside the polling center should be considered. As mentioned above, controlled regions seek to segregate the voters from the crowds. In contrast, mobile forces can move around the area of operation and help to identify such crowds and disperse them before they become large and agitated enough to instigate any potential hostility.

3. Absence of Foreign Troops

As mentioned in Chapter II, several polls have shown that the majority of Iraqi citizens want all foreign troops out of their country immediately. Some prominent groups, like IFTU and the Worker's Council, call for replacement of U.S. and British forces with neutral forces from the U.N., the Arab League and other nations as a transition.

This thesis strongly recommends a review to identify what kind of roles, and where and how can the Iraqi police, Iraqi military forces, neutral volunteers and peacekeeping forces contribute effectively and efficiently for the coming election.

4. Show of Force

Ralph Turner and Lewis Killian developed the emergent-norm theory of crowd dynamics. These researchers concede that social behavior is never entirely predictable, but neither are crowds irrational. "If similar interests may draw people together, distinctive patterns of behavior may emerge in the crowd itself. Emergent-norm theory points out that people in a crowd take on different roles. Some step forward as leaders; others become lieutenants, rank-and-file followers, inactive bystanders or even opponents." [Turner and Killian, 1993].

Therefore, leadership is a key component that peacekeeping forces can attempt to leverage when dealing with crowds or insurgency groups; i.e., disturber and trouble-maker groups. In this non-combat peacekeeping environment, any military "show of force" should rely primarily on their pressures and cooperative relationship with these leaders. Subsequently, the leaders will have dominating influences on their followers. For example, the hostile group leaders might cooperate with the military by urging their followers to stop any hostile actions. This can significantly reduce the fear among other civilians. In another example, leaders from those civilian groups that boycotted the last election might cooperate with the military by encouraging their followers to participate in the election and stay away from the conflict. This could significantly improve the voting participation turnout. This thesis proposes to look at the impact of the leadership influences on the disturber and trouble-maker groups.

Emergence of the group dynamics also depends primarily on individual, civilian personalities. Some civilians are less likely to join in hostile behavior groups; others may not obey their leadership instructions. Therefore, military measures should also consider the variability of the civilian personalities. The variability of the civilian personality in both the homogeneous and heterogeneous population case will be varied and analyzed.

C. MODELING PLATFORM

1. Agent-Based Peace Support Operation Model

Peace support operations focus on providing assistance and de-escalating problematic situations, as in an election support operation. Therefore, they cannot be modeled adequately with existing combat models that focus on MOEs such as force exchange ratios and number of enemy combatants killed.

“An agent-based modeling approach is appropriate, as it is possible to represent the actual situations that are closer to realistic situations. An important essence of the term "agent based" in the context of modeling is that real entities are correspondingly modeled as entities in the simulation model i.e., aggregated or individual. Agent based models are capable of modeling the non-linear effects caused by the behavior of individuals and their influences on the emerging behavior of groups. Therefore, we are able to trace, understand and assess what is happening in the model and compare those results with a comparable real situation.” [Schwarz, 2005].

2. Project Albert and Data Farming

The Marine Corps Warfighting Laboratory's Project Albert is the research and development effort whose goal is to develop the process and capabilities of Data Farming. This method addresses questions by applying high performance computing to run relatively simple models many times, allowing decision makers to examine and better understand the landscape of potential simulated outcomes, enhance their intuition, find surprises and outliers, and identify potential options.

Data Farming is the method by which potentially millions of data points are created and captured. It could be considered akin to Data Mining combined with feedback, which allows for an intelligent collection of data points.

The Project Albert modeling approach is achieved through the development of a suite of agent-based simulation platforms that facilitate the development of relatively simple models (sometimes called distillations). Project Albert drives home the point that these models are produced as an intentional complement to the very highly-detailed, physics-based simulations being used and developed within the DoD. Due to the fact that they are so highly-detailed, and changing characteristics within a particular scenario can be very cumbersome, they do not permit the examination of a very wide range of possibilities and outcomes. In contrast, distillation models are easier to run and understand. They have also proven to be effective tools that help capture and scientifically reproduce the ideas of Subject Matter Experts, such as those thinking about tomorrow's concepts, doctrine, and requirements. The Project Albert suite of models includes Map-Aware Non-Uniform Automata (MANA), Socrates, Pythagoras and PAX. This suite of entity-based models has inherent strengths and unique capabilities with regard to each aspect of modeling how entities think, decide, shoot, move, and communicate [Project Albert, 2005].

3. PAX

The agent-based model chosen for this thesis is PAX, because of its focus on peace support operations. PAX was developed by EADS Dornier for the German armed forces, initiated and funded by the Bundeswehr TRADOC and assisted by the Operations Research Division of the Bundeswehr Center for Analyses and Studies.

PAX concentrates on the modeling of peacekeeping aspects. The main effort lies on modeling civilians. PAX enables the user to investigate the effects of different actions of the military under certain conditions on the civilian side. PAX is able to show dependencies of the soldiers' behavior on the escalation and/or de-escalation of the situation. It is not combat or attrition orientated. Therefore, it

is more suitable for the analysis of peace support operations like humanitarian assistance operations or operations in the context of nation building processes.

In the application of the model PAX, we will not look only at the results of single runs of the simulation. The results of thousands of simulation runs may be statistically analyzed, or visualized in fitness landscapes that reveal the success of specific strategies and the effects of abilities in a certain context represented by parameters that cover important aspects of the situation [Schwarz, 2005].

a. Civilian Behavior Model

PAX was developed with collective inputs from experts in social psychology, systems theory, operations research and military advisors, proficient in peace support operations. Figure 5(adapted from Schwarz and Erlenbruch, 2003) illustrates a simplified logic flow of its civilian behavior model. This shows how the leading psychological drivers (such as a civilian's anger, need and fear) may be influenced by external factors from the environment (such as soldiers' actions and behaviors of other civilians).

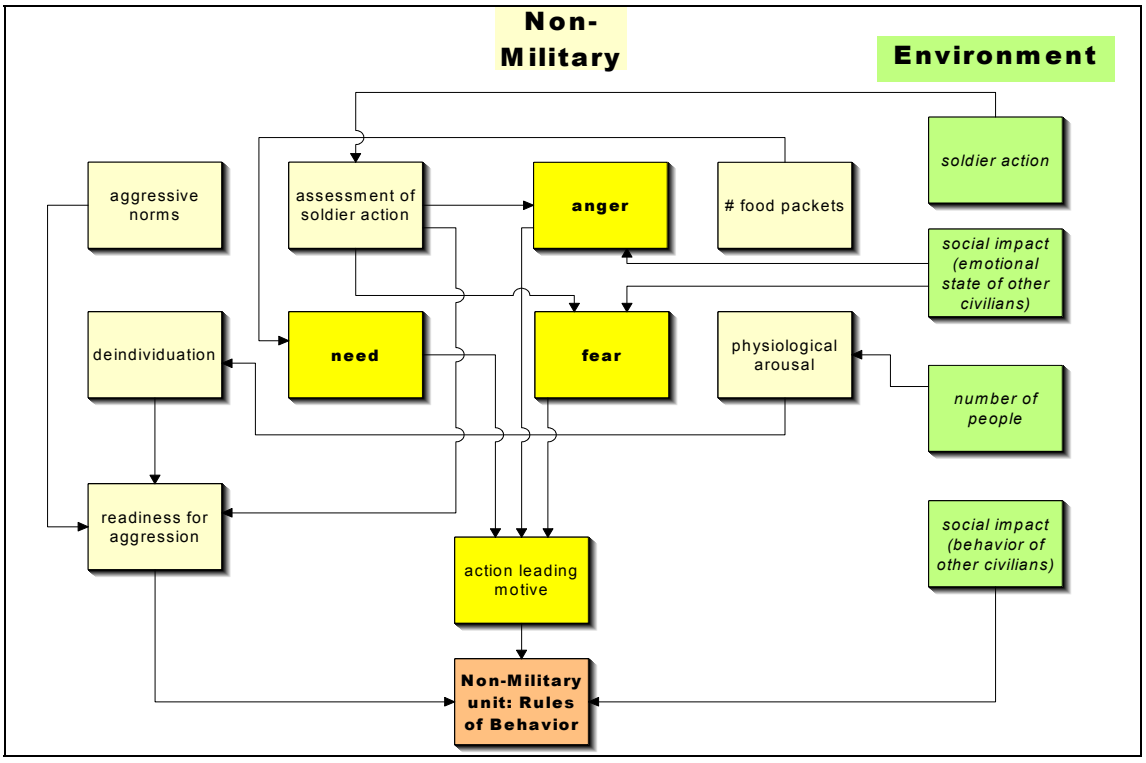


Figure 5 PAX Civilian Behavior Model (Simplified) (After: Schwarz and Erlenbruch, 2003

In PAX, the civilian group may have leaders. These leaders may influence their group members by their presence or via communications. The reaction of the group members or the condition of the civilian varies depending on how they evaluate the communication contents.

The civilians' motivations include anger, need, and fear (shown in Figure 5), along with election motivation and willingness for cooperation with the leader. Other parameters currently available in PAX include readiness for aggression, group cohesion, norms for anti-aggression, and the civilian's status (leader or normal), as well as the personality variance for fear, anger and aggression. Finally, the civilian's physical and motivational strength is represented by the pushing-strength parameter. In some situations, civilian's personalities are so low that they can hardly move, causing obstruction to other civilians from accessing the polling station. In such cases, civilians with higher pushing-strength values may push through and change positions with civilians having lower pushing-strength values.

b. Rules of Engagement – Rule Sets

PAX also has military agents, although the military side of the model is not as detailed as the civilian model in regards to the human side of their behavior. Soldiers are modeled in an aggregated way. They represent small groups of real soldier (e.g., infantry) entities who behave ideally according to certain rules. In this thesis, the term soldier will represent a small group of U.S. or U.N. infantry or Iraqi police forces.

There are no psychological aspects represented in the soldier agent's behavior in PAX at the present time. This enables the analyst to clearly look at consequences of certain tactics without having to deal with "weaknesses" of the human side of the military protagonists. Soldiers are able to communicate with the civilians, especially with the leaders. The communication between the military and civilians may be looked at as a certain way of giving commands. For example, soldiers may tell civilian leaders to leave a critical area together with their group [Schwarz, 2005].

The methods and behaviors that govern the soldiers' communication and commanding processes with the civilians are defined by a specified set of engagement rules. In PAX, there are currently six sets of engagement rules that are governed by the logic shown in Table 3.

There are two possible behaviors which an individual civilian can use when interacting with a soldier, namely "attack" and "threaten." A civilian may choose not to interact with a soldier, but positive interactions are not explicitly modeled. There are three possible behaviors that the dominating civilian group can exhibit, namely "attack," "threaten," or "not aggressive." The behavioral combinations of the individual civilian interacting with a soldier and dominating civilian group in the area generate six sets of situations that can occur during the simulation run. For example, Situation A arises when the civilian's behavior is "attack" and its dominating group's behavior is also "attack." In response to these six situations, there are six rule sets available for the soldiers to execute, namely 1 (PSO Manual), 2, 3, 4 (Gandhi), 5 and 6 (Zero Tolerance).

Civilian/Dominating Group's Behavior		**Situations**					
		A	**B**	**C**	**D**	**E**	**F**
1	Individual Civilian's Action: Attack	Y	Y	Y			N
2	Individual Civilian's Action: Threaten				Y	Y	N
3	Dominating Group's Action: Attack	Y					
4	Dominating Group's Action: Threaten		Y				
5	Dominating Group's Action: Not Aggressive			Y	N	Y	
Rule Set #		**ROE**					
1: "PSO Manual"		D	T	P	T	P	W
2		D	T	W	T	W	W
3		T	T	P	T	P	W
4: "Gandhi"		P	P	P	P	P	W
5		T	T	T	T	T	W
6: "Zero Tolerance"		D	D	D	D	D	W
Legend: D – Defend, T – Threaten, P – Pacify, W – Wait							

Table 3 Rule of Engagement Rule Sets

Rule sets that are referred to by names reflect the key principles governing the rules. For example, Rule set 1 is also referred to as “PSO Manual” where the soldiers engage the civilians with a wider range of actions for each appropriate situation much to the “teaching” of the Peace Support Operations Manual used by the German Military, for example in Kosovo, in an abstract way [Lampe, 2005]. Rule set 4 is commonly known as “Gandhi” strategy, as it employs the “always pacify” action at all times. Rule set 6 is referred to as “Zero Tolerance” as the soldiers always defend regardless of civilian’s actions or dominating group behavior. Note that once a rule set is assigned to a soldier, the soldier will follow this rule set during the entire simulation run.

An illustrative example of how a soldier’s behavior is governed by the rule set in any given situation follows. If a soldier is assigned Rule set 1 (PSO Manual), given Situation B, where the civilian’s behavior is “attack” and the dominating civilian group’s behavior is “threaten,” the soldier will execute a threatening action towards the civilian. Under the same Rule set 1, given a Situation C, where the civilian’s behavior is “attack” and the dominating civilian group’s behavior is “not aggressive,” the soldier will execute pacifying action towards the civilian.

D. BUILDING THE SCENARIOS

Based on the October 2005 referendum results as shown in Table 2, provinces with critical concerns such as low voter participation and high civilian escalation are identified for both the homogeneous and heterogeneous population scenarios.

Addressing the concerns, eight hybrid scenarios are derived for both the population types where the effects of military tactics, techniques and procedures, particularly the execution of security control regions, election booths and civilian group leadership influences are modeled.

1. A Representative Iraqi Election Town

A representative Iraqi election town is modeled in PAX for both the homogeneous and heterogeneous population types to aid the analysis on the proposed military measures.

a. General Layout

The general layout of a representative Iraqi election town used in this thesis is illustrated in Figure 6. Another representation of the Iraqi election town, taken from the PAX Scenario Editor graphical interface, appears in Figure 7.

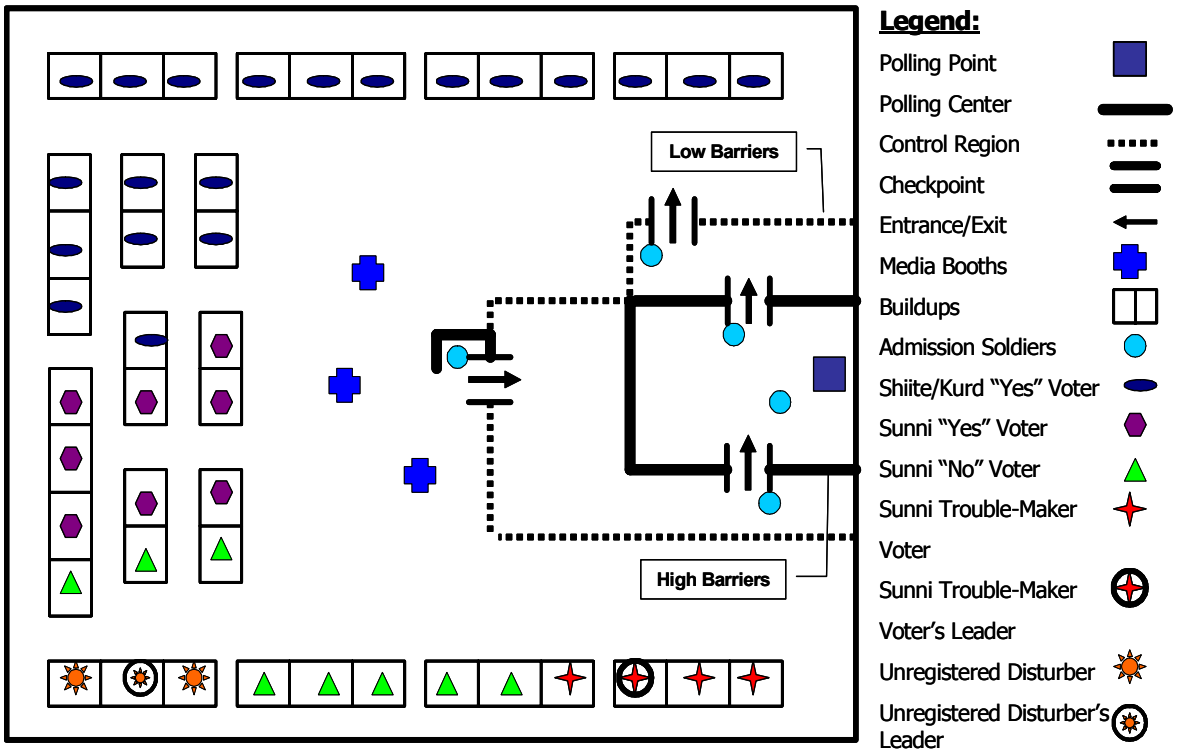


Figure 6 A Representative Iraqi Election Town

The structural layout in the Iraqi election town and polling center is similar for both the homogeneous and heterogeneous population case. The differences are the type and distribution of the civilians living in the Iraqi election town. For example, in the heterogeneous population scenario, the town consists of both Shiite and Sunni civilians, who tend to have similar characteristics and

stay close to others within their own group. In the homogeneous population scenario, the town consists of Sunni civilians and their distribution is more random.

In PAX, all the motivated civilian voters know where the polling point is and will move towards it. Civilians that are fearful will find built-up areas and hide in them to shield themselves away from the hostile civilians. Hostile civilians will move around the town and instigate conflicts by threatening or attacking other civilians and soldiers. There are two types of soldiers, namely *admission control* and *reserves*, that are each given a specific rule set for carrying out their engagement processes. The admission control soldiers can only engage the civilians at their assigned checkpoints. The reserves are allowed to move within certain proximity from their assigned posts to engage the civilians.

For a comprehensive guide to PAX, refer to the PAX Users' Manual [Schwarz, 2005] or the thesis titled Evaluating Sunni Participation in an Election in a Representative Iraqi Town [Gun, 2005].

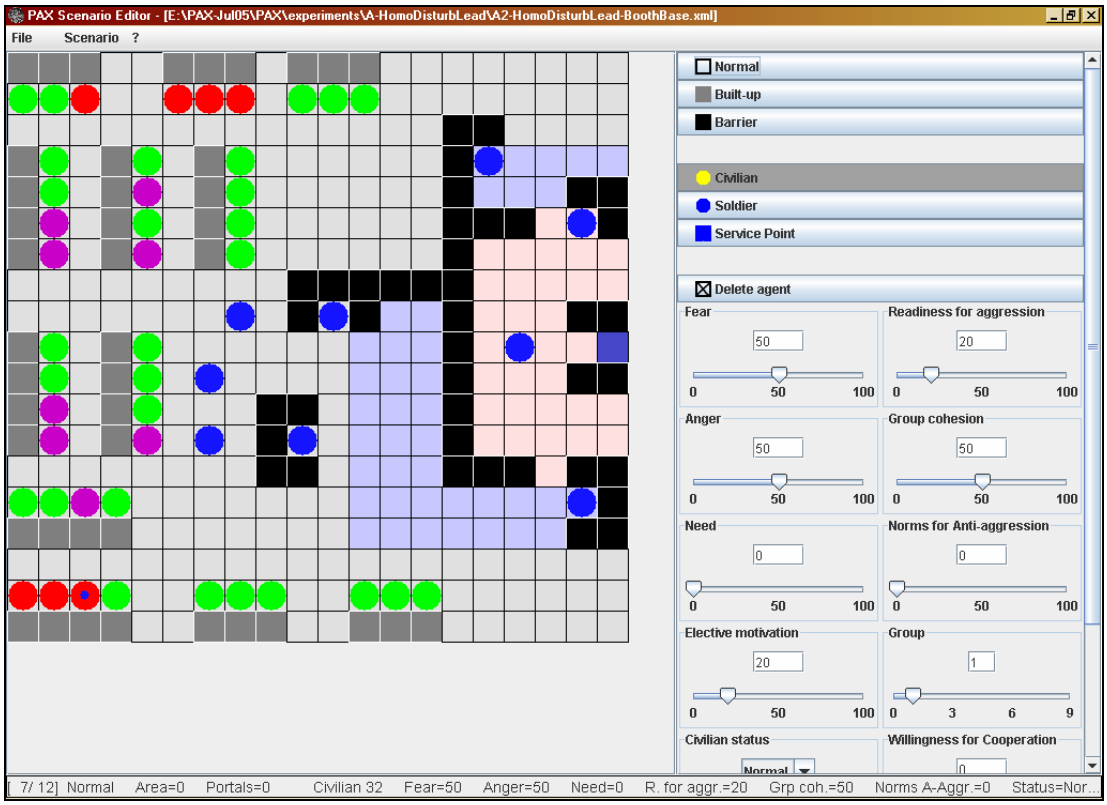


Figure 7 A Representative Iraqi Town (PAX Snapshot)

b. Security Control Regions

Two security control regions are implemented, namely the polling and control area as shown in Figure 6and Figure 7. They aim at providing physical and psychological security for the civilians and soldiers.

The polling area forms the inner ring protecting the polling point. It is modeled with a high security measure where it is fortified with high barriers such as a high wall and buildings. In PAX, no interaction is allowed across the high barrier. The control area forms the outer ring protecting the polling area. It is modeled with a lower barrier (representing a low wall, barbed wire, etc.) surrounding its perimeter. In PAX, human interaction is allowed across the low barriers, but movement is prohibited.

There is only one entrance and exit in each of the polling and control areas. Registered voters' movements inside the polling center are controlled and channeled based on these entrances and exits. At each entrance and exit, a checkpoint is set up where admission control soldiers are deployed to inspect all voters going in and out of the polling center. Note that only registered voters are allowed to enter the polling center via the checkpoints. In addition, the admission control soldiers only allow "not aggressive" registered voters to enter the polling center. Aggressive registered voters are civilians who have several previous records (a threshold value defined in PAX) of threatening and attacking behaviors.

c. Election Booths

To encourage voter participation, election booths are placed in the Iraqi town (outside the control regions) where neutral forces (i.e., U.N. volunteers, Iraqi volunteers, and Iraqi police) are deployed to motivate and promote elective motivation and harmonize sentiment in the Iraqi town. There are different ways this could be accomplished such as distribution of pro-election pamphlets, food and drinks to satisfy civilians' needs, but the model just focuses on the interactions between the civilians and neutral forces deployed at the booths. Three booths are modeled and are positioned in a "fan-out" pattern to cover the civilian movement approaching from the three different directions as

shown in Figure 6and Figure 7. In PAX, there are no neutral forces such as Iraqi volunteers; therefore, peacekeeping soldiers are deployed at these election booths. In order to exhibit and always pacify the less defensive ROE, these peacekeeping soldiers are assigned with ROE rule set 4 “Gandhi”. Note that the ROE assigned to a group of peacekeeping soldiers remains constant during the simulation run.

2. Homogeneous – Hybrid Scenarios

Two of the most critical concerns for the December 2005 election are voter participation and civilian escalation. From the October 2005 election outcomes, homogeneous populated provinces like Anbar (majority Sunni), Wasit (majority Shiite) and Dhi Qar (majority Shiite) had the lowest voting turnout rates, ranging from only 30% to 50%.

The Anbar province, with its capital at Ramadi, had the lowest voting turnout rate of about 30% and was reported having the most violence during the election period. Hence, this thesis will use the election results in Anbar as the basis for modeling the homogeneous (Sunni) population scenario. With only about a 30% turnout rate, the results in Anbar indicate that the motivated “Yes” and “No” voter group is the minority, while bystanders and fearful voters form the majority. This voter hierarchy of homogeneous (Sunni) population in Anbar is illustrated in Figure 8, while the rest of the civilian group hierarchies remain status quo as discussed in Chapter II.

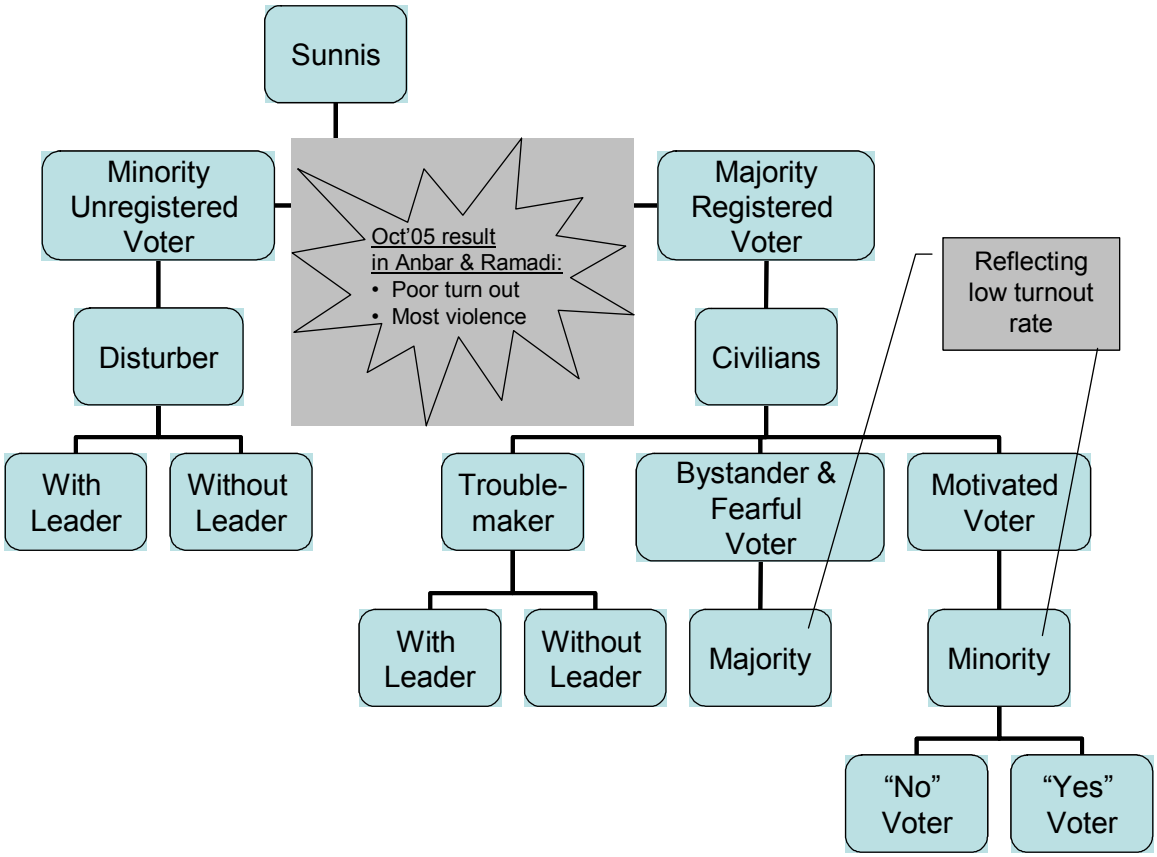


Figure 8 Voter Hierarchy in Homogeneous (Sunni) Population Hybrid Scenario

a. Scenarios

Given the voter hierarchy in Figure 8, two of the four possible homogeneous population scenarios, as shown in Table 4 are identified. These focus attention on the effect of influence by the peacekeeping force on civilian leaders in two different groups: the disturber and the trouble-maker group. In each of the scenarios, the effect of security control regions and election booths are also included, as are different rule sets for the various peace support units.

Scenario	Groups								
	Unregistered Disturber		Registered Voter (Trouble-Maker)				Bystander Fearful	Registered Voter (Motivated Voter)	
	Minority		Minority		Majority		Majority	Minority	Majority
	With Leader	Without Leader	With Leader	Without Leader	With Leader	Without Leader	-	-	-
1	☑					☑	☑	☑	
2		☑			☑		☑	☑	
3	☑			☑			☑		☑
4		☑	☑				☑		☑

Table 4 Homogeneous (Sunni) Population Hybrid Scenario

A total of four hybrid scenarios are generated for the homogeneous (Sunni) populations. For the purpose of easy identification and reference in this thesis, these four scenarios are coded with the name listed as follows:

- Homo+DisturberLead+CtrlRegion: This scenario models the effect of disturber group leadership and security control regions in a homogeneous Sunni population scenario.
- Homo+DisturberLead+CtrlRegion+Booth: This scenario models the effect of disturber group leadership, security control regions and election booths in a homogeneous Sunni population scenario.
- Homo+TroubleMakerLead+CtrlRegion: This scenario models the effect of trouble-maker group leadership and security control regions in a homogeneous Sunni population scenario.
- Homo+TroubleMakerLead+CtrlRegion+Booth: This scenario models the effect of trouble-maker group leadership, security control regions and election booths in a homogeneous Sunni population scenario.

b. Layout and Demographic

The general layout of a representative Iraqi election town for the proposed homogeneous (Sunni) population is shown in Figure 9. Figure 10 shows the scenario from the PAX Scenario Editor graphical interface.

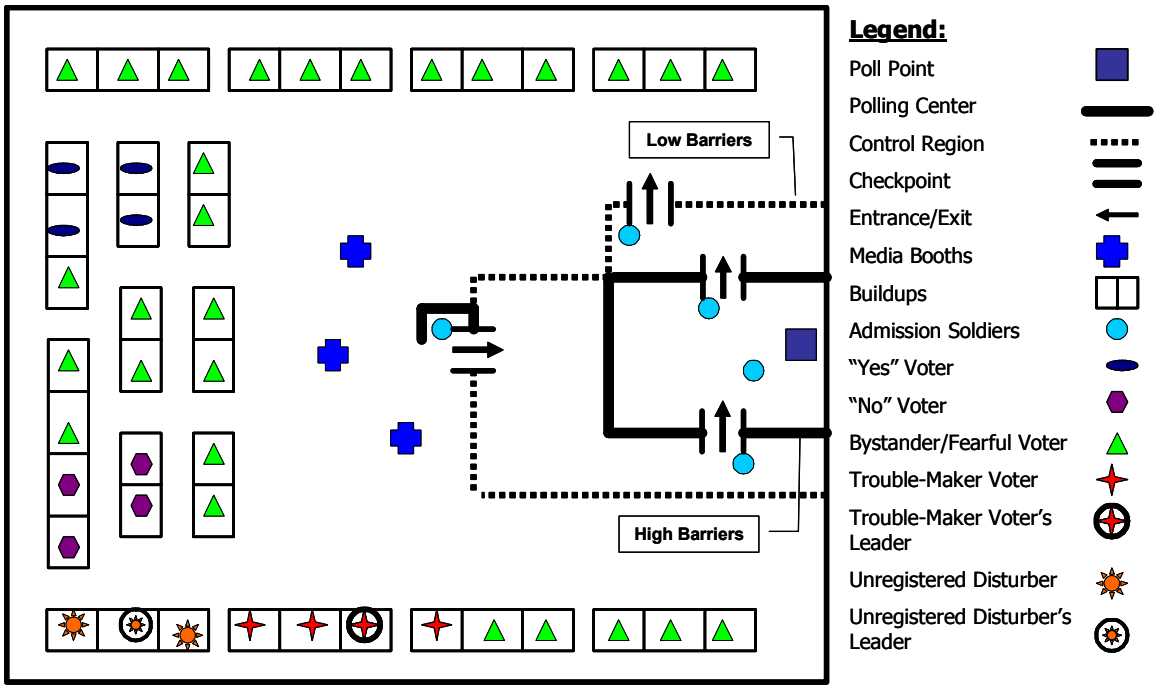


Figure 9 Homogeneous (Sunni) Population Scenario Layout

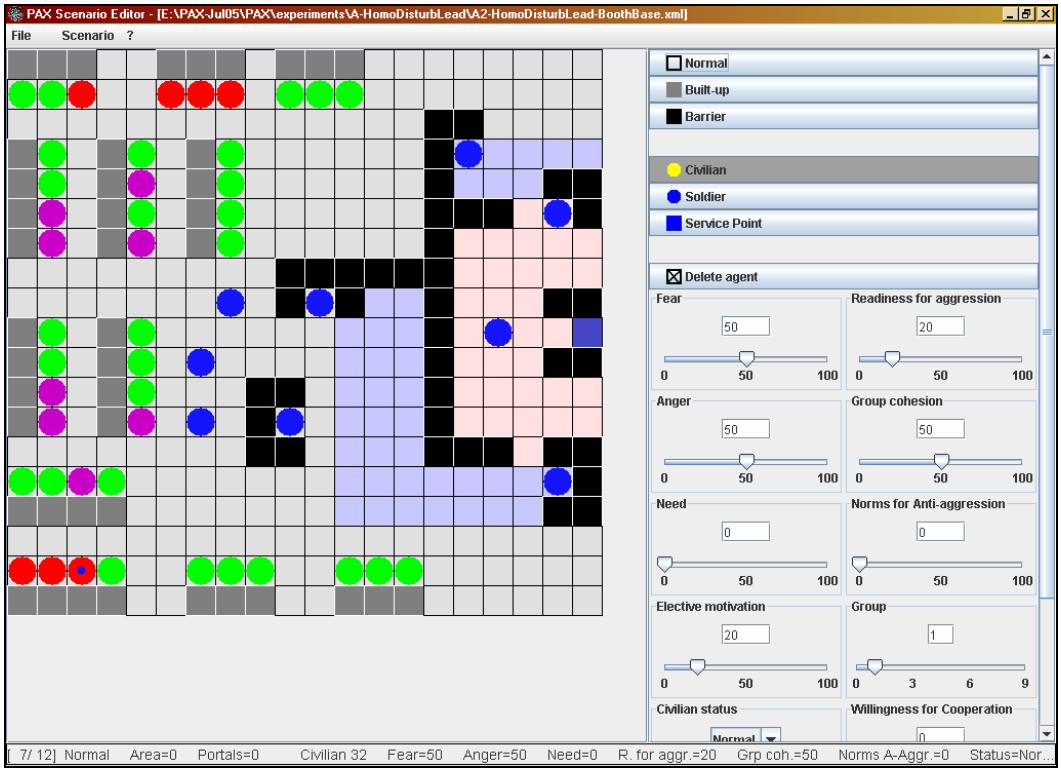


Figure 10 Homogeneous (Sunni) Population Scenario Layout in PAX

Adopting a conservative worst-case approach, this thesis assumes a lower turnout rate of only 20% where 10% of its registered voter populations are motivated “Yes” voters, 10% are motivated “No” voters, 70% are bystanders and fearful voters, and the remaining 10% are trouble-maker voters.

Using a scaled down population size of 40 registered voters, the following shows the population group breakdown in this homogeneous Sunni population hybrid scenario:

- 28 bystanders and fearful registered Sunni voters,
- 4 motivated “Yes” registered Sunni voters,
- 4 motivated “No” registered Sunni voters,
- 4 trouble-maker registered Sunni voters, and
- 3 unregistered disturbers.

Note that the three disturbers are not part of the 40 registered voter population and they are not allowed to enter the polling center. This thesis assumes there are fewer disturbers than trouble-makers.

c. Civilian Personalities

In this homogeneous (Sunni) population hybrid scenario, there are five groups of civilians. Each group is modeled with different behaviors distinctively differentiated by its individual personality parameter as follows:

- Initial Fear,
- Initial Anger,
- Initial Readiness for Aggression (RFA),
- Elective Motivation, and
- Willingness to Cooperate.

Fear, anger and RFA parameters are civilian personality characteristics that change during the simulation run. Their initial values represent the civilian’s emotional and psychological state prior to the election process. Willingness for cooperation is a parameter that remains constant during the simulation run, and its value reflects the civilian’s obedience towards their leaders and soldier commands. Elective motivation remains constant during the simulation run until the civilian votes, in which case it drops to zero. The fear

level also automatically increases after a civilian has cast his or her vote. This is a modeling trick to force the civilian to find a building and stay in it, so that civilians will not mingle around the polling center and cause disturbances or other interactions that may affect the accuracy of this simulation analysis.

Three qualitative levels (low, average and high) are used to differentiate the personalities of the five civilian groups, as shown in Table 5. As will be discussed in Chapter IV, these qualitative levels are converted to numerical values (ranging from 0 to 100) for running the PAX model.

Personality Factor	Unregistered Disturber	Registered Voter (Trouble-maker)	Bystander & Fearful Voter	Motivated "No" Voter	Motivated "Yes" Voter
Initial Fear	Low	Low	Average	Low	Low
Initial Anger	High	Average	Average	Low	Low
Initial Readiness For Aggression	High	High	Low	Low	Low
Elective Motivation	Low	Low	Low	High	High
Willingness for Cooperation	Low	Average	NA	NA	NA

Table 5 Homogeneous (Sunni) Population Civilian's Personality

The settings in Table 5 were determined in consultation with Professor Abbas, a subject matter expert from the National Security Affairs Department in the School of International Graduate Studies at the Naval Postgraduate School.

Base on the low turnout rate for the October 2005 election, and the most violent outcome in Anbar, it seems clear that disturber and trouble-maker groups both had low initial fear, high RFA and low elective motivation. Disturbers had high initial anger, though we assume that fewer hard-core insurgents were among the trouble-maker group, so this level is average.

In contrast, the motivated “Yes” and “No” registered voters had high elective motivation and their initial fear, initial anger and initial RFA for participating in the election were generally low. Intuitively, the bystander and fearful voters had low elective motivation, low initial RFA, and their initial fear and initial anger were average: some may support the insurgents, while others might be fearful of becoming victims of more insurgency threats.

Since the effect of leadership influence in motivated voters, bystanders and fearful voter groups are not studied in this thesis, their willingness for cooperation values are not assigned. The willingness for cooperation of the disturber group is low, given that there are more hardcore insurgents. The willingness for cooperation of the trouble-maker group, where the majorities are non-violent civilians, is assumed to be average.

3. Heterogeneous – Hybrid Scenarios

From the October 2005 election outcomes, heterogeneous populated provinces like Diyala, Tamin and Salahudin had the highest voting turnout rates, ranging from 70% to 90%. While this high level of voter participation is desirable, high civilian conflict and escalation become a critical concern, especially in the mixed areas.

The Tamin province, with its capital at Kirkuk, had one of the highest voting turnout rates of about 80%. Hence, this thesis will use the results in Tamin to model the heterogeneous (Sunni, Shiite/Kurd) population scenario. With about 80% turnout, the result in Tamin indicated that the majority of its population was motivated “Yes” and “No” registered voter group, and that trouble-maker, bystander, and fearful voter groups were in the minority.

This voter hierarchy of heterogeneous (Sunni, Shiite/Kurd) population in Tamin is illustrated in Figure 11, while the rest of the civilian group hierarchies remain status quo as discussed in Chapter II.

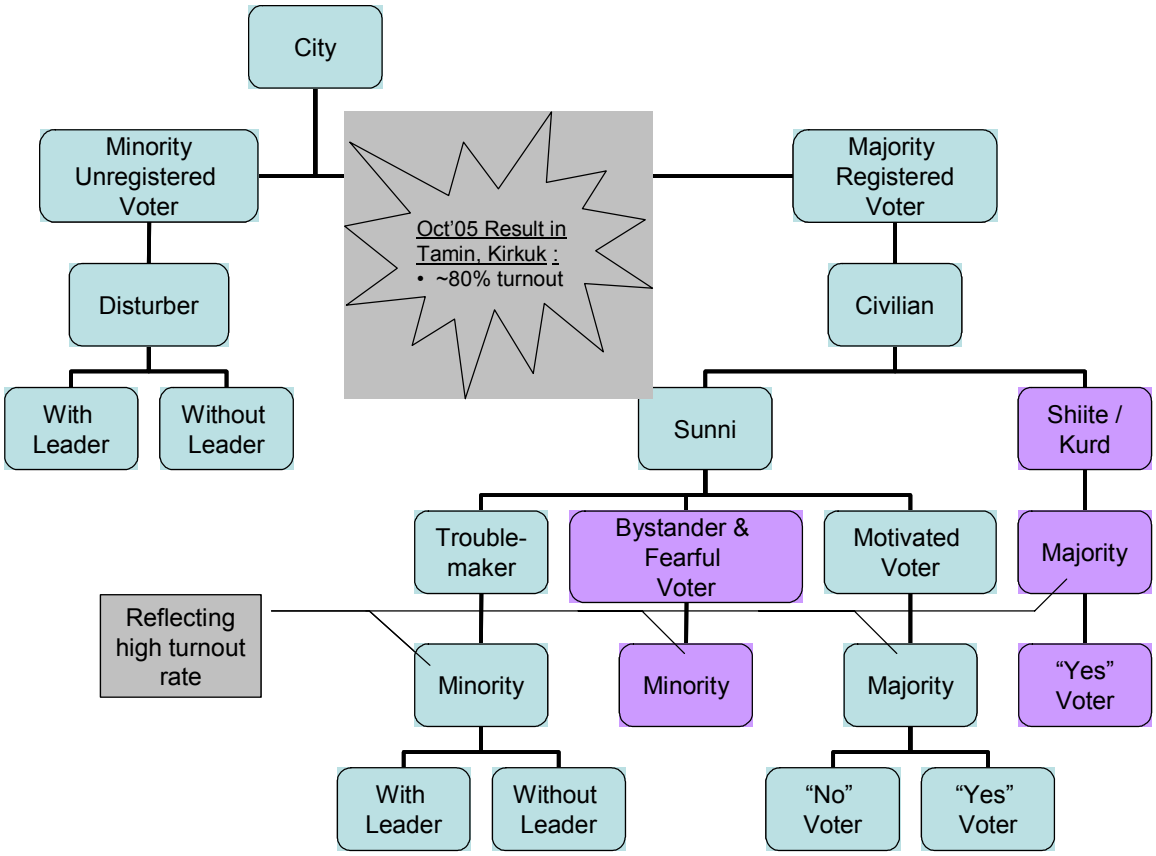


Figure 11 Voter Hierarchy in Heterogeneous (Sunni, Shiite/Kurd) Population Hybrid Scenario

a. Scenarios

Given the voter hierarchy in Figure 11, two of the four possible heterogeneous population scenarios as shown in Table 6 are identified.

Similar to the homogeneous population case, the effect of leadership influence on the disturber and trouble-maker group by the peacekeeping force can be investigated in this heterogeneous population case. In each of the scenario, the effect of security control regions and election booths are also included, as are different rule sets for the various peace support units.

Scenario	Groups								
	Unregistered Disturber		Registered Sunni Voter (Trouble-Maker)				Registered Shiite/Kurd Motivated Voter	Registered Sunni Voter (Motivated Voter)	
	Minority		Minority		Majority		Majority	Minority	Majority
	With Leader	Without Leader	With Leader	Without Leader	With Leader	Without Leader	-	-	-
1	☑					☑	☑	☑	
2		☑			☑		☑	☑	
3	☑			☑			☑		☑
4		☑	☑				☑		☑

Table 6 Heterogeneous (Sunni, Shiite/Kurd) Population Hybrid Scenario

A total of four hybrid scenarios are generated for the heterogeneous (Sunni, Shiite/Kurd) populations. For the purpose of easy identification and reference in this thesis, these four scenarios are coded with the names listed as follows:

- Heter+DisturberLead+CtrlRegion: This scenario models the effect of disturber group leadership and security control regions in a heterogeneous Sunni and Shiite/Kurd population scenario.
- Heter+DisturberLead+CtrlRegion+Booth: This scenario models the effect of disturber group leadership, security control regions and election booths in a heterogeneous Sunni and Shiite/Kurd population scenario.
- Heter+TroubleMakerLead+CtrlRegion: This scenario models the effect of trouble-maker group leadership and security control regions in a heterogeneous Sunni and Shiite/Kurd population scenario.
- Heter+TroubleMakerLead+CtrlRegion+Booth: This scenario models the effect of trouble-maker group leadership, security control regions and election booths in a heterogeneous Sunni and Shiite/Kurd population scenario.

b. Layout and Demographic

The general layout of a representative Iraqi election town for the proposed heterogeneous (Sunni, Shiite/Kurd) population is shown in Figure 12. Figure 13 shows the scenario as it appears in the PAX Scenario Editor graphical

interface. Adopting the October 2005 election result in Tamin, where a high turnout rate of about 80%, this thesis assumes 70% of its registered voter populations are motivated "Yes" voters, 20% are motivated "No" voters, and remaining 10% are trouble-maker voters. Note that since the bystander and fearful voter group constitute only a small minority in the election process, they are not modeled in this heterogeneous population scenario.

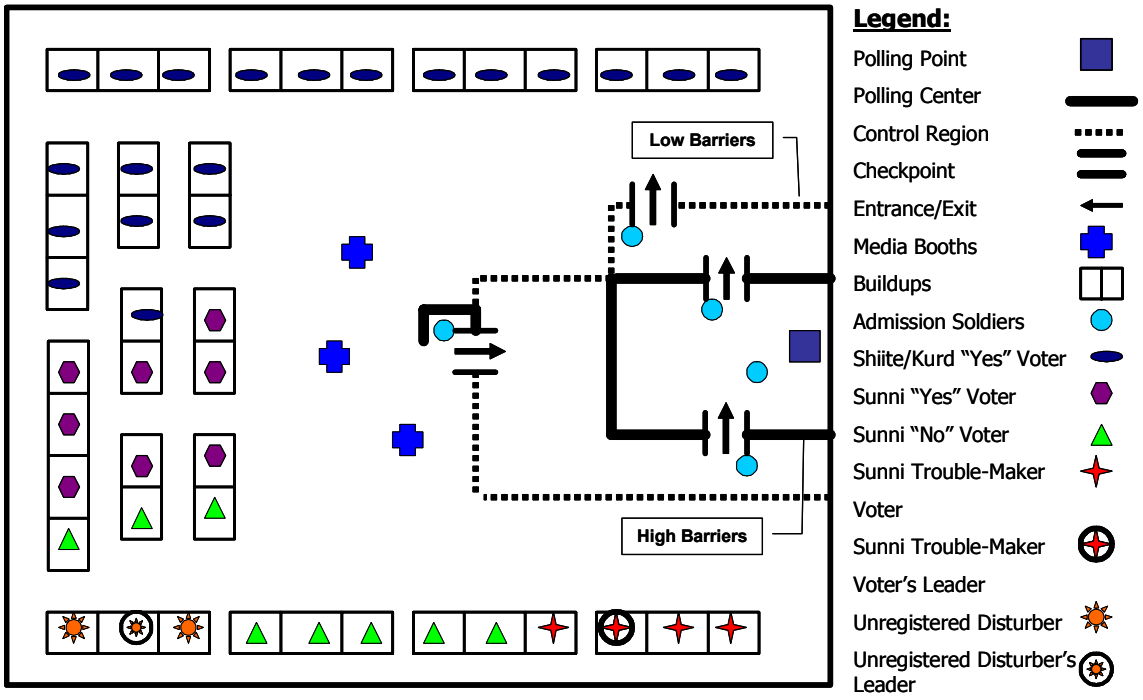


Figure 12 Heterogeneous (Sunni, Shiite/Kurd) Population Scenario Layout

Adopting a conservative worst-case approach, this thesis assumes 50% of the populations are Sunnis and the other 50% are Shiites. With this equal proportion between the Sunni and Shiite population, the chances of interactions and conflicts between them will be increased, hence render scenarios more likely to stress the peacekeeping force's ability to provide physical and psychological security. It is also assumed that all the Shiite/Kurd voters are registered motivated "Yes" voters who desire to come forward and participate in the election, hence increasing the opportunity for interaction with the Sunnis near or at the polling center. The Sunni distribution is as follows, 10% of the 50% Sunni

populations are trouble-makers, 20% are motivated “Yes” voters, and the remaining 20% are motivated “No” voters.

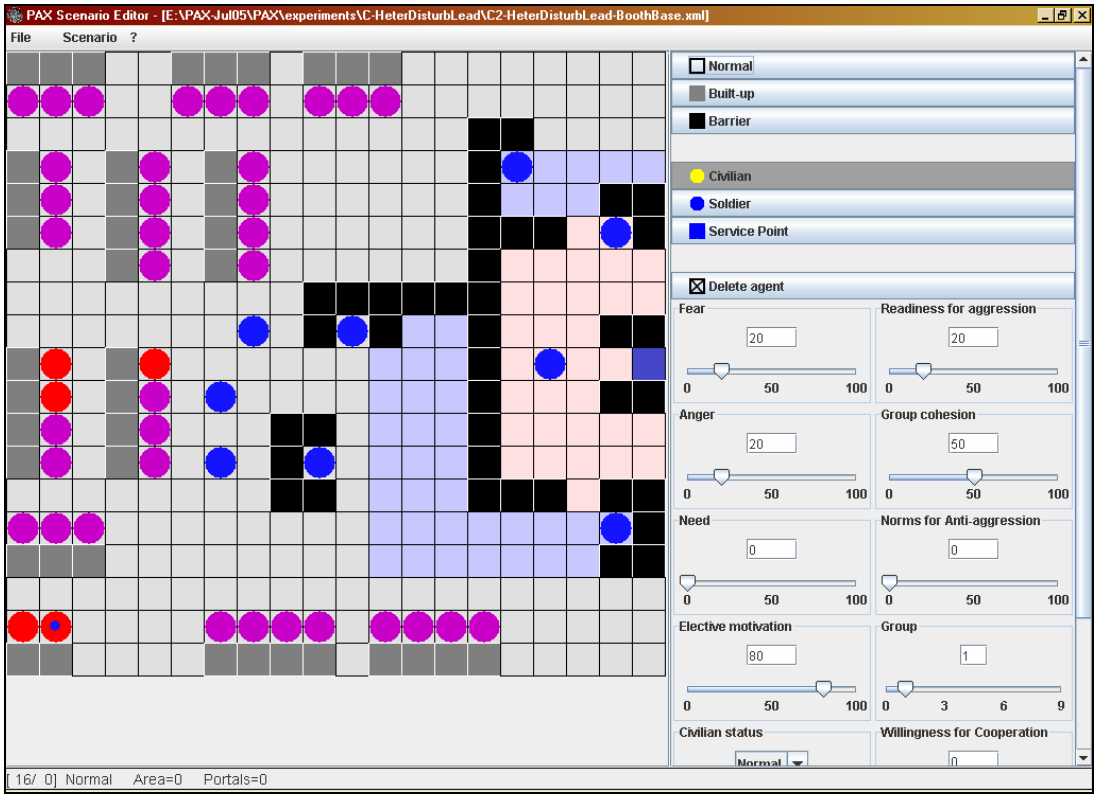


Figure 13 Heterogeneous (Sunni, Shiite/Kurd) Population Scenario Layout in PAX

Using a scaled down population size of 39 registered voters, the following shows the population group breakdown in this heterogeneous Sunni and Shiite/Kurd population hybrid scenario:

- 20 motivated “Yes” registered Shiite/Kurd voters,
- 8 motivated “Yes” registered Sunni voters,
- 8 motivated “No” registered Sunni voters,
- 3 trouble-maker registered Sunni voters, and
- 2 unregistered disturbers.

Note that the three disturbers are not part of the 39 registered voter population and they are not allowed to enter the polling center. This thesis assumes there are fewer disturbers than trouble-makers.

c. Civilian Personalities

In this heterogeneous (Sunni, Shiite/Kurd) population hybrid scenario, there are five groups of civilians. The groups are differentiated by the same civilian personality parameters that are modeled in the homogeneous population scenarios. The levels of these parameters (low, medium, and high) are shown in Table 7.

Personality Factor	Unregistered Disturber	Registered Sunni Voter (Trouble-maker)	Shiite/Kurd Motivated "Yes" Voter	Sunni Motivated "No" Voter	Sunni Motivated "Yes" Voter
Initial Fear	Low	Low	Low	Low	Low
Initial Anger	High	Average	Low	Low	Low
Initial Readiness For Aggression	High	Average	Low	Low	Low
Elective Motivation	Low	Low	High	High	High
Willingness for Cooperation	Low	Average	NA	NA	NA

Table 7 Heterogeneous (Sunni, Shiite/Kurd) Population Civilian's Personality

Once again, the motivated "Yes" and "No" registered voters had a high elective motivation, and their initial fear, initial anger and initial RFA for participating in the election was generally low. Note that this scenario has three groups of motivated voters, rather than two. Unregistered disturbers once again had low initial fear, high initial anger. Based on the turnout in Tamin for the October 2005 election, the registered Sunni trouble-makers are assumed to have fewer hardcore insurgents and lower group aggressiveness than the disturbers, so they are modeled as having low initial fear and election motivation, but average initial anger, RFA, and willingness for cooperation.

Since the effect of the leadership's influence in Shiite and Sunni motivated voters groups are not studied in this thesis, their willingness for cooperation values are not assigned. The willingness for cooperation of the

disturber and trouble-maker groups are low and average, respectively, given that the disturber group contains more hardcore insurgents, while most of the trouble-maker group are non-violent civilians.

E. LIMITATIONS AND ASSUMPTIONS

1. Limitations

The following are the limitations faced during the modeling of the scenarios:

One civilian group's leader per scenario In the early stages of building this model, scenarios where each civilian group had its own leader were explored. When escalation levels became high, soldiers could ask all leaders to cooperate and persuade their group members to calm down and return back to their homes, but could not target the leader of a single civilian group (i.e., that causing the commotion). Therefore, only one leader was modeled in each of the eight hybrid scenarios, although the leader was alternated between the disturbers and trouble-makers to obtain some insight regarding the relative impact of leaders in these groups.

No sympathy and antipathy in civilian model PAX uses a social psychological model for the emergence of collective aggression. This is, in principle, relatively simple to apply and interpret. For example, the cultural background and the circumstances in which a civilian has grown up can be modeled by changing the personality parameters (e.g., the norms for anti-aggression). Not every cultural or social aspect can be modeled in this way. Sympathy and antipathy between different civilian groups, and the behaviors resulting from these emotions, are an issue that needs further investigation [Lampe, 2005].

2. Assumptions

Some modeling assumptions, such as the group sizes and personality parameter ranges used in the eight scenarios, have already been discussed. The following are other assumptions made during the modeling process:

Norms for anti-aggression not modeled *Norms for anti-aggression* is one of the civilian parameters that can be specified in PAX models. These moderate the RFA since they represent the circumstances in which individuals have grown up with or used to live with in the past. In PAX, these "norms" do not change, especially when the scenario process only simulates over a short periods of time, therefore they can be assumed as being constant or zero. “Setting these norms to zero means that civilians have not learned to solve conflicts without violence, and are even more likely to act aggressively. Furthermore, norms for anti-aggression are usually set fairly low because of the assumption that we model a post-war area where people are generally used to seeing and experiencing violence.” [Lampe, 2005] Therefore, in this thesis, the norms for anti-aggression parameter were set to zero for all civilians in all eight scenarios in order to escalate the civilian aggressiveness over the short period of operations for the purpose of analyzing the military’s reaction in a more volatile environment.

Average group cohesiveness All civilian groups are assumed to have average group cohesiveness. In PAX, this *group cohesiveness* parameter (ranging from 0 to 100) is set to 50 for all civilians.

Civilian’s Personality Initial Variance Individual civilian’s initial fear, initial anger and initial RFA are modeled with variability ranging between -10 to 10 from their group average before the start of the simulation run.

Civilian’s Personality Randomness Mean deviation for randomness in model dynamics is set for civilian fear, anger and RFA ranging from -2 to 2. These values influence the simulation runs in that whenever an action is selected by an agent the relevant factors are manipulated according to uniform distributions with the mean deviations specified. The result is that some civilians may be slower or faster to respond to external stimuli than others.

No PC Fear, No PC Anger In PAX, PC Fear and PC Anger define the tendency for civilian fear and anger to increase over time. Since the variability and randomness of the civilian fear, anger and RFA are modeled during the simulation run, these features will not be activated. A civilian’s fear and anger

may increase during the run based on interactions with other civilians or soldiers, or the prevailing sentiments of the crowd.

No decrease of anger on success In PAX, specifying a decrease of anger on success allows the civilian's anger to drop by a certain amount once the civilians have successfully cast their votes. This decrease may reduce their aggressiveness. This study assumes that a civilian's anger cannot be decreased immediately after they cast a vote, but that such a decrease would only happen after the election is over, if at all.

IV. ANALYSIS METHODOLOGIES AND RESULTS

A. CHAPTER OVERVIEW

The analysis methodologies employed in this thesis exploit the statistical theory on design of experiments (DOE) that are developed specifically for exploring computer models such as PAX. The DOE factors, levels and design (in specific, the Near Orthogonal Latin Hypercube (NOLH) design), defined for this research's experiments will be discussed.

The statistical software package JMP (SAS Institute, 2005) will be used to interpret and analyze the collected data. Several JMP statistical tools are used to present the experiments' results and to identify significant factors that could lead to insights for the proposed military tactics, techniques and procedures experimented in all the eight hybrid scenarios.

B. DESIGN OF EXPERIMENTS (DOE)

In the context of DOE, an input or parameter in simulation model such as Civilian's Initial Fear is referred as a *factor*. A factor can be either qualitative or quantitative. For an example, in PAX, soldiers can be assigned to exercise one of six particular rule sets describing the rules of engagement, so Rule Set is a qualitative factor. Factors such as Initial Fear, Initial Anger and Initial RFA, defining the personality of a civilian, are continuous quantitative factors. Each factor can be set to two or more values called *factor levels*. These levels are typically coded numerically for analysis purposes. A scenario or design point is a combination of levels for all factors. In stochastic simulations, replicates mean that different pseudo-random numbers are used to simulate the same scenario [Kleijnen et al., 2005].

In practice, computer simulation models, such as PAX, often contain a large number of factors that the user could vary, via trial-and-error or designed experiments, to study how the simulation behaves. For example, in PAX, each civilian has about 14 factors (such as Initial Fear, Initial Anger, Initial RFA and

Elective Motivation) that the user can set to distinguish each civilian agent. Each of these factors has factor levels ranging from 0 to 100. To examine all possible combinations of these factor levels—even for a single agent—would require octillion (i.e., 10^{27}) of design points. Some might think it would be excellent if experiments could execute all the possible design points. However, it is not practical to implement this full set of experiments due to limitations such as computing resources and time. Fortunately, there are efficient designs that can be employed in these situations. The NOLH design is employed to minimize the large number of experiments.

1. Design Factors

In each of the four homogeneous population hybrid scenarios, five civilian groups and two soldier groups are modeled. These groups are listed and coded with names for the purpose of referencing as follows:

- Bystander and Fearful Sunni Registered Voters (HomoCiv1)
- Motivated “Yes” Sunni Registered Voters (HomoCiv2)
- Motivated “No” Sunni Registered Voters (HomoCiv3)
- Trouble-Maker Sunni Registered Voters (HomoCiv4)
- Disturber Unregistered Voters (HomoCiv5)
- Poll Area Admission Control Soldiers (HomoPollSol)
- Control Area Admission Control Soldiers (HomoCtrlSol)

The 24 factors described in Chapter III that are appropriate for this research experiment in a homogeneous population scenario are listed as follows:

- Initial Fear (For HomoCiv1 to HomoCiv5)
- Initial Anger (For HomoCiv1 to HomoCiv5)
- Initial Readiness For Aggression (RFA) (For HomoCiv1 to HomoCiv5)
- Elective Motivation (For HomoCiv1 to HomoCiv5)
- Willingness for Cooperation (For either HomoCiv4 or HomoCiv5)
- Poll Area ROE (For HomoPollSol)
- Control Region ROE (For HomoCtrlSol)
- Personality Variance (Common setting for Initial Fear, Anger and RFA)

Similarly, in each of the four heterogeneous population hybrid scenarios, five civilian groups and two soldier groups are modeled. These groups are listed and coded with names for the purpose of referencing as follows:

- Motivated Shiite/Kurd Registered Voters (HeterCiv1)
- Motivated "Yes" Sunni Registered Voters (HeterCiv2)
- Motivated "No" Sunni Registered Voters (HeterCiv3)
- Trouble-maker Sunni Registered Voters (HeterCiv4)
- Disturber Unregistered Voters (HeterCiv5)
- Poll Area Admission Control Soldiers (HeterPollSol)
- Control Area Admission Control Soldiers (HeterCtrlSol)

Similarly, a total of 24 factors described in Chapter III that are appropriate for this research experiment in a heterogeneous population scenario are listed as follows:

- Initial Fear (For HeterCiv1 to HeterCiv5)
- Initial Anger (For HeterCiv1 to HeterCiv5)
- Initial Readiness For Aggression (RFA) (For HeterCiv1 to HeterCiv5)
- Elective Motivation (For HeterCiv1 to HeterCiv5)
- Willingness for Cooperation (For either HeterCiv4 or HeterCiv5)
- Poll Area ROE (For HeterPollSol)
- Control Region ROE (For HeterCtrlSol)
- Personality Variance (Common setting for Initial Fear, Anger and RFA)

2. Design Factor Levels

With reference to Table 5 and Table 7 as shown in Chapter III, the following are the design factor levels defined for the civilians' personalities and soldiers' ROEs to be experimented in this research:

- Low Personality (Value ranging from 10 to 30)
- Average Personality (Value ranging from 40 to 60)
- High Personality (Value ranging from 70 to 90)
- Civilian Personality Variance (Value ranging from -10 to 10)
- Soldier ROE (Value ranging from 1 to 6)

In the experiment, Admission Control soldiers deployed in Poll and Control Areas are assigned with ROE that are varied from rule set one to six. This permits the analysis of ROE that best yield desired election outcome in each area given different election scenarios.

Note that the Civilian Personality Variance factor level ranges from -10 to 10; hence, the low and average personality factor levels can overlap, as can the average and high levels.. For example, if there are eight civilians in a group and the average Initial Fear in the group is Low (i.e., value ranging from 10 to 30), with the Civilian Personality Variance factor levels ranging from -10 to 10, PAX will set each of the eight civilians in the group with Initial Fear factor level ranging from 0 to 40 randomly, giving a maximum overlap of 10 between the Low and Average Personality factor levels. These overlaps are allocated to facilitate the analysis of variability in civilian's personalities that may contribute significant insights to the scenario outcome.

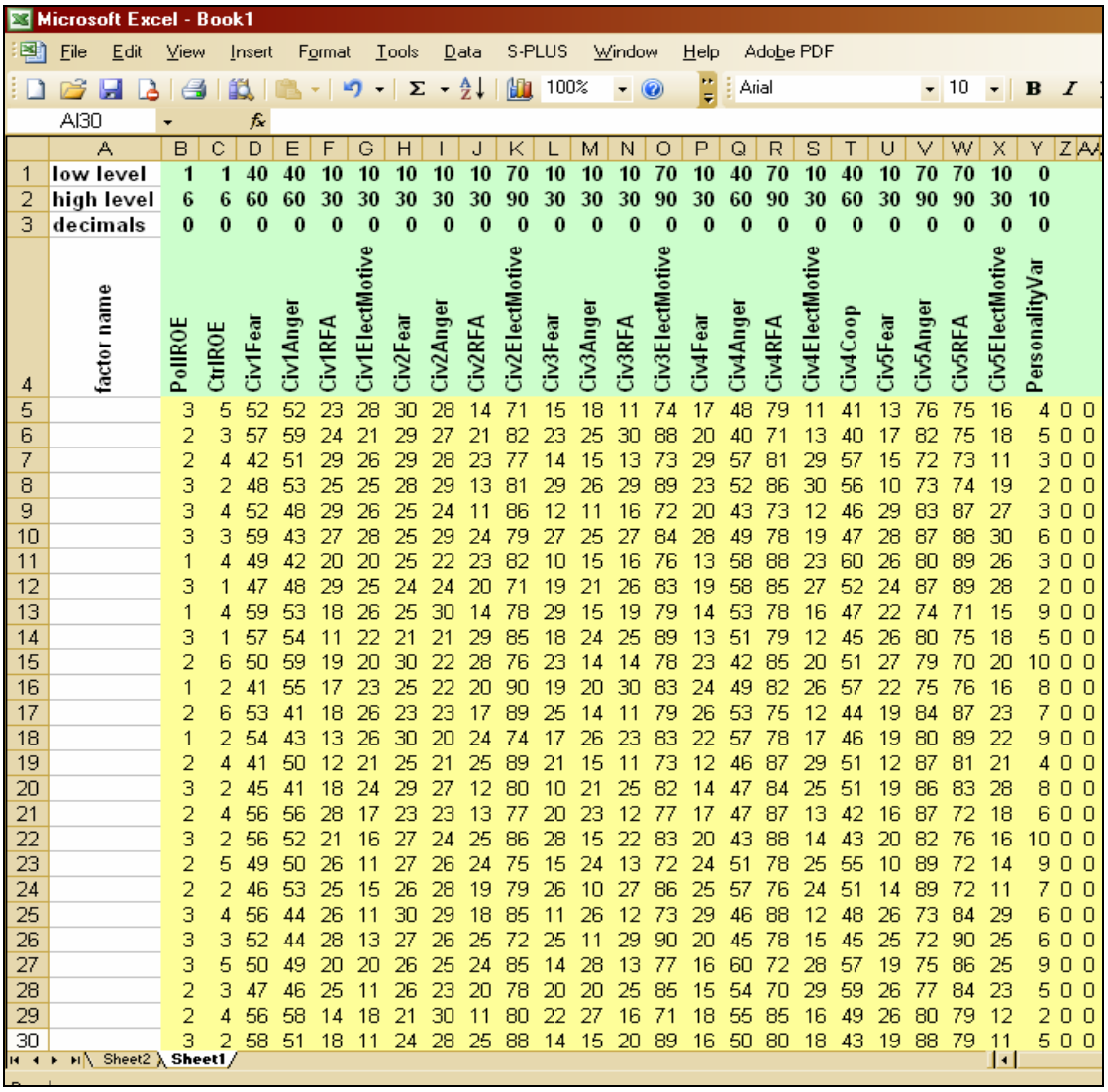
3. Near Orthogonal Latin Hypercube (NOLH) Design

The number of factors designed for the experiment of this research is considered relatively large, particularly since each factor has many possible levels. With constraints in computing resources and time, the number of simulation runs must be fixed and limited. Under such a situation, a nearly orthogonal Latin hypercube (NOLH) design is recommended [Kleijnen et al., 2005].

The salient characteristics of NOLH design include good space-filling and near orthogonality properties. Hence, the NOLH design is used to generate the design points required for this research experiment. To facilitate the use of these designs, the NOLH Design spreadsheet [Sanchez, 2005], adopted from the designs developed by Cioppa [Cioppa, 2002; see also Cioppa and Lucas, 2006], is used where low and high levels for each design factor are easily entered and design points are generated automatically by the spreadsheet.

In this research experiment, each of the eight hybrid scenarios have a 24-factor experiment with a total of 257 design points generated by the NOLH

Design spreadsheet. A snapshot of the NOLH Design spreadsheet, provided in Figure 14, shows part of the 257 design points generated for the Homo+TroubleMakerLead+CtrlRegion scenario.



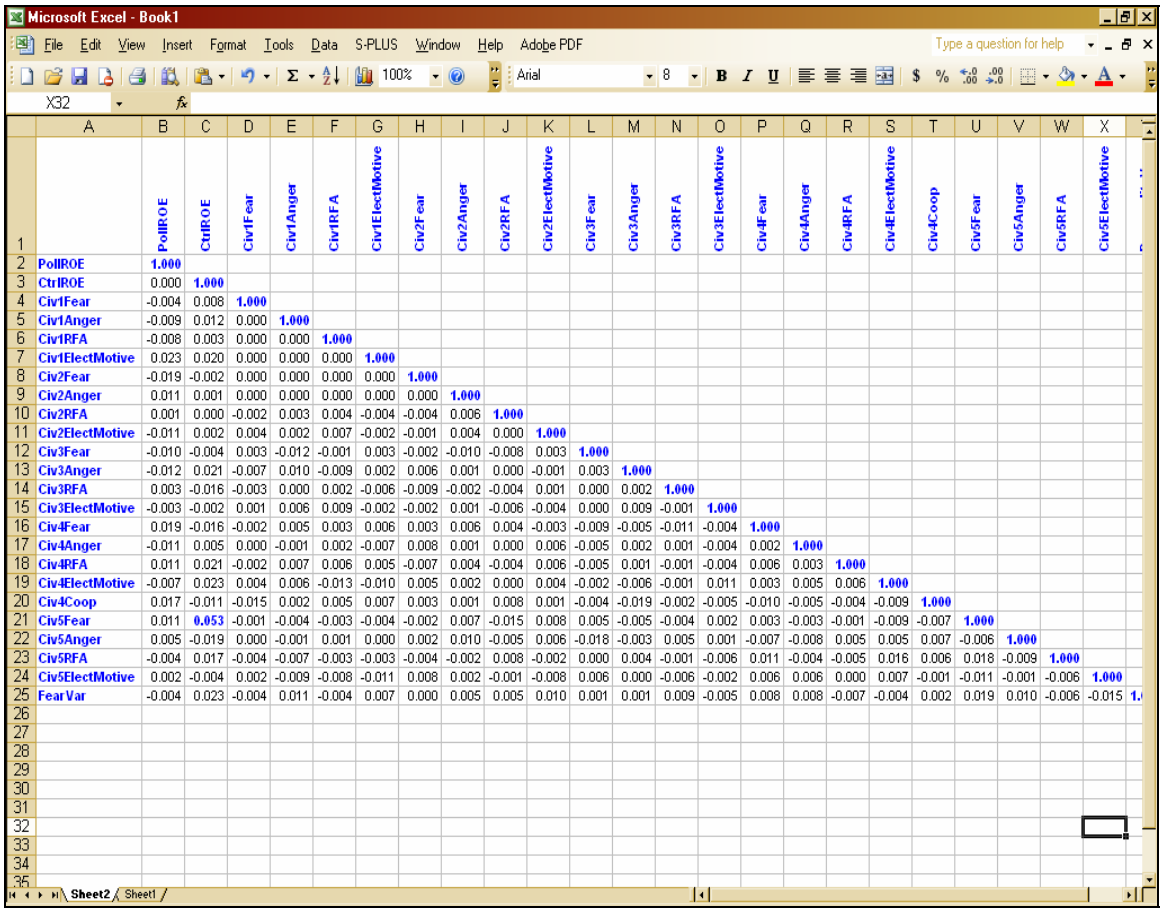
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA
1	low level	1	1	40	40	10	10	10	10	10	70	10	10	10	70	10	40	70	10	40	10	70	70	10	0		
2	high level	6	6	60	60	30	30	30	30	30	90	30	30	30	90	30	60	90	30	60	30	90	90	30	10		
3	decimals	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
4	factor name	PollROE	CtrlROE	Civ1Fear	Civ1Anger	Civ1RFA	Civ1ElectMotive	Civ2Fear	Civ2Anger	Civ2RFA	Civ2ElectMotive	Civ3Fear	Civ3Anger	Civ3RFA	Civ3ElectMotive	Civ4Fear	Civ4Anger	Civ4RFA	Civ4ElectMotive	Civ4Coop	Civ5Fear	Civ5Anger	Civ5RFA	Civ5ElectMotive	PersonalityVar			
5		3	5	52	52	23	28	30	28	14	71	15	18	11	74	17	48	79	11	41	13	76	75	16	4	0	0
6		2	3	57	59	24	21	29	27	21	82	23	25	30	88	20	40	71	13	40	17	82	75	18	5	0	0
7		2	4	42	51	29	26	29	28	23	77	14	15	13	73	29	57	81	29	57	15	72	73	11	3	0	0
8		3	2	48	53	25	25	28	29	13	81	29	26	29	89	23	52	86	30	56	10	73	74	19	2	0	0
9		3	4	52	48	29	26	25	24	11	86	12	11	16	72	20	43	73	12	46	29	83	87	27	3	0	0
10		3	3	59	43	27	28	25	29	24	79	27	25	27	84	28	49	78	19	47	28	87	88	30	6	0	0
11		1	4	49	42	20	20	25	22	23	82	10	15	16	76	13	58	88	23	60	26	80	89	26	3	0	0
12		3	1	47	48	29	25	24	24	20	71	19	21	26	83	19	58	85	27	52	24	87	89	28	2	0	0
13		1	4	59	53	18	26	25	30	14	78	29	15	19	79	14	53	78	16	47	22	74	71	15	9	0	0
14		3	1	57	54	11	22	21	21	29	85	18	24	25	89	13	51	79	12	45	26	80	75	18	5	0	0
15		2	6	50	59	19	20	30	22	28	76	23	14	14	78	23	42	85	20	51	27	79	70	20	10	0	0
16		1	2	41	55	17	23	25	22	20	90	19	20	30	83	24	49	82	26	57	22	75	76	16	8	0	0
17		2	6	53	41	18	26	23	23	17	89	25	14	11	79	26	53	75	12	44	19	84	87	23	7	0	0
18		1	2	54	43	13	26	30	20	24	74	17	26	23	83	22	57	78	17	46	19	80	89	22	9	0	0
19		2	4	41	50	12	21	25	21	25	89	21	15	11	73	12	46	87	29	51	12	87	81	21	4	0	0
20		3	2	45	41	18	24	29	27	12	80	10	21	25	82	14	47	84	25	51	19	86	83	28	8	0	0
21		2	4	56	56	28	17	23	23	13	77	20	23	12	77	17	47	87	13	42	16	87	72	18	6	0	0
22		3	2	56	52	21	16	27	24	25	86	28	15	22	83	20	43	88	14	43	20	82	76	16	10	0	0
23		2	5	49	50	26	11	27	26	24	75	15	24	13	72	24	51	78	25	55	10	89	72	14	9	0	0
24		2	2	46	53	25	15	26	28	19	79	26	10	27	86	25	57	76	24	51	14	89	72	11	7	0	0
25		3	4	56	44	26	11	30	29	18	85	11	26	12	73	29	46	88	12	48	26	73	84	29	6	0	0
26		3	3	52	44	28	13	27	26	25	72	25	11	29	90	20	45	78	15	45	25	72	90	25	6	0	0
27		3	5	50	49	20	20	26	25	24	85	14	28	13	77	16	60	72	28	57	19	75	86	25	9	0	0
28		2	3	47	46	25	11	26	23	20	78	20	20	25	85	15	54	70	29	59	26	77	84	23	5	0	0
29		2	4	56	58	14	18	21	30	11	80	22	27	16	71	18	55	85	16	49	26	80	79	12	2	0	0
30		3	2	58	51	18	11	24	28	25	88	14	15	20	89	16	50	80	18	43	19	88	79	11	5	0	0

Figure 14 NOLH Design Spreadsheet

The correlation of the generated design is analyzed and the resulting correlation matrix is shown in Figure 15. We observed that the correlation coefficients between any two factors are very low, with magnitudes not exceeding 0.053. This result indicates good orthogonality in the generated NOLH design even though some factors were rounded. The same steps were used to generate the NOLH design and correlation matrix for the remaining seven hybrid

scenarios. Similarly, the remaining seven designs also have orthogonality behavior, with the highest magnitude of the correlation between any two factors not exceeding 0.053.

Each design point is replicated 30 times using different random numbers, so each hybrid scenario has 30(257)=7,710 runs. In total, 61,680 simulation runs are made to explore all the eight hybrid scenarios of interest in this research.



Microsoft Excel - Book1

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	A	PollROE	CtrlROE	Civ1Fear	Civ1Anger	Civ1RFA	Civ1ElectMotive	Civ2Fear	Civ2Anger	Civ2RFA	Civ2ElectMotive	Civ3Fear	Civ3Anger	Civ3RFA	Civ3ElectMotive	Civ4Fear	Civ4Anger	Civ4RFA	Civ4ElectMotive	Civ4Coop	Civ5Fear	Civ5Anger	Civ5RFA	Civ5ElectMotive
2	PollROE	1.000																						
3	CtrlROE	0.000	1.000																					
4	Civ1Fear	-0.004	0.008	1.000																				
5	Civ1Anger	-0.009	0.012	0.000	1.000																			
6	Civ1RFA	-0.008	0.003	0.000	0.000	1.000																		
7	Civ1ElectMotive	0.023	0.020	0.000	0.000	0.000	1.000																	
8	Civ2Fear	-0.019	-0.002	0.000	0.000	0.000	0.000	1.000																
9	Civ2Anger	0.011	0.001	0.000	0.000	0.000	0.000	0.000	1.000															
10	Civ2RFA	0.001	0.000	-0.002	0.003	0.004	-0.004	-0.004	0.006	1.000														
11	Civ2ElectMotive	-0.011	0.002	0.004	0.002	0.007	-0.002	-0.001	0.004	0.000	1.000													
12	Civ3Fear	-0.010	-0.004	0.003	-0.012	-0.001	0.003	-0.002	-0.010	-0.008	0.003	1.000												
13	Civ3Anger	-0.012	0.021	-0.007	0.010	-0.009	0.002	0.006	0.001	0.000	-0.001	0.003	1.000											
14	Civ3RFA	0.003	-0.016	-0.003	0.000	0.002	-0.006	-0.009	-0.002	-0.004	0.001	0.000	0.002	1.000										
15	Civ3ElectMotive	-0.003	-0.002	0.001	0.006	0.009	-0.002	-0.002	0.001	-0.006	-0.004	0.000	0.009	-0.001	1.000									
16	Civ4Fear	0.019	-0.016	-0.002	0.005	0.003	0.006	0.003	0.006	0.004	-0.003	-0.009	-0.005	-0.011	-0.004	1.000								
17	Civ4Anger	-0.011	0.005	0.000	-0.001	0.002	-0.007	0.008	0.001	0.000	0.006	-0.005	0.002	0.001	-0.004	0.002	1.000							
18	Civ4RFA	0.011	0.021	-0.002	0.007	0.006	0.005	-0.007	0.004	-0.004	0.006	-0.005	0.001	-0.001	-0.004	0.006	0.003	1.000						
19	Civ4ElectMotive	-0.007	0.023	0.004	0.006	-0.013	-0.010	0.005	0.002	0.000	0.004	-0.002	-0.006	-0.001	0.011	0.003	0.005	0.006	1.000					
20	Civ4Coop	0.017	-0.011	-0.015	0.002	0.005	0.007	0.003	0.001	0.008	0.001	-0.004	-0.019	-0.002	-0.005	-0.010	-0.005	-0.004	-0.009	1.000				
21	Civ5Fear	0.011	0.053	-0.001	-0.004	-0.003	-0.004	-0.002	0.007	-0.015	0.008	0.005	-0.005	-0.004	0.002	0.003	-0.003	-0.001	-0.009	-0.007	1.000			
22	Civ5Anger	0.005	-0.019	0.000	-0.001	0.001	0.000	0.002	0.010	-0.005	0.006	-0.018	-0.003	0.005	0.001	-0.007	-0.008	0.005	0.005	0.007	-0.006	1.000		
23	Civ5RFA	-0.004	0.017	-0.004	-0.007	-0.003	-0.003	-0.004	-0.002	0.008	-0.002	0.000	0.004	-0.001	-0.006	0.011	-0.004	-0.005	0.016	0.006	0.018	-0.009	1.000	
24	Civ5ElectMotive	0.002	-0.004	0.002	-0.009	-0.008	-0.011	0.008	0.002	-0.001	-0.008	0.006	0.000	-0.006	-0.002	0.006	0.006	0.000	0.007	-0.001	-0.011	-0.001	-0.006	1.000
25	FearVar	-0.004	0.023	-0.004	0.011	-0.004	0.007	0.000	0.005	0.005	0.010	0.001	0.001	0.009	-0.005	0.008	0.008	-0.007	-0.004	0.002	0.019	0.010	-0.006	-0.015

Figure 15 Correlation Matrix

C. RUNNING THE EXPERIMENTS TO GENERATE DATA

The preparation process for setting up the production runs in PAX requires three stages. The first stage creates all eight hybrid scenarios using the PAX Scenario Editor. A Scenario Basecase file will be created for each hybrid scenario. In stage two, these Scenario Basecase files are read by the PAX

Experiments Editor one at a time, where the respective Experiment Study file is generated. In the final stage, the Experiment Study file is edited to extract the DOE design factors and levels from the NOLH Design spreadsheet. For a comprehensive guide to PAX, refer to the PAX Users' Manual [Schwarz, 2003].

With the completion of the above three stages, a total of eight sets of experiments were created. Production runs are prepared and executed to simulate all the 61,680 runs using the PAX "oldmcdata.start.bat" application. After the completion of the production runs, the generated simulation results are post-processed using PAX "paxPP.bat" application. The end product of this "paxPP.bat" application is a comma delimited (csv) formatted file containing the simulation results (i.e., number of votes, average civilian fear, etc) of all the excursions. For details about running these commands, refer to User's Guide, OldMcData – The Data Farmer, version 1.0 [Upton, 2004].

Note that for reference purposes, these eight sets of experiments are labeled with the same naming convention used earlier for naming the eight hybrid scenarios.

JMP 5.1 is used to interpret and analyze these eight sets of raw results. For each set of results, the raw data are summarized over replications, and the resulting 257 rows of mean statistical results are used for further analysis. The advantages of using JMP 5.1 include, but are not limited to, the ability to collate a huge amount of raw data and tabulate them into a structural and easy-to-read format. It also provides a user-friendly graphical interface for constructing distribution plots, contour plots, and interaction plots, etc., that make analysis simpler. Powerful statistical analysis tools, such as regression tree analysis, model fitting, and prediction profiler analysis, etc., are also available to make in-depth statistical analysis easy. Figure 16 and Figure 17 show the legends used in the data distribution plots [SAS, 2003].

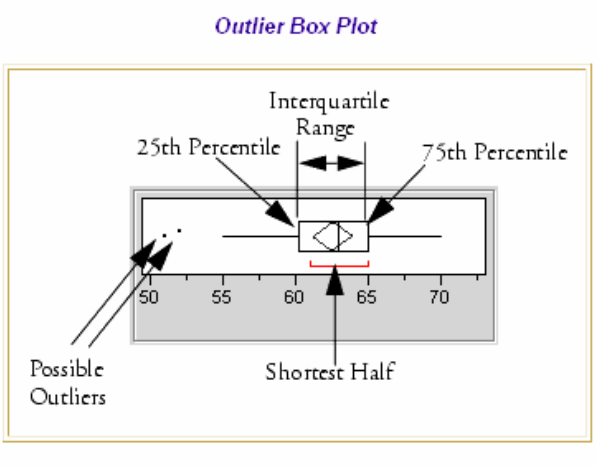

Figure 16 JMP Outlier Box Plot Legend

Note that after the raw data files are first imported into JMP, the ROE factors for Admission Control Soldiers and Reserve Soldiers are defined as a Nominal modeling type. This step is important, as it distinguishes the ROE factors as qualitative design factors with multiple categorical levels. JMP is then able to automatically handle these nominal factors appropriately in subsequent graphical and statistical analyses. The rest of the design factors and run outputs are, by default, defined to be of the Continuous modeling type when they are imported into JMP.

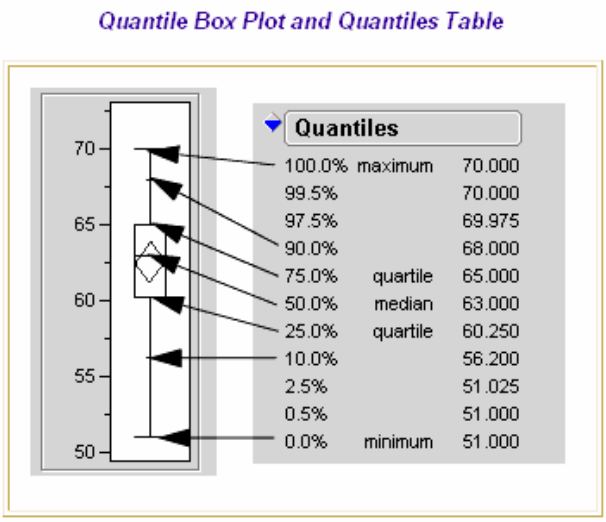

Figure 17 JMP Quantile Box Plot and Quantiles Table Legend

The following analysis steps are used to draw results and conclusions where significant factors for various MOEs are identified. These could provide insights regarding the proposed military tactics, techniques and procedures experimented in all eight hybrid scenarios:

- Data Distribution Analysis
- Regression Tree Analysis
- Model Fitting Analysis using Stepwise Linear Regression where R^2 and p-values are considered
- Prediction Profiler Analysis

D. HOMO+DISTURBERLEAD+CTRLREGION RESULTS

The results for the Homo+DisturberLead+CtrlRegion scenario follow. Recall that this is one of the scenarios where low voter turnout and high escalation are likely.

1. Data Distribution Analysis

a. Percentage of Votes

The final voting participation from the civilian voters in any scenario is often affected by the situations, such as conflicts, that occurred during the election proceeding. The dynamics of these evolving situations have direct influences on the civilian's behaviors and military measures. Therefore, the final percentage of votes cast at the end of the election is measured. Figure 18 shows the distribution of voter participation, in percent (i.e., the number of votes cast divided by the total number of registered voters) at the end of the election simulation.

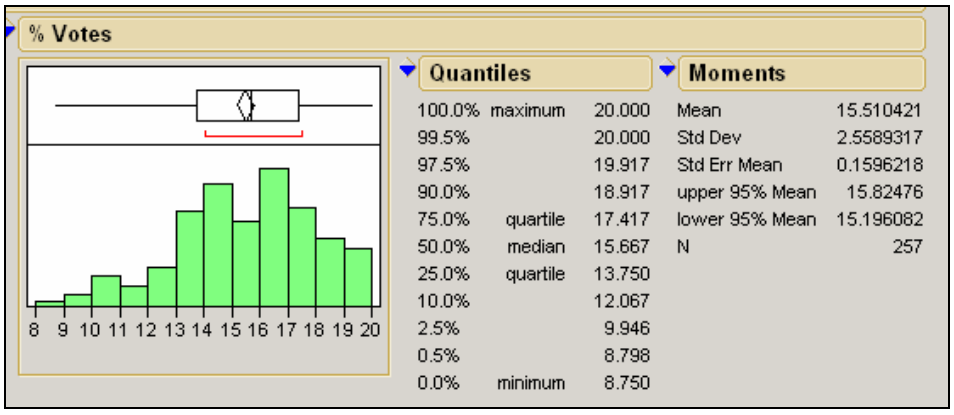

Figure 18 Homo+DisturberLead+CtrlRegion Voter Participation

This scenario corresponds to a town with a homogeneous Sunni population that had one of the lowest voting turnout rates for the October 2005 election. The simulation results show an average voter participation of about 15.5% with a standard deviation of about 2.6%. This result suggests that the simulation results are fairly consistent with the real-world results. The distribution of the results shown by the shortest half bracket (i.e., showing the densest 50% of the observations) indicates that the civilian voting participation varies over a large range. The fact that the distribution has a wide spread with highest percentage of vote at 20% and lowest at 8.8% shows that at least some factors may make a difference.

b. Aggregated Civilian Escalation

Aggregated civilian escalation refers to the value of the civilian escalation accumulated over the entire election simulation. The amount of threatening and attacking actions demonstrated by civilians against other civilians and soldiers are contributing to this measure of civilian escalation. Note that each threatening and each attacking action respectively contributes to the two and ten values of the accumulated civilian escalation.

Figure 19 shows the distribution of the civilian escalation accumulated in the scenario over the entire election simulation. The distribution of civilian escalation demonstrated against other civilians is illustrated in Figure 20. The distribution of civilian escalation demonstrated against the soldiers is illustrated in Figure 21.

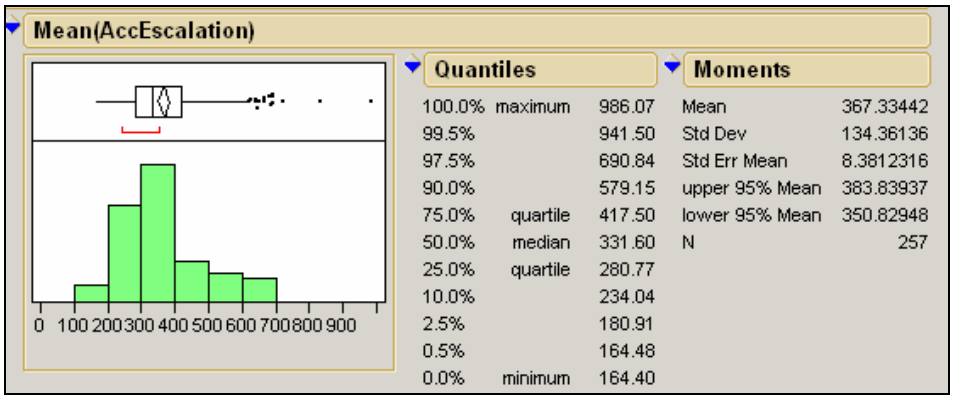

Figure 19 Homo+DisturberLead+CtrlRegion Aggregated Civilian Escalation

The aggregated civilian escalation results in this scenario have a mean value of about 367.3 units (i.e., threatening or attacking actions). The aggregated civilian escalation against other civilians has a mean value of about 286 units (about 78% of the total escalation). The mean aggregated civilian escalation against the soldier has a mean value of about 81.4 units (about 22% of the total escalation). This result indicates that the majority of the escalation is among the civilians. This is an undesirable situation during an election.

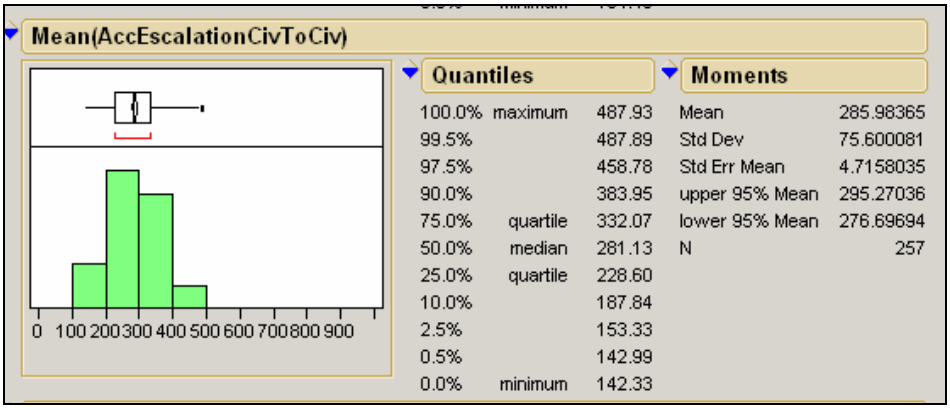

Figure 20 Homo+DisturberLead+CtrlRegion Aggregated Civilian Escalation (Civilians against other Civilians)

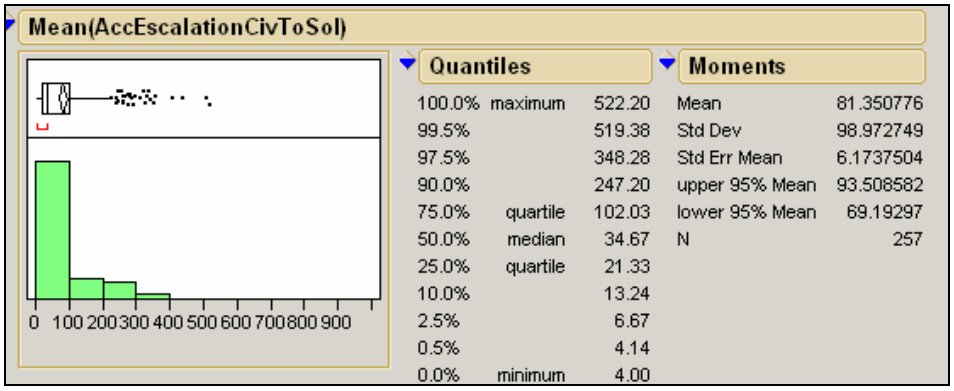

Figure 21 Homo+DisturberLead+CtrlRegion Aggregated Civilian Escalation (Civilians against Soldiers)

c. Average Civilian Fear, Anger and RFA

The effectiveness of the proposed military measures is primarily reflected in the resulting civilian's emotional and psychological states developed at the end of the election proceeding, averaged across all the civilians. The higher fear level indicates that the civilians are staying away from the election.

However, the reader must be informed that PAX will automatically increase the fear level of the civilians once they have cast their votes successfully, so that the civilians will move back to their homes after casting their votes and not mingle inside the voting area. Therefore, the reported high fear level may be overstated, especially in scenarios where many civilians vote. This thesis does not attempt to separate these two aspects and will assume the reader is aware of this overstated fear level from this point onwards. The higher anger level indicates that the civilians are getting more agitated and will be inclined toward aggressive behaviors. The likelihood that a civilian will act aggressively depends on their level of RFA. Therefore, it is important to analyze how these civilian's personalities have evolved over the entire election proceeding.

The distribution of the civilian average fear, anger and RFA levels at the end of the election simulation are illustrated in Figure 22, Figure 23 and Figure 24. A contour plot is shown in Figure 25 to illustrate the relationships between these three civilian personalities. Note that the maximum value for each factor is 100 units.

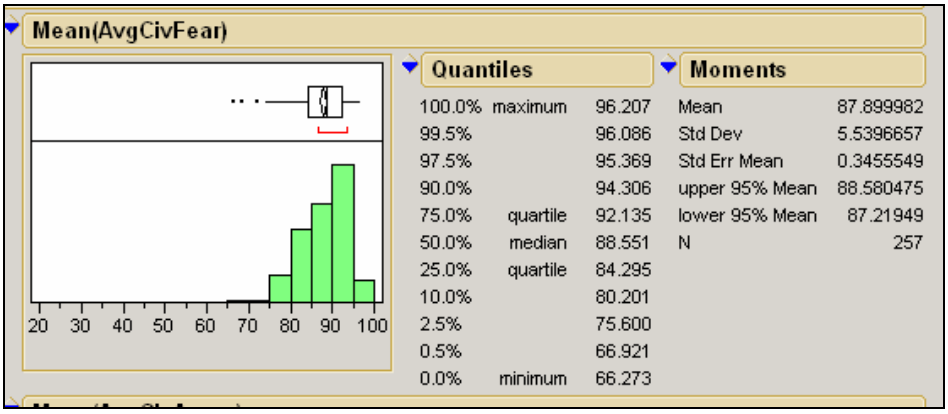

Figure 22 Homo+DisturberLead+CtrlRegion Average Civilian Fear

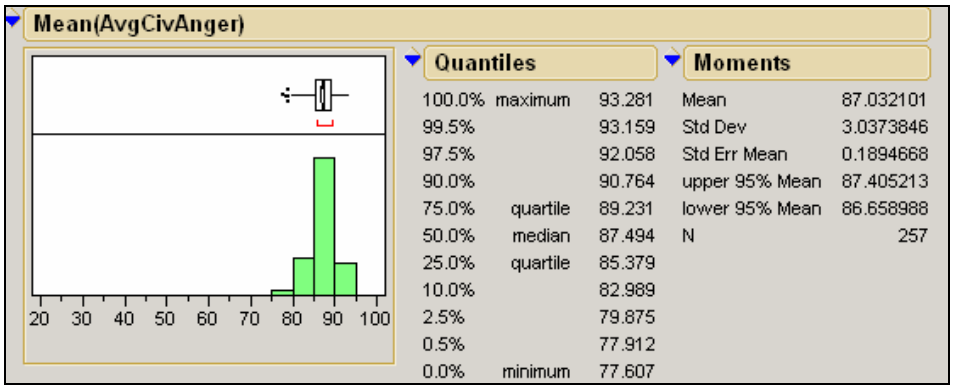

Figure 23 Homo+DisturberLead+CtrlRegion Average Civilian Anger

The average civilian fear and anger levels are high, with mean values of about 87 to 88 units. This result indicates that, on average, the civilians are fearful and angry. However, the average RFA level has a much lower mean value of about only 30 units. This suggests that on an average, the civilians may be angry and agitated at times but they are not likely to act aggressively.

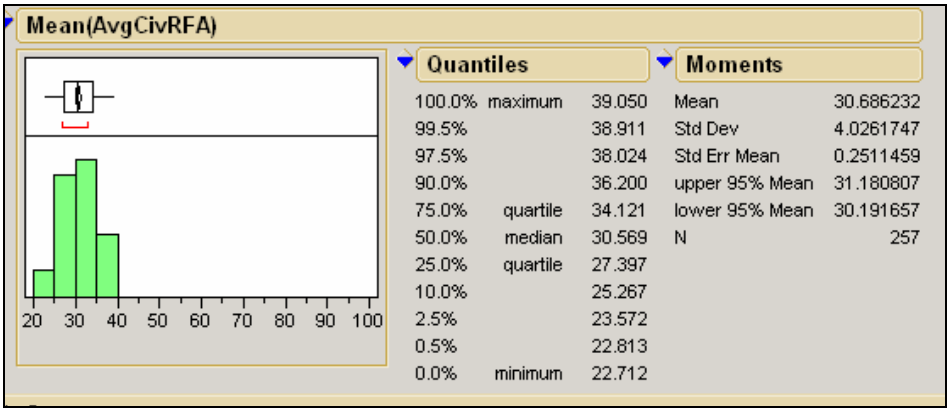

Figure 24 Homo+DisturberLead+CtrlRegion Average Civilian RFA

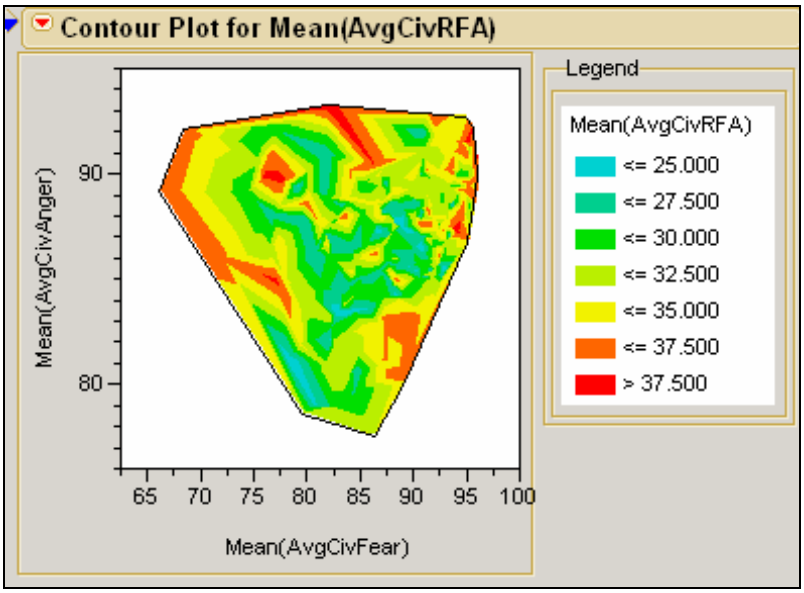

Figure 25 Homo+DisturberLead+CtrlRegion Average Civilian Fear, Anger and RFA Contour Plot

From the contour plot, it can be observed that the highest levels of civilian RFA occur mostly when the civilian anger level is very high regardless of the civilian fear level. However, no obvious scattering pattern is observed.

2. Regression Tree Analysis

Main effects are analyzed in a regression tree analysis that helps to identify significant factors contributing to the various MOEs defined. The Percentage of Votes and Aggregated Civilian Escalation are the two primary MOEs that will be addressed.

a. Percentage of Votes

The percentage of votes cast by the civilians is the response of the regression tree shown in Figure 26. This partition yields an R^2 value of 0.438, and indicates that the following design factor levels characterize those excursions where a high percentage of votes are observed:

- Civ1 – Sunni Bystander/Fearful Voter RFA (<26)
- Civ3 – Sunni "No" Voter Elective Motivation (>=75)
- Civ1 – Sunni Bystander/Fearful Voter Fear (<56)
- Civilian Personality Variance (<7)

The effect of Civ1 – Sunni Bystander/Fearful Voter RFA (>=26) factor has solely contributed in causing a low percentage of votes cast.

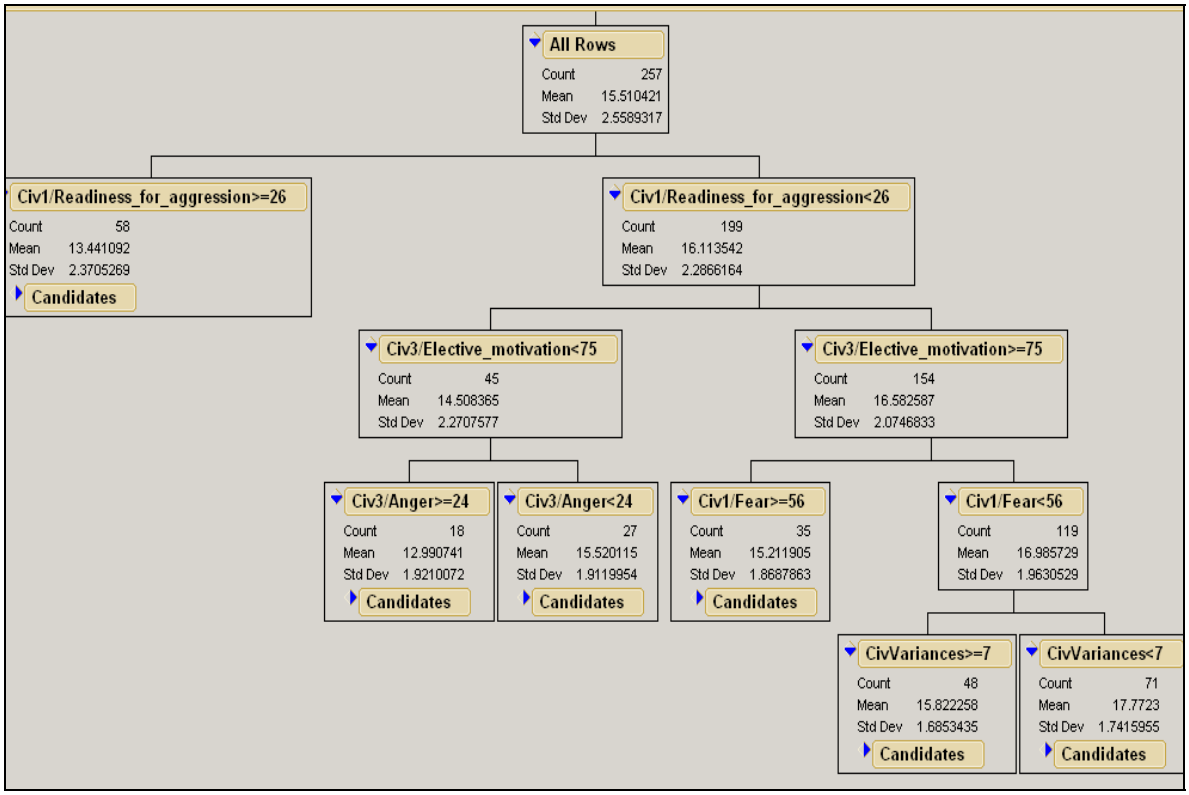

Figure 26 Homo+DisturberLead+CtrlRegion Vote Percentage Regression Tree

The Elective Motivation of the Civ3-Sunni "No" Voter has shown up as a key factor. Note that this thesis has modeled both the Sunni "Yes" and "No" Voters with similar personalities and population size, hence their results can be interpreted interchangeably. In this case, the fact that election motivation shows up for Sunni "No" Voters but not for Sunni "Yes" Voters is perhaps due to the fact that their initial locations are nearer to the polling center. This could indicate the benefit of having the first to arrive at the polls be highly motivated.

b. Aggregated Civilian Escalation

The regression tree for accumulated civilian escalation yields an R^2 value of 0.739, as shown in Figure 27, and indicates that the following design factor levels characterize those excursions where low aggregated civilian escalation is observed:

- Control Soldier ROE (Set 1, 2, 3, 5 & 6)
- Civ1 – Sunni Bystander/Fearful Voter Anger (<47)

If Control Soldier ROE (Set 4 “Gandhi”) is used, then escalation is highest if the troublemakers have low election motivation. If the control soldiers use any other rule set and the bystanders are angry (>=47), then escalation is slightly higher when they are not fearful (Civ1 – Sunni Bystander/Fearful Voter Fear < 47) then when they are fearful. Once again, the bystanders affect the outcome of the election.

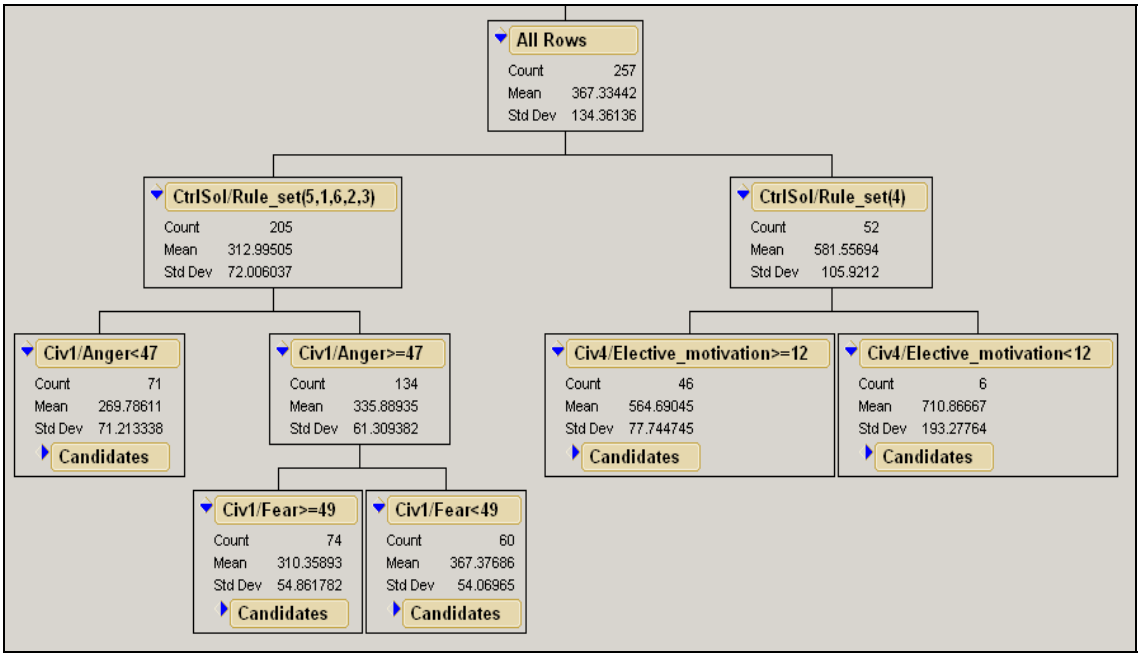

Figure 27 Homo+DisturberLead+CtrlRegion Aggregated Civilian Escalation Regression Tree

3. Model Fitting Analysis

Stepwise linear regression was performed to establish the relationship between the design factors and the responses generated in the simulation. The Percentage of Votes and Aggregated Civilian Escalation are the two primary responses that will be addressed in this analysis.

a. Percentage of Votes

The percentage of votes cast by the civilians is the response of this model fitting analysis. In order to achieve a simple model for analysis, the “best” model was finally selected after a few cycles of manual fitting with the main

effects, two-way interactions and quadratic terms. A satisfactory R^2 value of 0.73 and low p-values for all terms (i.e., highest at 0.055) were obtained. Refer to Figure 28 for details. Note that those factors highlighted by the regression tree were also included in the final model. A simple check of linearity and equal variance properties on the selected model indicated an absence of non-linearity and heteroskedacity problems. The metamodel for predicting the average civilian escalation is generated as follows:

Percentage of Votes Cast = *13.04 – 0.06(Civ1F) + 0.03(Civ1A) – 0.19(Civ1R) – 0.05(Civ2A) – 0.08(Civ3A) + 0.15(Civ3E) – 0.21(CivPV) – 0.17(PollROE) + 0.02(Civ1F-50.01)(Civ1R-20.01) + 0.03(Civ1F-50.01)(CivPV-5.0) – 0.01(Civ1A-50.01)(Civ1R-20.01) – 0.02(Civ1A-50.01)(CivPV-5.0) + 0.01(Civ3A-20.01)(Civ3E-80.01) – 0.01(Civ1F-50.01)(Civ1F-50.01) - 0.01(Civ1R-20.01)(Civ1R-20.01) – 0.01(Civ3E-80.01)(Civ3E-80.01)*

Where: Civ1F = Civ1 – Sunni Bystander/Fearful Voter Fear

Civ1A = Civ1 – Sunni Bystander/Fearful Voter Anger

Civ1R = Civ1 – Sunni Bystander/Fearful Voter RFA

Civ2A = Civ2 – Sunni “Yes” Voter Anger

Civ3A = Civ3 – Sunni “No” Voter Anger

Civ3E = Civ3 – Sunni “No” Voter Elective Motivation

CivPV = Civilian Personality Variance

PollROE = Poll Soldier ROE {2&3&6 – 1&4&5}

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	13.041924	1.665604	7.83	<.0001
Civ1/Fear	-0.0564	0.01476	-3.82	0.0002
Civ1/Anger	0.0343448	0.014763	2.33	0.0208
Civ1/Readiness_for_aggression	-0.194095	0.014923	-13.01	<.0001
Civ2/Anger	-0.04556	0.014772	-3.08	0.0023
Civ3/Anger	-0.082218	0.01477	-5.57	<.0001
Civ3/Elective_motivation	0.1528547	0.014763	10.35	<.0001
CivVariances	-0.208268	0.029347	-7.10	<.0001
PollSol/Rule_set{2&6&3-4&5&1}	-0.168079	0.086924	-1.93	0.0543
(Civ1/Fear-50.0078)*(Civ1/Readiness_for_aggression-20.0078)	0.0198229	0.002457	8.07	<.0001
(Civ1/Fear-50.0078)*(CivVariances-5.00389)	0.0285681	0.005641	5.06	<.0001
(Civ1/Anger-50.0078)*(Civ1/Readiness_for_aggression-20.0078)	-0.014731	0.00277	-5.32	<.0001
(Civ1/Anger-50.0078)*(CivVariances-5.00389)	-0.022814	0.004921	-4.64	<.0001
(Civ3/Anger-20.0078)*(Civ3/Elective_motivation-80.0078)	0.0144447	0.002438	5.93	<.0001
(Civ1/Fear-50.0078)*(Civ1/Fear-50.0078)	-0.012743	0.002862	-4.45	<.0001
(Civ1/Readiness_for_aggression-20.0078)*(Civ1/Readiness_for_aggression-20.0078)	-0.012588	0.002885	-4.36	<.0001
(Civ3/Elective_motivation-80.0078)*(Civ3/Elective_motivation-80.0078)	-0.009454	0.002881	-3.28	0.0012

Figure 28 Homo+DisturberLead+CtrlRegion Vote Percentage Model Fit

Positive coefficients indicate that the terms tend to increase the MOE, while negative coefficients indicate that the terms tend to decrease the MOE. Interaction terms can amplify or diminish the impact of main effects. Quadratic terms indicate the curvature in the relationships.

Note that JMP has automatically grouped Poll Area Soldier's ROE Set 2, 3 and 6 together (with value 1) as having the same effect on the response that is different from Poll Area Soldier's ROE Set 1, 4 and 5 (with value -1).

From the metamodel, the Civ1R and Civ3E terms stand out statistically from the rest with higher t ratio values. This agrees with the regression tree results. Overall, the result indicates that when the level of RFA among Civ1 (Sunni Bystander and Fearful Voters) increase, the percentage of votes will decrease. This is not a desirable outcome, as we want the percentage of votes to be high. In contrast, if the level of elective motivation among Civ3 (Sunni "No" Voters) increases, the percentage of votes will increase. This is a desirable outcome, as we want the percentage of votes to be high.

Since there are interaction and quadratic terms in the metamodel, the change in the main effects may affect the interactions and hence the overall results. Numerical examples that include the interactions using JMP Profiler Analysis tool will be discussed in Chapter V.

b. Aggregated Civilian Escalation

The civilian escalation accumulated during the entire simulation is the response of this model fitting analysis. In order to achieve a simple model for analysis, the "best" model was finally selected after a few cycles of manual fitting with the main effects, two-way interactions and quadratic terms. A satisfactory R^2 value of 0.76 and low p-values for all terms (i.e., highest at 0.02) were obtained. Refer to Figure 29 for details. Note that those factors highlighted by the regression tree were also included in the final model. A simple check of linearity and equal variance properties on the selected model indicated an absence of a non-linearity and heteroskedacity problems. The metamodel for predicting the average civilian escalation is generated as follows:

Aggregated Civilian Escalation = *-121.39 – 3.1(Civ1F) + 2.68(Civ1A) + 2.37(Civ2R) + 1.67(Civ3R) + 3.74(Civ4R) + 2.58(Civ5R) – 15.52(PollROE) – 128.83(CtrlROE) – 3.64(CtrlROE-0.60)(Civ1F-50.01)*

Where: Civ1F = Civ1 – Sunni Bystander/Fearful Voter Fear

Civ1A = Civ1 – Sunni Bystander/Fearful Voter Anger

Civ2R = Civ2 – Sunni "Yes" Voter RFA

Civ3R = Civ3 – Sunni "No" Voter RFA

Civ4R = Civ4 – Sunni Trouble-Maker Voter RFA

Civ5R = Civ5 – Disturber RFA

PollROE = Poll Soldier ROE {2&5&6 – 1&3&4}

CtrlROE = Control Soldier ROE {1&2&3&5&6 – 4}

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-121.3927	98.65245	-1.23	0.2197
Civ1/Fear	-3.102272	0.717382	-4.32	<.0001
Civ1/Anger	2.6805018	0.721527	3.72	0.0003
Civ2/Readiness_for_aggression	2.373209	0.717437	3.31	0.0011
Civ3/Readiness_for_aggression	1.6670369	0.719659	2.32	0.0214
Civ4/Readiness_for_aggression	3.7391832	0.723905	5.17	<.0001
Civ5/Readiness_for_aggression	2.5802286	0.718159	3.59	0.0004
PollSol/Rule_set{6&2&5-1&3&4}	-15.52032	4.196507	-3.70	0.0003
CtrlSol/Rule_set{5&1&6&2&3-4}	-128.8306	5.289222	-24.36	<.0001
(CtrlSol/Rule_set{5&1&6&2&3-4}-0.59533)*(Civ1/Fear-50.0078)	-3.637647	0.886155	-4.10	<.0001

Figure 29 Homo+DisturberLead+CtrlRegion Aggregated Civilian Escalation Model Fit

Note that JMP has automatically grouped Poll Area Soldier's ROE Set 2, 5 and 6 together (with value 1) as having the same effect on the response that is different from Poll Area Soldier's ROE Set 1, 3 and 4 (with value -1). Similarly, it has grouped Control Area Soldier's ROE Set 1, 2, 3, 5 and 6 together (with value 1) as having the same effect on the response that is different from Control Area Soldier's ROE Set 4 (with value -1).

From the metamodel, the CtrlROE terms stands out statistically from the rest with a very high t ratio value. Overall, the result indicates that when Control Area Admission Control Soldier employ ROE Set 1, 2, 3, 5 and 6, the level of aggregated civilian escalation will decrease. This is excellent, as we want the civilian escalation to be minimized.

E. HOMO+DISTURBERLEAD+CTRLREGION+BOOTH RESULTS

The results for the Homo+DisturberLead+CtrlRegion+Booth follow. Recall that this is one of the scenarios where low voter turnout and high escalation are likely.

1. Data Distribution Analysis

a. Percentage of Votes

In this experiment, the deployments of Election Booths are implemented. The purpose of deploying these Election Booths is to promote election motivation and encourage voter participation, so that the percentage of

votes is measured to evaluate the success rate of this implementation. Figure 30 shows the distribution of voter participation, in percent (i.e., the number of votes cast divided by the total number of registered voters) at the end of the election simulation.

This scenario corresponds to a town with a homogeneous Sunni population that had one of the lowest voting turnout rates for the October 2005 election. The simulation results show an average voter participation of about 17.7% with a standard deviation of about 2.5%. This result suggests that the simulation results are fairly consistent with the real-world results. The distribution of the shortest half bracket (i.e., showing the densest 50% of the observations) indicates that the civilian voting participation varies over only a small range. The fact that the distribution has a wide spread with highest percentage of vote at 20% and lowest at 9.2% shows that at least some factors may make a difference. Similar results can be observed from the quantile box plot, where the majority of the data is skewed towards the right.

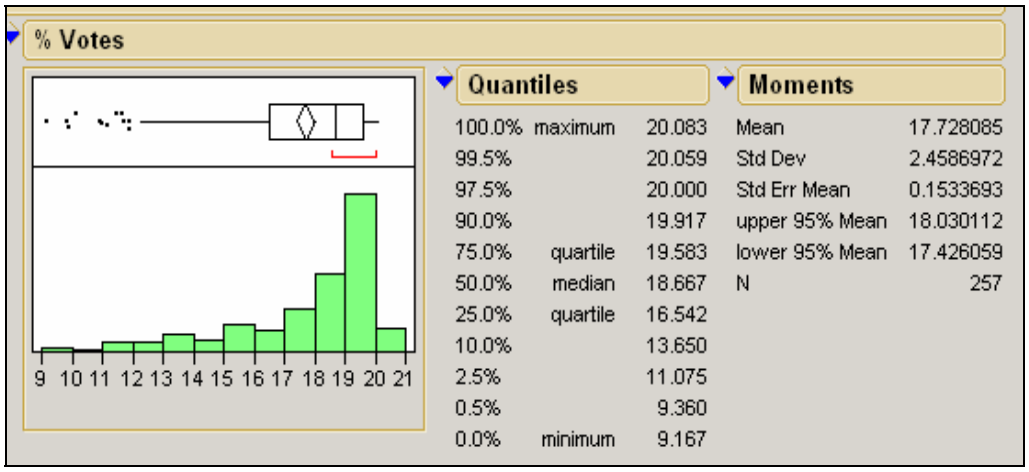

Figure 30 Homo+DisturberLead+CtrlRegion+Booth Voter Participation

Compared with the Homo+DisturberLead+CtrlRegion scenario, the voting participation in this Homo+DisturberLead+CtrlRegion+Booth scenario, where Election Booths are implemented, shows an improvement of about 2.2% on average with a tighter standard deviation of 1%. Tighter voting participation distribution towards the high side is also observed in this scenario.

b. Aggregated Civilian Escalation

Figure 31 shows the distribution of the civilian escalation accumulated in the scenario over the entire election simulation. The distribution of civilian escalation demonstrated against other civilians is illustrated in Figure 32. The distribution of civilian escalation demonstrated against the soldiers is illustrated in Figure 33.

The aggregated civilian escalation resulted in this scenario has a mean value at about 1234.7 units (i.e., threatening or attacking actions). The aggregated civilian escalation against other civilians has a mean value of about 406 units (about 33% of the total escalation). The mean aggregated civilian escalation against the soldier has a mean value of about 828.7 units (about 67% of the total escalation). This result indicates a huge increase in civilian escalation that developed in the scenario (where Election Booths are deployed). Intuitively, this increase escalation is definitely an undesirable situation.

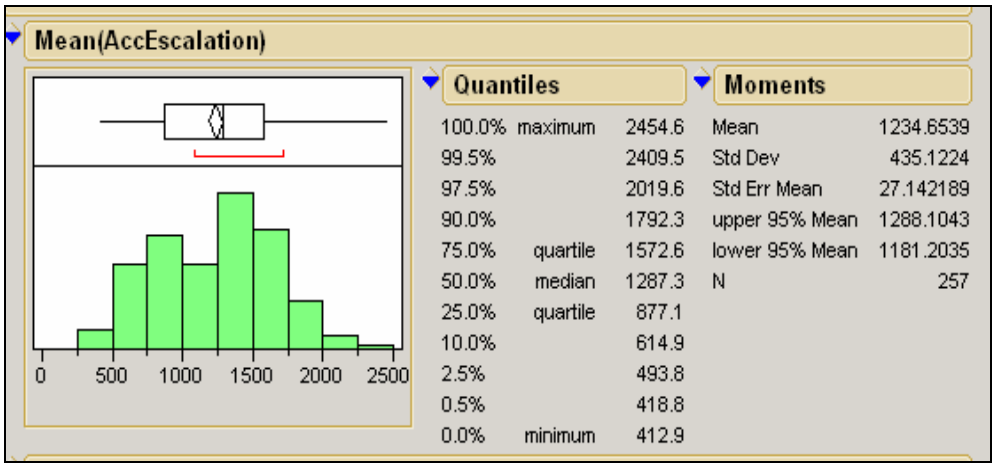

Figure 31 Homo+DisturberLead+CtrlRegion+Booth Aggregated Civilian Escalation

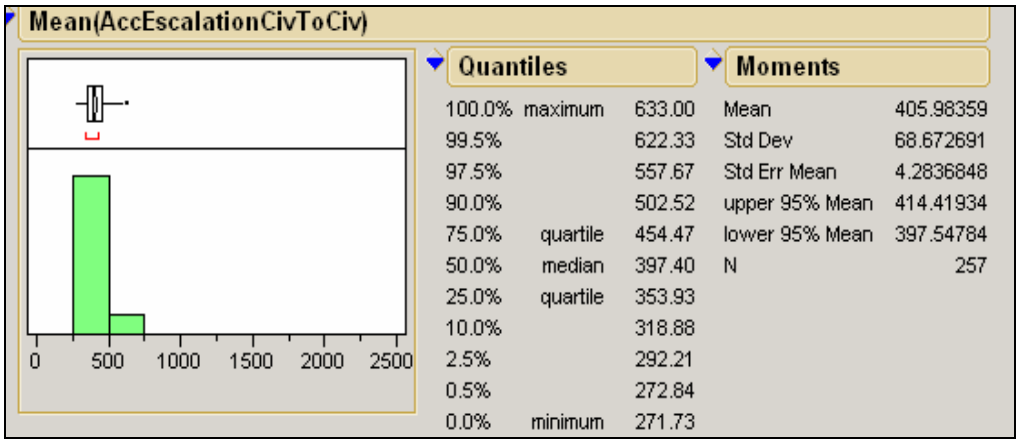

Figure 32 Homo+DisturberLead+CtrlRegion+Booth Aggregated Civilian Escalation (Civilians against other Civilians)

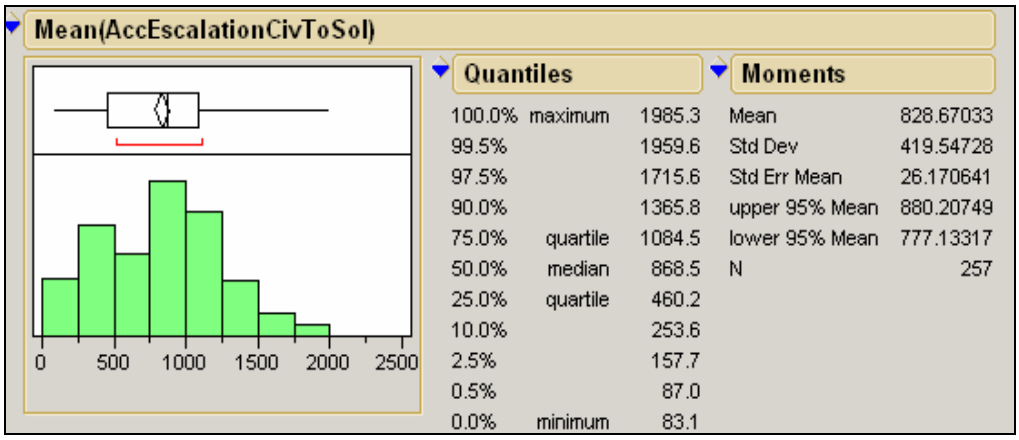

Figure 33 Homo+DisturberLead+CtrlRegion+Booth Aggregated Civilian Escalation (Civilians against Soldiers)

Surprisingly, this results indicate that the majority of the time, the escalation is between the civilians and soldiers. This is completely the opposite as compared to the Homo+DisturberLead+CtrlRegion scenario where no Election Booths were deployed. Together with the improvement in the voting participation, this result suggests that the implementation of the Election Booths had managed to attract the hostile civilians towards them and minimized the interactions among the civilians. Therefore, this allowed more motivated civilians to participate in the voting. Hence, this situation is considered controllable and is a desired election proceeding.

c. Average Civilian Fear, Anger and RFA

The distributions of the civilian average fear, anger and RFA level at the end of the election proceeding, averaged across all the civilians are illustrated in Figure 34, Figure 35 and Figure 36. A contour plot is shown in Figure 37 to illustrate the relationships between these three civilian personalities. Note that the maximum value for each factor is 100 units.

The average civilian fear and anger levels are high, with mean values of about 78 and 86 units. This result indicates that, on average, the civilians are fearful and angry. However, the average RFA level has a much lower mean value of about only 32 units. This suggests that on an average, the civilians may be angry and agitated at times but they are not likely to act aggressively.

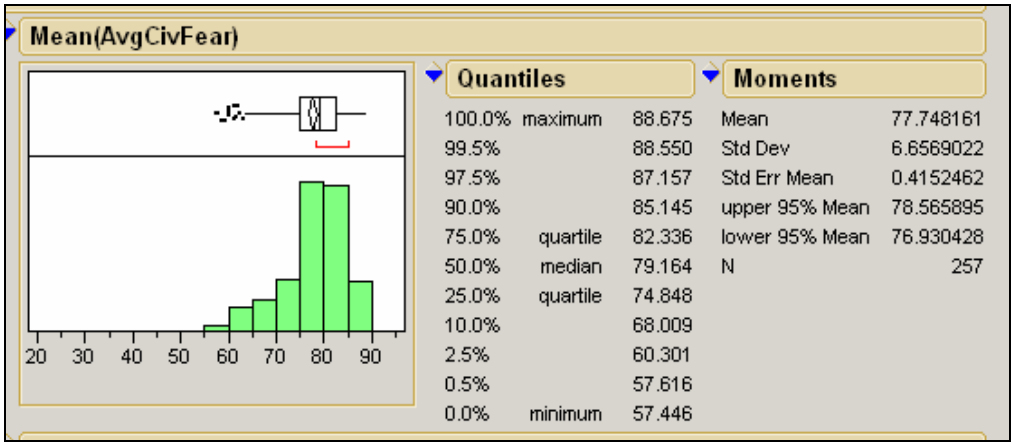

Figure 34 Homo+DisturberLead+CtrlRegion+Booth Average Civilian Fear

Note that the civilian fear level has dropped by 10 units as compared to the Homo+DisturberLead+CtrlRegion scenario where no Election Booths are deployed. This suggests that the Election Booths deployed in this scenario are gaining positive responses from the civilians. On an average, civilians are now less fearful and are coming out from their homes to participate in the election.

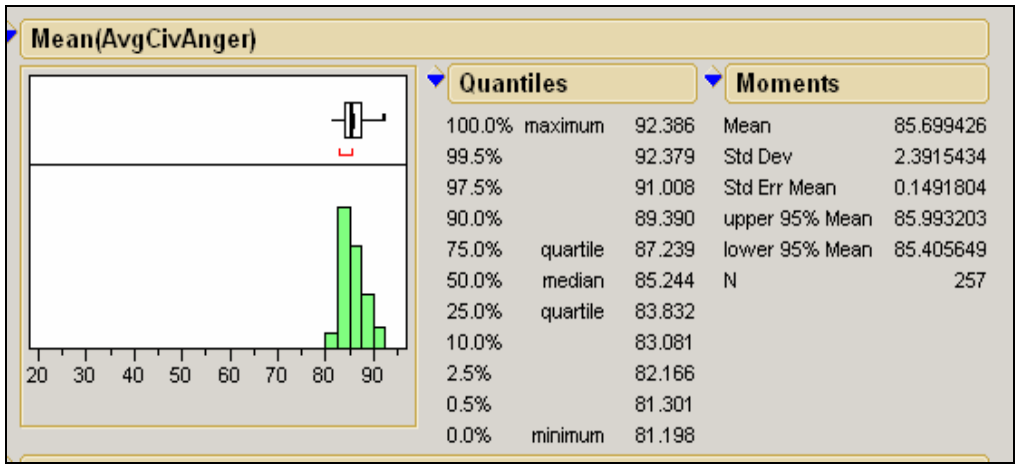

Figure 35 Homo+DisturberLead+CtrlRegion+Booth Average Civilian Anger

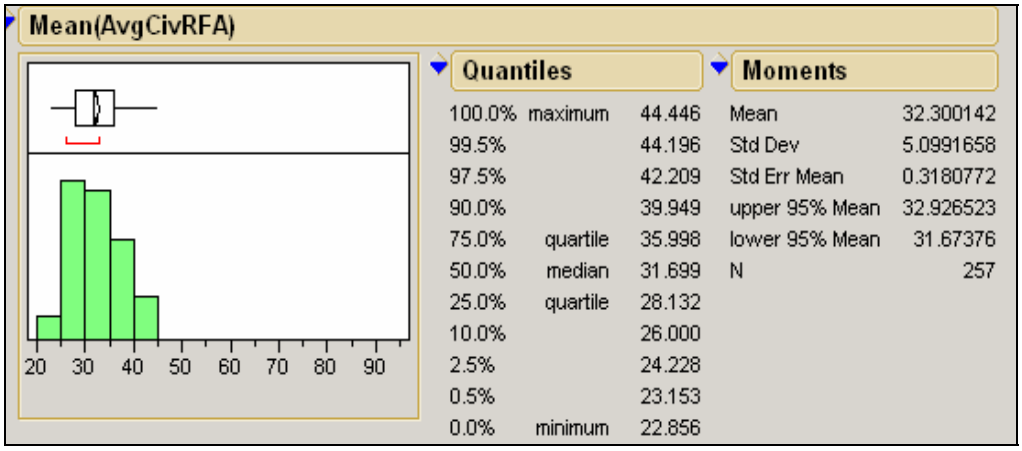

Figure 36 Homo+DisturberLead+CtrlRegion+Booth Average Civilian RFA

From the contour plot, it can be observed that the highest levels of civilian RFA occur mostly when the average civilian fear level is low and the anger level is very high. It is also observed that when the average civilian fear level is very high, the amount of average civilian RFA is always low regardless of the average civilian anger level. This suggests that on an average, the civilian fear may be a significant factor contributing to the low civilian RFA.

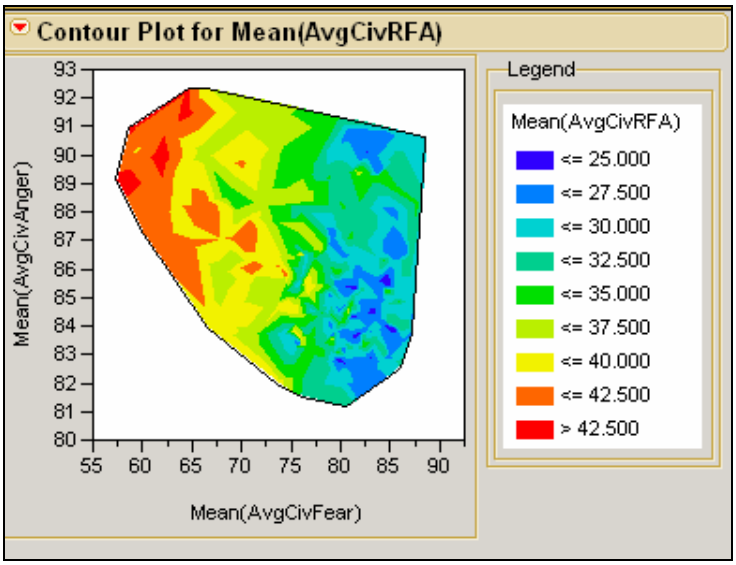

Figure 37 Homo+DisturberLead+CtrlRegion+Booth Average Civilian Fear, Anger and RFA Contour Plot

2. Regression Tree Analysis

a. Percentage of Votes

The percentage of votes cast by the civilians is the response of the regression tree shown in Figure 38. This partition yields an R^2 value of 0.404, and indicates that the effect of the Civ3 – Sunni "No" Voters Elective Motivation (>=80) design factors has solely contributed to the high voter participation in those excursions where a high percentage of votes are observed.

The effects of the following are the design factors that have contributed in causing a low percentage of votes cast:

- Civ3 – Sunni "No" Voter Elective Motivation (<80)
- Civ1 – Sunni Bystander/Fearful Voter Anger (>=49)
- Civ3 – Sunni "No" Voter Anger (>=23)

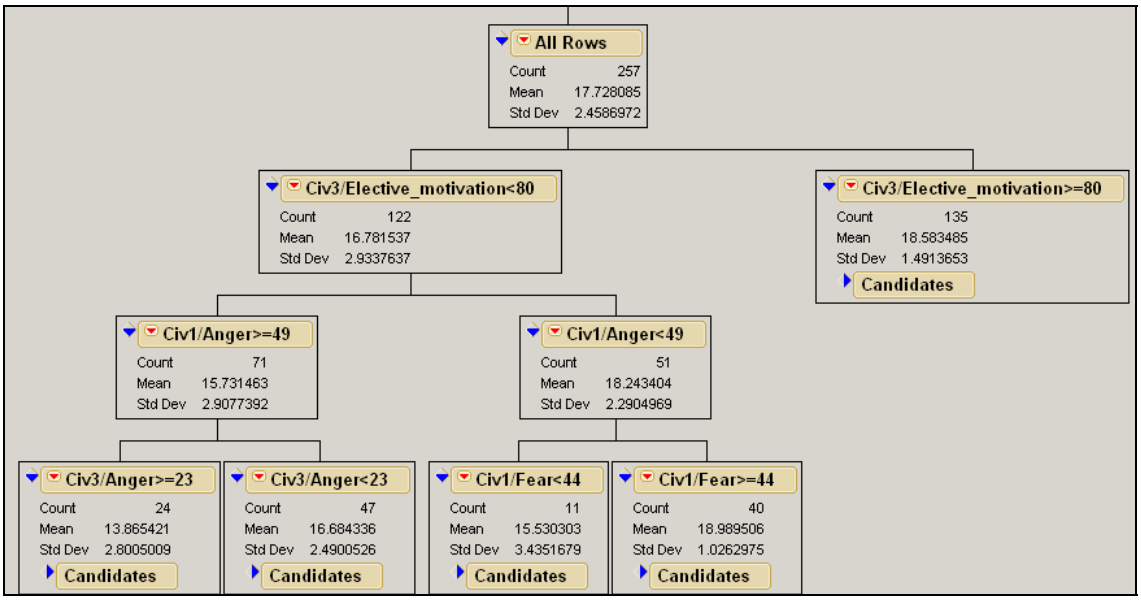

Figure 38 Homo+DisturberLead+CtrlRegion+Booth Vote Percentage Regression Tree

b. Aggregated Civilian Escalation

The regression tree for accumulated civilian escalation yields an R^2 value of 0.644, as shown in Figure 39, and indicates that the following design factor levels characterize those excursions where low aggregated civilian escalation is observed:

- Civ1 – Sunni Bystander/Fearful Voter RFA (<26)
- Civ1 – Sunni Bystander/Fearful Voter Fear (<51)
- Civ1 – Sunni Bystander/Fearful Voter Anger (<46)
- Civilian Personality Variance (<7)

The effect of the Civ1 – Sunni Bystander/Fearful Voter RFA (>=26) factor has solely contributed in causing high civilian escalation. Once again, the bystanders affect the outcome of the election.

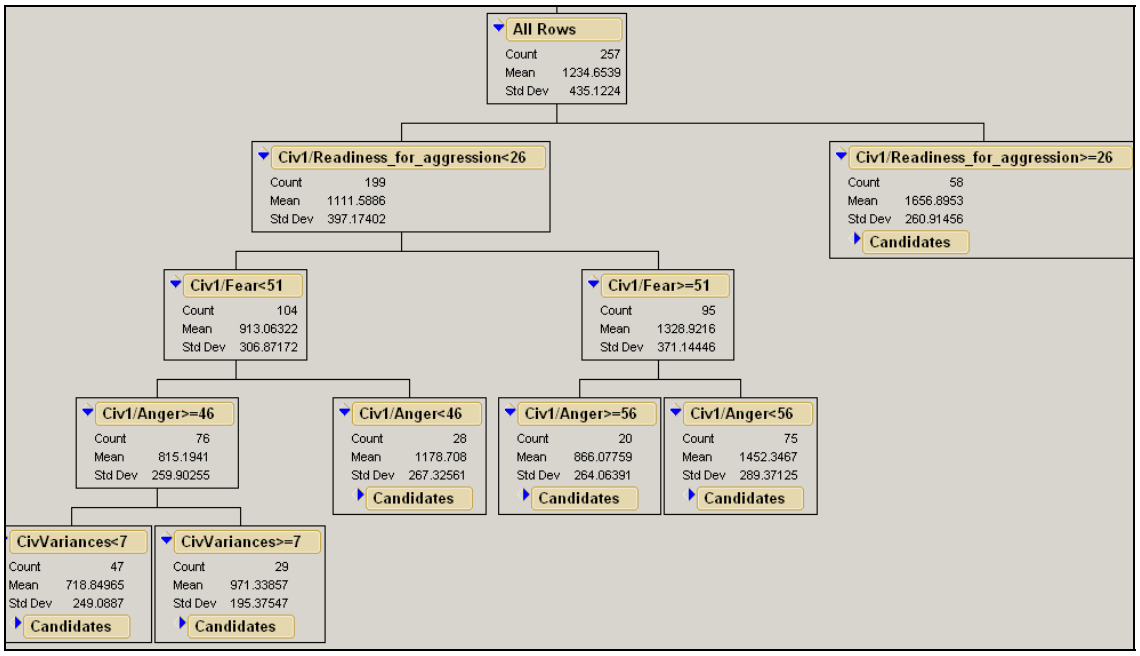

Figure 39 Homo+DisturberLead+CtrlRegion+Booth Aggregated Civilian Escalation Regression Tree

3. Model Fitting Analysis

a. Percentage of Votes

The percentage of votes cast by the civilians is the response of this model fitting analysis. In order to achieve a simple model for analysis, the "best" model was finally selected after a few cycles of manual fitting with the main effects, two-way interactions and quadratic terms. A satisfactory R^2 value of 0.74 and low p-values for all terms (i.e., highest at 0.05) were obtained. Refer to Figure 40 for details. Note that those factors highlighted by the regression tree were also included in the final model. A simple check of linearity on the selected model indicated an absence of non-linearity problems. Although there was some evidence of heteroskedacity, regression estimates are unbiased even when the error variance is not constant. So the regression metamodels can still be used to identify important terms. The metamodel for predicting the average civilian escalation is generated as follows:

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	10.8533	1.546886	7.02	<.0001
Civ1/Fear	0.1354387	0.013731	9.86	<.0001
Civ1/Anger	-0.133128	0.013734	-9.69	<.0001
Civ1/Readiness_for_aggression	-0.152275	0.013734	-11.09	<.0001
Civ2/Anger	-0.037695	0.013761	-2.74	0.0066
Civ3/Anger	-0.082969	0.013743	-6.04	<.0001
Civ3/Elective_motivation	0.166355	0.013764	12.09	<.0001
CivVariances	-0.195023	0.027301	-7.14	<.0001
PollSol/Rule_set{6&2&1&3&4-5}	-0.199869	0.101147	-1.98	0.0493
(Civ1/Fear-50.0078)*(Civ1/Readiness_for_aggression-20.0078)	0.0137177	0.002292	5.98	<.0001
(Civ1/Fear-50.0078)*(Civ3/Elective_motivation-80.0078)	-0.013036	0.002407	-5.41	<.0001
(Civ1/Anger-50.0078)*(Civ1/Readiness_for_aggression-20.0078)	-0.009299	0.002594	-3.58	0.0004
(Civ1/Anger-50.0078)*(Civ3/Elective_motivation-80.0078)	0.0155156	0.00251	6.18	<.0001
(Civ3/Anger-20.0078)*(Civ3/Elective_motivation-80.0078)	0.0124886	0.002296	5.44	<.0001

Figure 40 Homo+DisturberLead+CtrlRegion+Booth Vote Percentage Model Fit

Percentage of Votes Cast = *10.85 + 0.14(Civ1F) - 0.13(Civ1A) – 0.15(Civ1R) – 0.04(Civ2A) – 0.08(Civ3A) + 0.17(Civ3E) – 0.20(CivPV) – 0.20(PollROE) + 0.01(Civ1F-50.01)(Civ1R-20.01) - 0.01(Civ1F-50.01)(Civ3E-80.01) – 0.01(Civ1A-50.01)(Civ1R-20.01) + 0.02(Civ1A-50.01)(Civ3E-80.01) + 0.01(Civ3A-20.01)(Civ3E-80.01)*

Where: Civ1F = Civ1 – Sunni Bystander/Fearful Voter Fear

Civ1A = Civ1 – Sunni Bystander/Fearful Voter Anger

Civ1R = Civ1 – Sunni Bystander/Fearful Voter RFA

Civ2A = Civ2 – Sunni “Yes” Voter Anger

Civ3A = Civ3 – Sunni “No” Voter Anger

Civ3E = Civ3 – Sunni “No” Voter Elective Motivation

CivPV = Civilian Personality Variance

PollROE = Poll Soldier ROE {1&2&3&4&6 – 5}

Note that JMP has automatically grouped Poll Area Soldier’s ROE Set 1, 2, 3, 4 and 6 together (with value 1) as having the same effect on the response that is different from Poll Area Soldier’s ROE Set 5 (with value -1).

From the metamodel, the Civ1R and Civ3E terms stand out statistically from the rest with higher t ratio values. This agrees with the regression tree results. Overall, the results indicate that when the level of RFA among Civ1 (Sunni Bystander and Fearful Voters) increase, the percentage of votes will decrease. This is not desirable, as we want the percentage of votes to be high. On the contrary, if the level of elective motivation among Civ3 (Sunni "No" Voters) increase, the percentage of votes increase. This is preferred, as we want the percentage of votes to be high.

b. Aggregated Civilian Escalation

The civilian escalation accumulated during the entire simulation is the response of this model fitting analysis. In order to achieve a simple model for analysis, the "best" model was finally selected after a few cycles of manual fitting with the main effects, two-way interactions and quadratic terms. A satisfactory R^2 value of 0.71 and low p-values for all terms (i.e., highest at 0.06) were obtained. Refer to Figure 41 for details. Note that those factors highlighted by the regression tree were also included in the final model. A simple check of linearity and equal variance properties on the selected model indicated an absence of non-linearity and heteroskedacity problems. The metamodel for predicting the average civilian escalation is generated as follows:

Aggregated Civilian Escalation = *-2121.70 + 28.0(Civ1F) – 21.42(Civ1A) + 30.21(Civ1R) + 7.01(Civ4A) + 12.54(Civ4R) + 10.65(Civ5R) + 14.08(CivPV) – 28.84(PollROE) – 3.5(Civ1F-50.01)(Civ1R-20.01) – 4.15(Civ1F-50.01)(CivPV-5.0) + 2.64(Civ1A-50.01)(Civ1R-20.01) + 4.53(Civ1R-20.01)(Civ1R-20.01)*

Where: Civ1F = Civ1 – Sunni Bystander/Fearful Voter Fear

Civ1A = Civ1 – Sunni Bystander/Fearful Voter Anger

Civ1R = Civ1 – Sunni Bystander/Fearful Voter RFA

Civ4A = Civ4 – Sunni Trouble-Maker Voter Anger

Civ4R = Civ4 – Sunni Trouble-Maker Voter RFA

Civ5R = Civ5 – Disturber RFA

CivPV = Civilian Personality Variance

PollROE = Poll Soldier ROE {1&4&5&6 – 2&3}

Note that JMP has automatically grouped Poll Area Soldier's ROE Set 1, 4, 5 and 6 together (with value 1) as having the same effect on the response that is different from Poll Area Soldier's ROE Set 2 and 3 (with value -1).

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-2121.704	371.623	-5.71	<.0001
Civ1/Fear	27.993369	2.562441	10.92	<.0001
Civ1/Anger	-21.42443	2.562816	-8.36	<.0001
Civ1/Readiness_for_aggression	30.212528	2.58306	11.70	<.0001
Civ4/Anger	7.0057476	2.563526	2.73	0.0067
Civ4/Readiness_for_aggression	12.540679	2.562712	4.89	<.0001
Civ5/Readiness_for_aggression	10.646277	2.583818	4.12	<.0001
CivVariances	14.081407	5.095526	2.76	0.0062
PollSol/Rule_set{1&6&5&4-2&3}	-28.8355	15.54745	-1.85	0.0648
(Civ1/Fear-50.0078)*(Civ1/Readiness_for_aggression-20.0078)	-3.496919	0.42585	-8.21	<.0001
(Civ1/Fear-50.0078)*(CivVariances-5.00389)	-4.149789	0.977008	-4.25	<.0001
(Civ1/Anger-50.0078)*(Civ1/Readiness_for_aggression-20.0078)	2.6417806	0.480793	5.49	<.0001
(Civ1/Readiness_for_aggression-20.0078)*(Civ1/Readiness_for_aggression-20.0078)	4.5315946	0.490839	9.23	<.0001

Figure 41 Homo+DisturberLead+CtrlRegion+Booth Aggregated Civilian Escalation Model Fit

From the metamodel, the Civ1F and Civ1R terms stand out statistically from the rest with higher t ratio values. Overall, the results indicate that when the levels of fear and RFA among Civ1 (Sunni Bystander and Fearful Voters) increase, the level of aggregated civilian escalation will increase. This is not preferred, as we want the escalation to be low.

F. HOMO+TROUBLEMAKERLEAD+CTRLREGION RESULTS

The results for the Homo+TroubleMakerLead+CtrlRegion follow. Recall that this is one of the scenarios where low voter turnout and high escalation are likely.

1. Data Distribution Analysis

a. Percentage of Votes

Figure 42 shows the distribution of voter participation, in percent (i.e., the number of votes cast divided by the total number of registered voters) at the end of the election simulation.

This scenario corresponds to a town with a homogeneous Sunni population that had one of the lowest voting turnout rates for the October 2005 election. The simulation results show an average voter participation of about 15.4% with a standard deviation of about 2.7%. This result suggests that the simulation results are fairly consistent with the real-world results. The distribution of the shortest half bracket (i.e., showing the densest 50% of the observations) indicates that the civilian voting participation varies over a large range. The fact that the distribution has a wide spread with highest percentage of vote at 20% and lowest at 8.3% shows that at least some factors may make a difference.

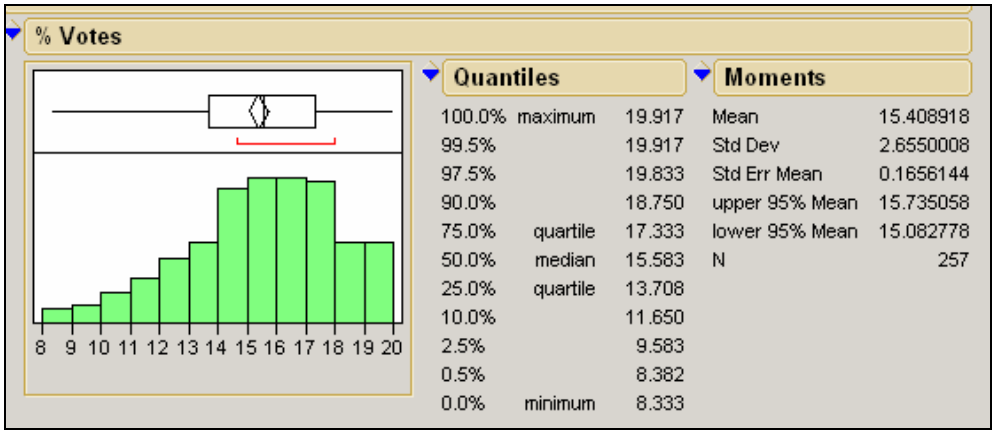

Figure 42 Homo+TroubleMakerLead+CtrlRegion Voter Participation

Comparing with the Homo+DisturberLead+CtrlRegion scenario, the voting participation in this Homo+TroubleMakerLead+CtrlRegion scenario (where both the scenarios do not have Election Booths deployed) shows very similar results.

b. Aggregated Civilian Escalation

Figure 43 shows the distribution of the civilian escalation accumulated in the scenario over the entire election simulation. The distribution

of civilian escalation demonstrated against other civilians is illustrated in Figure 44. The distribution of civilian escalation demonstrated against the soldiers is illustrated in Figure 45.

The aggregated civilian escalation that resulted in this scenario has a mean value of about 361.8 units (i.e., threatening or attacking actions). The aggregated civilian escalation against other civilian has a mean value of about 280.5 units (about 78% of the total escalation). The mean aggregated civilian escalation against the soldier has a mean value of about 81.3 units (about 22% of the total escalation). This result indicates that the majority of the escalation is among the civilians. This is an undesirable situation during an election.

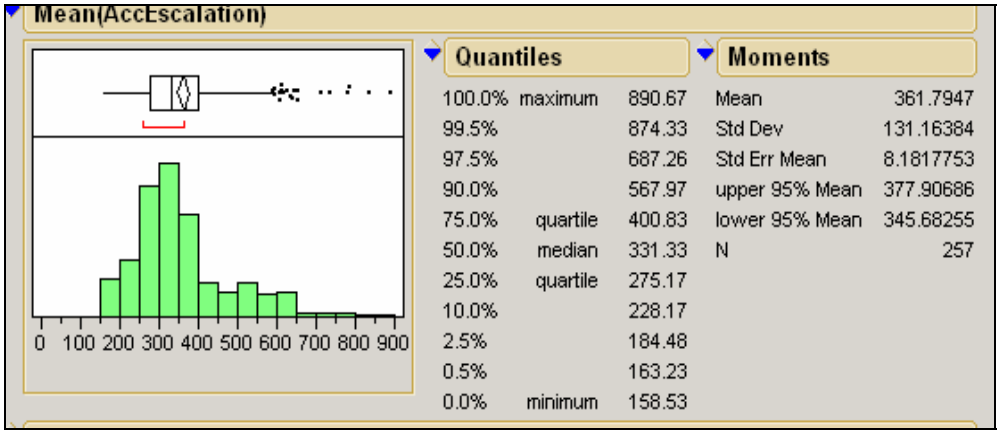

Figure 43 Homo+TroubleMakerLead+CtrlRegion Aggregated Civilian Escalation

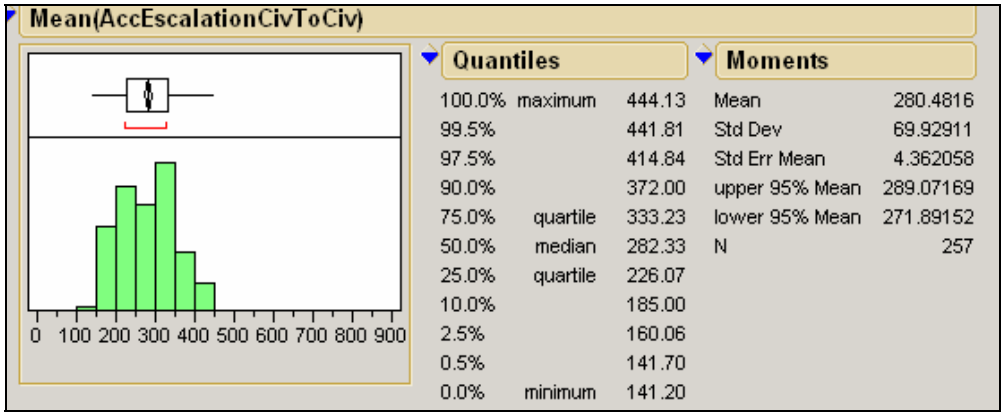

Figure 44 Homo+TroubleMakerLead+CtrlRegion Aggregated Civilian Escalation (Civilians against other Civilians)

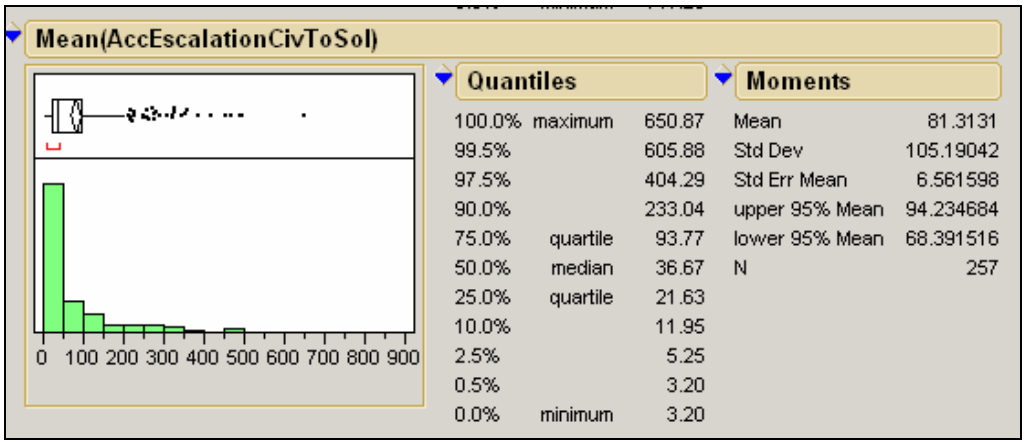

Figure 45 Homo+TroubleMakerLead+CtrlRegion Aggregated Civilian Escalation (Civilians against Soldiers)

Note that this scenario has a similar response as compared to the Homo+DisturberLead+CtrlRegion scenario. This suggests that there is no significant difference in the effect of leadership influences between disturber and trouble-maker groups in this homogeneous population scenario.

c. Average Civilian Fear, Anger and RFA

The distributions of the civilian average fear, anger and RFA level at the end of the entire election simulation are illustrated in Figure 46, Figure 47 and Figure 48A contour plot is shown in Figure 49 to illustrate the relationships between these three civilian personalities. Note that the maximum value for each factor is 100 units.

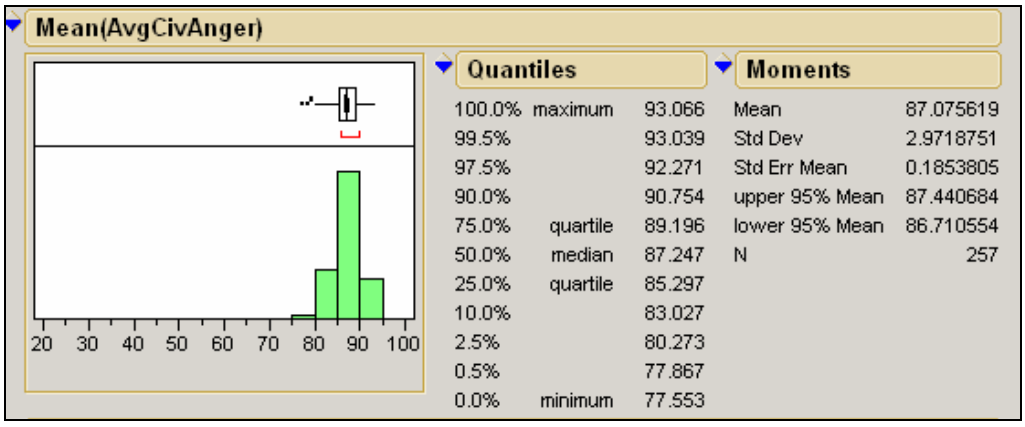

Figure 46 Homo+TroubleMakerLead+CtrlRegion Average Civilian Fear

The average civilian fear and anger levels are high, with mean values of about 88 and 87 units. This result indicates that, on average, the civilians are fearful and angry. However, the average RFA level has a much lower mean value of about only 31 units. This suggests that on an average, the civilians may be angry and agitated at times but they are not likely to act aggressively.

From the contour plot, it can be observed that the highest levels of civilian RFA occurred mostly when the civilian anger level is very high regardless of the civilian fear level. Note that this scenario has a similar response as compared to the Homo+DisturberLead+CtrlRegion scenario where the Disturber's leadership is modeled. This suggests that, on average, there is no significant difference between the Disturber's and Trouble-maker's leadership.

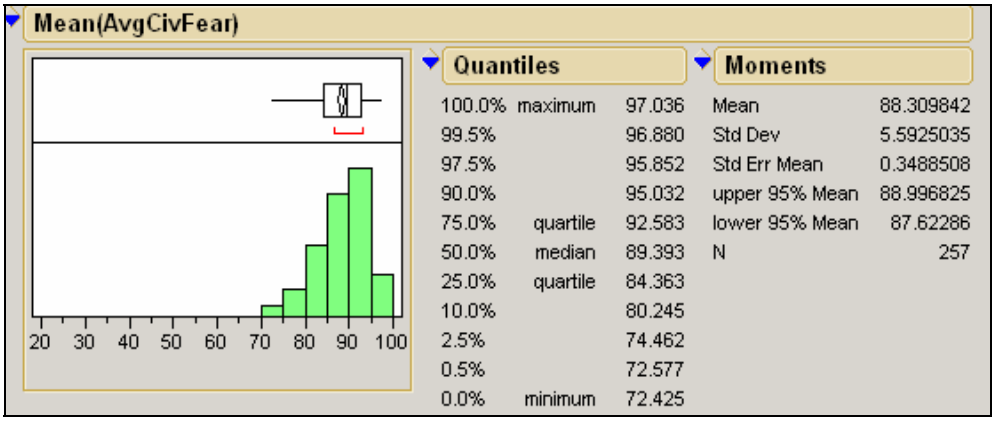

Figure 47 Homo+TroubleMakerLead+CtrlRegion Average Civilian Anger

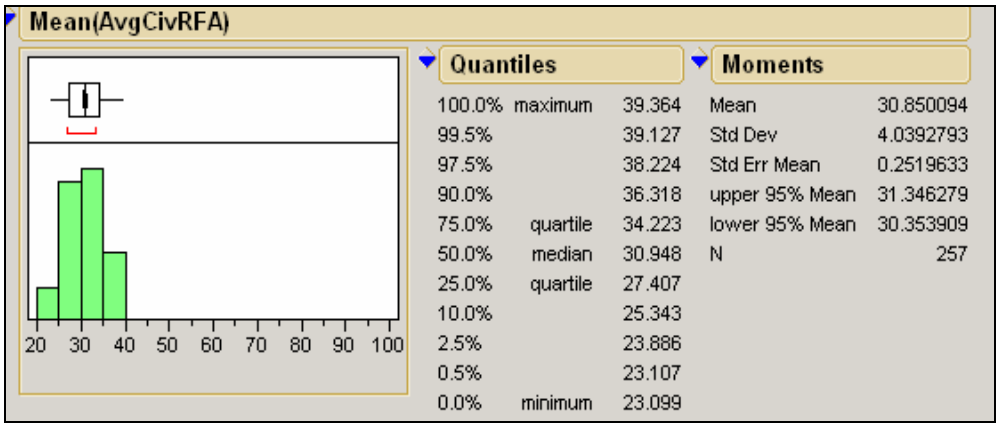

Figure 48 Homo+TroubleMakerLead+CtrlRegion Average Civilian RFA

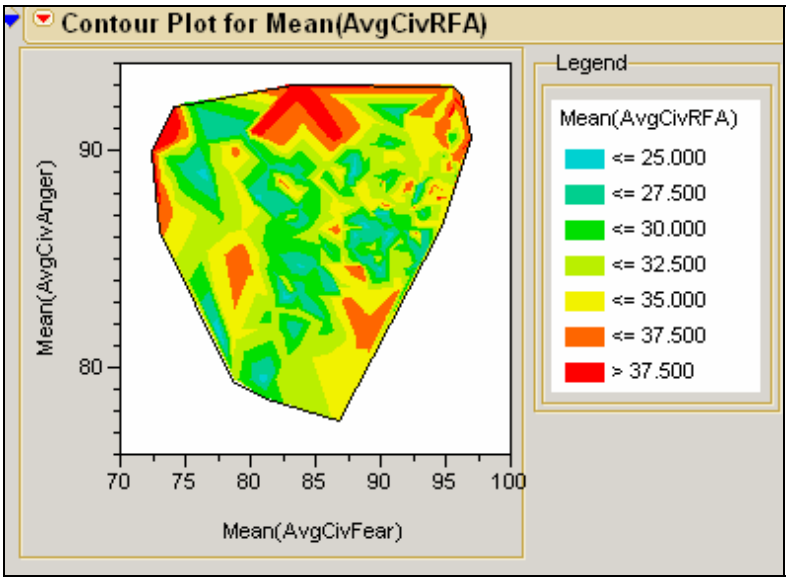

Figure 49 Homo+TroubleMakerLead+CtrlRegion Average Civilian Fear, Anger and RFA Contour Plot

2. Regression Tree Analysis

a. Percentage of Votes

The percentage of votes cast by the civilians is the response of the regression tree shown in Figure 50. This partition yields an R^2 value of 0.446, and indicates that the following design factor levels characterize those excursions where a high percentage of votes are observed:

- Civ1 – Sunni Bystander/Fearful Voter RFA (<26)
- Civ3 – Sunni "No" Voter Elective Motivation (>=75)
- Civilian Personality Variance (<6)
- Civ1 – Sunni Bystander/Fearful Voter Fear (<56)

The effect of Civ1 – Sunni Bystander/Fearful Voter RFA (>=26) and Civ1 – Sunni Bystander/Fearful Voter Anger (>=46) factors have contributed to causing a low percentage of votes cast.

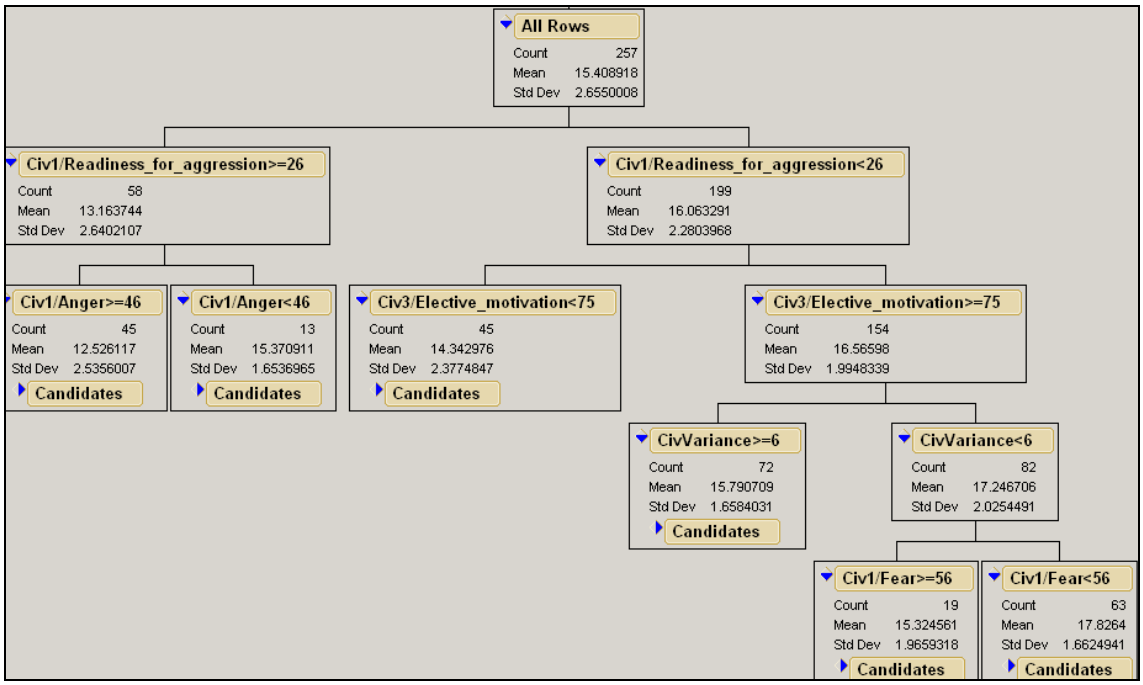

Figure 50 Homo+TroubleMakerLead+CtrlRegion Vote Percentage Regression Tree

b. Aggregated Civilian Escalation

The regression tree for accumulated civilian escalation yields an R^2 value of 0.774, as shown in Figure 51, indicates that the following design factor levels characterize those excursions where low aggregated civilian escalation is observed:

- Control Soldier ROE (Set 1, 2, 3, 5 & 6)
- Civ1 – Sunni Bystander/Fearful Voter Anger (<48)
- Civ1 – Sunni Bystander/Fearful Voter Fear (>=45)

The effects of the following design factors have contributed in causing high civilian escalation:

- Control Soldier ROE (Set 4 “Gandhi”)
- Civ1 – Sunni Bystander/Fearful Voter RFA (>=26)
- Civ5 – Sunni Disturber Voter Anger (<81)

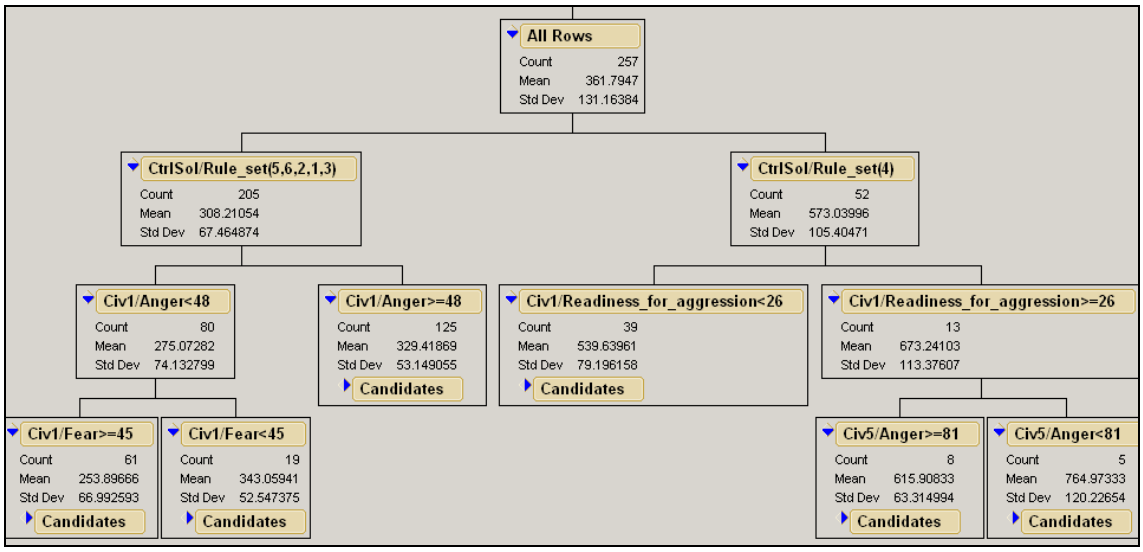

Figure 51 Homo+TroubleMakerLead+CtrlRegion Aggregated Civilian Escalation Regression Tree

3. Model Fitting Analysis

a. Percentage of Votes

The percentage of votes cast by the civilians is the response of this model fitting analysis. In order to achieve a simple model for analysis, the "best" model was finally selected after a few cycles of manual fitting with the main effects, two-way interactions and quadratic terms. A satisfactory R^2 value of 0.50 and low p-values for all terms (i.e., highest at 0.2) were obtained. Refer to Figure 52 for details. Note that those factors highlighted by the regression tree were also included in the final model. A simple check of linearity and equal variance properties on the selected model indicated an absence of non-linearity and heteroskedacity problems. The metamodel for predicting the average civilian escalation is generated as follows:

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	10.652601	2.073411	5.14	<.0001
Civ1/Readiness_for_aggression	-0.207221	0.020684	-10.02	<.0001
Civ2/Anger	-0.03173	0.020469	-1.55	0.1224
Civ3/Anger	-0.078516	0.02047	-3.84	0.0002
Civ3/Elective_motivation	0.1686283	0.020456	8.24	<.0001
Civ4/Willingness_for_Cooperation	-0.026777	0.020653	-1.30	0.1960
CivVariance	-0.202533	0.04066	-4.98	<.0001
PollSol/Rule_set{6&2&3-4&1&5}	-0.183932	0.12158	-1.51	0.1316
(PollSol/Rule_set{6&2&3-4&1&5}+0.00389)*(Civ1/Readiness_for_aggression-20.0078)	-0.057471	0.020757	-2.77	0.0061
(PollSol/Rule_set{6&2&3-4&1&5}+0.00389)*(Civ2/Anger-20.0078)	0.0499425	0.020589	2.43	0.0160
(Civ3/Anger-20.0078)*(Civ3/Elective_motivation-80.0078)	0.0162018	0.003372	4.80	<.0001

Figure 52 Homo+TroubleMakerLead+CtrlRegion Vote Percentage Model Fit

Percentage of Votes Cast = *10.65 – 0.21(Civ1R) – 0.03(Civ2A) – 0.08(Civ3A) + 0.17(Civ3E) – 0.03(Civ4W) – 0.20(CivPV) – 0.18(PollROE) - 0.06(PollROE+0.004)(Civ1R-20.01) + 0.05(PollROE+0.004)(Civ2A-20.01) + 0.02(Civ3A-20.01)(Civ3E-80.01)*

Where: Civ1R = Civ1 – Sunni Bystander/Fearful Voter RFA

Civ2A = Civ2 – Sunni “Yes” Voter Anger

Civ3A = Civ3 – Sunni “No” Voter Anger

Civ3E = Civ3 – Sunni “No” Voter Elective Motivation

Civ4W = Civ4 – Sunni Trouble-Maker Voter WillCoop

CivPV = Civilian Personality Variance

PollROE = Poll Soldier ROE {2&3&6 – 1&4&5}

Note that JMP has automatically grouped Poll Area Soldier’s ROE Set 2, 3 and 6 together (with value 1) as having the same effect on the response that is different from Poll Area Soldier’s ROE Set 1, 4 and 5 (with value -1).

From the metamodel, the Civ1R and Civ3E terms stand out statistically from the rest with higher t ratio values. This agrees with the regression tree results. Overall, the results indicate that when the level of RFA among Civ1 (Sunni Bystander and Fearful Voters) increase, the percentage of votes will decrease. This is not preferred, as we want the percentage of votes to

be high. Similarly, if the level of elective motivation among Civ3 (Sunni "No" Voters) increase, the percentage of votes will increase. This is desirable, as we want the percentage of votes to be high.

Note that, with comparison to Homo+DisturberLead+CtrlRegion scenario, this scenario has Civ4W term shown in the metamodel. This suggests that the effect of Trouble-Maker's leadership is statistically more significant than Disturber's leadership in contributing to the percentage of votes.

b. Aggregated Civilian Escalation

The civilian escalation accumulated during the entire simulation is the response of this model fitting analysis. In order to achieve a simple model for analysis, the "best" model was finally selected after a few cycles of manual fitting with the main effects, two-way interactions and quadratic terms. A satisfactory R^2 value of 0.80 and low p-values for all terms (i.e., highest at 0.07) were obtained. Refer to Figure 53 for details. Note that those factors highlighted by the regression tree were also included in the final model. A simple check of linearity and equal variance properties on the selected model indicated an absence of non-linearity and heteroskedacity problems. The metamodel for predicting the average civilian escalation is generated as follows:

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-27.64347	96.36298	-0.29	0.7745
Civ1/Fear	-2.923816	0.652073	-4.48	<.0001
Civ1/Anger	3.0125236	0.652982	4.61	<.0001
Civ1/Readiness_for_aggression	1.1994567	0.651426	1.84	0.0668
Civ2/Readiness_for_aggression	1.598159	0.649044	2.46	0.0145
Civ4/Readiness_for_aggression	2.745464	0.657741	4.17	<.0001
Civ4/Willingness_for_Cooperation	1.1925457	0.651295	1.83	0.0683
Civ5/Fear	-1.849237	0.658766	-2.81	0.0054
Civ5/Readiness_for_aggression	2.0828065	0.648374	3.21	0.0015
CtrlSol/Rule_set{5&6&2&1&3-4}	-130.8734	4.802347	-27.25	<.0001
(CtrlSol/Rule_set{5&6&2&1&3-4}-0.59533)*(Civ1/Fear-50.0078)	-3.188583	0.820293	-3.89	0.0001
(CtrlSol/Rule_set{5&6&2&1&3-4}-0.59533)*(Civ1/Anger-50.0078)	4.0148648	0.840045	4.78	<.0001
(CtrlSol/Rule_set{5&6&2&1&3-4}-0.59533)*(Civ1/Readiness_for_aggression-20.0078)	-4.500625	0.804503	-5.59	<.0001

Figure 53 Homo+TroubleMakerLead+CtrlRegion Aggregated Civilian Escalation Model Fit

Aggregated Civilian Escalation = *-27.64 – 2.92(Civ1F) + 3.01(Civ1A) + 1.2(Civ1R) + 1.6(Civ2R) + 2.75(Civ4R) + 1.19(Civ4W) – 1.85(Civ5F) + 2.08(Civ5R) – 130.87(CtrlROE) – 3.19(CtrlROE-0.6)(Civ1F-50.01) + 4.01(CtrlROE-0.6)(Civ1A-50.01) – 4.5(CtrlROE-0.6)(Civ1R-20.01)*

Where: Civ1F = Civ1 – Sunni Bystander/Fearful Voter Fear

Civ1A = Civ1 – Sunni Bystander/Fearful Voter Anger

Civ1R = Civ1 – Sunni Bystander/Fearful Voter RFA

Civ2R = Civ2 – Sunni "Yes" Voter RFA

Civ4R = Civ4 – Sunni Trouble-Maker Voter RFA

Civ4W = Civ4 – Sunni Trouble-Maker Voter WillCoop

Civ5F = Civ5 – Disturber Fear

Civ5R = Civ5 – Disturber RFA

CtrlROE = Control Soldier ROE {1&2&3&5&6 – 4}

Note that JMP has automatically grouped Control Area Soldier's ROE Set 1, 2, 3, 5 and 6 together (with value 1) as having the same effect on the response that is different from Control Area Soldier's ROE Set 4 (with value -1).

From the metamodel, the CtrlROE term stands out statistically from the rest with a very high t ratio value. Overall, the result indicates that when Control Area Admission Control Soldier employ ROE Set 1, 2, 3, 5 and 6, the level of aggregated civilian escalation will decrease, which is excellent as we want the civilian escalation to be minimized. Therefore, ROE Set 1, 2, 3, 5 and 6 are excellent choices for Control Area in this election scenario.

Note that, with comparison to Homo+DisturberLead+CtrlRegion scenario, this scenario has Civ4W term shown in the metamodel. This again suggests that the effect of Trouble-Maker's leadership is statistically more significant than Disturber's leadership in contributing to the civilian escalation.

G. HOMO+TROUBLEMAKERLEAD+CTRLREGION+BOOTH RESULTS

The results for the Homo+TroubleMakerLead+CtrlRegion+Booth follow. Recall that this is one of the scenarios where low voter turnout and high escalation are likely.

1. Data Distribution Analysis

a. Percentage of Votes

In this experiment, the deployments of Election Booths are implemented similar to the Homo+DisturberLead+CtrlRegion+Booth scenario. Figure 54 shows the distribution of voter participation, in percent (i.e., the number of votes cast divided by the total number of registered voters) at the end of the election simulation.

This scenario corresponds to a town with a homogeneous Sunni population that had one of the lowest voting turnout rates for the October 2005 election. The simulation results show an average voter participation of about 17.3% with a standard deviation of about 2.8%. This result suggests that the simulation results are fairly consistent with the real-world results. The distribution of the shortest half bracket (i.e., showing the densest 50% of the observations) indicated that the civilian voting participation varies over only a small range. Similar results can be observed from the quantile box plot, where the majority of the data is skewed towards the right. The fact that the distribution has a wide spread with highest percentage of vote at 20% and lowest at 7% shows that at least some factors may make a difference.

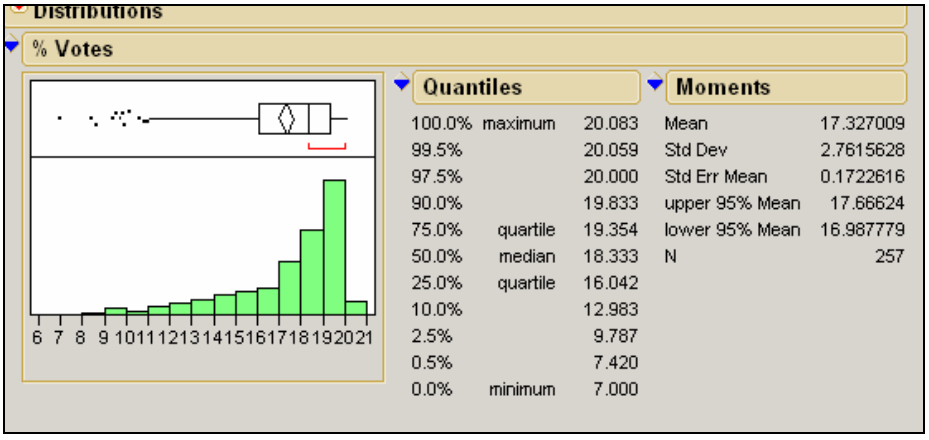

Figure 54 Homo+TroubleMakerLead+CtrlRegion+Booth Voter Participation

Compared with the Homo+TroubleMakerLead+CtrlRegion scenario, the voter participation in this Homo+TroubleMakerLead+CtrlRegion+Booth scenario, where Election Booths are implemented, has shown improvement of about 1.9% on average with about the same standard deviation. Tighter voter participation distribution towards the high side is also observed in this scenario.

Note that this Homo+TroubleMakerLead+CtrlRegion+Booth scenario results have similar good responses as the Homo+DisturberLead+CtrlRegion+Booth scenario where both scenarios have Election Booths deployed. Similar improvement results are achieved over the comparisons with their similar scenario where Election Booths are not deployed.

b. Aggregated Civilian Escalation

Figure 55 shows the distribution of the civilian escalation accumulated in the scenario over the entire election simulation. The distribution of civilian escalation demonstrated against other civilians is illustrated in Figure 56. The distribution of civilian escalation demonstrated against the soldiers is illustrated in Figure 57.

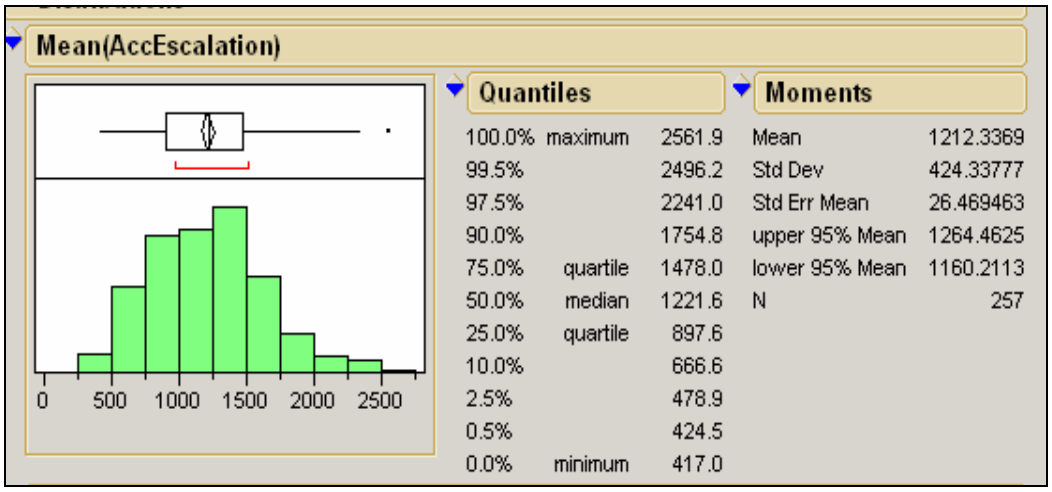

Figure 55 Homo+TroubleMakerLead+CtrlRegion+Booth Aggregated Civilian Escalation

The aggregated civilian escalation that resulted in this scenario has a mean value at about 1212.3 units (i.e., threatening or attacking actions). The aggregated civilian escalation against other civilian has a mean value of about

398.8 units (about 33% of the total escalation). The mean aggregated civilian escalation against the soldier has a mean value of about 813.5 units (about 67% of the total escalation).

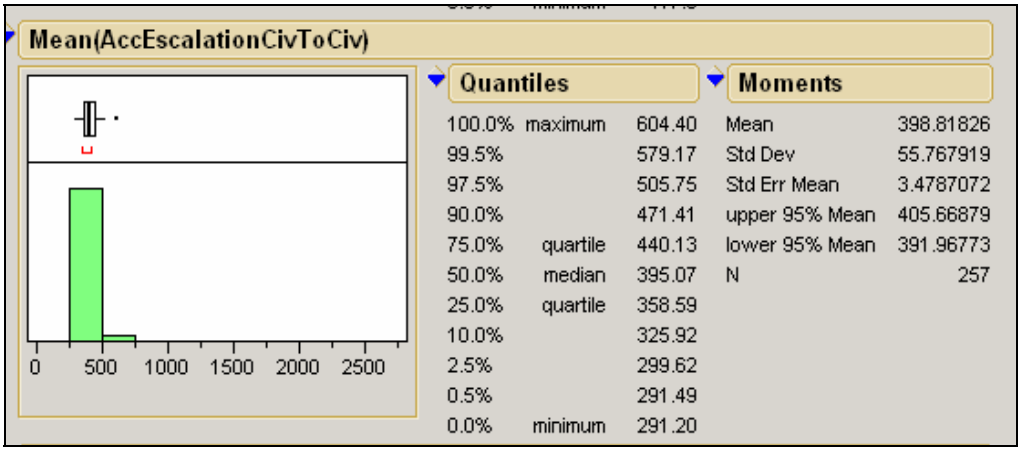

Figure 56 Homo+TroubleMakerLead+CtrlRegion+Booth Aggregated Civilian Escalation (Civilians against other Civilians)

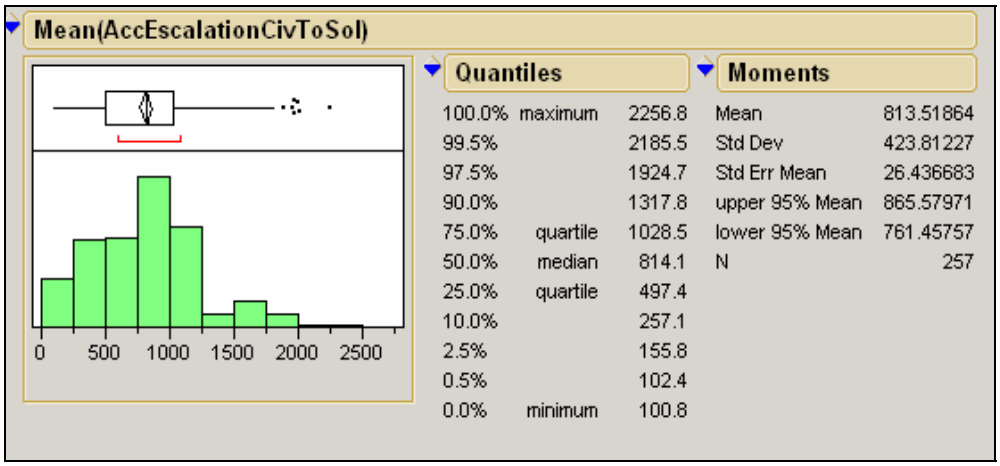

Figure 57 Homo+TroubleMakerLead+CtrlRegion+Booth Aggregated Civilian Escalation (Civilians against Soldiers)

This result has a similar response as compared to the Homo+DisturberLead+CtrlRegion+Booth scenario, where huge increases in civilian escalation are observed. The majority of the time the escalation is between the civilians and soldiers. Similarly, this scenario has improvement in its voter participation, therefore supporting the same indication that the implementation of the Election Booths had managed to attract the hostile civilians

towards them and minimized the interactions among the civilians. This allows more motivated civilians to participate in the voting. Therefore, this situation is also considered controllable and is a desired election proceeding.

c. Average Civilian Fear, Anger and RFA

The distributions of the civilian average fear, anger and RFA level at the end of the entire election simulation are illustrated in Figure 58, Figure 59 and Figure 60. A contour plot is shown in Figure 61 to illustrate the relationships between these three civilian personalities. Note that the maximum value for each factor is 100 units.

The average civilian fear and anger levels are high, with mean values of about 78 and 86 units. This result indicates that, on average, the civilians are fearful and angry. However, the average RFA level has a much lower mean value of about only 32 units. This suggests that on an average, the civilians may be angry and agitated at times but they are not likely to act aggressively.

Note that the civilian fear level has dropped by 10 units as compared to the Homo+TroublemakerLead+CtrlRegion scenario where no Election Booths are deployed. This suggests that the Election Booths deployed in this scenario are gaining positive responses from the civilians. On an average, Civilians are now less fearful and are coming out from their homes to participate in the election.

From the contour plot, it can be observed that the highest levels of civilian RFA occurred mostly when the civilian fear level was low and anger level was very high. It is also observed that when the civilian fear level was very high, the amount of civilian RFA was always low regardless of the civilian anger level. This suggests that on average, the civilian fear may be a significant factor contributing to the low civilian RFA. Note that this scenario has a similar response as compared to the Homo+DisturberLead+CtrlRegion+Booth scenario

where the Disturber's leadership is modeled. This suggests that, on average, there is no significant difference between the Disturber's and Trouble-maker's leadership.

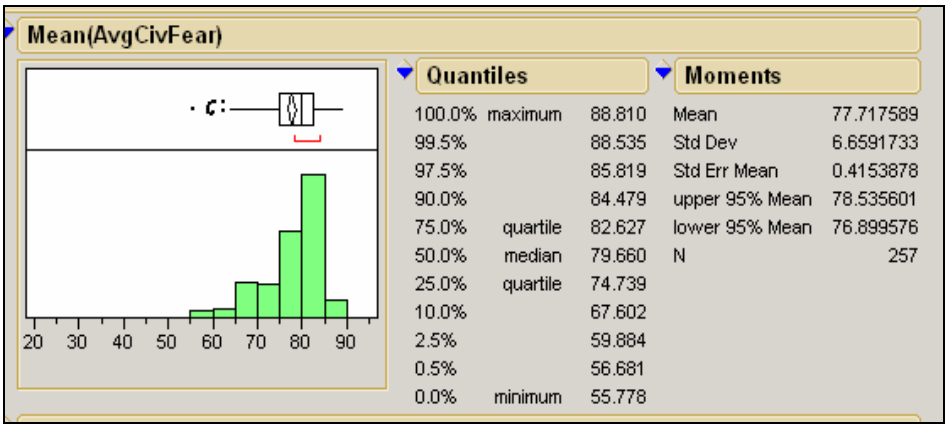

Figure 58 Homo+TroubleMakerLead+CtrlRegion+Booth Average Civilian Fear

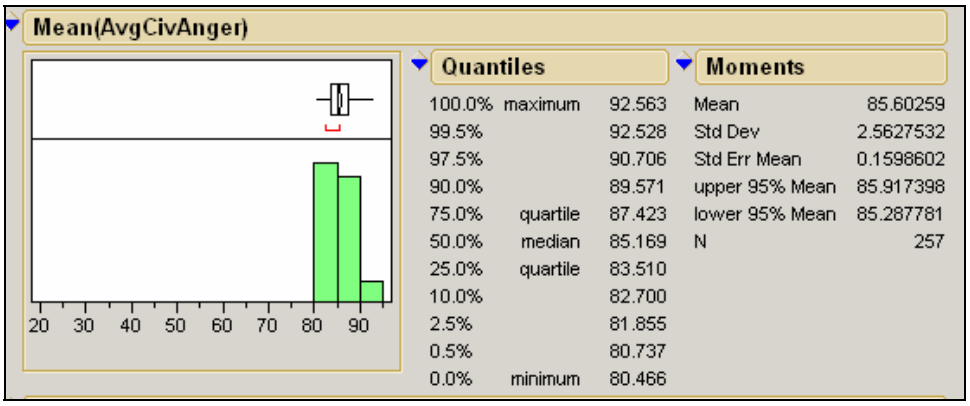

Figure 59 Homo+TroubleMakerLead+CtrlRegion+Booth Average Civilian Anger

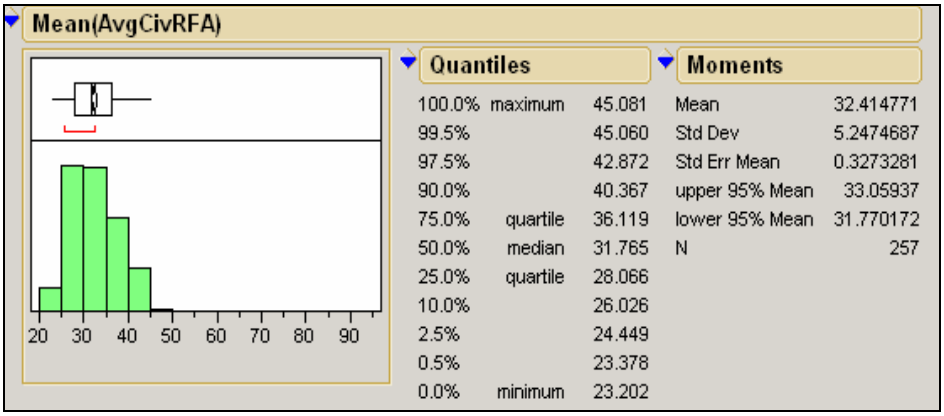

Figure 60 Homo+TroubleMakerLead+CtrlRegion+Booth Average Civilian RFA

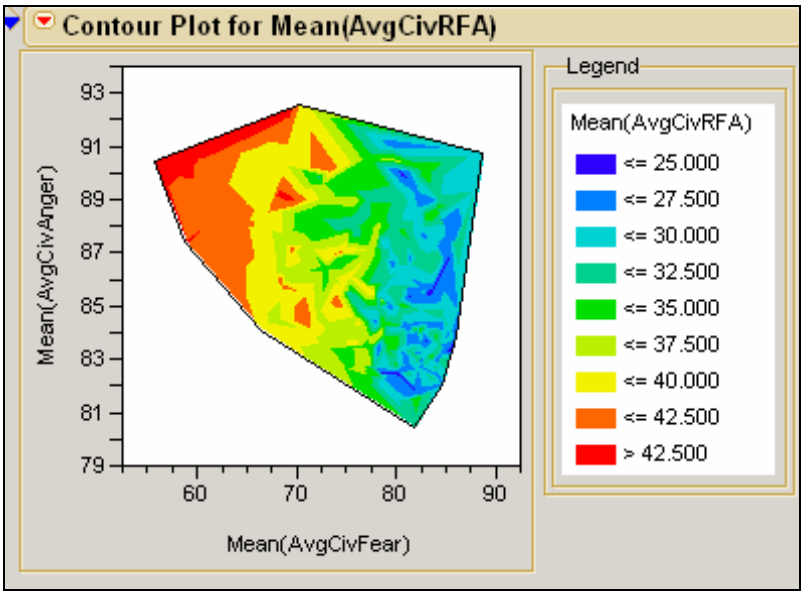

Figure 61 Homo+TroubleMakerLead+CtrlRegion+Booth Average Civilian Fear, Anger and RFA Contour Plot

2. Regression Tree Analysis

a. Percentage of Votes

The percentage of votes cast by the civilians is the response of the regression tree shown in Figure 62. This partition yields an R^2 value of 0.463, and indicates that the following design factor levels characterize those excursions where a high percentage of votes are observed:

- Civ1 – Sunni Bystander/Fearful Voter RFA (<28)
- Civ3 – Sunni "No" Voter Elective Motivation (>=75)

The effect of Civ1 – Sunni Bystander/Fearful Voter RFA (>=28) and Civ1 – Sunni Bystander/Fearful Voter Fear (<46) factors have contributed in causing a low percentage of votes cast.

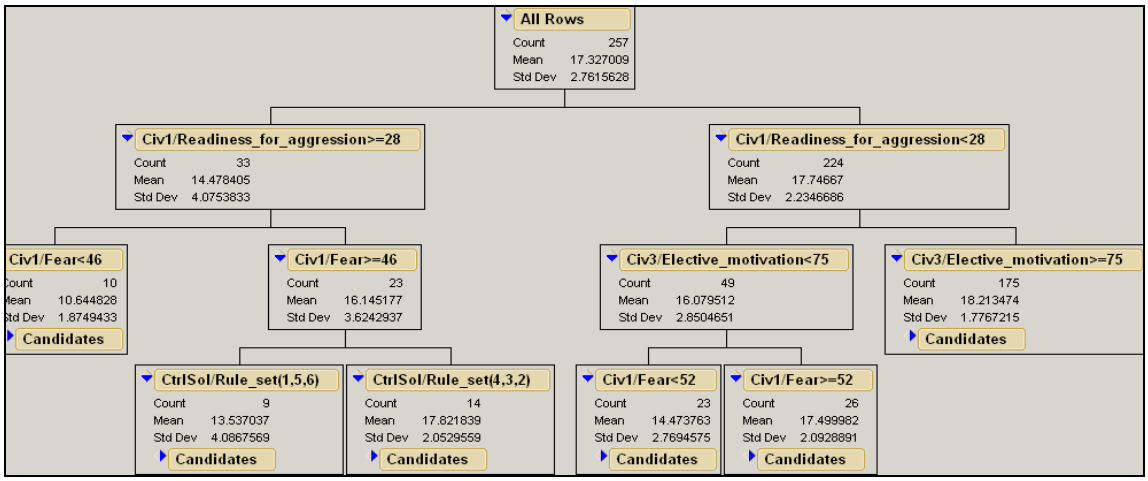

Figure 62 Homo+TroubleMakerLead+CtrlRegion+Booth Vote Percentage Regression Tree

b. Aggregated Civilian Escalation

The regression tree for accumulated civilian escalation yields an R^2 value of 0.66, as shown in Figure 63, indicates that the following design factor levels characterize those excursions where low aggregated civilian escalation is observed:

- Civ1 – Sunni Bystander/Fearful Voter RFA (<26)
- Civ1 – Sunni Bystander/Fearful Voter Anger (>=56)

The effect of the following design factors have contributed in causing high civilian escalation:

- Civ1 – Sunni Bystander/Fearful Voter RFA (>=26)
- Civ1 – Sunni Bystander/Fearful Voter Anger (>=46)
- Civ1 – Sunni Bystander/Fearful Voter Fear (<54)

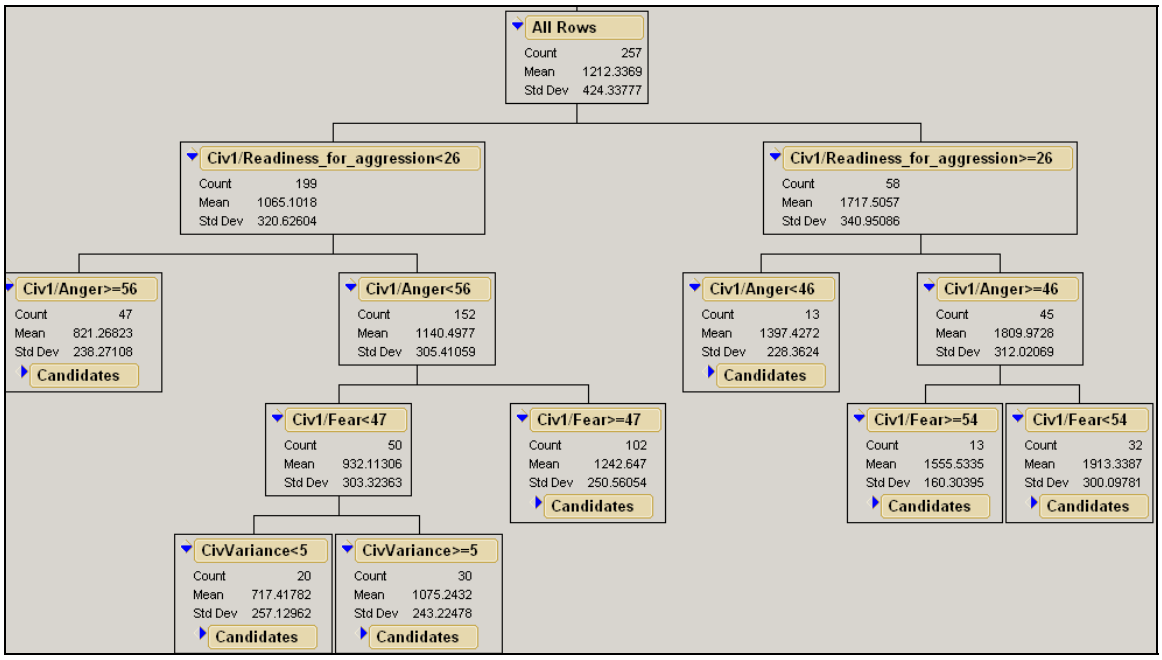

Figure 63 Homo+TroubleMakerLead+CtrlRegion+Booth Aggregated Civilian Escalation Regression Tree

3. Model Fitting Analysis

a. Percentage of Votes

The percentage of votes cast by the civilians is the response of this model fitting analysis. In order to achieve a simple model for analysis, the "best" model was finally selected after a few cycles of manual fitting with the main effects, two-way interactions and quadratic terms. A satisfactory R^2 value of 0.71 and low p-values for all terms (i.e., highest at 0.2) were obtained. Refer to Figure 64 for details. Note that those factors highlighted by the regression tree were also included in the final model. A simple check of linearity on the selected model indicated an absence of any non-linearity problems. The metamodel for predicting the average civilian escalation is generated as follows:

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	15.942865	2.46352	6.47	<.0001
Civ1/Fear	0.1297937	0.01661	7.81	<.0001
Civ1/Anger	-0.126823	0.016642	-7.62	<.0001
Civ1/Readiness_for_aggression	-0.182949	0.016636	-11.00	<.0001
Civ2/Anger	-0.048345	0.016695	-2.90	0.0041
Civ3/Anger	-0.089882	0.016613	-5.41	<.0001
Civ3/Readiness_for_aggression	-0.026612	0.016641	-1.60	0.1111
Civ3/Elective_motivation	0.1719266	0.016684	10.30	<.0001
Civ4/Willingness_for_Cooperation	-0.026412	0.016625	-1.59	0.1134
Civ5/Anger	-0.039796	0.016611	-2.40	0.0174
CivVariance	-0.199716	0.033023	-6.05	<.0001
CtrlSol/Rule_set{2&1&6&4-3}	-0.152807	0.123671	-1.24	0.2178
(Civ1/Fear-50.0078)*(Civ1/Readiness_for_aggression-20.0078)	0.0195065	0.002772	7.04	<.0001
(Civ1/Fear-50.0078)*(Civ3/Elective_motivation-80.0078)	-0.014382	0.002915	-4.93	<.0001
(Civ1/Anger-50.0078)*(Civ1/Readiness_for_aggression-20.0078)	-0.013287	0.003145	-4.23	<.0001
(Civ1/Anger-50.0078)*(Civ3/Elective_motivation-80.0078)	0.0149618	0.003044	4.92	<.0001
(Civ3/Anger-20.0078)*(Civ3/Elective_motivation-80.0078)	0.0147724	0.002784	5.31	<.0001
(Civ1/Anger-50.0078)*(Civ3/Anger-20.0078)	-0.008449	0.003147	-2.69	0.0078

Figure 64 Homo+TroubleMakerLead+CtrlRegion+Booth Vote Percentage Model Fit

Percentage of Votes Cast = *15.94 + 0.13(Civ1F) – 0.13(Civ1A) – 0.18(Civ1R) – 0.05(Civ2A) – 0.09(Civ3A) – 0.03(Civ3R) + 0.17(Civ3E) – 0.03(Civ4W) – 0.04(Civ5A) – 0.2(CivPV) – 0.15(CtrlROE) + 0.02(Civ1F-50.01)(Civ1R-20.01) – 0.01(Civ1F-50.01)(Civ3E-80.01) – 0.01(Civ1A-50.01)(Civ1R-20.01) + 0.01(Civ1A-50.01)(Civ3E-80.01) + 0.01(Civ3A-20.01)(Civ3E-80.01) – 0.01(Civ1A-50.01)(Civ3A-20.01)*

Where: Civ1F = Civ1 – Sunni Bystander/Fearful Voter Fear

Civ1A = Civ1 – Sunni Bystander/Fearful Voter Anger

Civ1R = Civ1 – Sunni Bystander/Fearful Voter RFA

Civ2A = Civ2 – Sunni “Yes” Voter Anger

Civ3A = Civ3 – Sunni “No” Voter Anger

Civ3R = Civ3 – Sunni “No” Voter RFA

Civ3E = Civ3 – Sunni “No” Voter Elective Motivation

Civ4W = Civ4 – Sunni Trouble-Maker Voter WillCoop

Civ5A = Civ5 – Disturber Anger

CivPV = Civilian Personality Variance

CtrlROE = Control Soldier ROE {1&2&4&6 – 3}

Note that JMP has automatically grouped Control Area Soldier's ROE Set 1, 2, 4 and 6 together (with value 1) as having the same effect on the response that is different from Control Area Soldier's ROE Set 3 (with value -1).

From the metamodel, the Civ1R and Civ3E terms stand out statistically from the rest with higher t ratio values. Overall, the results indicate that when the level of RFA among Civ1 (Sunni Bystander and Fearful Voters) increase, the percentage of votes will decrease. This is not preferred, as we want the percentage of votes to be high. On the contrary, if the level of elective motivation among Civ3 (Sunni "No" Voters) increase, the percentage of votes will increase. This is desirable, as we want the percentage of votes to be high.

b. Aggregated Civilian Escalation

The civilian escalation accumulated during the entire simulation is the response of this model fitting analysis. In order to achieve a simple model for analysis, the "best" model was finally selected after a few cycles of manual fitting with the main effects, two-way interactions and quadratic terms. A satisfactory R^2 value of 0.6 and low p-values for all terms (i.e., highest at 0.02) were obtained. Refer to Figure 65 for details. Note that those factors highlighted by the regression tree were also included in the final model. A simple check of linearity and equal variance properties on the selected model indicated an absence of non-linearity and heteroskedacity problems. The metamodel for predicting the average civilian escalation is generated as follows:

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-1952.206	425.2561	-4.59	<.0001
Civ1/Fear	12.886079	2.932664	4.39	<.0001
Civ1/Anger	-10.87874	2.933152	-3.71	0.0003
Civ1/Readiness_for_aggression	38.826969	2.960224	13.12	<.0001
Civ4/Anger	8.3834569	2.934053	2.86	0.0046
Civ4/Readiness_for_aggression	10.288156	2.933029	3.51	0.0005
Civ5/Readiness_for_aggression	11.104774	2.933621	3.79	0.0002
CivVariance	30.636187	5.831573	5.25	<.0001
PollSol/Rule_set{1&6&5&4-2&3}	-43.71061	18.02044	-2.43	0.0160
PollSol/Rule_set{1&6-5&4}	-61.44845	23.47139	-2.62	0.0094
(Civ1/Fear-50.0078)*(Civ1/Readiness_for_aggression-20.0078)	-3.580147	0.487069	-7.35	<.0001
(Civ1/Anger-50.0078)*(Civ1/Readiness_for_aggression-20.0078)	3.3530055	0.554487	6.05	<.0001

Effect Tests

Figure 65 Homo+TroubleMakerLead+CtrlRegion+Booth Aggregated Civilian Escalation Model Fit

Aggregated Civilian Escalation = *-1952.21 + 12.89(Civ1F) – 10.88(Civ1A) + 38.83(Civ1R) + 8.38(Civ4A) + 10.29(Civ4R) + 11.1(Civ5R) + 30.64(CivPV) – 43.71(PollROE1) – 61.45(PollROE2) – 3.58(Civ1F-50.01)(Civ1R-20.01) + 3.35(Civ1A-50.01)(Civ1R-20.01)*

Where: Civ1F = Civ1 – Sunni Bystander/Fearful Voter Fear

Civ1A = Civ1 – Sunni Bystander/Fearful Voter Anger

Civ1R = Civ1 – Sunni Bystander/Fearful Voter RFA

Civ4A = Civ4 – Sunni Trouble-Maker Voter Anger

Civ4R = Civ4 – Sunni Trouble-Maker Voter RFA

Civ5R = Civ5 – Disturber RFA

CivPV = Civilian Personality Variance

PollROE1 = Poll Soldier ROE {1&4&5&6 –2&3}

PollROE2 = Poll Soldier ROE {1&4&5&6}

Note that JMP has automatically grouped Poll Area Soldier's ROE Set 1, 4, 5 and 6 together (with value 1) as having the same effect on the response that is different from Poll Area Soldier's ROE Set 2 and 3 (with value -1).

From the metamodel, the Civ1R term stands out statistically from the rest with a very high t ratio value. Overall, the result indicates that when the level of RFA among Civ1 (Sunni Bystander and Fearful Voters) increase, the level of aggregated civilian escalation will increase. This is not preferred, as we want the escalation to be low.

H. HETER+DISTURBERLEAD+CTRLREGION RESULTS

The results for the Heter+DisturberLead+CtrlRegion follow. Recall that this is one of the scenarios where high voter turnout and high escalation are likely.

1. Data Distribution Analysis

a. Percentage of Votes

In this mixed population scenario, a high voting turnout rate is expected. However, the increase in the civilian participation from different groups may result in a surge of civilian conflicts during the election proceeding. This surge could affect the voter participation rate. Figure 66 shows the distribution of voter participation, in percent (i.e., the number of votes cast divided by the total number of registered voters) at the end of the election simulation.

This scenario corresponds to a town with a heterogeneous Sunni and Shiite/Kurd population that had one of the highest voting turnout rates for the October 2005 election. The simulation results show an average voter participation of about 28.3% with a standard deviation of about 6.2%. This result has certainly showed a better voter participation rate over those results achieved in the homogeneous Sunni population scenarios. The distribution of the shortest half bracket (i.e., showing the densest 50% of the observations) indicates that the civilian voting participation varies over a large range. This result is much lower than expected in the hypothetical scenario. This could due to the fact that different ROE rule sets, human behaviors, etc., are modeled in the simulations. However, the fact that the distribution has a wide spread with highest percentage of vote at 45% and lowest at 12% shows that at least some factors may make a difference.

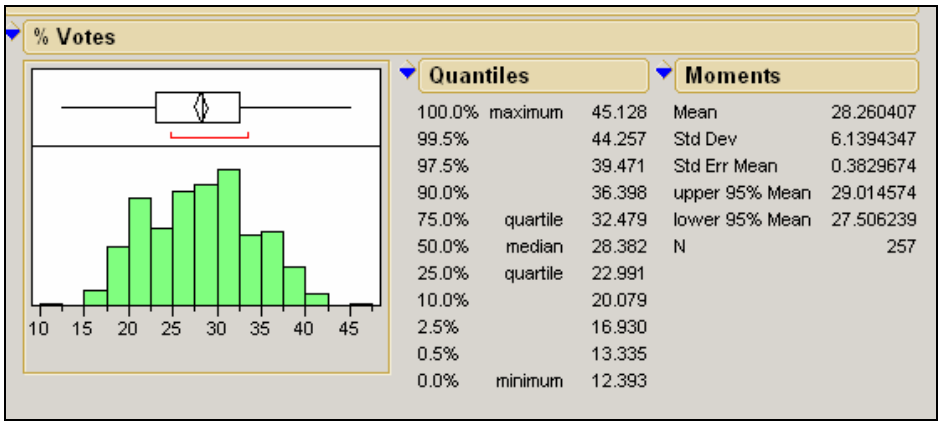

Figure 66 Heter+DisturberLead+CtrlRegion Voter Participation

b. Aggregated Civilian Escalation

Figure 67 shows the distribution of the civilian escalation accumulated in the scenario over the entire election simulation. The distribution of civilian escalation demonstrated against other civilians is illustrated in 0. The distribution of civilian escalation demonstrated against the soldiers is illustrated in Figure 69.

The aggregated civilian escalation results in this scenario have a mean value of about 251.6 units (i.e., threatening or attacking actions). The aggregated civilian escalation against other civilians has a mean value of about 197 units (about 78% of the total escalation). The mean aggregated civilian escalation against the soldier has a mean value of about 54.7 units (about 22% of the total escalation). This result indicates that the majority of the escalation is among the civilians. This is a undesirable situation during an election. However, it is observed that this scenario has a lower civilian escalation as compared to the Homo+DisturberLead+CtrlRegion scenario.

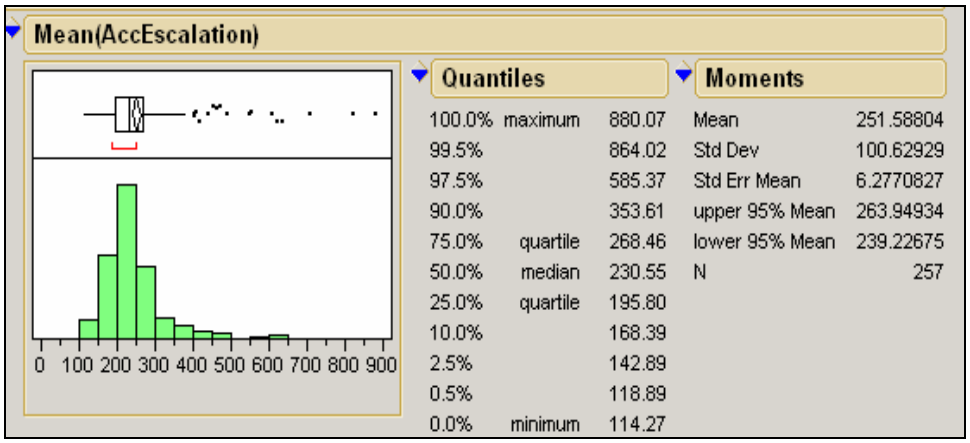

Figure 67 Heter+DisturberLead+CtrlRegion Aggregated Civilian Escalation

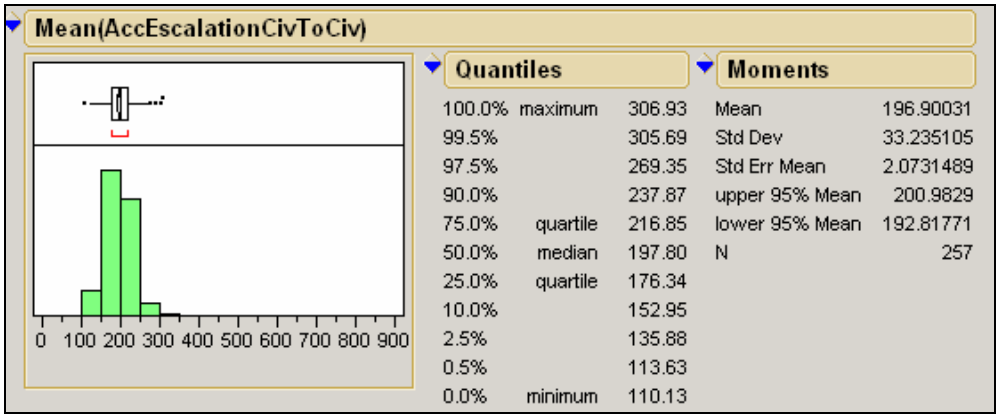

Figure 68 Heter+DisturberLead+CtrlRegion Aggregated Civilian Escalation (Civilians against other Civilians)

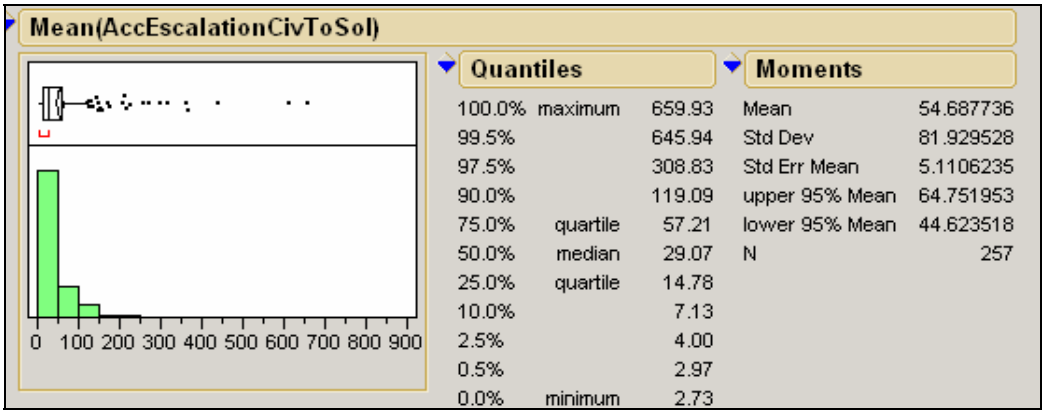

Figure 69 Heter+DisturberLead+CtrlRegion Aggregated Civilian Escalation (Civilians against Soldiers)

c. Average Civilian Fear, Anger and RFA

The distributions of the civilian average fear, anger and RFA level at the end of the entire election simulation are illustrated in Figure 70, Figure 71 and Figure 72. A contour plot is shown in Figure 73 to illustrate the relationships between these three civilian personalities. Note that the maximum value for each factor is 100 units.

The average civilian fear and anger levels are high, with mean values of about 88 and 81 units. This result indicates that, on average, the civilians are fearful and angry. However, the average RFA level has a much lower mean value of about only 27 units. This suggests that on an average, the civilians may be angry and agitated at times but they are not likely to act aggressively.

From the contour plot, it can be observed that the highest levels of civilian RFA occur mostly when the civilian fear and anger levels are both very high. Note that this scenario has a similar civilian fear and anger response as compared to the Homo+DisturberLead+CtrlRegion scenario where the homogeneous population is modeled. On average, it has a slight decrease in civilian RFA of about five units.

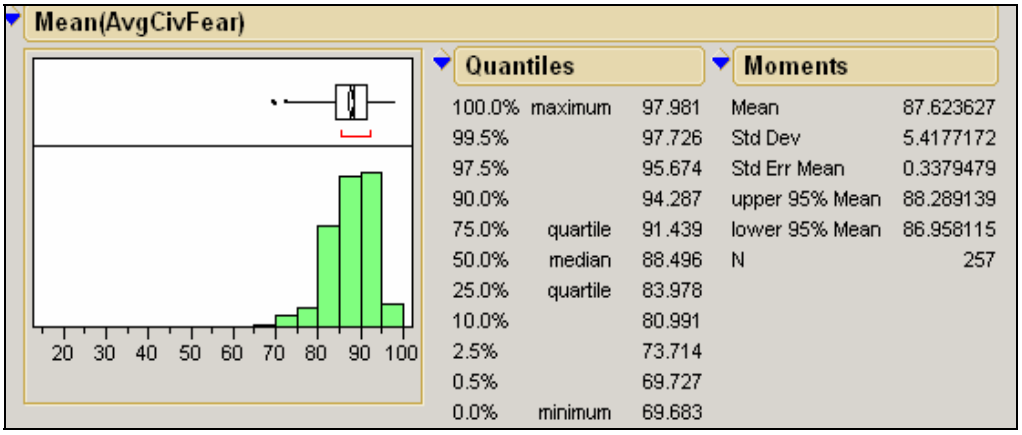

Figure 70 Heter+DisturberLead+CtrlRegion Average Civilian Fear

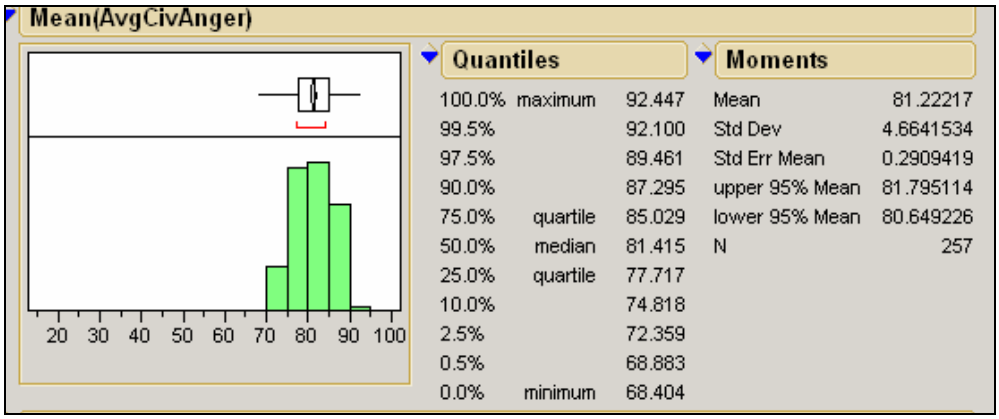

Figure 71 Heter+DisturberLead+CtrlRegion Average Civilian Anger

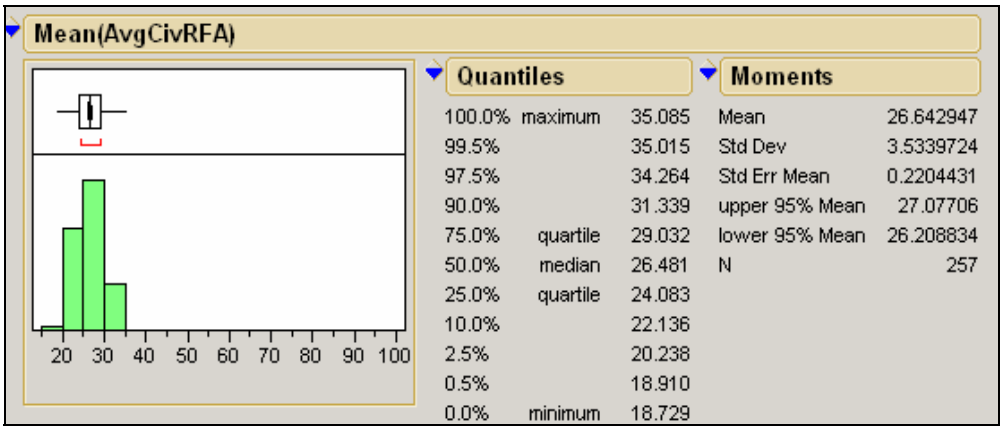

Figure 72 Heter+DisturberLead+CtrlRegion Average Civilian RFA

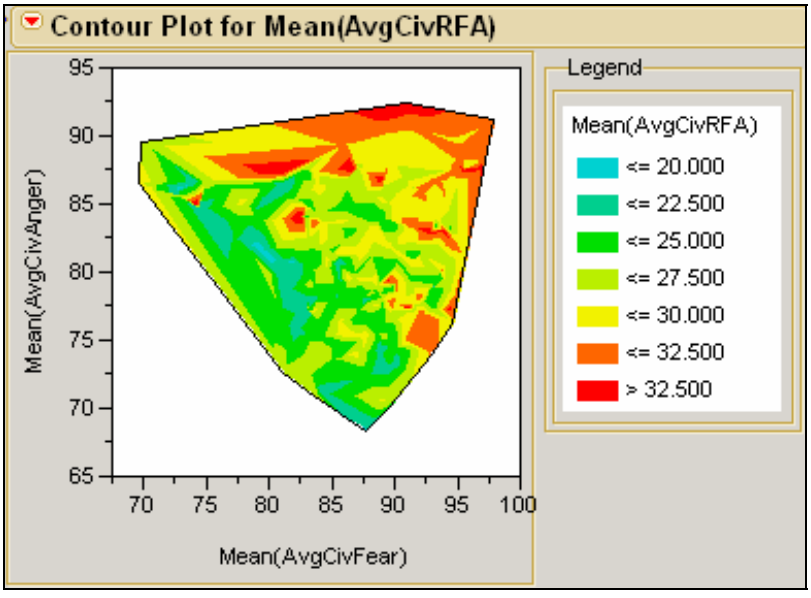

Figure 73 Heter+DisturberLead+CtrlRegion Average Civilian Fear, Anger and RFA Contour Plot

2. Regression Tree Analysis

a. Percentage of Votes

The percentage of votes cast by the civilians is the response of the regression tree shown in Figure 74. This partition yields an R^2 value of 0.468 as shown in has indicates that the effect of the Civ1 – Shiite/Kurd Voters Elective Motivation (>=83) factor has solely contributed to the high voter participation in those excursions where a high percentage of votes are observed.

The effect of the following design factor levels characterize those excursions where a low percentage of votes are observed:

- Civ1 – Shiite/Kurd Voter Elective Motivation (<83)
- Civ1 – Shiite/Kurd Voter Elective Motivation (<78)
- Civ1 – Shiite/Kurd Voter RFA (>=26)

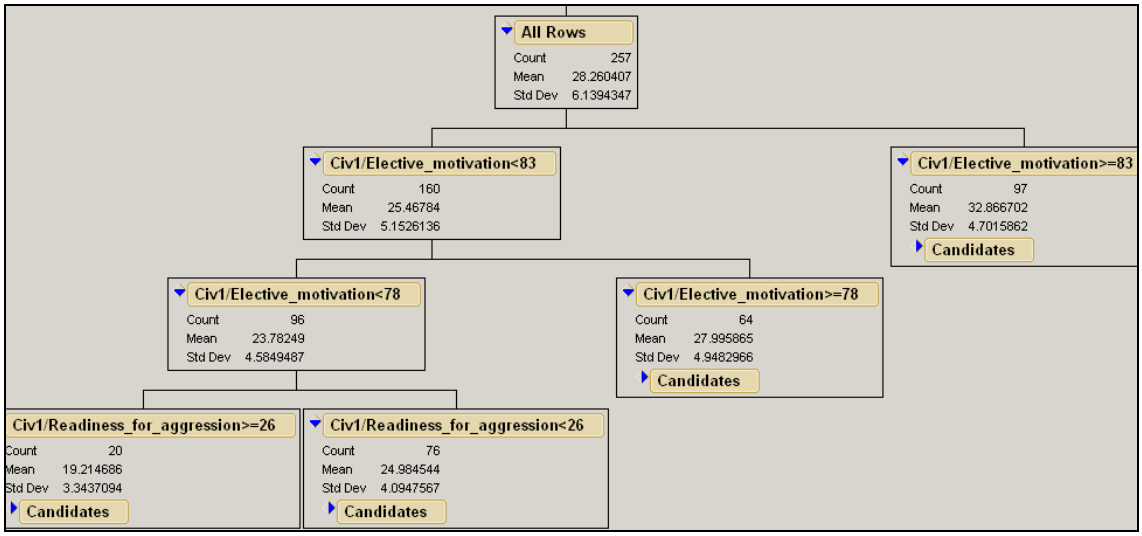

Figure 74 Heter+DisturberLead+CtrlRegion Vote Percentage Regression Tree

b. Aggregated Civilian Escalation

The regression tree for accumulated civilian escalation yields an R^2 value of 0.48, as shown in Figure 75, indicates that the effect of Control Soldier ROE (Set 1, 2, 3, 5 & 6) design factor has solely contributed to the low civilian escalation in those excursions where low aggregated civilian escalation are observed.

The effect of the following design factors have contributed in causing high civilian escalation:

- Control Soldier ROE (Set 4 “Gandhi”)
- Civ1 – Shiite/Kurd Voter RFA (>=28)
- Civ3 – Sunni “No” Voter Elective Motivation (>=80)

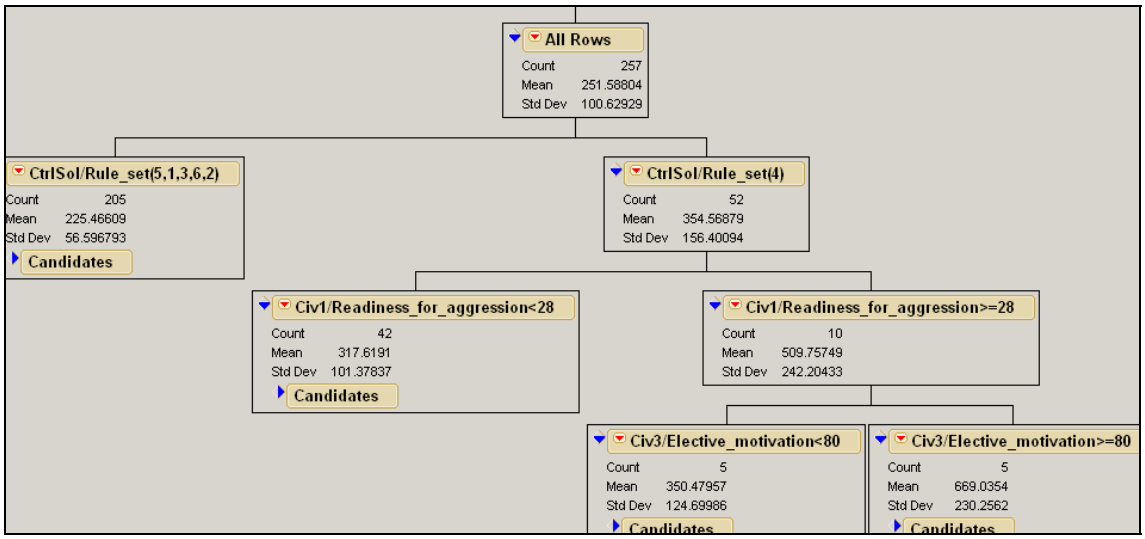

Figure 75 Heter+DisturberLead+CtrlRegion Aggregated Civilian Escalation Regression Tree

3. Model Fitting Analysis

a. Percentage of Votes

The percentage of votes cast by the civilians is the response of this model fitting analysis. In order to achieve a simple model for analysis, the “best” model was finally selected after a few cycles of manual fitting with the main effects, two-way interactions and quadratic terms. A satisfactory R^2 value of 0.66 and low p-values for all terms (i.e. highest at 0.004) were obtained. Refer to Figure 76 for details. Note that those factors highlighted by the regression tree were also included in the final model. A simple check of linearity and equal variance properties on the selected model indicated an absence of non-linearity and heteroskedacity problems. The metamodel for predicting the average civilian escalation is generated as follows:

Percentage of Votes Cast = *-10.07 – 0.29(Civ1A) – 0.24(Civ1R) + 0.67(Civ1E) – 0.15(Civ2R) – 0.11(Civ2E) + 0.12(Civ3E) – 0.47(CivPV) – 0.02(Civ1R-20.01)(Civ3E-80.01) + 0.02(Civ2E-80.01)(Civ3E-80.01)*

Where: Civ1A = Civ1 – Shiite/Kurd Voter Anger

Civ1R = Civ1 – Shiite/Kurd Voter RFA

Civ1E = Civ1 – Shiite/Kurd Voter EMotivation

Civ2R = Civ2 – Sunni "Yes" Voter RFA

Civ2E = Civ2 – Sunni "Yes" Voter EMotivation

Civ3E = Civ3 – Sunni "No" Voter EMotivation

CivPV = Civilian Personality Variance

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-10.0725	5.577129	-1.81	0.0721
Civ1/Anger	-0.294561	0.038891	-7.57	<.0001
Civ1/Readiness_for_aggression	-0.238213	0.038891	-6.13	<.0001
Civ1/Elective_motivation	0.6725139	0.038889	17.29	<.0001
Civ2/Readiness_for_aggression	-0.153072	0.03889	-3.94	0.0001
Civ2/Elective_motivation	-0.113221	0.038891	-2.91	0.0039
Civ3/Elective_motivation	0.1207105	0.038892	3.10	0.0021
CivVariances	-0.467878	0.077327	-6.05	<.0001
(Civ1/Readiness_for_aggression-20.0078)*(Civ3/Elective_motivation-80.0078)	-0.02115	0.006322	-3.35	0.0009
(Civ2/Elective_motivation-80.0078)*(Civ3/Elective_motivation-80.0078)	0.020533	0.006695	3.07	0.0024

Figure 76 Heter+DisturberLead+CtrlRegion Vote Percentage Model Fit

From the metamodel, the Civ1E term stands out statistically from the rest with a higher t ratio value. Overall, the result indicates that if the level of elective motivation among Civ1 (Shiite/Kurd Voter) increases, the percentage of votes will increase. This is preferred, as we want the percentage of votes to be high.

b. Aggregated Civilian Escalation

The number of civilian escalation accumulated during the entire simulation is the response of this model fitting analysis. In order to achieve a simple model for analysis, the "best" model was finally selected after a few cycles of manual fitting with the main effects, two-way interactions and quadratic terms.

A satisfactory R^2 value of 0.59 and low p-values for all terms (i.e., highest at 0.01) were obtained. Refer to Figure 77 for details. Note that those factors highlighted by the regression tree were also included in the final model. A simple check of linearity and equal variance properties on the selected model indicated an absence of non-linearity and heteroskedacity problems. The metamodel for predicting the average civilian escalation is generated as follows:

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-261.401	71.69658	-3.65	0.0003
Civ1/Readiness_for_aggression	4.3533863	0.719989	6.05	<.0001
Civ2/Readiness_for_aggression	3.2119671	0.706369	4.55	<.0001
Civ3/Readiness_for_aggression	1.7439205	0.708164	2.46	0.0145
Civ4/Readiness_for_aggression	3.1157959	0.723592	4.31	<.0001
Civ5/Readiness_for_aggression	2.3176538	0.70682	3.28	0.0012
CivVariances	6.1364745	1.405236	4.37	<.0001
PollSol/Rule_set{6&5&1&2-3&4}	-17.62299	4.233609	-4.16	<.0001
CtrlSol/Rule_set{5&1&3&6&2-4}	-67.21232	5.212102	-12.90	<.0001
(PollSol/Rule_set{6&5&1&2-3&4}-0.19844)*(Civ1/Readiness_for_aggression-20.0078)	-1.8559	0.718455	-2.58	0.0104
(CtrlSol/Rule_set{5&1&3&6&2-4}-0.59533)*(Civ1/Readiness_for_aggression-20.0078)	-3.013354	0.867519	-3.47	0.0006
(CtrlSol/Rule_set{5&1&3&6&2-4}-0.59533)*(Civ2/Readiness_for_aggression-20.0078)	-3.875565	0.881614	-4.40	<.0001
(CtrlSol/Rule_set{5&1&3&6&2-4}-0.59533)*(Civ3/Readiness_for_aggression-20.0078)	-2.598383	0.918041	-2.83	0.0050

Figure 77 Heter+DisturberLead+CtrlRegion Aggregated Civilian Escalation Model Fit

Aggregated Civilian Escalation = *-261.4 + 4.35(Civ1R) + 3.21(Civ2R) + 1.74(Civ3R) + 3.12(Civ4R) + 2.32(Civ5R) + 6.14(CivPV) – 17.62(PollROE) – 67.21(CtrlROE) – 1.86(PollROE-0.2)(Civ1R-20.01) – 3.01(CtrlROE-0.6)(Civ1R-20.01) – 3.88(CtrlROE-0.6)(Civ2R-20.01) – 2.6(CtrlROE-0.6)(Civ3R-20.01)*

Where: Civ1R = Civ1 – Shiite/Kurd Voter RFA

Civ2R = Civ2 – Sunni “Yes” Voter RFA

Civ3R = Civ3 – Sunni “No” Voter RFA

Civ4R = Civ4 – Sunni Trouble-Maker Voter RFA

Civ5R = Civ5 – Disturber RFA

CivPV = Civilian Personality Variance

PollROE = Poll Soldier ROE {1&2&5&6 – 3&4}

CtrlROE = Control Soldier ROE {1&2&3&5&6 – 4}

Note that JMP has automatically grouped the Poll Area Soldier's ROE Set 1, 2, 5 and 6 together (with value 1) as having the same effect on the response that is different from Poll Area Soldier's ROE Set 3 and 4 (with value -1). Similarly, it has grouped Control Area Soldier's ROE Set 1, 2, 3, 5 and 6 together (with value 1) as having the same effect on the response that is different from Control Area Soldier's ROE Set 4 (with value -1).

From the metamodel, the CtrlROE term stands out statistically from the rest with a very high t ratio value. Overall, the result indicates that when the Control Area Admission Control Soldier employ ROE Set 1, 2, 3, 5 and 6, the level of aggregated civilian escalation will decrease, which is excellent as we want the civilian escalation to be minimized. Therefore, ROE Set 1, 2, 3, 5 and 6 are excellent choices for the Control Area in this election scenario.

Note that the "main effect" terms are mainly RFA factors from all civilian groups and they all have positive coefficient values. This suggests that if the level of civilian RFA is high in all the civilian groups, then the level of civilian escalation in this given heterogeneous population scenario will be increased. Therefore, this situation must be avoided.

I. HETER+DISTURBERLEAD+CTRLREGION+BOOTH RESULTS

The results for the Heter+DisturberLead+CtrlRegion+Booth follow. Recall that this is one of the scenarios where high voter turnout and high escalation are likely.

1. Data Distribution Analysis

a. Percentage of Votes

In this experiment, the deployments of Election Booths are implemented. Figure 78 shows the distribution of voter participation, in percent (i.e., the number of votes cast divided by the total number of registered voters) at the end of the election simulation.

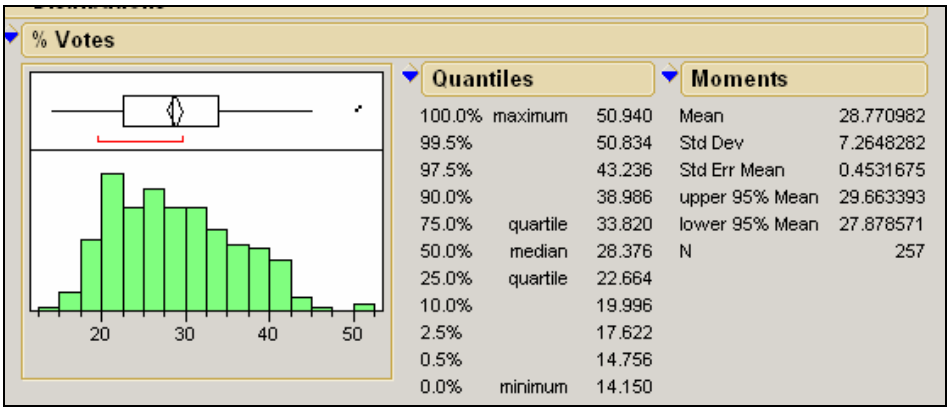

Figure 78 Heter+DisturberLead+CtrlRegion+Booth Voter Participation

This scenario corresponds to a town with a heterogeneous Sunni and Shiite/Kurd population that had one of the highest voting turnout rates for the October 2005 election. The simulation results show an average voter participation of about 28.8% with a standard deviation of about 7.3%. The distribution of the shortest half bracket (i.e., showing the densest 50% of the observations) indicates that the civilian voting participation varies over a large range. The fact that the distribution has a wide spread with highest percentage of vote at 50.9% and lowest at 14% shows that at least some factors may make a difference.

Comparing with the Heter+DisturberLead+CtrlRegion scenario, the voting participation in this Heter+DisturberLead+CtrlRegion+Booth scenario where Election Booths are implemented, does not show any sizable improvement. Very similar voting participation distributions are observed in both scenarios.

b. Aggregated Civilian Escalation

Figure 79 shows the distribution of the civilian escalation accumulated in the scenario over the entire election simulation. The distribution of civilian escalation demonstrated against other civilians is illustrated in Figure 80. The distribution of civilian escalation demonstrated against the soldiers is illustrated in Figure 81.

The aggregated civilian escalation resulted in this scenario has a mean value at about 1047.6 units (i.e., threatening or attacking actions). The aggregated civilian escalation against other civilian has a mean value of about 282.8 units (about 27% of the total escalation). The mean aggregated civilian escalation against soldiers has a mean value of about 764.8 units (about 73% of the total escalation). This result indicates a huge increase in civilian escalation occurs in this scenario (where Election Booths are deployed).

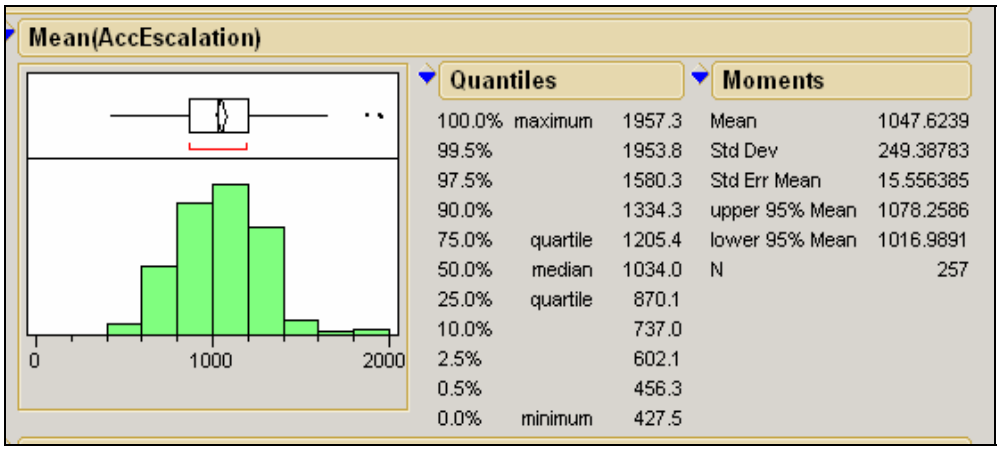

Figure 79 Heter+DisturberLead+CtrlRegion+Booth Aggregated Civilian Escalation

This result also indicates that the majority of the escalation is between the civilians and soldiers, which is completely the opposite as compared to the Heter+DisturberLead+CtrlRegion scenario where no Election Booths are deployed. Since there is no sizeable improvement in the voter participation the increase in civilian escalation suggests that the deployment of Election Booth is redundant in this heterogeneous population scenario and is not a preferred election proceeding.

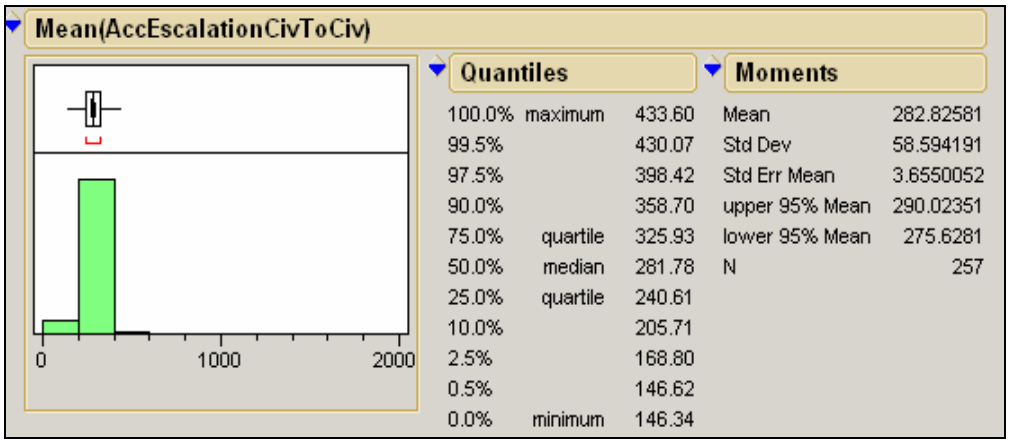

Figure 80 Heter+DisturberLead+CtrlRegion+Booth Aggregated Civilian Escalation (Civilians against other Civilians)

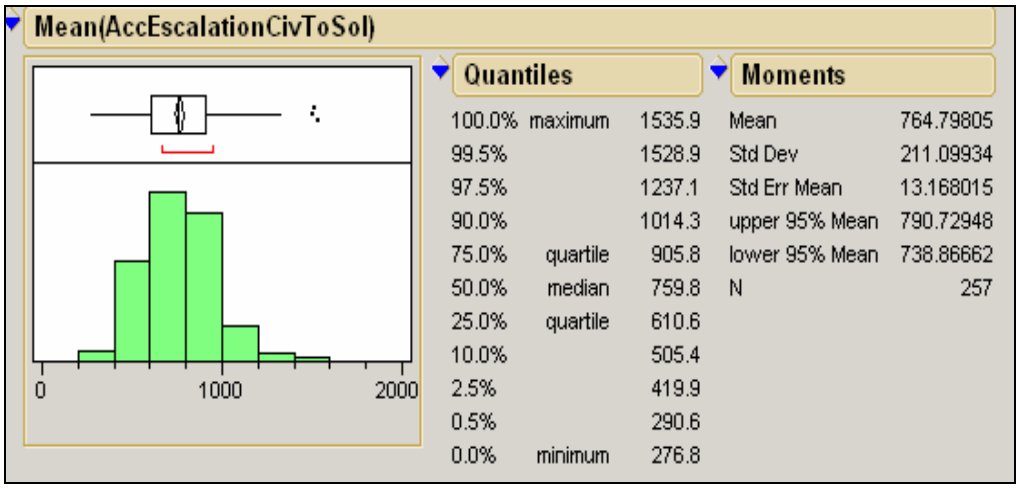

Figure 81 Heter+DisturberLead+CtrlRegion+Booth Aggregated Civilian Escalation (Civilians against Soldiers)

c. Average Civilian Fear, Anger and RFA

The distributions of the civilian average fear, anger and RFA level at the end of the entire election simulation are illustrated in Figure 83 and Figure 84. A contour plot is shown in Figure 85 to illustrate the relationships between these three civilian personalities. Note that the maximum value for each factor is 100 units.

The average civilian fear and anger levels are high, with mean values of about 78 and 83 units. This result indicates that, on average, the civilians are fearful and angry. However, the average RFA level has a much

lower mean value of about only 28 units. This suggests that on an average, the civilians may be angry and agitated at times but they are not likely to act aggressively.

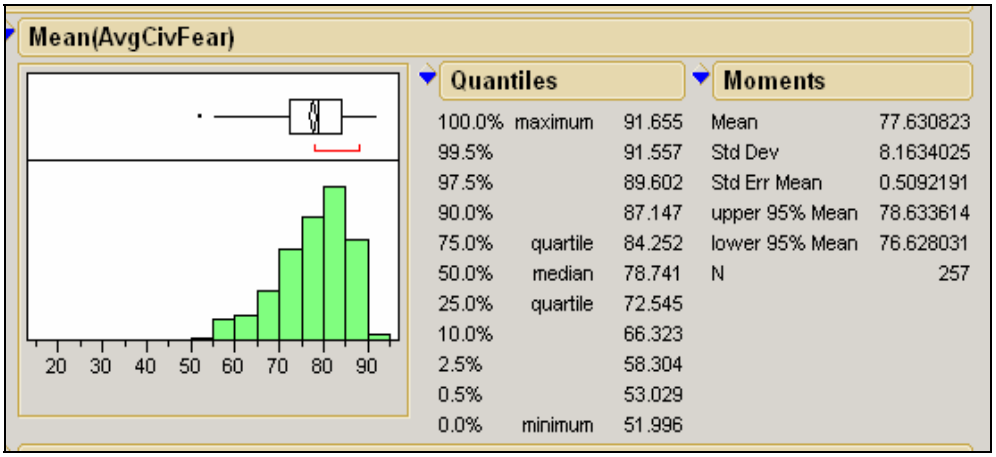

Figure 82 Heter+DisturberLead+CtrlRegion+Booth Average Civilian Fear

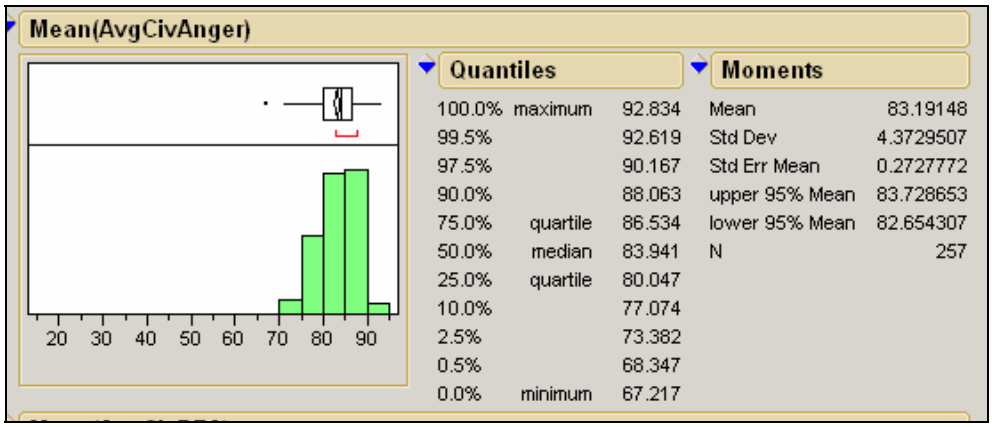

Figure 83 Heter+DisturberLead+CtrlRegion+Booth Average Civilian Anger

Note that the civilian fear level has dropped by 10 units as compared to the Heter+DisturberLead+CtrlRegion scenario where no Election Booths are deployed. This suggests that the Election Booths deployed in this scenario are gaining positive responses from the civilians. On average, Civilians are now less fearful and are coming out from their homes to participate in the election.

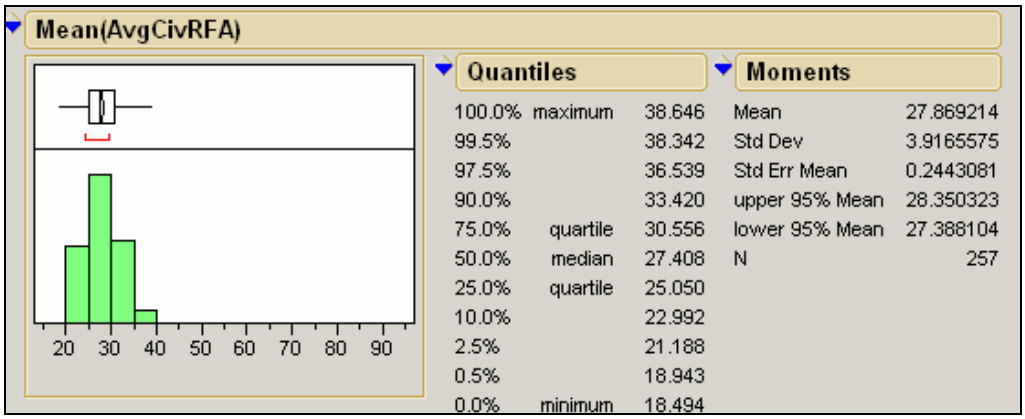

Figure 84 Heter+DisturberLead+CtrlRegion+Booth Average Civilian RFA

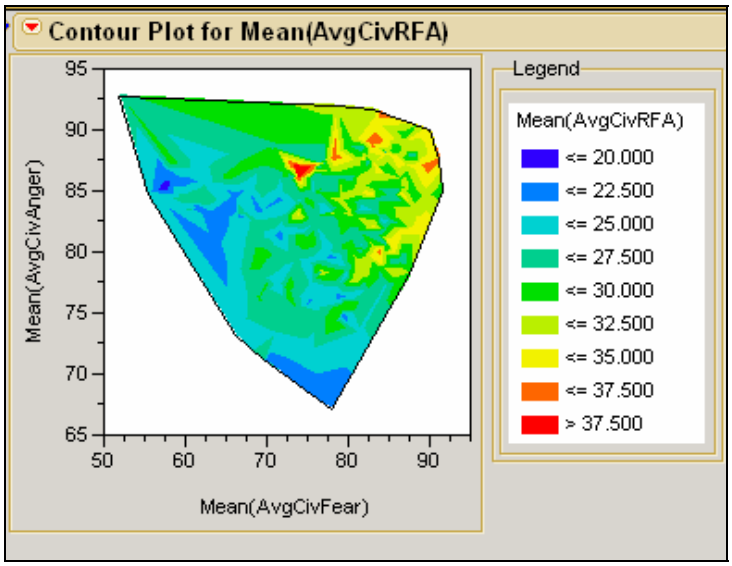

Figure 85 Heter+DisturberLead+CtrlRegion+Booth Average Civilian Fear, Anger and RFA Contour Plot

From the contour plot, it can be observed that the highest levels of civilian RFA occur mostly when the civilian fear and anger levels are both very high. These high RFA observations are isolated to the top right hand corner of the contour plot, suggesting that the majority of the time, the election proceeding is peaceful with low civilian escalation. This also suggest that, on average, the Election Booths might have contributed to the results whereas the hostilities are now isolated during the election proceeding.

2. Regression Tree Analysis

a. Percentage of Votes

The percentage of votes cast by the civilians is the response of the regression tree shown in Figure 86. This partition yields an R^2 value of 0.526, and indicates that the effect of Civ1 – Shiite/Kurd Voter Elective Motivation (>=84) design factor has solely contributed to the high voter participation in those excursions where a high percentage of votes are observed.

The effect of Civ1 – Shiite/Kurd Voter Elective Motivation (<84) and Civ1 – Shiite/Kurd Voter Elective Motivation (<76) design factors have contributed in causing a low percentage of votes cast.

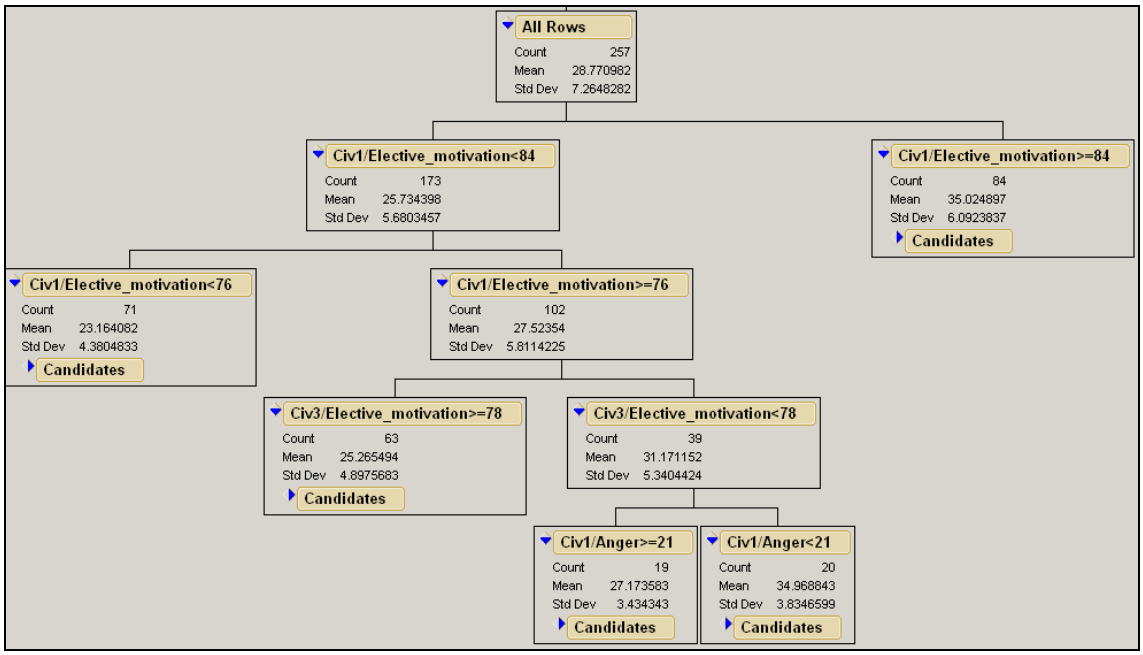

Figure 86 Heter+DisturberLead+CtrlRegion+Booth Vote Percentage Regression Tree

b. Aggregated Civilian Escalation

The regression tree for accumulated civilian escalation yields an R^2 value of 0.209 as shown in Figure 87, indicates that the following design factor levels characterize those excursions where low aggregated civilian escalation is observed:

- Civ5 – Disturber RFA (<84)
- Civ3 – Sunni “No” Voter Elective Motivation (<85)

The effect of Civ5 – Disturber RFA (>=84) and Civilian Personality Variance (>=4) factors have contributed in causing a high civilian escalation.

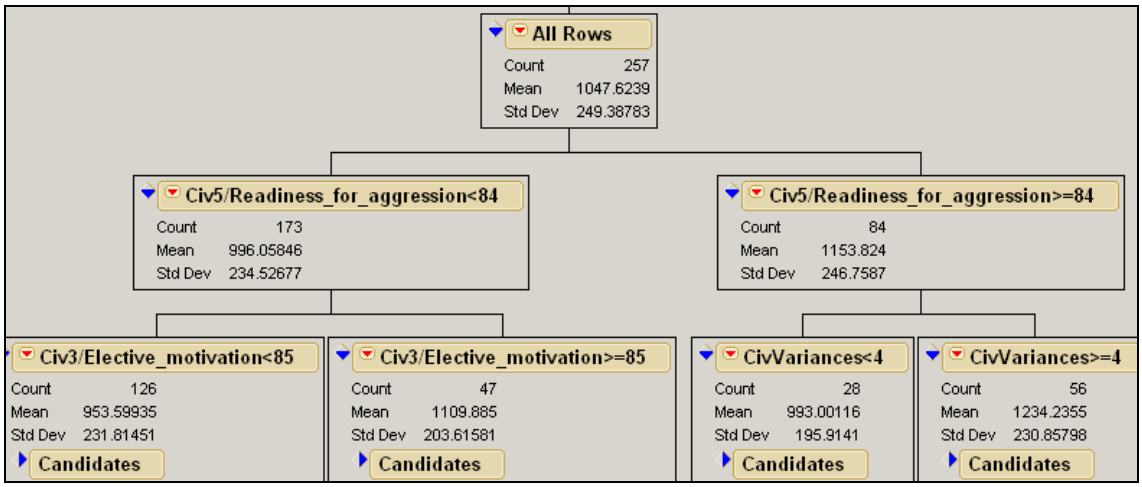

Figure 87 Heter+DisturberLead+CtrlRegion+Booth Aggregated Civilian Escalation Regression Tree

3. Model Fitting Analysis

a. Percentage of Votes

The percentage of votes cast by the civilians is the response of this model fitting analysis. In order to achieve a simple model for analysis, the "best" model was finally selected after a few cycles of manual fitting with the main effects, two-way interactions and quadratic terms. A satisfactory R^2 value of 0.62 and low p-values for all terms (i.e., highest at 0.006) were obtained. Refer to Figure 88 for details. Note that those factors highlighted by the regression tree were also included in the final model. A simple check of linearity and equal variance properties on the selected model indicated an absence of non-linearity and heteroskedacity problems. The metamodel for predicting the average civilian escalation is generated as follows:

Percentage of Votes Cast = *1.64 – 0.33(Civ1A) – 0.22(Civ1R) + 0.81(Civ1E) – 0.14(Civ2A) – 0.19(Civ2R) – 0.22(Civ3E) – 0.47(CivPV)*

Where: Civ1A = Civ1 – Shiite/Kurd Voter Anger

Civ1R = Civ1 – Shiite/Kurd Voter RFA

Civ1E = Civ1 – Shiite/Kurd Voter EMotivation

Civ2A = Civ2 – Sunni “Yes” Voter Anger

Civ2R = Civ2 – Sunni “Yes” Voter RFA

Civ3E = Civ3 – Sunni “No” Voter EMotivation

CivPV = Civilian Personality Variance

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.6404717	5.845769	0.28	0.7792
Civ1/Anger	-0.332871	0.048503	-6.86	<.0001
Civ1/Readiness_for_aggression	-0.215272	0.048502	-4.44	<.0001
Civ1/Elective_motivation	0.8074462	0.048501	16.65	<.0001
Civ2/Anger	-0.13501	0.048501	-2.78	0.0058
Civ2/Readiness_for_aggression	-0.186654	0.048503	-3.85	0.0002
Civ3/Elective_motivation	-0.221486	0.048504	-4.57	<.0001
CivVariances	-0.469229	0.096435	-4.87	<.0001

Figure 88 Heter+DisturberLead+CtrlRegion+Booth Vote Percentage Model Fit

From the metamodel, the Civ1E term stands out statistically from the rest with a higher t ratio value. Overall, the result indicates that if the level of elective motivation among Civ1 (Shiite/Kurd Voter) increase, the percentage of votes will increase. This is preferred, as we want the percentage of votes to be high.

b. Aggregated Civilian Escalation

The civilian escalation accumulated during the entire simulation is the response of this model fitting analysis. In order to achieve a simple model for analysis, the “best” model was finally selected after a few cycles of manual fitting with the main effects, two-way interactions and quadratic terms. A satisfactory R^2 value of 0.50 and low p-values for all terms (i.e., highest at 0.03) were obtained. Refer to Figure 89 for details. Note that those factors highlighted by the regression tree were also included in the final model. A simple check of linearity and equal variance properties on the selected model indicated an absence of non-linearity and heteroskedacity problems. The metamodel for predicting the average civilian escalation is generated as follows:

Aggregated Civilian Escalation = *242.83 + 8.95(Civ1R) – 10.13(Civ1E) + 7.76(Civ2R) + 4.28(Civ2E) + 9.52(Civ3E) – 10.78(Civ5A) + 11.83(Civ5R) + 24.7(CivPV) – 36.84(PollROE) – 62.29(CtrlROE) – 6.18(CtrlROE-0.6)(Civ1R-20.01)*

Where: Civ1R = Civ1 – Shiite/Kurd Voter RFA

Civ1E = Civ1 – Shiite/Kurd Voter EMotivation

Civ2R = Civ2 – Sunni "Yes" Voter RFA

Civ2E = Civ2 – Sunni "Yes" Voter EMotivation

Civ3E = Civ3 – Sunni "No" Voter EMotivation

Civ5A = Civ4 – Disturber Anger

Civ5R = Civ5 – Disturber RFA

CivPV = Civilian Personality Variance

PollROE = Poll Soldier ROE {1&5&6 – 2&3&4}

CtrlROE = Control Soldier ROE {1&2&3&5&6 –4}

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	242.82897	353.2031	0.69	0.4924
Civ1/Readiness_for_aggression	8.9522868	1.945982	4.60	<.0001
Civ1/Elective_motivation	-10.13308	1.944508	-5.21	<.0001
Civ2/Readiness_for_aggression	7.7566933	1.944997	3.99	<.0001
Civ2/Elective_motivation	4.2817175	1.956755	2.19	0.0296
Civ3/Elective_motivation	9.5237777	1.949001	4.89	<.0001
Civ5/Anger	-10.78074	1.958935	-5.50	<.0001
Civ5/Readiness_for_aggression	11.827847	1.947115	6.07	<.0001
CivVariances	24.699841	3.867499	6.39	<.0001
PollSol/Rule_set{6&1&5-4&2&3}	-36.83518	11.5681	-3.18	0.0016
CtrlSol/Rule_set{6&2&1&3&5-4}	-62.29341	14.19581	-4.39	<.0001
(CtrlSol/Rule_set{6&2&1&3&5-4}-0.59533)*(Civ1/Readiness_for_aggression-20.0078)	-6.177494	2.383701	-2.59	0.0101

Figure 89 Heter+DisturberLead+CtrlRegion+Booth Aggregated Civilian Escalation Model Fit

Note that JMP has automatically grouped the Poll Area Soldier's ROE Set 1, 5 and 6 together (with value 1) as having the same effect on the response that is different from Poll Area Soldier's ROE Set 2, 3 and 4 (with value -1). Similarly, it has grouped Control Area Soldier's ROE Set 1, 2, 3, 5 and 6

together (with value 1) as having the same effect on the response that is different from Control Area Soldier's ROE Set 4 (with value -1).

From the metamodel, the majority of the main effect terms except Civ2E and PollROE terms, are statistically significant in the presence of the rest with all having fairly close t ratio values. For example, the overall result indicates that when the Control Area Admission Control Soldier employs ROE Sets 1, 2, 3, 5 and 6, the level of aggregated civilian escalation will decrease. This is excellent, as we want the civilian escalation to be minimized. Therefore, ROE Sets 1, 2, 3, 5 and 6 are excellent choices for the Control Area in this election scenario. In another example, the overall result indicates that if the personalities among the civilians vary over a large range, the level of aggregated civilian escalation will increase. This is also not preferred, as we want the civilian escalation to be minimized.

J. HETER+TROUBLEMAKERLEAD+CTRLREGION RESULTS

The results for the Heter+TroubleMakerLead+CtrlRegion follow. Recall that this is one of the scenarios where high voter turnout and high escalation are likely.

1. Data Distribution Analysis

a. Percentage of Votes

Figure 90 shows the distribution of voter participation, in percent (i.e., the number of votes cast divided by the total number of registered voters) at the end of the election simulation.

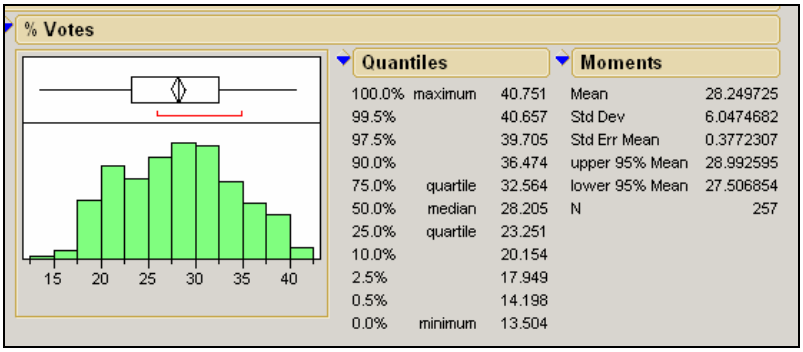

Figure 90 Heter+TroubleMakerLead+CtrlRegion Voter Participation

This scenario corresponds to a town with a heterogeneous Sunni and Shiite/Kurd population that had one of the highest voting turnout rates for the October 2005 election. The simulation results show an average voter participation of about 28.2% with a standard deviation of about 6.0%. The distribution of the shortest half bracket (i.e., showing the densest 50% of the observations) indicates that the civilian voting participation varies over a large range. Since the distribution has a wide spread with highest percentage of vote at 40.8% and lowest at 13.5%, some factors may make a difference. Compared with the Heter+DisturberLead+CtrlRegion and the Heter+DisturberLead+CtrlRegion+Booth scenarios, the voter participation in this Heter+TroubleMakerLead+CtrlRegion scenario has shown almost similar results.

b. Aggregated Civilian Escalation

Figure 91 shows the distribution of the civilian escalation accumulated in the scenario over the entire election simulation. The distribution of civilian escalation demonstrated against other civilians is illustrated in Figure 92. The distribution of civilian escalation demonstrated against the soldiers is illustrated in Figure 93. The aggregated civilian escalation results in this scenario have a mean value of about 250.5 units (i.e., threatening or attacking actions). The aggregated civilian escalation against other civilians has a mean value of about 196 units (about 78% of the total escalation). The mean aggregated civilian escalation against the soldier has a mean value of about 54.6 units (about 22% of the total escalation). This result indicates that the majority of the escalation is among the civilians. This is an undesirable situation during an election.

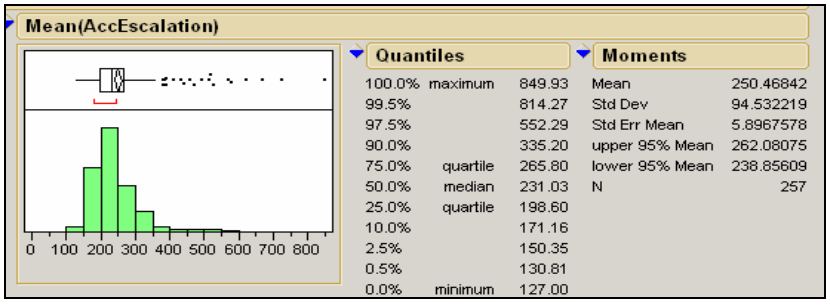

Figure 91 Heter+TroubleMakerLead+CtrlRegion Aggregated Civilian Escalation

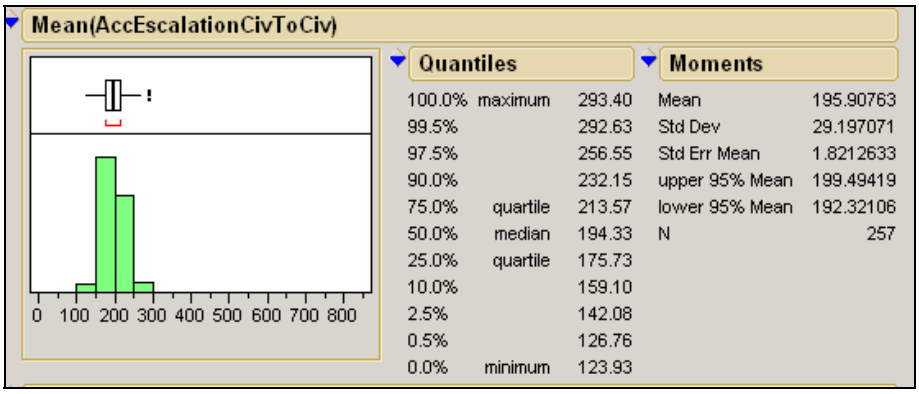

Figure 92 Heter+TroubleMakerLead+CtrlRegion Aggregated Civilian Escalation (Civilians against other Civilians)

Note that this scenario has a similar response as compared to the Heter+DisturberLead+CtrlRegion scenario. This suggests that there is no significant different in the effect of the leadership's influences between disturber and trouble-maker groups in this heterogeneous population scenario.

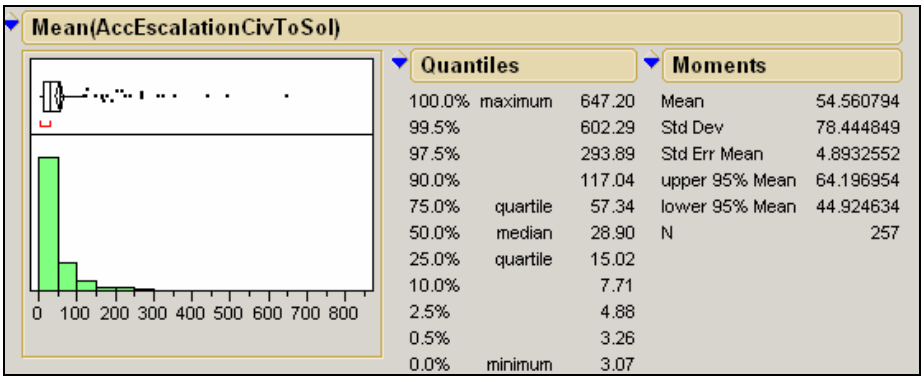

Figure 93 Heter+TroubleMakerLead+CtrlRegion Aggregated Civilian Escalation (Civilians against Soldiers)

c. Average Civilian Fear, Anger and RFA

The distributions of the civilian average fear, anger and RFA level at the end of the entire election simulation are illustrated in Figure 94, Figure 95 and Figure 96. A contour plot is shown in Figure 97 to illustrate the relationships between these three civilian personalities. Note that the maximum value for each factor is 100 units.

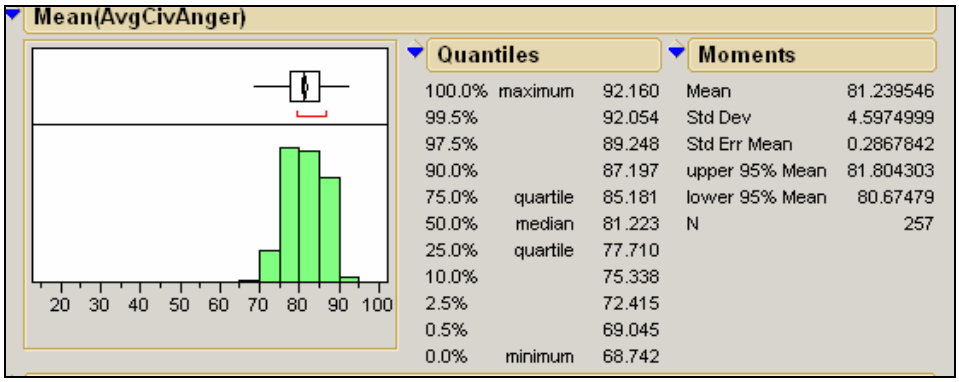

Figure 94 Heter+TroubleMakerLead+CtrlRegion Average Civilian Fear

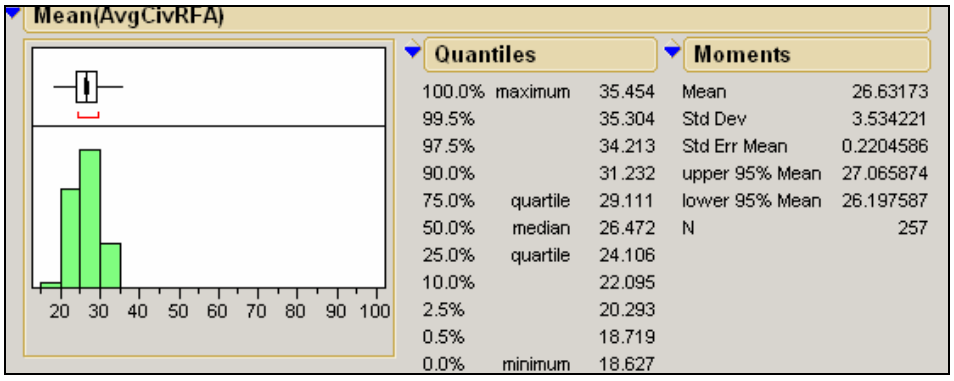

Figure 95 Heter+TroubleMakerLead+CtrlRegion Average Civilian Anger

The average civilian fear and anger levels are high, with mean values of about 88 and 81 units. This result indicates that, on average, the civilians are fearful and angry. However, the average RFA level has a much lower mean value of about only 27 units. This suggests that on an average, the civilians may be angry and agitated at times but they are not likely to act aggressively.

From the contour plot, it can be observed that the highest levels of civilian RFA occur mostly when the civilian anger level is very high regardless of the civilian fear level. Note that this scenario has a similar response as compared to the Heter+DisturberLead+CtrlRegion scenario where the Disturber's leadership is modeled. This suggests that, on average, there is no significant difference between the Disturber's and Trouble-Maker's leadership.

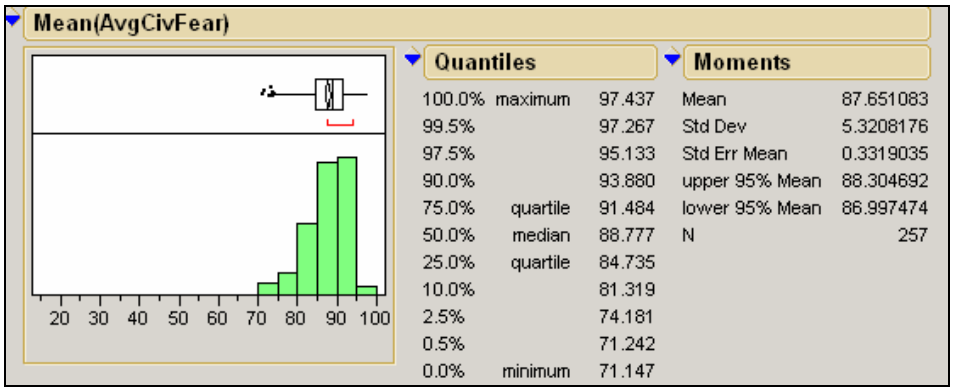

Figure 96 Heter+TroubleMakerLead+CtrlRegion Average Civilian RFA

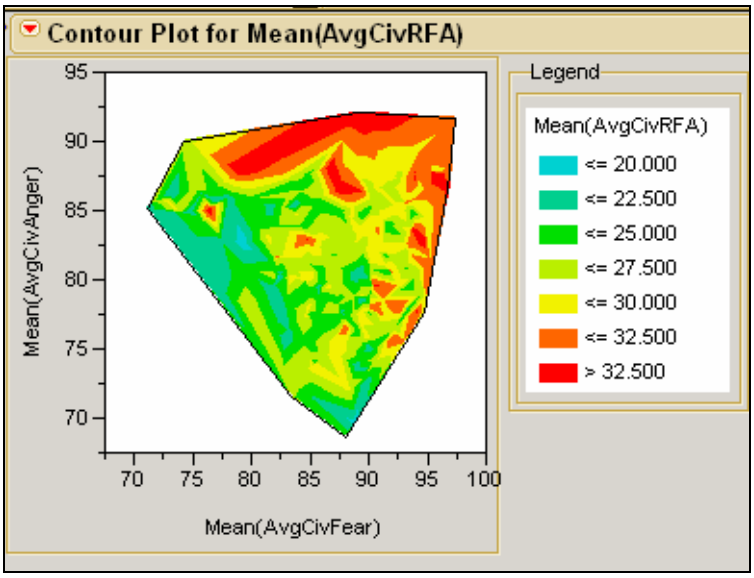

Figure 97 Heter+TroubleMakerLead+CtrlRegion Average Civilian Fear, Anger and RFA Contour Plot

2. Regression Tree Analysis

a. Percentage of Votes

The percentage of votes cast by the civilians is the response of the regression tree shown in Figure 98. This partition yields an R^2 value of 0.509, and indicates that the effect of Civ1 – Shiite/Kurd Voter Elective Motivation (>=83) design factor has solely contributed to the high voter participation in those excursions where a high percentage of votes are observed. The effect of the following design factor levels characterize those excursions where a low percentage of votes are observed:

- Civ1 – Shiite/Kurd Voter Elective Motivation (<83)
- Civ1 – Shiite/Kurd Voter Elective Motivation (<78)
- Civ1 – Shiite/Kurd Voter RFA (>=26)

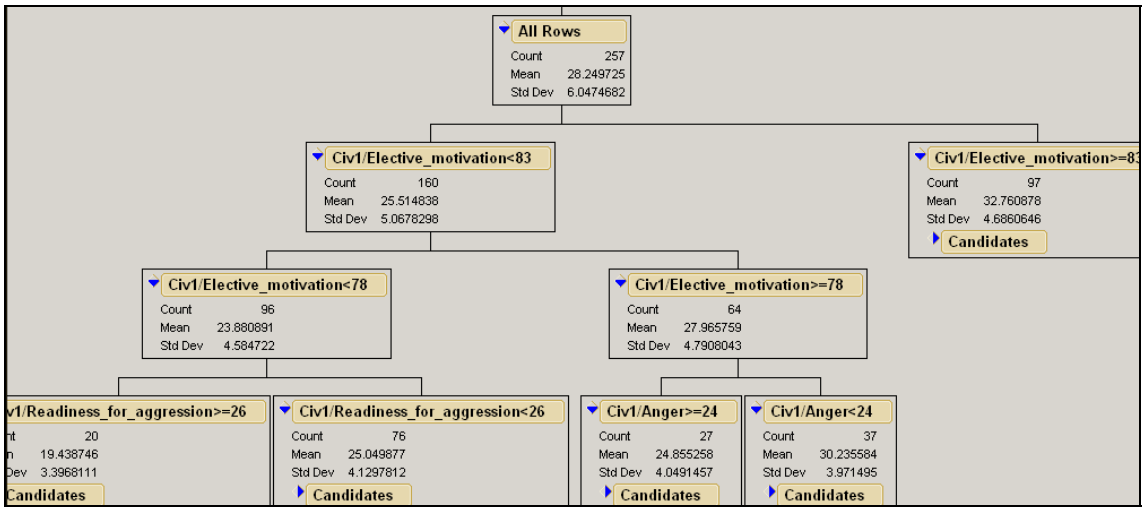

Figure 98 Heter+TroubleMakerLead+CtrlRegion Vote Percentage Regression Tree

b. Aggregated Civilian Escalation

The regression tree for accumulated civilian escalation yields an R^2 value of 0.475, as shown in Figure 99, indicates that the effect of Control Soldier ROE (Set 1, 2, 3, 5 & 6) factor has solely contributed to the low civilian escalation in those excursions where low aggregated civilian escalation are observed.

The effect of the following design factor levels characterize those excursions where high aggregated civilian escalation is observed:

- Control Soldier ROE (Set 4 “Gandhi”)
- Civ1 – Shiite/Kurd Voter RFA (>=28)
- Civ3 – Sunni “No” Voter Elective Motivation (>=80)

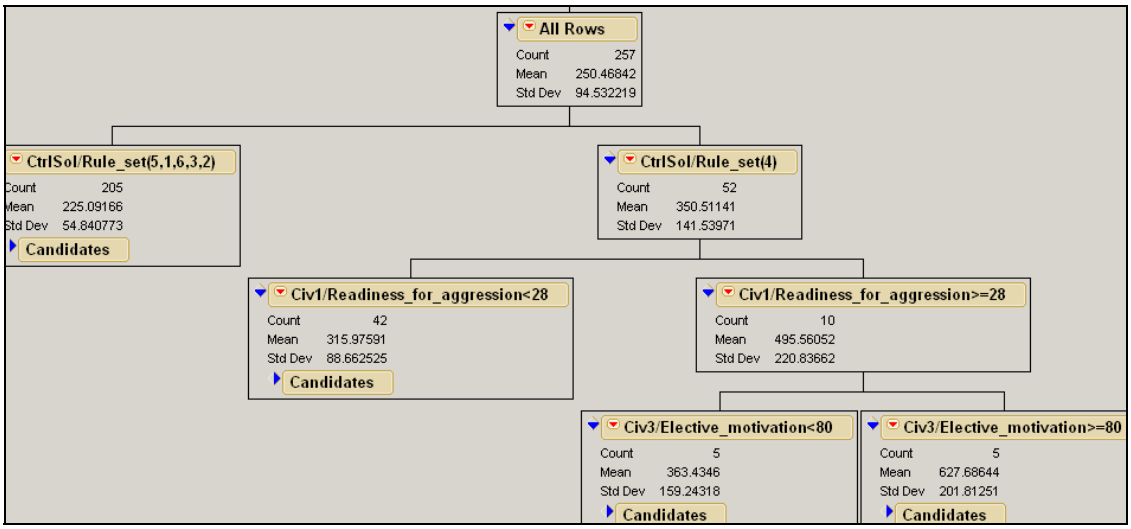

Figure 99 Heter+TroubleMakerLead+CtrlRegion Aggregated Civilian Escalation Regression Tree

3. Model Fitting Analysis

a. Percentage of Votes

The percentage of votes cast by the civilians is the response of this model fitting analysis. In order to achieve a simple model for analysis, the "best" model was finally selected after a few cycles of manual fitting with the main effects, two-way interactions and quadratic terms. A satisfactory R^2 value of 0.66 and low p-values for all terms (i.e., highest at 0.03) were obtained. Refer to Figure 100 for details. Note that those factors highlighted by the regression tree were also included in the final model. A simple check of linearity and equal variance properties on the selected model indicated an absence of non-linearity and heteroskedacity problems. The metamodel for predicting the average civilian escalation is generated as follows:

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-8.344267	5.512246	-1.51	0.1314
Civ1/Anger	-0.290921	0.038434	-7.57	<.0001
Civ1/Readiness_for_aggression	-0.218304	0.038522	-5.67	<.0001
Civ1/Elective_motivation	0.6610216	0.038439	17.20	<.0001
Civ2/Readiness_for_aggression	-0.171452	0.038435	-4.46	<.0001
Civ2/Elective_motivation	-0.13016	0.03845	-3.39	0.0008
Civ3/Elective_motivation	0.1242629	0.03846	3.23	0.0014
CivVariance	-0.487095	0.076426	-6.37	<.0001
PollSol/Rule_set{6&1-2&3&5}	-0.61729	0.281972	-2.19	0.0295
(Civ1/Readiness_for_aggression-20.0078)*(Civ3/Elective_motivation-80.0078)	-0.023997	0.006263	-3.83	0.0002

Figure 100 Heter+TroubleMakerLead+CtrlRegion Vote Percentage Model Fit

Percentage of Votes Cast = -8.34 – 0.29(Civ1A) – 0.22(Civ1R) + 0.66(Civ1E) – 0.17(Civ2R) – 0.13(Civ2E) + 0.12(Civ3E) – 0.49(CivPV) – 0.62(PollROE) – 0.02(Civ1R-20.01)(Civ3E-80.01)

Where: Civ1A = Civ1 – Shiite/Kurd Voter Anger

Civ1R = Civ1 – Shiite/Kurd Voter RFA

Civ1E = Civ1 – Shiite/Kurd Voter EMotivation

Civ2R = Civ2 – Sunni "Yes" Voter RFA

Civ2E = Civ2 – Sunni "Yes" Voter EMotivation

Civ3E = Civ3 – Sunni "No" Voter EMotivation

CivPV = Civilian Personality Variance

PollROE = Poll Soldier ROE {1&6 – 2&3&5}

Note that JMP has automatically grouped the Poll Area Soldier's ROE Set 1 and 6 together (with value 1) as having the same effect on the response that is different from Poll Area Soldier's ROE Set 2, 3 and 5 (with value -1).

From the metamodel, the Civ1E term stands out statistically from the rest with a higher t ratio value. Overall, the result indicates that if the level of elective motivation among the Civ1 (Shiite/Kurd Voter) increase, the percentage of votes will increase, which is excellent as we want the percentage of votes to be high.

b. Aggregated Civilian Escalation

The civilian escalation accumulated during the entire simulation is the response of this model fitting analysis. In order to achieve a simple model for analysis, the "best" model was finally selected after a few cycles of manual fitting with the main effects, two-way interactions and quadratic terms. A satisfactory R^2 value of 0.69 and low p-values for all terms (i.e., highest at 0.0003) were obtained. Refer to Figure 101 for details. Note that those factors highlighted by the regression tree were also included in the final model. A simple check of

linearity and equal variance properties on the selected model indicated an absence of non-linearity and heteroskedacity problems. The metamodel for predicting the average civilian escalation is generated as follows:

Aggregated Civilian Escalation = *112.33 + 4.93(Civ1R) – 2.16(Civ1E) + 2.84(Civ2R) + 2.34(Civ3R) + 2.84(Civ4R) + 5.92(CivPV) – 33.34(PollROE) – 66.65(CtrlROE) + 22.14(PollROE-0.6)(CtrlROE-0.6) – 2.98(PollROE-0.6)(Civ1R-20.01) – 3.63(CtrlROE-0.6)(Civ1R-20.01) – 3.12(CtrlROE-0.6)(Civ2R-20.01) – 3.25(CtrlROE-0.6)(Civ3R-20.01)*

Where: Civ1R = Civ1 – Shiite/Kurd Voter RFA

Civ1E = Civ1 – Shiite/Kurd Voter EMotivation

Civ2R = Civ2 – Sunni “Yes” Voter RFA

Civ3R = Civ3 – Sunni “No” Voter RFA

Civ4R = Civ4 – Sunni Trouble-Maker Voter RFA

CivPV = Civilian Personality Variance

PollROE = Poll Soldier ROE {1&2&3&5&6 – 4}

CtrlROE = Control Soldier ROE {1&2&3&5&6 – 4}

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	112.32987	60.11642	1.87	0.0629
Civ1/Readiness_for_aggression	4.9347617	0.593378	8.32	<.0001
Civ1/Elective_motivation	-2.164947	0.588587	-3.68	0.0003
Civ2/Readiness_for_aggression	2.8378281	0.585302	4.85	<.0001
Civ3/Readiness_for_aggression	2.3416752	0.592249	3.95	0.0001
Civ4/Readiness_for_aggression	2.8440845	0.602689	4.72	<.0001
CivVariance	5.9180372	1.164932	5.08	<.0001
PollSol/Rule_set{6&2&5&1&3-4}	-33.33615	4.380982	-7.61	<.0001
CtrlSol/Rule_set{5&1&6&3&2-4}	-66.64805	4.331003	-15.39	<.0001
(PollSol/Rule_set{6&2&5&1&3-4}-0.59533)*(CtrlSol/Rule_set{5&1&6&3&2-4}-0.59533)	22.143461	5.364516	4.13	<.0001
(PollSol/Rule_set{6&2&5&1&3-4}-0.59533)*(Civ1/Readiness_for_aggression-20.0078)	-2.97759	0.708811	-4.20	<.0001
(CtrlSol/Rule_set{5&1&6&3&2-4}-0.59533)*(Civ1/Readiness_for_aggression-20.0078)	-3.627046	0.738112	-4.91	<.0001
(CtrlSol/Rule_set{5&1&6&3&2-4}-0.59533)*(Civ2/Readiness_for_aggression-20.0078)	-3.122284	0.741422	-4.21	<.0001
(CtrlSol/Rule_set{5&1&6&3&2-4}-0.59533)*(Civ3/Readiness_for_aggression-20.0078)	-3.250036	0.762396	-4.26	<.0001

Figure 101 Heter+TroubleMakerLead+CtrlRegion Aggregated Civilian Escalation Model Fit

Note that JMP has automatically grouped the Poll Area Soldier's ROE Set 1, 2, 3, 5 and 6 together (with value 1) as having the same effect on the response that is different from the Poll Area Soldier's ROE Set 4 (with value -1). Similarly, it has grouped the Control Area Soldier's ROE Set 1, 2, 3, 5 and 6 together (with value 1) as having the same effect on the response that is different from the Control Area Soldier's ROE Set 4 (with value -1).

From the metamodel, the Civ1R, PollROE and CtrlROE terms stand out statistically from the rest with higher t ratio values. For example, the overall results indicate that when the Control Area Admission Control Soldier employ ROE Set 1, 2, 3, 5 and 6, the level of aggregated civilian escalation will decrease. This is excellent, as we want the civilian escalation to be minimized. Therefore, ROE Set 1, 2, 3, 5 and 6 are excellent choices for Control Area in this election scenario. Similarly, ROE Set 1, 2, 3, 5 and 6 are excellent choices for Poll Area in this election scenario. In another example, the overall result indicates that if the level of RFA among Civ1 (Shiite/Kurd Voter) increase, the level of aggregated civilian escalation will increase. This is undesirable, as we want the civilian escalation to be minimized.

K. HETER+TROUBLEMAKERLEAD+CTRLREGION+BOOTH RESULTS

The results for the Heter+TroubleMakerLead+CtrlRegion+Booth follow. Recall that this is one of the scenarios where high voter turnout and high escalation are likely.

1. Data Distribution Analysis

a. Percentage of Votes

In this experiment, the deployments of Election Booths are implemented similar to the Heter+DisturberLead+CtrlRegion+Booth scenario. Figure 102 shows the distribution of voter participation, in percent (i.e., the number of votes cast divided by the total number of registered voters) at the end of the election simulation.

This scenario corresponds to a town with a heterogeneous Sunni and Shiite/Kurd population that had one of the highest voting turnout rates for the October 2005 election. The simulation results show an average voter participation of about 28.6% with a standard deviation of about 7.2%. The distribution of the shortest half bracket (i.e., showing the densest 50% of the observations) indicates that the civilian voting participation varies over a large range. The fact that the distribution has a wide spread with highest percentage of vote at 50.5% and lowest at 12.3% shows that at least some factors may make a difference.

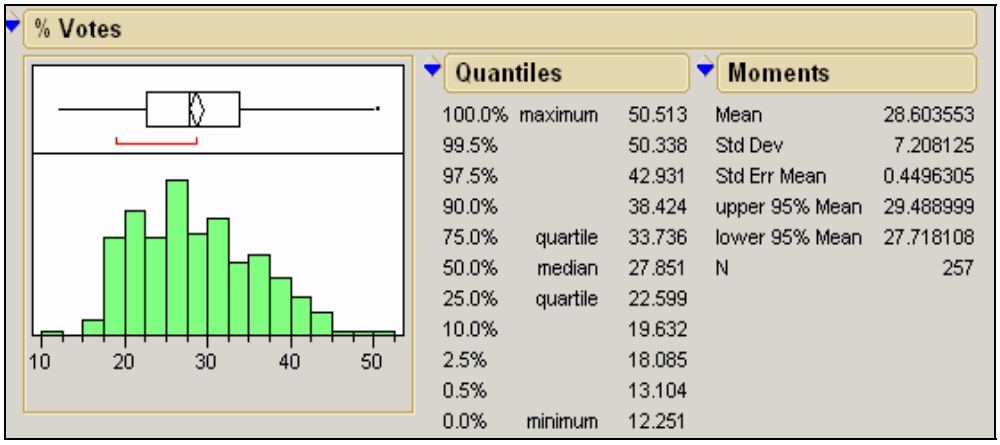

Figure 102 Heter+TroubleMakerLead+CtrlRegion+Booth Voter Participation

Compared with the Heter+DisturberLead+CtrlRegion, Heter+DisturberLead+CtrlRegion+Booth and the Heter+TroubleMakerLead+CtrlRegion scenarios, the voter participation in this Heter+TroubleMakerLead+CtrlRegion+Booth scenario has shown almost similar results.

With this comparison, the results suggest that the deployments of Election Booths in the heterogeneous population scenarios are not contributing much improvement to the average voter participation rate.

b. Aggregated Civilian Escalation

Figure 103 shows the distribution of the civilian escalation accumulated in the scenario over the entire election simulation. The distribution

of civilian escalation demonstrated against other civilians is illustrated in Figure 104. The distribution of civilian escalation demonstrated against the soldiers is illustrated in Figure 105.

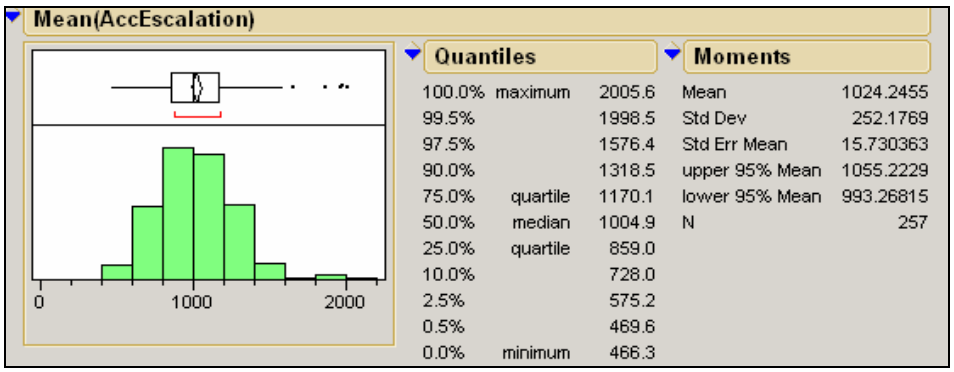

Figure 103 Heter+TroubleMakerLead+CtrlRegion+Booth Aggregated Civilian Escalation

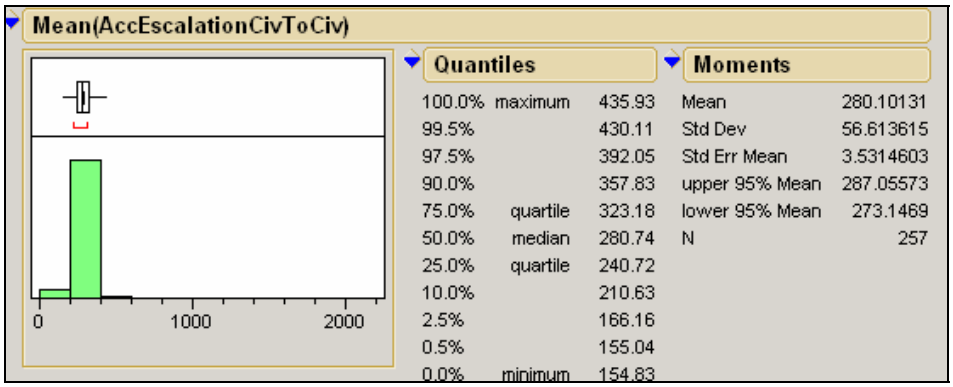

Figure 104 Heter+TroubleMakerLead+CtrlRegion+Booth Aggregated Civilian Escalation (Civilians against other Civilians)

The aggregated civilian escalation resulted in this scenario has a mean value of about 1024.2 units (i.e., threatening or attacking actions). The aggregated civilian escalation against other civilians has a mean value of about 280.1 units (about 27% of the total escalation). The mean aggregated civilian escalation against the soldier has a mean value of about 744 units (about 73% of the total escalation).

This result has a similar response as compared to the Heter+DisturberLead+CtrlRegion+Booth scenario. There was a huge increase in civilian escalation and the majority of the time the escalation is between the

civilians and soldiers. Similarly, this scenario does not yield much improvement in its voter participation, therefore supporting the same indication that the implementation of the Election Booths is redundant in this heterogeneous population scenario and is not a desired election proceeding.

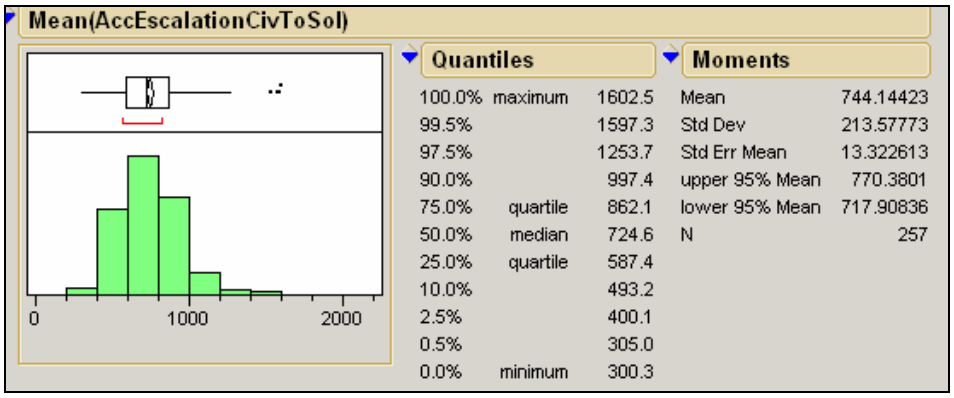

Figure 105 Heter+TroubleMakerLead+CtrlRegion+Booth Aggregated Civilian Escalation (Civilians against Soldiers)

c. Average Civilian Fear, Anger and RFA

The distributions of the civilian average fear, anger and RFA level at the end of the entire election simulation are illustrated in Figure 106, Figure 107 and Figure 108. A contour plot is shown in Figure 109 to illustrate the relationships between these three civilian personalities. Note that the maximum value for each factor is 100 units.

The average civilian fear and anger levels are high, with mean values of about 78 and 83 units. This result indicates that, on average, the civilians are fearful and angry. However, the average RFA level has a much lower mean value of about only 29 units. This suggests that on an average, the civilians may be angry and agitated at times but they are not likely to act aggressively.

Note that civilian fear level has dropped by 10 units as compared to the Heter+TroubleMakerLead+CtrlRegion scenario where no Election Booths are deployed. This suggests that the Election Booths deployed in this scenario are gaining positive responses from the civilians. On an average, civilians are now less fearful and are coming out from their homes to participate in the election.

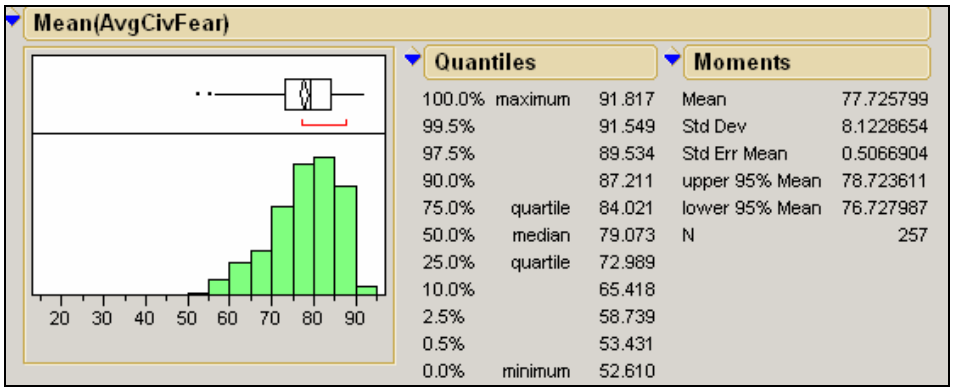

Figure 106 Heter+TroubleMakerLead+CtrlRegion+Booth Average Civilian Fear

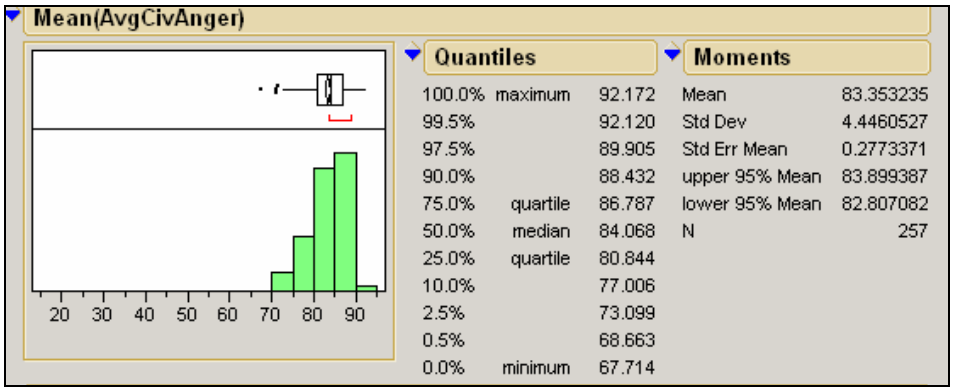

Figure 107 Heter+TroubleMakerLead+CtrlRegion+Booth Aggregated Civilian Anger

From the contour plot, it can be observed that the highest levels of civilian RFA occur mostly when the civilian fear and anger levels are both very high. These high RFA observations are isolated to the top right hand corner of the contour plot, suggesting that the majority of the time, the election proceeding is peaceful with low civilian escalation. This also suggest that, on average, the Election Booths might have contributed to the results where hostilities are now isolated during the election proceeding.

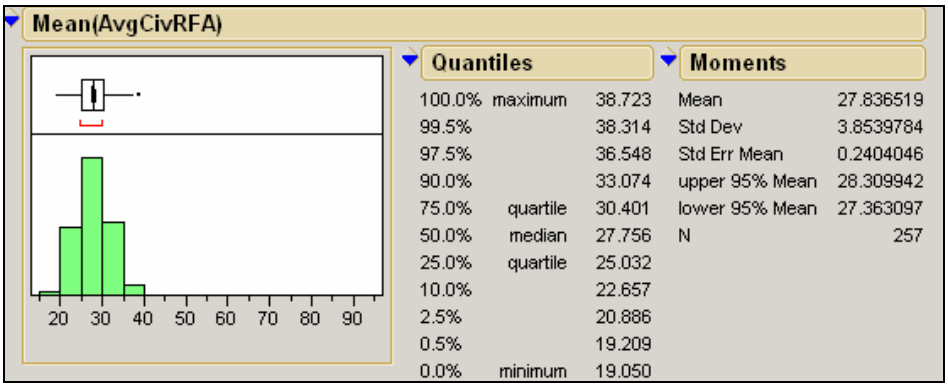

Figure 108 Heter+TroubleMakerLead+CtrlRegion+Booth Aggregated Civilian RFA

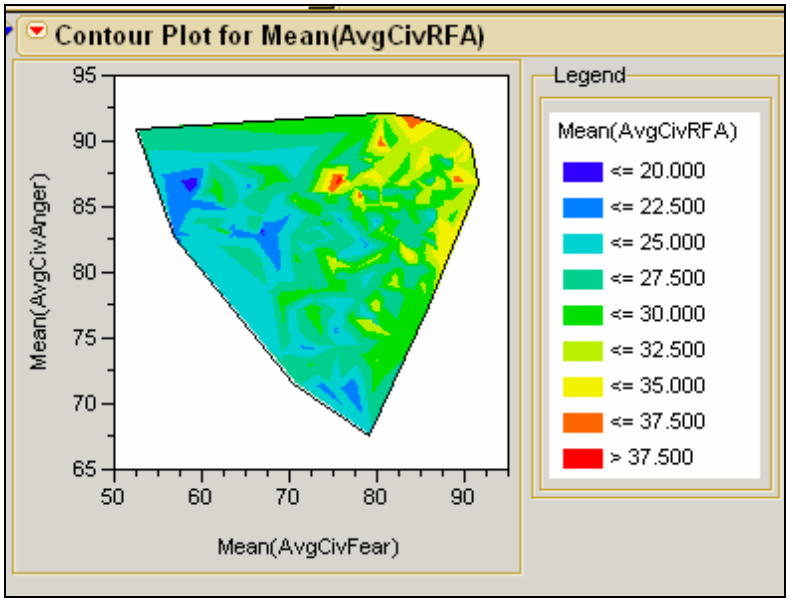

Figure 109 Heter+TroubleMakerLead+CtrlRegion+Booth Aggregated Civilian Fear, Anger and RFA Contour Plot

Note that this scenario has a similar response as compared to the Heter+DisturberLead+CtrlRegion+Booth scenario where the Disturber's leadership is modeled. This suggests that, on average, there is no significant difference between the Disturber's and Trouble-maker's leadership.

However, with comparison to the homogeneous population scenario, where similar Election Booths are deployed, it is observed that on average, in this heterogeneous population scenario (with Election Booths), the majority of the high RFA occurred when the civilian fear is high. On the contrary,

on average, in this homogeneous population scenario (with Election Booths), the majority of the high RFA occurred when the civilian fear is low.

2. Regression Tree Analysis

a. Percentage of Votes

The percentage of votes cast by the civilians is the response of the regression tree shown in Figure 110. This partition yields an R^2 value of 0.526, and indicates that the effect of Civ1 – Shiite/Kurd Voter Elective Motivation (>=84) factor has solely contributed to the high voter participation in those excursions where a high percentage of votes are observed.

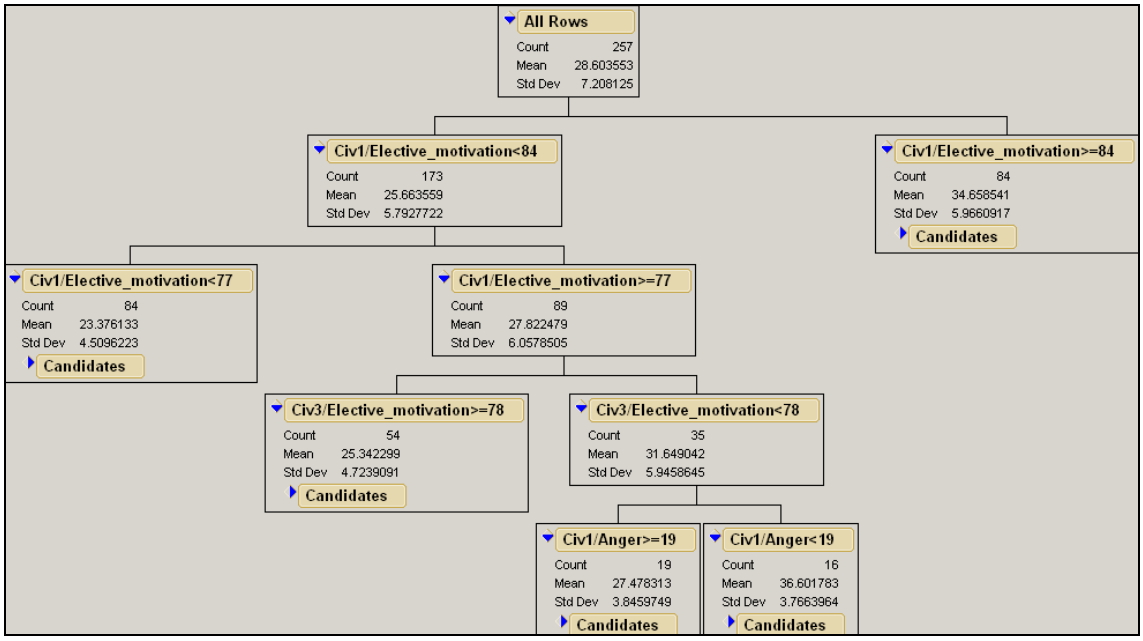

Figure 110 Heter+TroubleMakerLead+CtrlRegion+Booth Vote Percentage Regression Tree

The effect of Civ1 – Shiite/Kurd Voter Elective Motivation (<84) and Civ1 – Shiite/Kurd Voter Elective Motivation (<77) factors have contributed in causing a low percentage of votes cast.

b. Aggregated Civilian Escalation

The regression tree for accumulated civilian escalation yields an R^2 value of 0.262, as shown in Figure 111, and indicates that the following design factor levels characterize those excursions where low aggregated civilian escalation is observed:

- Civilian Personality Variance (<5)
- Civ1 – Shiite/Kurd Voter RFA (<28)

The effect of Civilian Personality Variance (>=5) factor has solely contributed in causing high civilian escalation.

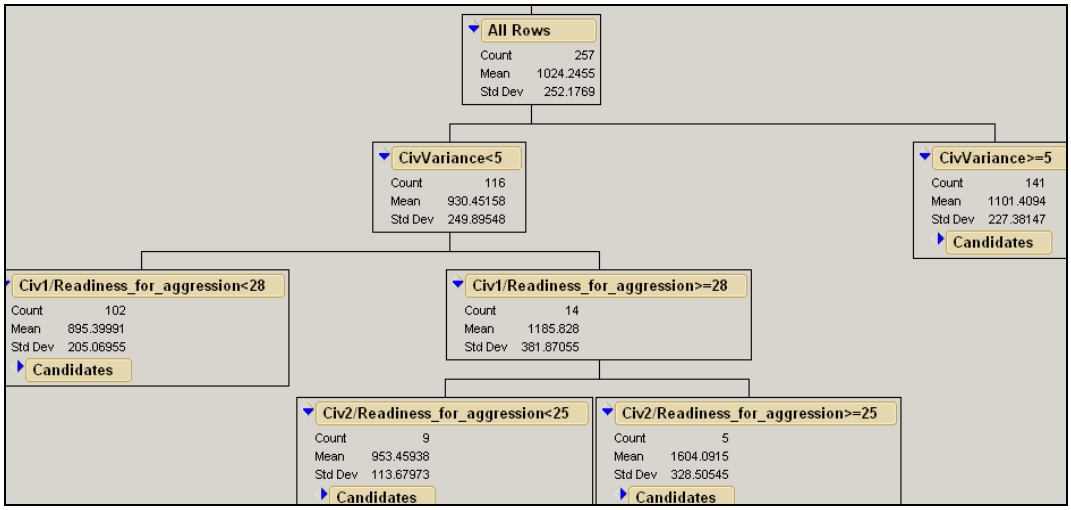

Figure 111 Heter+TroubleMakerLead+CtrlRegion+Booth Aggregated Civilian Escalation Regression Tree

3. Model Fitting Analysis

a. Percentage of Votes

The percentage of votes cast by the civilians is the response of this model fitting analysis. In order to achieve a simple model for analysis, the "best" model was finally selected after a few cycles of manual fitting with the main effects, two-way interactions and quadratic terms. A satisfactory R^2 value of 0.65 and low p-values for all terms (i.e., highest at 0.008) were obtained. Refer to Figure 112 for details. Note that those factors highlighted by the regression tree were also included in the final model. A simple check of linearity and equal variance properties on the selected model indicated an absence of non-linearity and heteroskedacity problems. The metamodel for predicting the average civilian escalation is generated as follows:

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	5.3682048	5.71531	0.94	0.3485
Civ1/Anger	-0.341687	0.046744	-7.31	<.0001
Civ1/Readiness_for_aggression	-0.2064	0.046743	-4.42	<.0001
Civ1/Elective_motivation	0.788783	0.046743	16.87	<.0001
Civ2/Anger	-0.146186	0.046742	-3.13	0.0020
Civ2/Readiness_for_aggression	-0.194244	0.046744	-4.16	<.0001
Civ3/Readiness_for_aggression	-0.125351	0.046744	-2.68	0.0078
Civ3/Elective_motivation	-0.213762	0.046745	-4.57	<.0001
CivVariance	-0.497823	0.092942	-5.36	<.0001
(Civ1/Elective_motivation-80.0078)*(Civ3/Readiness_for_aggression-20.0078)	-0.02665	0.008212	-3.25	0.0013

Figure 112 Heter+TroubleMakerLead+CtrlRegion+Booth Vote Percentage Model Fit

Percentage of Votes Cast = *5.37 – 0.34(Civ1A) – 0.21(Civ1R) + 0.79(Civ1E) – 0.15(Civ2A) – 0.19(Civ2R) – 0.13(Civ3R) – 0.21(Civ3E) – 0.5(CivPV) – 0.03(Civ1E-80.01)(Civ3R-20.01)*

Where: Civ1A = Civ1 – Shiite/Kurd Voter Anger

Civ1R = Civ1 – Shiite/Kurd Voter RFA

Civ1E = Civ1 – Shiite/Kurd Voter EMotivation

Civ2A = Civ2 – Sunni “Yes” Voter Anger

Civ2R = Civ2 – Sunni “Yes” Voter RFA

Civ3R = Civ3 – Sunni “No” Voter RFA

Civ3E = Civ3 – Sunni “No” Voter EMotivation

CivPV = Civilian Personality Variance

From the metamodel, the Civ1E term stands out statistically from the rest with a higher t ratio value. Overall, the result indicates that if the level of elective motivation among the Civ1 (Shiite/Kurd Voter) increases, the percentage of votes will increase. This is excellent, as we want the percentage of votes to be high.

b. Aggregated Civilian Escalation

The civilian escalation accumulated during the entire simulation is the response of this model fitting analysis. In order to achieve a simple model for analysis, the “best” model was finally selected after a few cycles of manual fitting

with the main effects, two-way interactions and quadratic terms. A satisfactory R^2 value of 0.53 and low p-values for all terms (i.e., highest at 0.05) were obtained. Refer to Figure 113 for details. Note that those factors highlighted by the regression tree were also included in the final model. A simple check of linearity and equal variance properties on the selected model indicated an absence of non-linearity and heteroskedacity problems. The metamodel for predicting the average civilian escalation is generated as follows:

Aggregated Civilian Escalation = *164.1 – 28.92(PollROE) – 50.15(CtrlROE) + 4.61(Civ1F) + 8.59(Civ1R) – 13.8(Civ1E) + 8.73(Civ2R) + 5.36(Civ2E) + 3.85(Civ3F) – 5.17(Civ5F) + 12.25(Civ5R) + 33.58(CivPV) – 0.98(Civ2R-20.01)(Civ2E-80.01) + 1.08(Civ3F-20.01)(Civ5F-20.01)*

Where: Civ1F = Civ1 – Shiite/Kurd Voter Fear

Civ1R = Civ1 – Shiite/Kurd Voter RFA

Civ1E = Civ1 – Shiite/Kurd Voter EMotivation

Civ2R = Civ2 – Sunni “Yes” Voter RFA

Civ2E = Civ2 – Sunni “Yes” Voter EMotivation

Civ3F = Civ3 – Sunni “No” Voter Fear

Civ5F = Civ5 – Disturber Fear

Civ5R = Civ5 – Disturber RFA

CivPV = Civilian Personality Variance

PollROE = Poll Soldier ROE {1&2&5&6 –3&4}

CtrlROE = Control Soldier ROE {1&2&3&5 – 4&6}

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	164.10242	278.1262	0.59	0.5557
PollSol/Rule_set{6&1&5&2-4&3}	-28.92363	11.36082	-2.55	0.0115
CtrlSol/Rule_set{2&5&3&1-6&4}	-50.14969	12.14159	-4.13	<.0001
Civ1/Fear	4.6149642	1.905132	2.42	0.0162
Civ1/Readiness_for_aggression	8.5869485	1.906841	4.50	<.0001
Civ1/Elective_motivation	-13.79992	1.906919	-7.24	<.0001
Civ2/Readiness_for_aggression	8.7339476	1.905546	4.58	<.0001
Civ2/Elective_motivation	5.3647798	1.905517	2.82	0.0053
Civ3/Fear	3.8476211	1.91346	2.01	0.0454
Civ5/Fear	-5.169503	1.906674	-2.71	0.0072
Civ5/Readiness_for_aggression	12.246455	1.906624	6.42	<.0001
CivVariance	33.580915	3.78958	8.86	<.0001
(Civ2/Readiness_for_aggression-20.0078)*(Civ2/Elective_motivation-80.0078)	-0.983118	0.349209	-2.82	0.0053
(Civ3/Fear-20.0078)*(Civ5/Fear-20.0078)	1.081613	0.320732	3.37	0.0009

Figure 113 Heter+TroubleMakerLead+CtrlRegion+Booth Aggregated Civilian Escalation Model Fit

Note that JMP has automatically grouped the Poll Area Soldier's ROE Set 1, 2, 5 and 6 together (with value 1) as having the same effect on the response that is different from the Poll Area Soldier's ROE Set 3 and 4 (with value -1). Similarly, it has grouped the Control Area Soldier's ROE Set 1, 2, 3 and 5 together (with value 1) as having the same effect on the response that is different from the Control Area Soldier's ROE Set 4 and 6 (with value -1).

From the metamodel, the Civ1E, Civ5R and CivPV terms stand out statistically from the rest with higher t ratio values. Overall, the results indicate that if the personalities among the civilians vary over a large range, the level of aggregated civilian escalation will increase. This is undesirable, as we want the civilian escalation to be minimized.

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V. RESULTS SUMMARY AND COMPARISON ANALYSIS

A. CHAPTER OVERVIEW

This chapter summarizes the results presented in Chapter IV and provides detailed comparisons between the homogeneous and heterogeneous population scenarios. It will attempt to identify significant factors and draw conclusions on the proposed military tactics, techniques and procedures that are modeled and studied in this research.

B. HOMOGENEOUS SUNNI POPULATION SCENARIO

1. Data Distribution Analysis

a. Percentage of Votes

The summary of the voter participation results for all homogeneous Sunni population scenarios generated in Chapter IV are tabulated in Table 8. Refer to Figure 114 for a chart comparison on the mean percentage voter participation results between the scenarios.

Number of Votes (Percentage) - Homogeneous Sunni Population Scenario						
S/No	Scenario	Lowest	Mean	Median	Highest	Dense
1	Homo+DisturberLead+CtrlRegion	8.8	15.5	15.7	20.0	No
2	Homo+DisturberLead+CtrlRegion+Booths	9.2	17.7	18.7	20.1	Yes
3	Homo+TroubleMakerLead+CtrlRegion	8.3	15.4	15.6	19.9	No
4	Homo+TroubleMakerLead+CtrlRegion+Booths	7.0	17.3	18.3	20.1	Yes

Table 8 Summary of Voter Participation (%) in Homogeneous Sunni Population Hybrid Scenarios

Generally, the average voter participation has improved (p-value < 0.05) in those scenarios where Election Booths are deployed. The simulation results in each of those scenarios have a narrower half-bracket (i.e., the densest 50% of the observations) distribution near the upper end of the distribution, indicating that although voter participation is still low, very unfavorable results are less likely to occur when Election Booths are present. This can also be observed from their higher median values (indicating where half of the observations fall on higher voter participation regions). Therefore, from the average vote percentage

results, this research reveals that the deployment of Election Booths has generally contributed improvement to the average voter participation in homogeneous Sunni population scenario. Note that there is also a marginal but statistically significant (p-value < 0.055) improvement in the voter participation in those scenarios with Disturber's leadership influence.

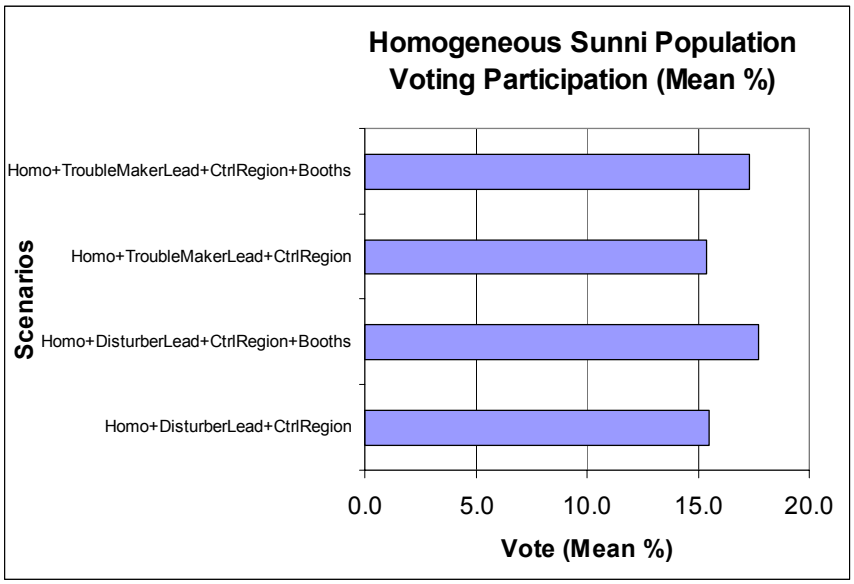

Figure 114 Summary of Voter Participation (Mean %) in Homogeneous Sunni Population Hybrid Scenarios

b. Aggregated Civilian Escalation

The summary of the average aggregated civilian escalation results for all homogeneous Sunni population scenarios generated in Chapter IV are tabulated in Table 9. Refer to Figure 115 for a chart comparison on the mean aggregated civilian escalation results between the scenarios. Civilian escalations against other Civilians or against Soldiers are also identified.

Aggregated Civilian Escalation - Homogeneous Sunni Population Scenario				
S/No	Scenario	Overall Mean	Civ To Civ Mean	Civ To Sol Mean
1	Homo+DisturberLead+CtrlRegion	367	286	81
2	Homo+DisturberLead+CtrlRegion+Booths	1235	406	829
3	Homo+TroubleMakerLead+CtrlRegion	362	281	81
4	Homo+TroubleMakerLead+CtrlRegion+Booths	1212	399	813

Table 9 Summary of Aggregated Civilian Escalation in Homogeneous Sunni Population Hybrid Scenarios

Obviously, civilian escalation has increased significantly in those scenarios where Election Booths were deployed. At first, this appears to contradict the earlier observations where deployments of Election Booths improved the voter participation.

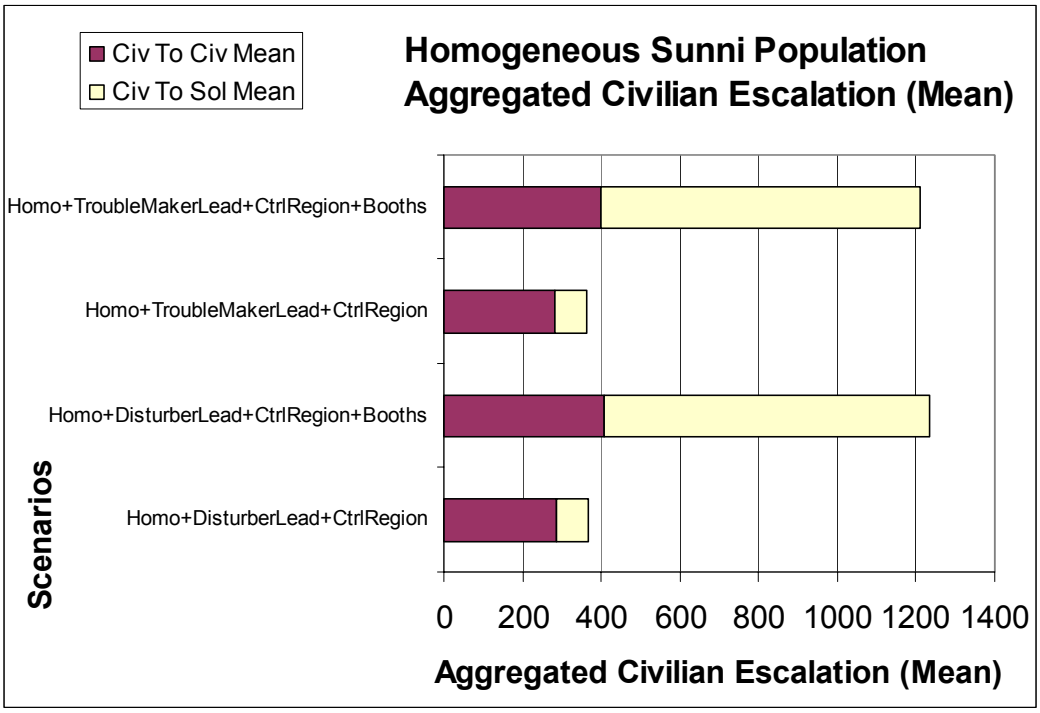

Figure 115 Summary of Aggregated Civilian Escalation in Homogeneous Sunni Population Hybrid Scenarios

However, a closer look reveals that the majority of the escalation is between the Civilians and Soldiers. Note that this relationship is opposite that observed in those scenarios where no Election Booths are deployed, for which the majority of the escalation is between the civilians. The escalation between the civilians also increased, however the percentage of votes also increased, again this may indicate that the situation is manageable and is not chasing the civilians away from the polling center. Since PAX did not report the different actions carried out by the civilian groups, we can only interpret that the majority of the escalation is between the hostile civilians.

The type and number of actions carried out by Soldiers against Civilians during the entire simulations in both the scenarios where Election Booths are deployed are also of interest. Figure 116, Figure 117 and Figure 118 show the results for the Homo+DisturberLead+CtrlRegion+Booth scenario and the results are about the same for the other scenario. Clearly, the majority (i.e., 97%) of the actions carried out by the Soldiers are attempting to calm the civilians, rather than threatening or attacking the civilians. Recall also that a Soldier will only "attack" as a defensive measure in response to civilian actions, according to the specific ROE. Overall, the Soldiers' actions are considered non-alarming and non-violent.

Observations made from the simulation runs also indicate that the Election Booths manage to attract hostile civilians. While Soldiers at the Election Booths attempt to calm and pacify the civilians, opportunities are created for motivated civilians to proceed to the poll center and cast their votes. Because voter participation increases, these opportunities appear to lead to success. Taken together, these findings suggest that minimal violence has taken place and the average aggregated civilian escalation is manageable and is under control. For example, in over half of the scenarios the Soldiers took no attacking actions. In over 90% of the scenarios, at most one such action occurred.

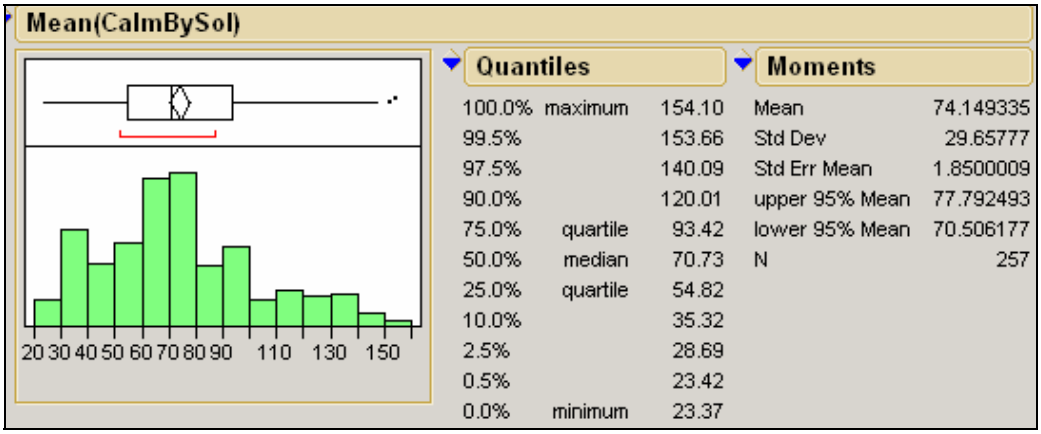

Figure 116 Calming Actions By Soldiers in Homogeneous Sunni Population Scenarios with Election Booths

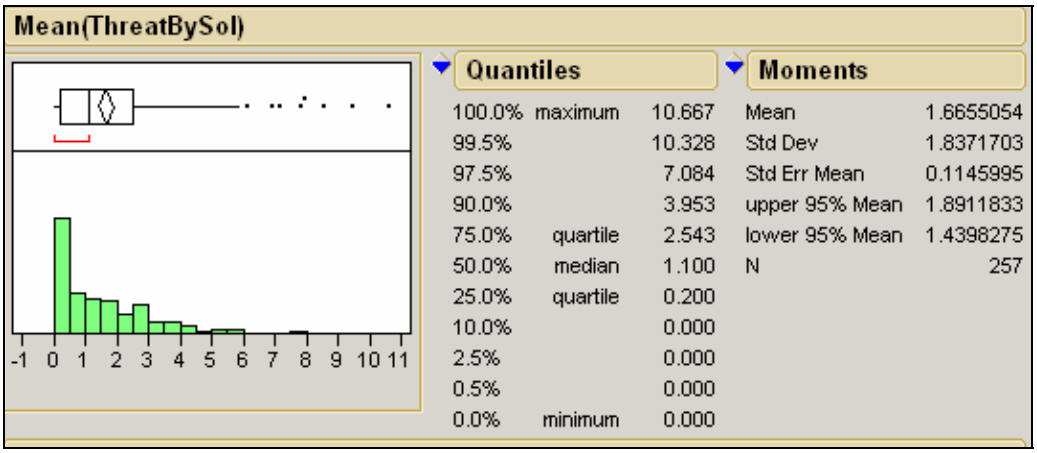

Figure 117 Threatening Actions By Soldiers in Homogeneous Sunni Population Scenarios with Election Booths

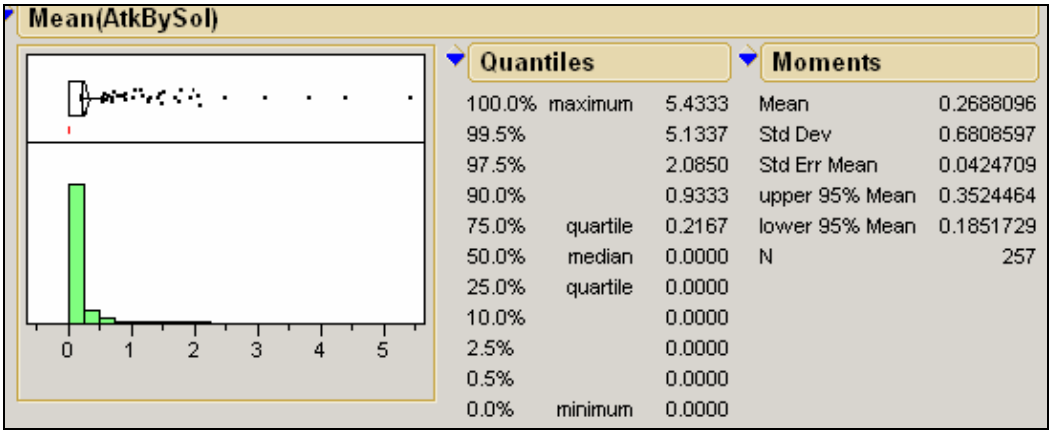

Figure 118 Attacking Actions By Soldiers in Homogeneous Sunni Population Scenarios with Election Booths

This again indicates that on an average, the deployment of Election Booths has contributed positive outcomes in Homogeneous Sunni Population scenarios.

c. Average Civilian Fear, Anger and RFA

The summary of the average civilian fear, anger and RFA results for all homogeneous Sunni population scenarios generated in Chapter IV are tabulated in Table 10. Refer to Figure 119 for a chart comparison on the average civilian fear, anger and RFA results between the scenarios.

Average Civilian Fear, Anger and RFA - Homogeneous Sunni Population Scenario				
S/No	Scenario	Fear	Anger	RFA
1	Homo+DisturberLead+CtrlRegion	88	87	31
2	Homo+DisturberLead+CtrlRegion+Booths	78	86	32
3	Homo+TroubleMakerLead+CtrlRegion	88	87	31
4	Homo+TroubleMakerLead+CtrlRegion+Booths	78	86	32

Table 10 Summary of the Average Civilian Fear, Anger and RFA in Homogeneous Sunni Population Scenario

The table and chart clearly indicate that the average civilian fear and anger levels are high and the average civilian RFA level is low. This shows that in this scenario, the civilians are generally fearful, easily agitated and become angry, but their likelihood of acting aggressively is low. Therefore, on an average, the propensity towards a high conflict and hostile environment in this scenario is low.

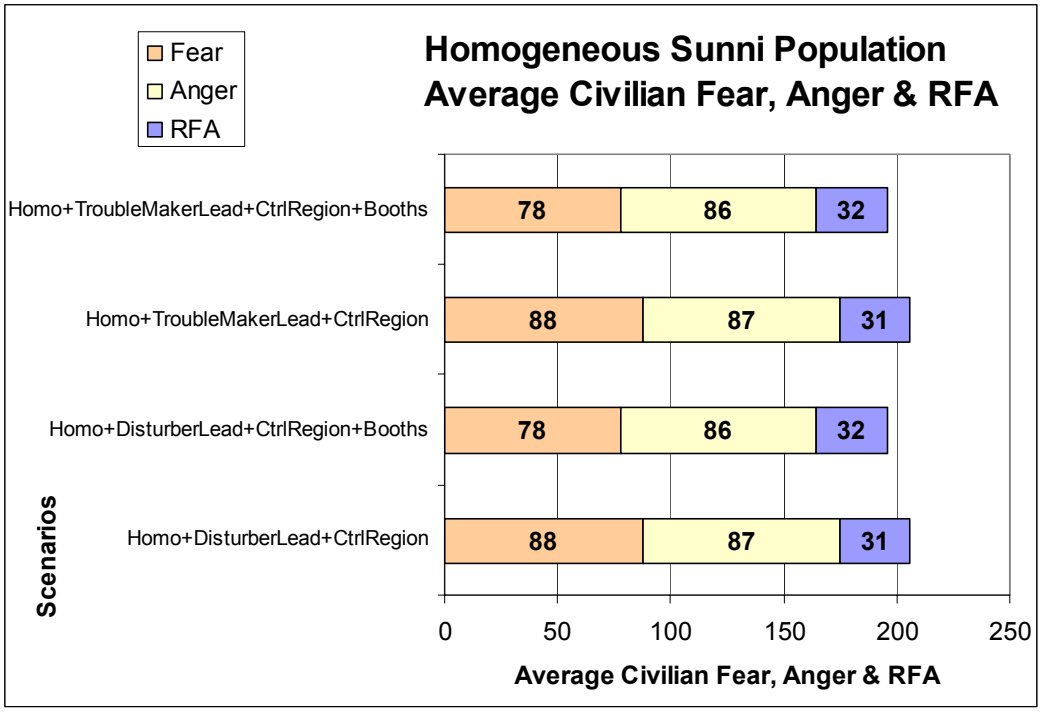

Figure 119 Summary of the Average Civilian Fear, Anger and RFA in Homogeneous Sunni Population Scenario

A sizeable reduction of civilian fear and a marginal reduction in civilian anger are observed in those scenarios with Election Booths deployed. On the other hand, there is a marginal deterioration in civilian RFA. But, this marginal increase in RFA level may be considered insignificant since their values are low.

The proportions of the average civilian anger and RFA across all the scenarios are quite similar. This equal proportions suggest that these average civilian emotional and psychological states can be considered constant across all scenarios. Having these civilian states constant, we attempt to identify the differences between all the scenarios and their contributed outcomes. We identified that the deployment of the Election Booth is the only change made and its positive contributions, especially improvement in voter participation, are highlighted in the previous sections. This increased in voter participation coupled with the decrease in civilian fear indicated another advantage that the actual civilian fears in the scenarios with Election Booths are even lower.

In general, this research demonstrates that the deployment of Election Booths improves the average voter participation while containing civilian escalation within a manageable and non-violent environment. Therefore, it is a military measure worthy of consideration for deployment in future elections.

2. Regression Tree and Model Fitting Analysis

The summary of the “main effect” terms that show up statistically as contributing factors in the metamodels of Voter Participation Percentage and Aggregated Civilian Escalation for any of the homogeneous Sunni population scenarios in Chapter IV, is tabulated as shown in Table 11. A “+” sign indicates that the presence of the term in the model has a positive impact on the stated MOE. For quantitative factors, this means that increasing the factor will improve the MOE (i.e., increase the voter participation or decrease the escalation). For qualitative factors, a “+” sign indicates the particular factor level is associated with improved MOEs. A “(+)” sign has the same indication as a “+” sign, but has a greater positive impact to the model. A “-“ sign indicates that the term has a negative effect on the model. A “(-)” sign has the same indication as a “-” sign but has a greater negative impact to the model.

Homogeneous Sunni Population Scenario								
MOE	Percentage of Votes				Aggregated Civ Escalation			
Scenarios	DisturberLead +CtrlRegion	DisturberLead +CtrlRegion +Booth	TroubleMakerLead +CtrlRegion	TroubleMakerLead +CtrlRegion +Booth	DisturberLead +CtrlRegion	DisturberLead +CtrlRegion +Booth	TroubleMakerLead +CtrlRegion	TroubleMakerLead +CtrlRegion +Booth
Significant Terms / R^2 Value	0.73	0.74	0.5	0.71	0.76	0.71	0.8	0.6
Civ1: Sunni Bystander/Fearful								
Fear	-	+		+	+	(-)	+	-
Anger	+	-		-	-	+	-	+
RFA	(-)	(-)	(-)	(-)		(-)	-	(-)
Elective Motivation								
Civ2: Sunni "Yes" Voter								
Fear								
Anger	-	-	-	-				
RFA					-		-	
Elective Motivation								
Civ3: Sunni "No" Voter								
Fear								
Anger	-	-	-	-				
RFA				-	-			
Elective Motivation	(+)	(+)	(+)	(+)				
Civ4: Sunni Trouble-Maker Voter								
Fear								
Anger						-		-
RFA					-	-	-	-
Elective Motivation								
Willingness to Cooperate			-	-			-	
Civ5: Disturber								
Fear							+	
Anger				-				
RFA					-	-	-	-
Elective Motivation								
Willingness to Cooperate								
Civilian Personality Variance	-	-	-	-		-		-
Poll Soldier ROE Set 1	+	-	+		-	+		+
Poll Soldier ROE Set 2	-	-	-		+	-		-
Poll Soldier ROE Set 3	-	-	-		-	-		-
Poll Soldier ROE Set 4	+	-	+		-	+		+
Poll Soldier ROE Set 5	+	+	+		+	+		+
Poll Soldier ROE Set 6	-	-	-		+	+		+
Control Soldier ROE Set 1				-	(+)		(+)	
Control Soldier ROE Set 2				-	(+)		(+)	
Control Soldier ROE Set 3				+	(+)		(+)	
Control Soldier ROE Set 4				-	(-)		(-)	
Control Soldier ROE Set 5					(+)		(+)	
Control Soldier ROE Set 6				-	(+)		(+)	

Table 11 Summary of Model Terms for Homogeneous Sunni Population Scenario

Note that some factors did not show up in any of the models, such as Sunni Bystander and Fearful Voter Elective Motivation, Sunni "Yes" Voter Elective Motivation, Sunni "No" Voter Fear, Sunni Trouble-Maker Voter Fear and Disturber Willingness To Cooperate. This does not mean that they are not important, but rather they are not statistically proven to be significant in the presence of other factors that are studied in the experiment for the stated MOE. Instead of discussing the results separately for each MOE, we now summarize some of the important findings that provide general guidance.

a. Percentage of Votes

From those terms that show up in the experiment for MOE – Percentage of Votes, some terms (such as Sunni Bystander and Fearful Voters Anger and Poll Soldiers' ROE Set 1) appear to have mixed impacts for different scenarios. Other factors appear to have a consistently positive or negative impact on the MOE across all scenarios. These are of particular interest, because appropriate changes in the factor levels can lead to improvements across all scenarios.

The Sunni "No" Voter Elective Motivation term has a very high positive impact across all scenarios. This indicates that in order to achieve high voter participation, the level of elective motivation among the Sunni "No" Voters must be maintained at high levels in all homogeneous Sunni population scenarios. Recall that the result for Sunni "Yes" and "No" Voters are interpreted interchangeably, therefore the level of elective motivation should be high for both.

The Sunni Bystander and Fearful Voter RFA term has shown up statistically significant with high negative impact on the model and is constant throughout all scenarios. This indicates that in order to achieve a high voting participation, the level of RFA among Sunni Bystander and the Fearful Voter must be kept at their lowest in all homogeneous Sunni population scenarios.

Sunni "Yes" Voter Anger, Sunni "No" Voter, Anger and Civilian Personality Variance terms have shown up with a negative impact to the model consistently throughout all scenarios, but each of these terms has a smaller

impact than the terms mentioned above. Nevertheless, they are considered key factors for the election scenarios, and their levels must be kept at their lowest values in order to achieve better voting participation results.

b. Aggregated Civilian Escalation

Similarly, from the metamodels of the MOE – Aggregated Civilian Escalation, some terms (such as Sunni Bystander and Fearful Voter Anger and Poll Soldiers' ROE Set 1) appear to have mixed impacts on different scenarios. Other terms appear to have constant positive or negative impact on the MOE across all scenarios.

Control Soldiers' ROE Set 1, 2, 3, 5 and 6 appear highly beneficial when no Election Booths are deployed. This indicates that in order to achieve low civilian escalation in homogeneous Sunni population scenarios where no Election Booths are deployed, Control Soldiers' ROE Set 1, 2, 3, 5 and 6 must be executed. On the contrary, the execution of Control Soldiers' ROE Set 4 "Gandhi" in the same scenarios has statistically significant negative impact to the stated MOE and therefore must be avoided. Note that in those scenarios where Election Booths are deployed, Control Soldiers' ROE terms did not show up in the model. This suggests that any of the six ROE rule sets can be executed at the Control Area with similar civilian escalation outcomes.

The Sunni Bystander and Fearful Voter RFA term shows up with high negative impacts on the models; especially in the scenarios where Election Booths are deployed. This suggests that in order to achieve a low civilian escalation in the scenarios where Election Booths are deployed, the level of RFA among Sunni Bystander and Fearful Voters must be kept low.

The RFA term in both Sunni Trouble-Maker Voter and Disturber groups show up with a negative impact to the model consistently throughout all scenarios, but each of these terms has a lesser statistical significant impact. Nevertheless, they are considered key factors that have significant contribution to the election scenarios and in this case, their levels must be kept at their lowest in order to improve the civilian escalation.

3. Effect of ROE

It is clearly illustrated in Table 11 that the Control Soldiers' ROE does not contribute in the aspect of improving voter participation in all scenarios. However, it has significant contribution in improving civilian escalation especially in scenarios where Election Booths are deployed. In this case, the execution of ROE Set 1, 2, 3, 5 and 6 will be desired at the Control Area. On the contrary, Soldiers at the Control Area should avoid ROE Set 4 "Gandhi" at all times.

Looking across all scenarios, most Poll Soldiers' ROE terms have a mix of positive and negative impacts. However, Poll Soldiers' ROE Set 5 has a positive impact in six of the eight scenarios, and no impact in the remaining two scenarios. This suggests that Soldiers at the Poll Area should execute ROE Set 5 at all times to achieve good overall results for voter participation and civilian escalation. Conversely, Poll Soldiers' ROE Set 3 has a consistent negative impact to the model across all scenarios. Therefore, it suggests that Soldiers at the Poll Area should avoid executing ROE Set 3 at all times.

However, precaution must be taken to consider the interactions between the Poll and Control Solders' ROE factors with other factors in the model. The importance of this interaction's effects is highlighted with the Homo+DisturberLead+CtrlRegion scenario, where we have both Poll and Control Soldiers' ROE terms appearing together as key factors in the aggregated civilian escalation model.

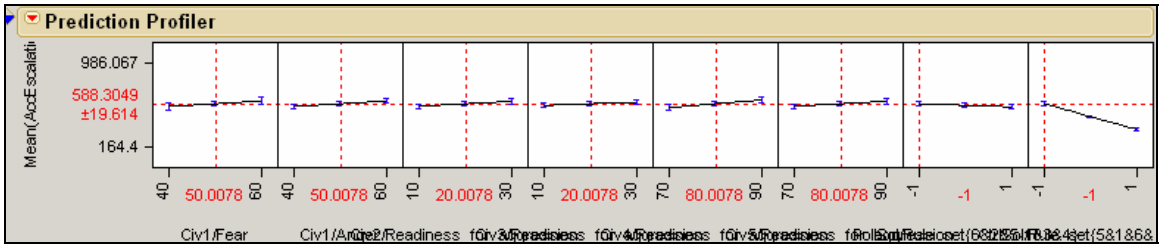

Figure 120 Profiler Analysis on Poll and Control Soldiers' ROE (Value = -1) in Homo+DisturberLead+CtrlRegion Scenario

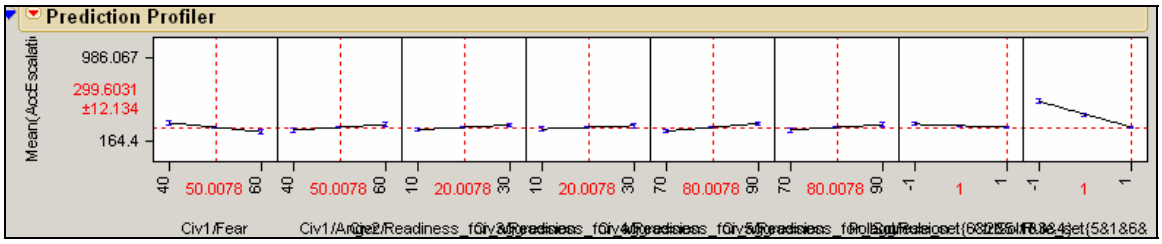

Figure 121 Profiler Analysis on Poll and Control Soldiers' ROE (Value = 1) in Homo+DisturberLead+CtrlRegion Scenario

JMP provides a prediction profiler tool which made the analysis of the model's main effects and their interactions easier. This tool provides a prediction trace on the response variable as it changes while keeping the other factors constant at their current values. Refer to Figure 120 and Figure 121 for the effects of the Poll and Control Soldiers' ROE on the civilian escalation when they are both set to value -1 and 1. The Prediction Profiler plots illustrated that when the Poll and Control Soldiers' ROE are both set to the value -1, the aggregated civilian escalation is 588 units. When they are both set to the value 1, the aggregated civilian escalation drops significantly from 588 to 300 units. Notice that the marginal effect of the Civ1F (Sunni Bystander and Fearful Voter Fear) term has changed because of its interaction with the rule set. In Figure 120, increasing Civ1F will increase escalation; in Figure 121, increasing Civ1F will decrease escalation.

4. Effect of Civilian Personality Variability

It is clearly illustrated in Table 11 that the Civilian Personality Variance term consistently shows up with negative effects in the most of the models. This suggests that the variability of fear, anger and RFA level among the civilians an impact on the election outcome.

The results suggest that small personality variances among the civilian are desired in most of the scenarios in order to achieve good voter participation and low civilian escalation in the presence of the recommended military measures.

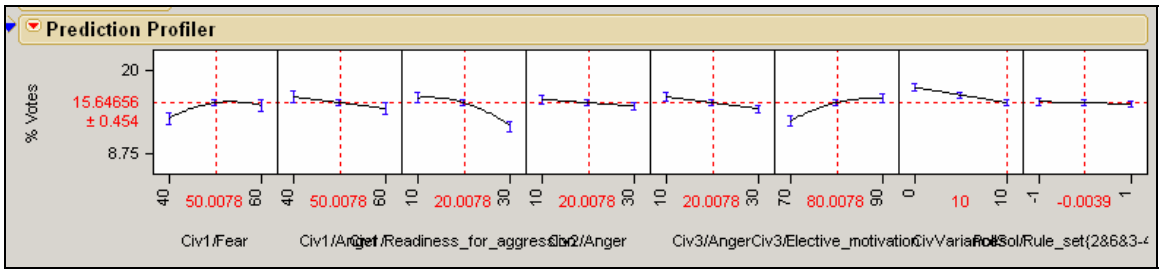

Figure 122 Profiler Analysis on Civilian Personality Variance (Value = 10) in Homo+DisturberLead+CtrlRegion Scenario

Prediction Profiler analysis is conducted for the effect of Civilian Personality Variance term on the voter participation outcome in Homo+DisturberLead+CtrlRegion scenario. Refer to Figure 122 and Figure 123 for the effects of Civilian Personality Variance on the voter participation when it is set to value 10 and 0, respectively. The Prediction Profiler plots illustrate that when the civilian personality has a smaller variability, the vote percentage is 18% (vs. 16% when civilian personality variability is high). Note that the effects of strong interaction terms are also felt in Civ1F and Civ1A terms (Sunni Bystander and Fearful Voter Fear and Anger).

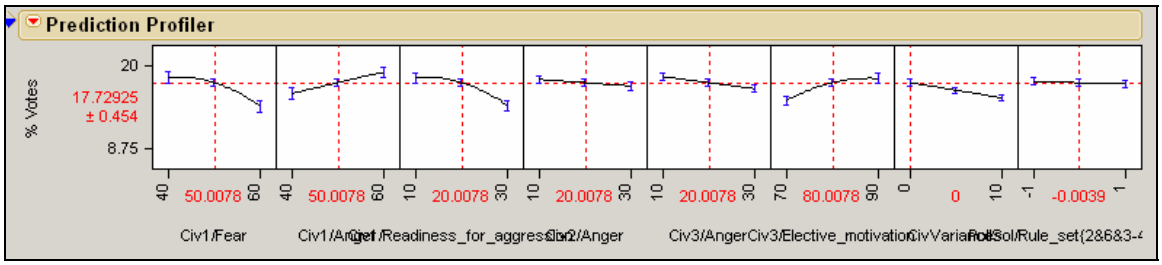

Figure 123 Profiler Analysis on Civilian Personality Variance (Value = 0) in Homo+DisturberLead+CtrlRegion Scenario

5. Effect of Civilian Leadership Influence

The Civ4W – Sunni Trouble-Maker Voter Leadership Willingness-To-Cooperate term shows up three times over the eight scenarios in Table 11. On the contrary, Civ5W – Disturber Leadership Willingness-To-Cooperate term does not show up at all.

This distinction clearly identifies that the Civ4W has a greater impact on the election outcome than does the Civ5W term. Therefore, the importance of a

leadership's influences that the military can leverage on in homogeneous Sunni population scenarios lies with the Civ4 – Sunni Trouble-Maker Voter Leaders.

However, note that when the Civ4W term appears, it has a negative impact. This indicates that too much cooperative effort from Sunni Trouble-Maker Voter Leaders may not be desired at times, as it can worsen the situation. This might be partially due to the limited type of cooperation possible in PAX. The only thing a leader can do is to suggest his followers to go home. This might lead to civilians within the polling area deciding to leave before casting their votes.

C. HETEROGENEOUS SUNNI, SHIITE/KURD POPULATION SCENARIO

1. Data Distribution Analysis

a. Percentage of Votes

The summary of the voter participation results for all heterogeneous Sunni, Shiite/Kurd population scenarios generated in Chapter IV are tabulated in Table 12. Refer to Figure 124 for a chart comparison on the mean percentage of voter participation results between the scenarios.

Number of Votes (Percentage) - Heterogeneous Sunni + Shiite/Kurd Population Scenario						
S/No	Scenario	Lowest	Mean	Median	Highest	Dense
1	Heter+DisturberLead+CtrlRegion	12.4	28.3	28.4	45.1	No
2	Heter+DisturberLead+CtrlRegion+Booths	14.2	28.8	28.4	50.9	No
3	Heter+TroubleMakerLead+CtrlRegion	13.5	28.3	28.2	40.8	No
4	Heter+TroubleMakerLead+CtrlRegion+Booths	12.3	28.6	27.9	50.5	No

Table 12 Summary of Voter Participation (%) in Heterogeneous Sunni, Shiite/Kurd Population Hybrid Scenarios

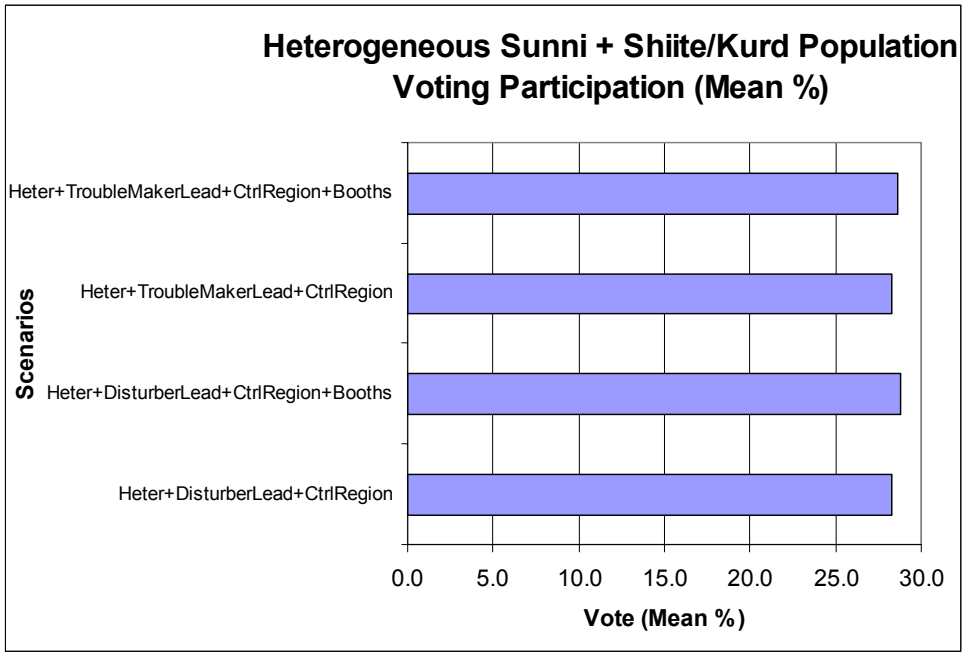

Figure 124 Summary of Voter Participation (%) in Heterogeneous Sunni, Shiite/Kurd Population Hybrid Scenarios

The average voter participation has improved in those scenarios where Election Booths are deployed. However, although this improvement is statistically significant (p-value < 0.008), it is so small that it is of little practical importance. This can also be observed from the similarity of the median values, across all scenarios. Therefore, from the average vote percentage results, this research reveals that the deployment of Election Booths leads to a small but statistically significant improvement to the average voter participation in heterogeneous Sunni, Shiite/Kurd population scenario. Note that the maximum participation rates are higher when the Election Booths are deployed, suggesting that there may be a greater possibility of a very high voter turnout. Perhaps if resources are limited, then election booths might be better deployed in towns that had low turnouts in previous elections.

b. Aggregated Civilian Escalation

The summary of the average aggregated civilian escalation results for all heterogeneous Sunni, Shiite/Kurd population scenarios generated in Chapter IV are tabulated in Table 13. Refer to Figure 125 for a chart comparison

on the mean aggregated civilian escalation results between the scenarios. Civilian escalations against other Civilians or against Soldiers are also identified.

Aggregated Civilian Escalation - Heterogeneous Sunni + Shiite/Kurd Population Scenario				
S/No	Scenario	Overall Mean	Civ To Civ Mean	Civ To Sol Mean
1	Heter+DisturberLead+CtrlRegion	252	197	55
2	Heter+DisturberLead+CtrlRegion+Booths	1048	283	765
3	Heter+TroubleMakerLead+CtrlRegion	251	196	55
4	Heter+TroubleMakerLead+CtrlRegion+Booths	1024	280	744

Table 13 Summary of Aggregated Civilian Escalation in Heterogeneous Sunni, Shiite/Kurd Population Hybrid Scenarios

Obviously, civilian escalation has increased significantly in those scenarios where Election Booths are deployed. The results indicated that the majority of the escalation is between the Civilians and Soldiers. Note that this proportion is the opposite of those scenarios where no Election Booths are deployed where majority of the escalation is between the civilians.

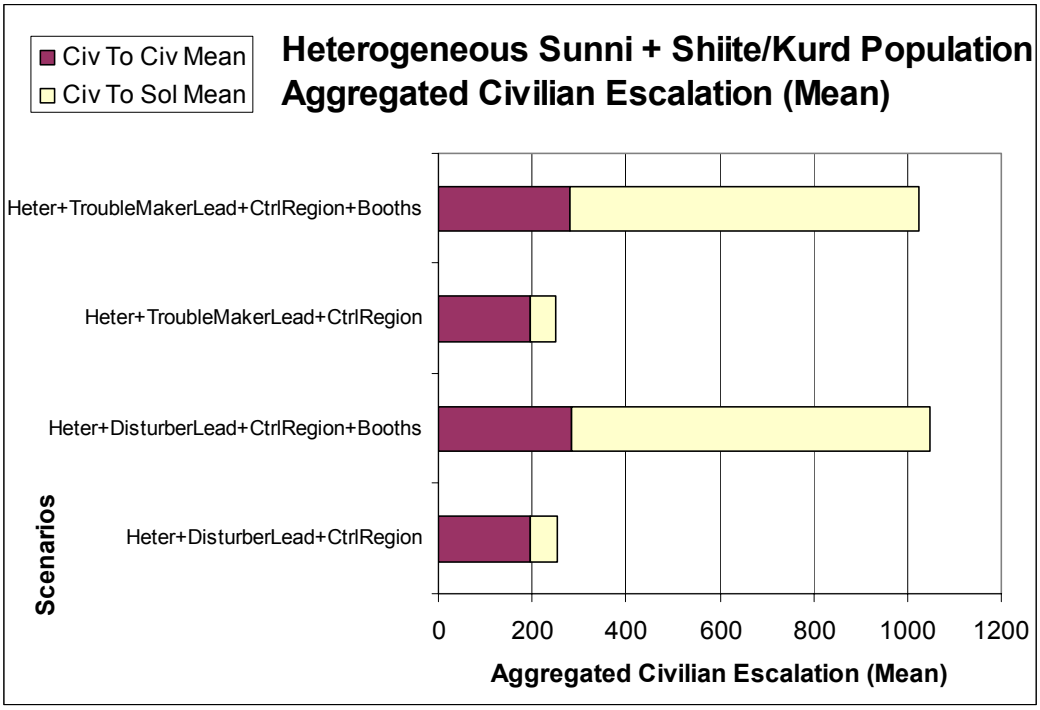

Figure 125 Summary of Aggregated Civilian Escalation in Heterogeneous Sunni, Shiite/Kurd Population Hybrid Scenarios

The type and number of aggressive actions carried out during the entire simulations in both the scenarios where Election Booths are deployed are investigated. Figure 126, Figure 127 and Figure 128 show the results for the Heter+TroubleMakerLead+CtrlRegion+Booth scenario and the results are about the same for the other scenario. It has clearly indicated that majority (i.e., 94%) of the actions carried out by the Soldiers are attempts to calm the civilians. This action is considered non-alarming and non-violent, as compared to the threatening and attacking actions that are occasionally conducted by the Soldiers.

Observations made from the simulation runs also indicated that the Election Booths manages to attract hostile civilians, just as they did for the homogeneous scenarios. While Soldiers at the Election Booths are attempting to calm and pacify the civilians, opportunities are created for elective motivated civilians to proceed to the poll center and cast their votes. This suggests that minimal violence has taken place and the average aggregated civilian escalation is manageable and is under control. It would be interesting for future studies to investigate whether the increased escalation among civilians occurs primarily among the hostile civilians clustered around the election booths, rather than between hostile civilians and registered voters or bystanders.

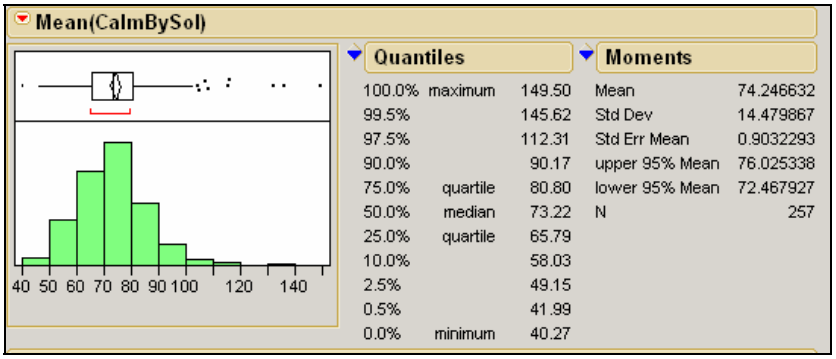

Figure 126 Calming Actions By Soldiers in Heterogeneous Sunni, Shiite/Kurd Population Scenarios with Election Booths

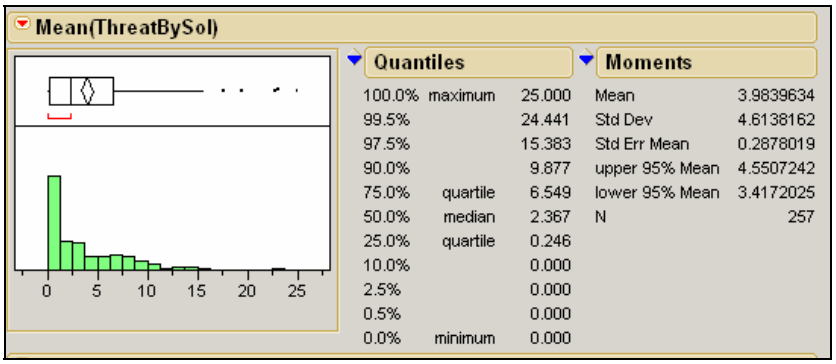

Figure 127 Threatening Actions By Soldiers in Heterogeneous Sunni, Shiite/Kurd Population Scenarios with Election Booths

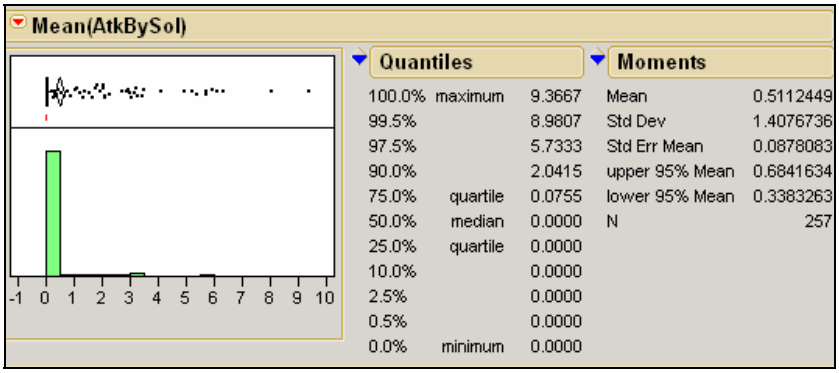

Figure 128 Attacking Actions By Soldiers in Heterogeneous Sunni, Shiite/Kurd Population Scenarios with Election Booths

c. Average Civilian Fear, Anger and RFA

The summary of the average civilian fear, anger and RFA results for all heterogeneous Sunni, Shiite/Kurd population scenarios generated in Chapter IV are tabulated in Table 14. Refer to Figure 129 for a chart comparison on the average civilian fear, anger and RFA results between the scenarios.

Average Civilian Fear, Anger and RFA - Heterogeneous Sunni + Shiite/Kurd Population Scenario				
S/No	**Scenario**	**Fear**	**Anger**	**RFA**
1	Heter+DisturberLead+CtrlRegion	88	81	27
2	Heter+DisturberLead+CtrlRegion+Booths	78	83	28
3	Heter+TroubleMakerLead+CtrlRegion	88	81	27
4	Heter+TroubleMakerLead+CtrlRegion+Booths	78	83	28

Table 14 Summary of the Average Civilian Fear, Anger and RFA in Heterogeneous Sunni, Shiite/Kurd Population Scenario

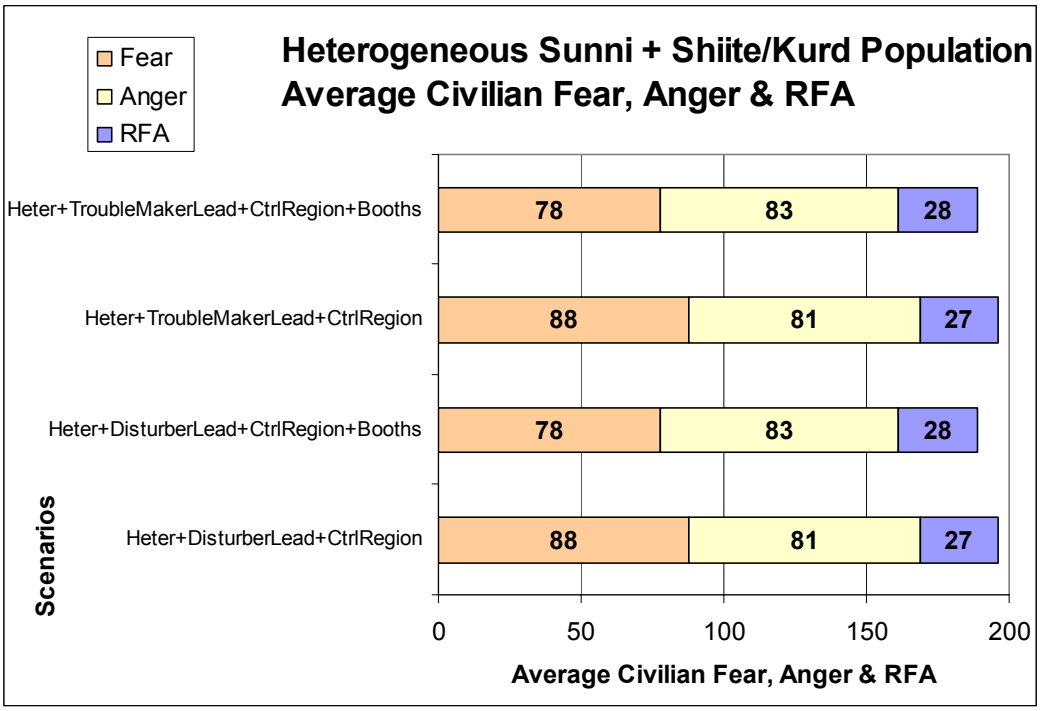

Figure 129 Summary of the Average Civilian Fear, Anger and RFA in Heterogeneous Sunni, Shiite/Kurd Population Scenario

From the table and chart, it is clearly that the average civilian fear and anger levels are high and the average civilian RFA level is low. The average anger and RFA are lower than in the homogeneous scenarios by about 4 units. This indicates that in this scenario, the civilians are generally fearful, easily agitated and become angry but their likelihood of acting aggressively is low. Therefore, on an average, the propensity towards a high conflict and hostile environment in this scenario is low.

A sizeable reduction in civilian fear is observed in those scenarios with Election Booths deployed. On the other hand, there is a marginal deterioration in both civilian RFA and anger.

The proportions of the average civilian anger and RFA across all the scenarios are almost similar. This equal proportion indicated that in general, the average civilian emotional and psychological states can be considered constant across all scenarios. Having these civilian's states constant, we identified that the deployment of Election Booths is the only change made.

However, it did not have any significant improvement to the voter participation and civilian escalation.

In general, this experiment demonstrates that the deployment of Election Booth has little impact on the overall situation in this heterogeneous Sunni, Shiite/Kurd population scenario.

2. Regression Tree and Model Fitting Analysis

The summary of the "main effect" terms that showed up statistically as contributing factors in the metamodels of Voter Participation and Aggregated Civilian Escalation for any of the heterogeneous Sunni, Shiite/Kurd population scenarios in Chapter IV is tabulated as shown in Table 15. A "+" sign indicates that the presence of the term in the model has a positive impact on the model or is improving the stated MOE. A "(+)" sign has the same indication as a "+" sign, but has a greater positive significant impact to the model. A "-" sign indicates that the term has a negative effect on the model. A "(-)" sign has the same indication as a "-" sign but has a greater negative significant impact to the model.

Heterogeneous Sunni, Shiite/Kurd Population Scenario								
MOE	**Percentage of Votes**				**Aggregated Civ Escalation**			
Scenarios	DisturberLead +CtrlRegion	DisturberLead +CtrlRegion +Booth	TroubleMakerLead +CtrlRegion	TroubleMakerLead +CtrlRegion +Booth	DisturberLead +CtrlRegion	DisturberLead +CtrlRegion +Booth	TroubleMakerLead +CtrlRegion	TroubleMakerLead +CtrlRegion +Booth
Significant Terms / R^2 Value	0.73	0.74	0.5	0.71	0.76	0.71	0.8	0.6
Civ1: Shiite/Kurd "Yes" Voter								
Fear								-
Anger	-	-	-	-				
RFA	-	-	-	-	-	(-)	(-)	-
Elective Motivation	(+)	(+)	(+)	(+)		(+)	+	+
Civ2: Sunni “Yes” Voter								
Fear								
Anger		-		-				
RFA	-	-	-	-	-	(-)	-	-
Elective Motivation	-		-			-		-
Civ3: Sunni “No” Voter								
Fear								-
Anger								
RFA				-	-		-	
Elective Motivation	+	-	+	-		(-)		
Civ4: Sunni Trouble-Maker Voter								
Fear								
Anger								
RFA					-		-	
Elective Motivation								
Willingness to Cooperate								
Civ5: Disturber								
Fear								+
Anger						(+)		
RFA					-	(-)		-
Elective Motivation								
Willingness to Cooperate								
Civilian Personality Variance	-	-	-	-	-	(-)	-	(-)
Poll Soldier ROE Set 1			-		+	+	(+)	(+)
Poll Soldier ROE Set 2			+		+	-	(+)	(+)
Poll Soldier ROE Set 3			+		-	-	(+)	(-)
Poll Soldier ROE Set 4					-	-	(-)	(-)
Poll Soldier ROE Set 5			+		+	+	(+)	(+)
Poll Soldier ROE Set 6			-		+	+	(+)	(+)
Control Soldier ROE Set 1					(+)	(+)	(+)	(+)
Control Soldier ROE Set 2					(+)	(+)	(+)	(+)
Control Soldier ROE Set 3					(+)	(+)	(+)	(+)
Control Soldier ROE Set 4					(-)	(-)	(-)	(-)
Control Soldier ROE Set 5					(+)	(+)	(+)	(+)
Control Soldier ROE Set 6					(+)	(+)	(+)	(-)

Table 15 Summary of Model Terms for Heterogeneous Sunni, Shiite/Kurd Population Scenario

It is observed that some factors did not show up in any of the models, such as Sunni "Yes" Voter Fear, Sunni "No" Voter Anger, Sunni Trouble-Maker Voter and Disturber Willingness to Cooperate. Note that it is not conclusive that they are not important, but rather they are not statistically proven to be significant in the presence of other factors that are studied in the experiment for the stated MOE.

a. Percentage of Votes

From those terms that have shown up in the experiment for MOE – Number of Vote Percentage, only the Sunni "No" Voter Elective Motivation term appear to have mixed impacts for different scenarios. Some terms appear to have constantly positive or negative impact on the MOE across all scenarios.

The Shiite/Kurd Voter Elective Motivation term has a high positive impact across all scenarios. This indicates that in order to achieve high voter participation, the level of elective motivation among the Shiite/Kurd Voter must be maintained at high levels in all heterogeneous Sunni, Shiite/Kurd population scenarios. Once again, since the "Yes" and "No" Shiite/Kurd Voters are modeled in the same manner, this can be interpreted as maintaining high levels of election motivation among all Shiite/Kurd voters.

No term with consistently high negative impacts show up in any of the models. However, the Shiite/Kurd Voter Anger and RFA, Sunni "Yes" Voter RFA and Civilian Personality Variance terms show up with negative impact across most of the scenarios. These are considered key factors that have significant contribution to the election scenarios. Their levels must be kept at low values in order to achieve high voter participation.

b. Aggregated Civilian Escalation

Similarly, from those terms that show up in the experiment for MOE – Aggregated Civilian Escalation, some terms such as Poll Soldiers' ROE Set 2, 3 and 4 appear to have mixed impacts on different scenarios. Other terms appear to have a consistent positive or negative impact on the MOE across all scenarios.

Control Soldiers' ROE Set 1, 2, 3 and 5 terms show up with a high positive impact on the model across all scenarios. This indicates that in order to achieve low civilian escalation in heterogeneous Sunni, Shiite/Kurd population scenarios, Control Soldiers' ROE Set 1, 2, 3 and 5 must be executed. In contrast, the execution of Control Soldiers' ROE Set 4 "Gandhi" in the same scenarios has statistically significant negative impact to the stated MOE and therefore must be avoided.

The Shiite/Kurd Voter RFA, Sunni "Yes" Voter RFA and Civilian Personality Variance terms show up with a consistent negative impact. This suggests that in order to achieve low civilian escalation in the scenarios, the level of RFA among Shiite/Kurd Voters and Sunni "Yes" Voters must be kept at their lowest level. At the same time, less escalation occurs if the variation in initial fear, anger and RFA personalities among each group of civilians is small.

3. Effect of ROE

It is clearly illustrated in Table 15 that the Control Soldiers' ROE term does not affect voter participation. However, it has significant contribution in improving civilian escalation in all scenarios. In this case, the execution of ROE Set 1, 2, 3 and 5 at the Control Area is desirable. In contrast, Soldiers at the Control Area should avoid ROE Set 4 "Gandhi" at all times.

As for the homogeneous cases, the Poll Soldiers' ROE terms have mixed positive and negative impacts to the model. However, Poll Soldiers' ROE Set 5 has the most constant positive impact to the model across all scenarios. This suggests that Soldiers at the Poll Area should execute ROE Set 5 at all times to achieve the best overall results for voter participation and civilian escalation. In contrast, Poll Soldiers' ROE Set 4 "Gandhi" has a constant negative impact on escalation in all four models. This suggests that Soldiers at the Poll Area should avoid executing ROE Set 4 "Gandhi" at all times.

However, precaution must be taken to consider the interactions between the Poll and Control Solders' ROE factors with other factors in the model. The importance of this interaction effect is highlighted with the

Heter+TroubleMakerLead+CtrlRegion scenario where we have both Poll and Control Soldiers' ROE terms appearing together as key factors in the aggregated civilian escalation model.

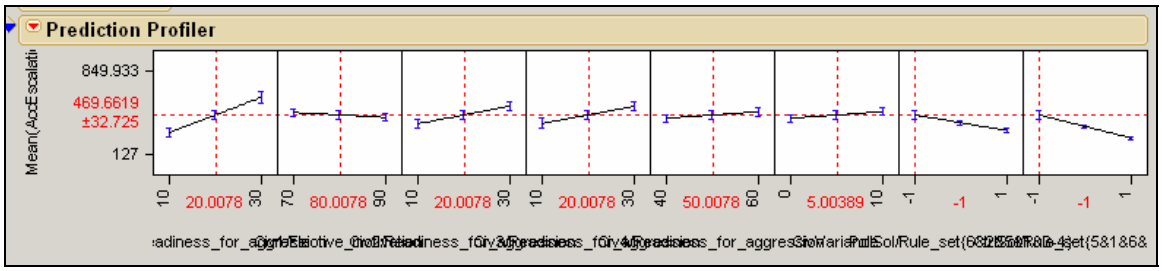

Figure 130 Profiler Analysis on Poll and Control Soldiers' ROE (Value = -1) in Heter+TroubleMakerLead+CtrlRegion Scenario

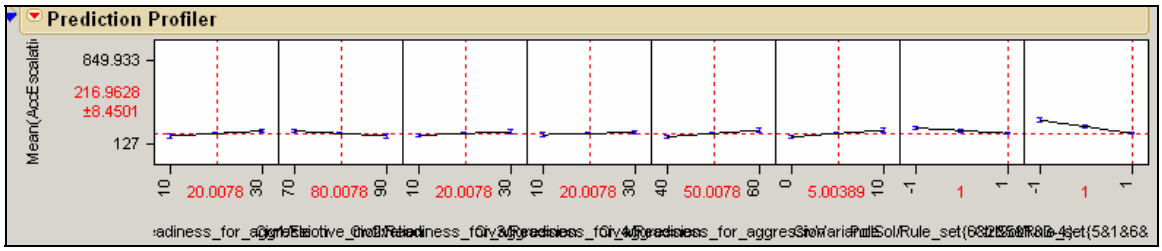

Figure 131 Profiler Analysis on Poll and Control Soldiers' ROE (Value = 1) in Heter+TroubleMakerLead+CtrlRegion Scenario

The JMP Prediction Profiler tool can be used to analyze their interaction effects. Refer to Figure 130 and Figure 131 for the effects of Poll and Control Soldiers' ROE on the civilian escalation when they are both set to the value -1 and 1, respectively. The Prediction Profiler plots illustrated that when the Poll and Control Soldiers' ROE are both set to value 1, the aggregated civilian escalation drops significantly from 470 to 217 units. Notice that the marginal effects of Civ1R (Shiite/Kurd Voter RFA), Civ2R (Sunni "Yes" Voter RFA) and Civ3R (Sunni "No" Voter RFA) change because of their interaction with the Poll and Control Soldier's ROEs. The resulting plots also indicate that a more robust result is achieved when Poll and Control Soldiers' ROEs are both set to the value 1, since the subplot lines that indicate marginal effects are nearly horizontal.

4. Effect of Civilian Personality Variability

It is clearly illustrated in Table 15 that the Civilian Personality Variance term consistently shows up with negative effects in most of the models. This

suggests that the variability of fear, anger and RFA level among the civilians has an impact on the election outcome.

The results suggest that small personality variances among the civilian are desired in most of the scenarios in order to achieve good voter participation and low civilian escalation in the presence of the recommended military's measures.

5. Effect of Civilian Leadership Influence

The Willingness-To-Cooperate terms in both Civ4W – Sunni Trouble-Maker Voters and Civ5W – Disturbers did not show up in any of the models summarized in Table 15.

This indicates that the military cannot improve election operations by attempting to leverage leadership's influences among trouble-maker or disturber groups in heterogeneous Sunni, Shiite/Kurd population scenarios. They are equally effective or ineffective by dealing with threatening or attacking civilians on an individual basis.

D. HOMOGENEOUS AND HETEROGENEOUS POPULATION SCENARIOS COMPARISON

The summary of the "main effect" terms that showed up statistically as contributing factors, with reference to the MOE –Percentage of Vote and Aggregated Civilian Escalation in the metamodel generated for both homogeneous and heterogeneous population scenarios is tabulated as shown in Table 16. Note that the signs' representations are similar to the earlier description and their respective signs are appended when the same factor has shown up in multiple scenarios.

Combine Homogeneous & Heterogeneous Population Scenarios								
MOE	Percentage of Votes				Aggregated Civ Escalation			
Scenarios	DisturberLead +CtrlRegion	DisturberLead +CtrlRegion +Booth	TroubleMakerLead +CtrlRegion	TroubleMakerLead +CtrlRegion +Booth	DisturberLead +CtrlRegion	DisturberLead +CtrlRegion +Booth	TroubleMakerLead +CtrlRegion	TroubleMakerLead +CtrlRegion +Booth
Civ1: Sunni Bystander/Fearful								
Fear	-	+		+	+	(-)	+	-
Anger	+	-		-	-	+	-	+
RFA	(-)	(-)	(-)	(-)		(-)	-	(-)
Elective Motivation								
Civ1: Shiite/Kurd "Yes" Voter								
Fear								-
Anger	-	-	-	-				
RFA	-	-	-	-	-	(-)	(-)	-
Elective Motivation	(+)	(+)	(+)	(+)		(+)	+	+
Civ2: Sunni “Yes” Voter								
Fear								
Anger	-	--	-	--				
RFA	-	-	-	-	--	(-)	--	-
Elective Motivation	-		-			-		-
Civ3: Sunni “No” Voter								
Fear								-
Anger	-	-	-	-				
RFA				--	--		-	
Elective Motivation	(+)+	(+)-	(+)+	(+)-		(-)		
Civ4: Sunni Trouble-Maker Voter								
Fear								
Anger						-		-
RFA					--	-	--	-
Elective Motivation								
Willingness to Cooperate			-	-			-	
Civ5: Disturber								
Fear							+	+
Anger				-		(+)		
RFA					--	(-)-	-	--
Elective Motivation								
Willingness to Cooperate								
Civilian Personality Variance	--	--	--	--	--	(-)-	-	(-)-
Poll Soldier ROE Set 1	+	-	+-		+-	++	(+)	(+)+
Poll Soldier ROE Set 2	-	-	+-		++	--	(+)	(+)-
Poll Soldier ROE Set 3	-	-	+-		--	--	(+)	(-)-
Poll Soldier ROE Set 4	+	-	+		--	+-	(-)	(-)+
Poll Soldier ROE Set 5	+	+	++		++	++	(+)	(+)+
Poll Soldier ROE Set 6	-	-	--		++	++	(+)	(+)+
Control Soldier ROE Set 1				-	(+)(+)	(+)	(+)(+)	(+)
Control Soldier ROE Set 2				-	(+)(+)	(+)	(+)(+)	(+)
Control Soldier ROE Set 3				+	(+)(+)	(+)	(+)(+)	(+)
Control Soldier ROE Set 4				-	(-)(-)	(-)	(-)(-)	(-)
Control Soldier ROE Set 5					(+)(+)	(+)	(+)(+)	(+)
Control Soldier ROE Set 6				-	(+)(+)	(+)	(+)(+)	(-)

Table 16 Summary of Model Terms for Both Homogeneous and Heterogeneous Population Scenarios

1. Effect of Election Booth

In summary, the deployment of the Election Booth in homogeneous Sunni population scenarios has proven its ability to attract hostile civilians towards it, and in turn create opportunities for motivated civilian voters to advance towards the Poll Center and cast their votes. Hence, the average voter participation has improved. However, only marginal improvements are observed in the heterogeneous Sunni, Shiite/Kurd population scenarios. This result seems intuitive since the civilians in the latter scenarios are already highly motivated to participate in the election.

An increased in civilian escalation is observed in both homogeneous and heterogeneous scenarios when Election Booths are deployed. However, the majority of these civilian escalations occur mainly between civilians and soldiers – presumably the soldiers manning the Election Booths. More escalation among civilians is also observed, but since voter participation remains the same or rises, this escalation may only be among hostile civilians clustered around the Election Booths. Furthermore, the aggressive actions in the increased escalation are mainly calming actions performed by the soldiers towards the civilians. Hence, the increased civilian escalation is considered non-violent and controllable.

2. Effect of ROE

It is clearly illustrated in Table 16 that Poll Soldiers' ROE Set 5 consistently shows up with a positive impact in all homogeneous and heterogeneous scenarios. However, there are mixed negative and positive impacts from the other five ROE sets. Therefore, this result indicates that military measures should consider executing ROE Set 5 in the Poll Area for both homogeneous and heterogeneous scenarios. Alternatively, the prediction profiler tool could be used to see whether using other ROE sets leads to large or small degradations in the MOEs.

Table 16 also shows that the choice of Control Soldiers' ROE does not contribute to improved voter participation, but using ROE Set 3 and 5 decreases the escalation in all homogeneous and heterogeneous scenarios. Therefore, this result indicates that military measures should consider executing ROE Set 3 and

5 in the Control Area for both homogeneous and heterogeneous scenarios. Recall that ROE Set 3 is similar to the PSO Manual Ruleset, except that the Soldier threatens (rather than defends) in situations where the civilian attacks and the dominating group behavior is also "attack." For ROE Set 5, the Soldier threatens any civilian who attacks or threatens the Soldier, regardless of the dominating group behavior.

In contrast, it is also highlighted in Table 16 that the effect of Control Soldiers' ROE Set 4 "Gandhi" has shown up with significant negative impact to the model in all scenarios. Therefore, this result indicates that military measures should avoid executing ROE Set 4 "Gandhi" in the Control Area for both homogeneous and heterogeneous scenarios.

3. Effect of Civilian Personality Variability

The Civilian Personality Variance term has consistently shown up with a negative impact to the models in all homogeneous and heterogeneous scenarios, as illustrated in Table 16. This result has indicated that the election outcomes are better if the variability of fear, anger and RFA from the average level within each civilian group is small.

4. Effect of Civilian Leadership Influence

The effect of Sunni Trouble-Maker Voter Leadership's Willingness-To-Cooperate term shows up in three out of the 16 models with a negative impact. However, the effect of Disturber Leadership's Willingness-To-Cooperate term does not show up at all. This result indicates that the Sunni Trouble-Maker Voter Leadership has greater potential influence on the election outcome than the Disturber Leadership in both homogeneous and heterogeneous scenario. Therefore, the importance of leadership's influences that the military can leverage on should lie with the Sunni Trouble-Maker Voter Leaders.

However, note that Sunni Trouble-Maker Voter Leadership's Willingness-To-Cooperate term shows up in the models with a negative impact. This indicates that too much cooperation from Sunni Trouble-Maker Voter Leaders may not be desirable especially in the homogeneous population scenario,

because at times, as it can make the situation take a turn for the worst. This may be due, in part, to the limited type of cooperation possible in PAX.

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VI. CONCLUSIONS AND RECOMMENDATIONS

This chapter concludes the analysis of the military tactics, techniques and procedures that are proposed and modeled in this research. It also proposes desired enhancements in PAX and possible areas for future research.

A. PEACEKEEPING – ELECTION OPERATIONS

This thesis is based on the belief that one of the primary priorities in peacekeeping election operation effort is to provide physical and psychological security for the Iraqi voters in the election areas. The proposed multiple security control regions (i.e., Poll and Control Areas) with manned checkpoints aim to provide a secure and safe environment for both the soldiers and Iraqi voters. Election Booths are deployed to encourage voter participation and deter escalation of civilian aggression. Trouble-maker and disturber leaderships are also studied to identify how cooperation from these civilian groups' leaders might influence the election outcomes.

Four representative homogeneous Sunni population hybrid scenarios are modeled after the Anbar province, which was reported as having the lowest voter participation and the most violence during the last election. Another four representative heterogeneous Sunni, Shiite/Kurd population hybrid scenarios are modeled after the Tamin province, which had one of the highest voter participation rates in a mixed area during the last election. An agent-based simulation system designed specifically for peace-support operations is employed to aid in the modeling and simulation of these eight hybrid scenarios. Over 61,680 simulation runs are conducted, using very efficient experimental designs, in order to explore 24 factors that potentially influence the election outcomes. The following MOEs are examined to evaluate the effectiveness of the proposed military tactics, techniques and procedures:

- Percentage of votes
- Aggregated civilian escalation
- Average civilian fear, anger and RFA
- Number and type of aggressive actions carried out by the civilians and soldiers

Regression analyses techniques are used to generate metamodels of the MOEs. These metamodels reveal which of the many experimental factors (including characteristics of the civilian groups as well as military tactics, techniques, and procedures) are have the greatest influence on the MOEs. The expected voter participation and expected civilian escalation in each of the eight hybrid scenarios.

One criticism of agent-based simulations has been the inherent difficulty in accurately modeling human behavior. Note that this thesis does not attempt to make accurate predictions of outcomes for future elections. Instead, varying factors (including civilian personality and motivation factors) in a designed experiment allows the analyst to identify the important factors and come up with general insights. This thesis can act as a basis for future studies on other Iraq cities or other nations that are facing similar election situations. Over time, comparisons of model results with real-world outcomes might provide guidance for selecting appropriate ranges for some of the civilian personality factors.

B. RECOMMENDATIONS

From the experiment and analysis results, the following are the recommendations proposed for both the homogeneous and heterogeneous population scenarios.

1. Homogeneous Sunni Population Scenario

The deployment of Election Booths significantly improves the average voter participation. It also results in higher civilian escalation, but this is not considered alarming because the majority of the escalation is between civilians and soldiers. Furthermore, majority of the time, the soldiers are calming and pacifying the civilians instead of threatening or defending against them.

Therefore, with this controllable escalation and improvement in the average voter participation, this thesis recommends implementing the deployment of Election Booths in the homogeneous population scenario. Recall that these Election Booths represent stations manned by non-military agencies such as U.N. volunteers, Iraqi civilian volunteers, Iraqi police or other neutral forces. Their primary roles are to encourage civilians to come forward and cast votes, and to promote harmony in the election area. There are several ways these stations might attract a civilian's attention; such as by distributing tangible incentive benefits like "goodie" bags packed with pro-election pamphlets, food, or drink. In practice, specific methods for accomplishing the "pacifying" activities may be best determined by consulting with non-military agencies.

With respect to the average voter participation and aggregated civilian escalation, the following factors have positive impacts on the election outcomes:

- Sunni "No" Voter Elective Motivation
- Poll Soldiers' ROE Set 5
- Control Soldiers' ROE Set 3 and 5

The following are the identified significant factors that have a negative statistical impact on the election outcomes:

- Sunni Bystanders and Fearful Voter RFA
- Sunni "Yes" Voter Anger
- Sunni "No" Voter Anger
- Sunni Trouble-Maker Voter RFA
- Disturber RFA
- Civilian Personality Variance
- Poll Soldiers' ROE Set 3
- Control Soldiers' ROE Set 4

Therefore, this thesis recommends ROE Set 3 or 5 for the Control Area, and ROE Set 5 for Poll Area, in order to achieve high voter participation and low civilian escalation.

The results also indicate that efforts to enlist to cooperation of civilian leaders should focus on the Sunni Trouble-Maker Voter group (rather than the Disturber Group) since the Sunni Trouble-Maker Voter leadership's willingness to cooperate effect has greater effects on the election outcomes.

In addition to the measures recommended above, the analysis also shows that a small variability among civilian personalities results in higher voter participation and lower civilian escalation. This suggests that the potential for conflict is greater when the individual civilian groups are less homogeneous.

2. Heterogeneous Sunni, Shiite/Kurd Population Scenario

In these scenarios, the deployment of Election Booths has little impact on the average voter participation. As in the homogeneous population scenario, the civilian escalation increases but the situation is not considered alarming. To avoid the risk of increased escalation without a corresponding increase in voter participation, this thesis does not recommend implementing the deployment of Election Booths in the heterogeneous population scenario.

With respect to the average voter participation and aggregated civilian escalation, the following factors are found to have positive impacts on the election outcomes:

- Shiite/Kurd Voter Elective Motivation
- Poll Soldiers' ROE Set 5
- Control Soldiers' ROE Set 1, 2, 3 and 5

The following factors have negative impacts on the election outcomes:

- Shiite/Kurd Voter RFA
- Sunni "Yes" Voter RFA
- Civilian Personality Variance
- Poll Soldiers' ROE Set 4
- Control Soldiers' ROE Set 4

Therefore, this thesis recommends ROE Set 1, 2, 3 and 5 for Control Area Soldiers and ROE Set 5 for Poll Area Soldiers in order to achieve high voting participation and low civilian escalation.

In this heterogeneous population scenario, neither the Sunni Trouble-Maker Voter leadership nor the Disturbers leadership's willingness to cooperate effects appear in the models. This indicates that the military soldiers can focus on responding to individual civilians.

In addition to the measures recommended above, the analysis also concludes that small variability among civilian personalities is associated with higher voter participation and lower civilian escalation. This is consistent with the findings for the homogeneous population scenarios.

According to Coalition Provisional Authority – Iraq Coalition, Iraqi citizens are moving towards having the means to provide for their own defense and police forces, and to assume responsibility for both external and internal security [CPA, 2005b]. In support of this independent effort, the results and insights from this thesis may act as possible guidelines or references in preparing the Iraqi forces for the upcoming elections - especially in the area of training and deployment measures.

This study also identified that Poll Area ROE Set 5 and Control Area ROE Set 3 have consistently positive impacts on the election outcomes for both the homogeneous and heterogeneous population scenarios. The common ROEs suggest that the effort required to train the ill-equipped and unprepared Iraqi forces could be streamlined. Focusing only on these two identified ROEs for deployment could shorten the learning curve required for training the Iraqi forces

C. FUTURE WORKS

1. PAX Development

Unlike the traditional combat attrition-based models, PAX has the ability to model civilian behaviors and enables the user to investigate the effects of different actions of the military under specific civilian conditions. This has made it a suitable tool for the analysis of peace support operations like election operations.

The following feedback to the developers is intended to enhance the system for the benefit of the larger simulation community:

- Currently, ten different civilian groups can be modeled in a single PAX scenario. However, the generated MOEs (such as End of Simulation Fear, Anger and RFA) are only available for the first five groups of civilians. Expanding this capability to all ten groups would allow a more comprehensive analysis in situations where there are more than five groups of civilians. For example, an analyst could evaluate the civilian fear levels at the end of the simulation for all ten groups to seek to understand the long term effects on different segments of the civilian population.
- Currently, PAX does not allow a Soldier to target a single group leader and request their cooperation. This restriction makes it more difficult to study situations where there is more than one civilian group with leaders.
- In a typical election scenario, we have different groups of law enforcers and facilitators such as police, military soldiers, non-government officials, U.N. forces, neutral volunteers, etc. They each exhibit different roles and interactions with the civilians. The modeling of these different types of agents may facilitate the study of their contributions in election situations like Iraq. For example, pacifying actions may be more successful if they are conducted by non-military agents than by soldiers.
- The presence of law enforcers in the election town may influence the law and order of the civilians. Measure such as the capability for soldiers to patrol by foot along the streets in the town may be beneficial. Such features in PAX would provides more flexibility for modeling peace support operations
- Currently, PAX automatically increases the fear level of the civilians once they have cast their votes successfully. This is to force the civilians to move back into their homes and not to mingle inside the polling area. This has caused the reported high fear level to be overstated. Therefore, it is desired for PAX to report the actual civilian fear level apart from those fear levels accumulated due to civilians who have voted.

2. Research Areas

The availability of high-performance computing and maturing of agent-based models, coupled with good experimental designs and data-farming techniques, has extended the boundary limit of research on peace support operations. The following are some areas worthy of future exploration:

- The civilian “Norms for Anti-Aggression” personality is not modeled in this research because the Iraqis are so used to daily violence occurring around them that their “Norms for Anti-Aggression” level is generally low. However, this behavior may vary differently across cities and nations depending on the area of study. For example, humanitarian assistance operations may occur in places devastated by either natural disasters or civil strife, but civilians may be much more used to violence in the latter situation. Hence, future research may consider implementing this factor.
- Similarly, experiments can be performed which vary the civilian “Group Cohesiveness” behaviors. This would permit detailed analyses in scenarios involving a distinct group with strong group dynamics and unity.
- The civilian personality variance in this thesis varies according to a single variance factor. The results indicate that variability within civilian groups does impact the MOEs. Future research may choose to define separate variance factors for each civilian personality, so as to facilitate in-depth analysis of their importance.

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