



# **NAVAL POSTGRADUATE SCHOOL**

**MONTEREY, CALIFORNIA**

## **THESIS**

**EVALUATING SUNNI PARTICIPATION IN AN ELECTION  
IN A REPRESENTATIVE IRAQI TOWN**

by

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September 2005

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**EVALUATING SUNNI PARTICIPATION IN AN ELECTION IN A  
REPRESENTATIVE IRAQI TOWN**

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## **ABSTRACT**

What we once thought of as purely civilian considerations are today increasingly significant matters to international peace and security. Conflicts within states and urban encounters make civilian considerations particularly troublesome for military forces sent to stabilize that country. Along with these changes in the patterns of war, the techniques that are used in operations have also changed. Stability operations are an application of military power to influence the political and civilian environment. Often these take the specific form of peacekeeping or peace support operations. Peace Support Operations (PSO) are military operations to support, provide and sustain a long-term political settlement. PSO and conventional war have different characteristics. It is possible to generalize the main purpose of conventional war as “defeat the enemy,” whereas peacekeeping attempts to “win the peace.” At tactical level, some of the goals of peacekeeping missions are to help and protect civilians, to avoid violence and escalation, and to ensure the safety of the public with civilians in a stability operation than in combat. Secondly, stability operations are executed in a more diverse range of environments than those of conventional war. Furthermore, depending upon the mandate, soldiers must use different sets of engagement rules when interacting with civilians.

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# **I. INTRODUCTION**

## **A. BACKGROUND**

The threat of global war subsided with the end of the Cold War, but global uncertainty and instability did not. Early predictions about the future after the Cold War were global peace, prosperity and extensive multi-national collaborations. However, this was too optimistic for a world that can easily reach extremes of madness. Problems that had been suppressed emerged in regions that previously had been stable during the Cold War. With the fall of the Iron Curtain, regional conflicts, ethnic cleansing, poverty and illnesses became the major issues for international peace and security.

Peace operations during the Cold War could be described as deploying long-lasting multi-national forces, under restrictive rules of engagement, into buffer zones between rival nations to oversee implementation of a peace accord. The number of the peace operations increased in number and form after the Cold War. Since 1948, the United Nations conducted 60 peace operations, 42 of which started after 1990. In May 2005, there were 16 ongoing operations around the world.<sup>1</sup> The graphic in Figure 1 shows the operations begun since the 1990s.

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<sup>1</sup> United Nation Peacekeeping Operation, retrieved July 17, 2005 from <http://www.un.org/Depts/dpko/dpko/bnote.htm>

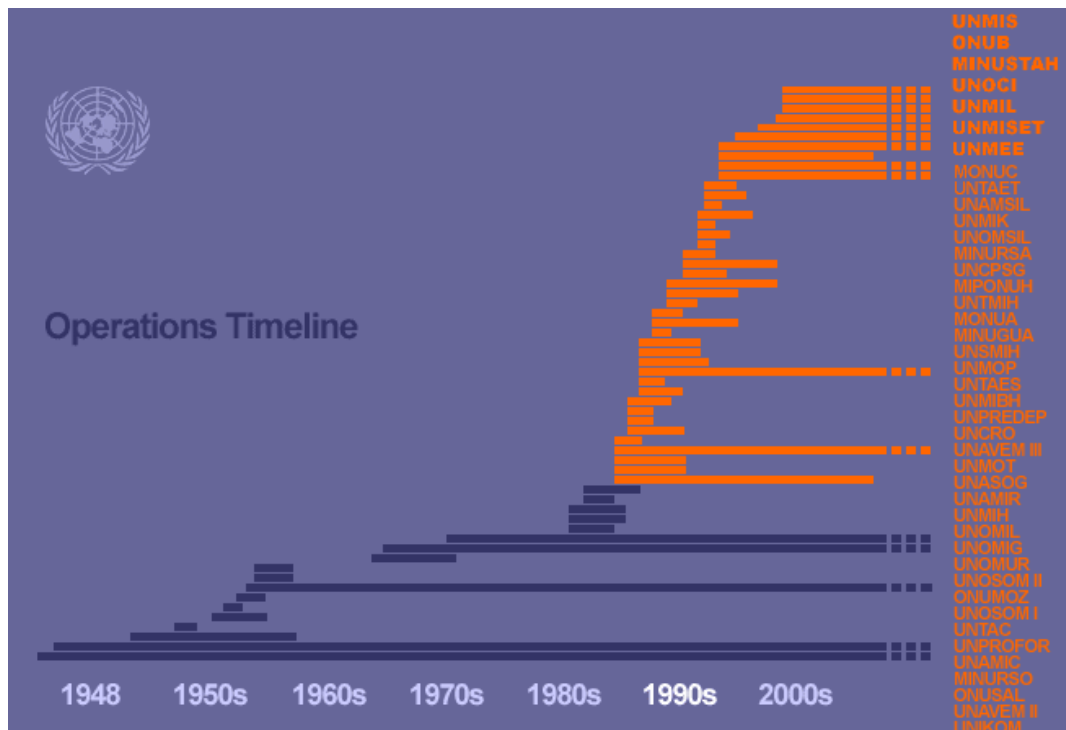


Figure 1. UN Peace Operations after the Cold War<sup>2</sup>

Just as the problems cover a broad spectrum, so do the types of operations. Peace operations are generally categorized into three groups: peacekeeping (PK), peace enforcement (PE) and support to diplomacy.<sup>3</sup> Peacekeeping operations are the “military operations undertaken with the consent of all major parties to the dispute, designed to monitor and facilitate implementation of an agreement (ceasefire, truce, etc.) and support diplomatic efforts to reach a long-term political settlement.”<sup>4</sup> Peace enforcement operations are “the applications of military force, or the threat of its use, normally pursuant to international authorization, to compel compliance with resolutions or sanctions designed to maintain or restore peace and order.”<sup>5</sup> The third category is defined as “military support of diplomatic efforts that improves the chances for success in the peace process by lending credibility to diplomatic actions and demonstrating

<sup>2</sup> The graphic is adopted from Operation Timeline, retrieved July 18, 2005 from <http://www.un.org/Depts/dpko/dpko/timeline/pages/timeline.html>, and modified to show the operations started after 1990.

<sup>3</sup> Department of the Army, *Stability Operations and Support Operations*, Field Manual 3-07, (20 Feb 2003), p 4-2.

<sup>4</sup> Ibid.

<sup>5</sup> Ibid.

resolve to achieve viable political settlements.”<sup>6</sup> Further explanations of these operations are beyond the scope of this thesis; however, it is beneficial to provide an accepted list of common operations. Peace operations include but are not limited to:

- Humanitarian relief and assistance
- Managing and supervising cease-fires
- Observing and monitoring international agreements
- Resettling displaced population
- Assisting civil authorities
- Assisting or maintaining public order
- Establishing an interim government
- Restoring essential services and building infrastructure
- Helping governments to restore economy
- Fighting against deadly diseases like AIDS
- Organizing or supporting elections

One of the most important things that set peace operations apart from conventional war is its participants. The participants in peace operations are generally noncombatants. Each operation has its unique set of mandates and objectives. Furthermore, the operation environments are far different than those of conventional war. Therefore, tactics, techniques and procedures must be operation-specific.

## **B. RESEARCH QUESTIONS**

The peace support operation examined in this thesis is the safeguarding of elections. The operation is investigated using an agent-based model called PAX, developed by EADS-Dornier for the German army. The election is held in an Iraqi town which is inhabited mostly by one ethnic group. There are some minorities in the town, too. Participants register polling at stations according to their residence. So, the inhabitants of the town vote in the polling station which

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<sup>6</sup> Department of the Army, *Stability Operations and Support Operations*, Field Manual 3-07, (20 Feb 2003), p 4-2.

was built in the town. There are Peace Support Units (PSU) assigned to provide security and prevent escalations before, during and after the election. Furthermore, the polling station is accessible through a check point. Because of high security precautions, terrorist attacks within stations are unlikely but still possible. However, there are some disturbers whose intentions are to scare and threaten voters. The questions this research aims to answer are:

- 1- Does the number of civilians in the theatre make any difference in the outcomes? People tend to behave differently in groups than when they are alone. Furthermore, it is likely that group size will affect the group dynamics. A person might become aggressive or calm down faster or more slowly in a big group, depending on the group's tendency. To observe the effects of group size on outcome of the simulation, this project tracks the escalation level among the groups, the number of threats and attacks from a particular group to PSU soldiers and other groups, the ratio of the number of votes to the number of voters in the theater, the number of aggressive and fearful people at the end of the simulation, and some other Measures of Effectiveness (MOEs) provided by the PAX model.
- 2- Does the ratio of disturbers to voters have any impact on the outcomes? It seems likely that having people from different ethnic groups (with different emotions, motivations and interest in the theater) will affect the larger group's behavior. The number of threats and attacks from one group to another group and to PSU soldiers is examined to measure the effects of different ratios.
- 3- What is the impact of duty posts on the security of PSU soldiers and the outcomes of the election? Soldiers generally wait in secure posts for self protection, and become involved if something wrong happens. The number of threats and attacks is an appropriate MOE for this purpose.

In addition to these questions, this thesis looks at long term effects. PSU soldiers do not leave the country the day after an election. Leaving behind angry and agitated people would cause serious problems. The number of angry people at the end of the simulation is a suitable MOE for indicating these long term

effects. Depending on the outcome of the study, answers to these questions might suggest interventions that could be taken to increase voter participation in elections and improve the long term outlook.

The Iraqi forces themselves provided the security for the January 30 election with the help of the international forces in stand-off position. The PSU soldiers in the simulation are implemented as the forces that are in charge of the security of the election.

### **C. PURPOSE AND SCOPE OF THE THESIS**

The purpose of this thesis is to create an election scenario in a representative Iraqi town to point out the most important factors that impact the outcome of the election and the security of civilians and PSUs. Of particular interests are the effects of the factors under the control of the PSU, such as duty posts, the number of voters assigned to a particular voting area, and the rules of engagement (ROE) for the soldiers. This thesis also provides some feedback to the developers of the model PAX. Some useful suggestions are made to decision makers, as well. It is important to note that this thesis does not provide predictions about the future of Iraq or the results of the upcoming elections.

This research focuses primarily on the impacts of instituting different sets of rules for PSUs in an election in an Iraqi town. A representative Iraqi town is built in the simulation that reflects the general environmental layout and population. The decision factors that warrant further exploration include:

1. Size of the civilian group
2. Proportion of disturbers in the vicinity
3. Rules of Engagement (ROE)
4. Presence/non-presence of duty posts for PSU soldiers
5. Uncontrollable factors include the population's internal states, listed below:
  - Fear
  - Anger
  - Readiness for aggression

- Group cohesion
- Norms for anti-aggression
- Elective motivation

In order to compare after the outcomes from different scenarios, some MOEs are needed. Some of the MOEs include:

1. Number of civilians who voted
2. Number of angry civilians at the end of the simulation
3. Number of fearful civilians at the end of the simulation
4. Level of escalation at the end of the simulation
5. Proportion of population that turns violent, cooperative or neutral

The scenarios are created and simulations are conducted in the agent-based model PAX that was developed for peace support operations. The regression analyses and regression tree methods are adopted for data analysis purposes.

#### **D. THESIS ORGANIZATION**

This thesis is organized into five chapters. Chapter I, where the scope of the thesis and specific research questions are addressed, provides background information and draws an outline of the thesis.

Chapter II provides detail about the Iraqi population, particularly the Arab Sunnis, and the January 30 election results. The reasons for a lower Arab Sunni turnout than the other groups – the Shiites and Kurds – are of particular concern.

In the 10<sup>th</sup> Project Albert International Workshop held in Stockholm, in May 2005 (PAIW10) the developers of the PAX modeling platform introduced new futures, upgraded since the previous workshop. Chapter III provides a detailed description of the latest version of PAX, including how to create and conduct experiments using PAX. A detailed description of the scenarios is provided as well.

Chapter IV presents the results and detailed analysis of the experiment and Chapter V is devoted to the conclusion and suggestions for future studies.



## **II. AN OVERVIEW OF THE SITUATION IN IRAQ**

### **A. BACKGROUND**

The United States and Coalition invasion of Iraq -- Operation Iraqi Freedom -- was launched on March 20, 2003. It can be summarized as the simultaneous execution of an intensive air campaign and ground offensive, fast movement of troops, blasts of the most high-tech and deadly weapons over Iraq's skies, and the most extensive coordination of different military services in the history of war.<sup>7</sup> It took less than a month to topple a tyrant from power, and all the legends about an almighty army eager to fight to the last breath turned out to be nothing but a myth. Of course, the superiority of the US troops over the Iraqi military was undisputable, but one must acknowledge the success of the US troops.

As Secretary of Defense Donald Rumsfeld stated in a press conference on March 28, 2003, the US was capable of destroying a tank under a bridge without damaging the bridge.<sup>8</sup> On the same day, an unexplained bomb hit a crowded marketplace in Baghdad, killing 15 and wounding 30 Iraqi civilians, most of whom were women and children. While Iraqis cursed the US for this incident, US spokesmen insisted that they were not targeting that area and it would have to have been a misfired Iraqi missile. Regardless of which side was responsible, this was one of the most tragic moments of the operation.

By April 9, 2003 the military campaign achieved its primary goal: disempowering a dictator and his ruling organizations that had caused so many

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<sup>7</sup> The operation resembled a showcase of newly developed high-tech weapons and weapon systems such as the RQ-1 Predator, a remotely operated unmanned aerial vehicle capable of operating for 24 hours without landing, and loaded with Hellfire missiles. The satellite guided smart ammunitions, which are lot more accurate than those infrared guided bombs that are heavily dependent on clear view, showed that the US learned its lessons from Gulf War I. Exploiting weather forecast data to shape the battlefield, especially during the sand storm that started on March 26, was another outstanding achievement from the military perspective.

<sup>8</sup> Donald H. Rumsfeld, US Secretary of Defense, press conference, March 28, 2003. Retrieved July 20, 2005 from <http://www.iiss.org/iraqCrisis-more.php?itemID=88>

people to suffer over the previous 24 years. No one knows how many Iraqis died during the operation, but it cost 139 lives from the Coalition Forces.<sup>9</sup>

The initial focus of the operation was to march rapidly towards Baghdad while securing the important oil fields. It turned into a hunt for Saddam Hussein and his key aides. Although the report was widely doubted, Saddam Hussein was reported captured in a foxhole on December 13, 2003.

## **B. POST-SADDAM IRAQ**

The Pentagon's Office of Reconstruction and Humanitarian Assistance (ORHA), headed by retired US Army Lt. General Jay Garner, was initially established and charged with coordinating the relationships between the government agencies and non-governmental organizations that would participate in post-war Iraq. On April 13, 2003, Garner chaired a meeting in the town of Nasiriyah. Americans and Iraqi representatives from inside and outside the country discussed the future of Iraq. Secretary of Defense Donald Rumsfeld stated the purpose of this meeting in a press conference: "The purpose is to begin a dialogue with Iraqis on the future of their country, to build momentum for the formation of an Iraqi interim authority, and to help pave the way for a free Iraqi government that will eventually be chosen by the Iraqi people."<sup>10</sup> Clearly, elections are a mechanism for Iraq's transformation to independence, and its new status as a democratic nation.

On April 21, 2003, ORHA was transformed into the Coalition Provisional Authority (CPA) as an occupation government. Authorized by UN Security Council Resolution 1483 (2003),<sup>11</sup> the CPA equipped itself with executive,

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<sup>9</sup> "Operation Iraqi Freedom Military Deaths." Washington Headquarter Services, Directorate for Information Operations and Reports, retrieved July 20, 2005 from <http://web1.whs.osd.mil/mm/casualty/OIF-Deaths-Before.pdf>. The reported number includes the deaths from the beginning of OIF to April 30, 2003.

<sup>10</sup> Kathleen T. Rhem and Jim Garamone, "Iraqis Discuss Future Government in 'Big Tent' Meeting." American Forces Information Service News Articles. April 15, 2003, Retrieved July 22, 2005 from [http://www.defenselink.mil/news/Apr2003/n04152003\\_200304157.html](http://www.defenselink.mil/news/Apr2003/n04152003_200304157.html)

<sup>11</sup> UN Security Council Resolution 1483 (2003). *The Situation between Iraq and Kuwait*. Retrieved July 24, 2005 from [http://www.un.org/Docs/sc/unsc\\_resolutions03.html](http://www.un.org/Docs/sc/unsc_resolutions03.html)

legislative, and judicial authority over the Iraqi government. The main CPA objectives were establishing security, providing essential services, building a market-based economy, and establishing a fully functioning government.<sup>12</sup> The UN approval of coalition actions in post-war Iraq was crucial for bringing the necessary legitimacy to the process, because involving a highly respected international organization such as the UN is more appropriate than carrying out the process unilaterally.

The most urgent and important problem the CPA had to deal with was establishing security. In 2004, it was clear that the security troubles in Iraq were not due only to looting and opportunistic attacks against former adversaries. It was clear that there was an insurgency in Iraq attacking nascent Iraqi institutions, and that insurgency grew in 2004. Approximately 25 attacks per day were reported at the beginning of 2004, which increased to 60 by the end of the year. Figure 2 shows the number of daily attacks executed by insurgents by month.<sup>13</sup>

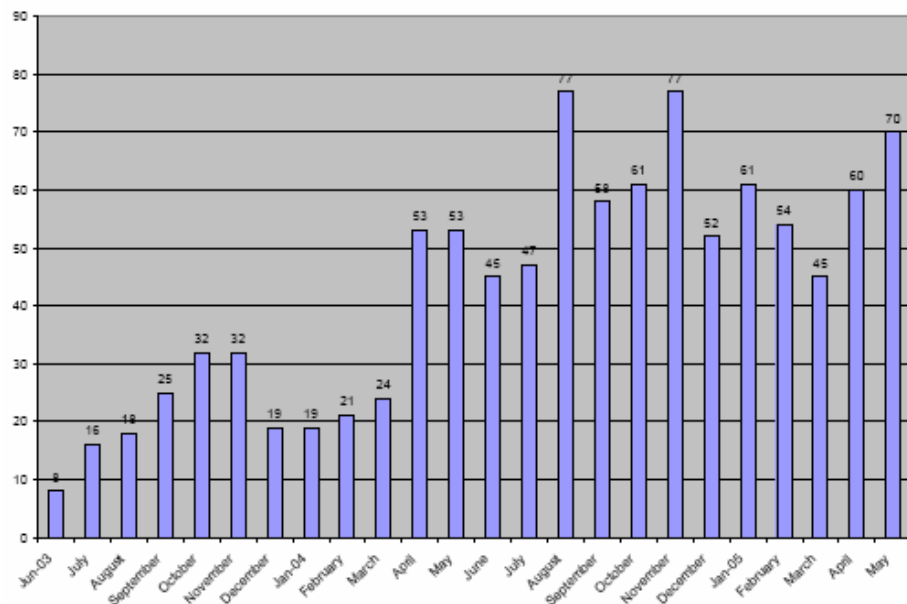


Figure 2. Number of Daily Attacks by Insurgents

<sup>12</sup> "An Historic Review of CPA Accomplishments." Coalition Provisional Authority Press Releases, June 28, 2004. Retrieved July 23, 2005 from <http://www.iraqcoalition.org/pressreleases>

<sup>13</sup> The chart is taken from "Iraq Index: Tracking Variables of Reconstruction & Security in Post-Saddam Iraq" by the Brookings Institution. Retrieved July 15, 2005 from <http://www.brookings.edu/fp/saban/iraq/index.pdf>

The gradual removal of US troops from Iraqi cities, and the lack of troop support from all countries but Great Britain, drove the Americans to press for “Iraqization”--the process of building Iraqi security forces.

Although security was the first and foremost concern, the CPA decided to disband the former Iraqi army and build a new one from scratch. About 400,000 trained soldiers were fired and not accepted into the new army. This caused serious complications for security. First of all, hiring them might have shortened the process of building the new army and enabled them to establish security faster. Secondly, most of the former army members provided valuable resources, like manpower and knowledge, to insurgent groups like Former Regime Loyalists (FRL). De-Baathisation included not only soldiers but also the former administrators, officials, teachers and other government employees. These people were Baath Party members. However, they joined the Baath Party not because they supported the Baath Party regime, but simply to attain or retain their jobs. Employing them and benefiting from their service and experience would have helped the reconstruction process flourish. Furthermore, the disbanded army consisted of mostly Sunnis, and firing the government employees who were also mostly Sunnis further alienated the Sunni population.

The CPA started the process of recruiting, training and equipping the Iraqi Armed Forces (IAF). The IAF was to consist of the Iraqi Army (two divisions of motorized infantry), Iraqi National Guard, Iraqi Intervention Force, Iraqi Special Operations Forces – Iraqi Counter Terrorist Force, Iraqi Coastal Defense Force, and Iraqi Air Force.

The CPA also sought to transfer sovereignty to an Iraqi transitional administration. On July 22, 2003, the CPA founded the Iraqi Interim Governing Council (IGC) and appointed its members. The Council members were generally Iraqi expatriates who had been in exile or escaped from the country during the rule of Saddam Hussein. There were also many opposition leaders who had been silent during the Saddam Hussein regime. The Council consisted of

different ethnic and religious groups including 13 Shiites, five Sunni Arabs, five Kurds, one Turkmen and one Assyrian Christian<sup>14</sup>.

The IGC had its own responsibilities. On November 15, 2003, the CPA and IGC reached an accord on the process of political transition.<sup>15</sup> On March 8, 2004, the IGC signed an interim constitution known as "Transitional Administrative Law" (TAL) that would serve as the interim constitution effective from June 28, 2004, when the CPA would transfer sovereignty to the Iraqi people, until a permanent constitution could be approved by an elected parliament.

The TAL guaranteed the fundamental rights of Iraqi citizens. Not surprisingly, it clearly defines who Iraqi citizens are. Anyone who carries Iraqi nationality is deemed as being an Iraqi citizen. Any Iraqi whose citizenship was withdrawn for political, religious, racial, or sectarian reasons during Saddam's reign was granted the right to reclaim his citizenship. Freedom of religion, freedom of speech, freedom of press and the right of privacy are among the rights TAL guarantees. It also set an election date for the National Assembly: January 30, 2005.

### **C. JANUARY 30 ELECTIONS: A STEP FORWARD TO DEMOCRACY**

The Iraqi election at the end of January, 2005 was perhaps one of the most controversial elections in recent history. Some view the election as a step forward on the way to democracy for Iraqi citizens, while others view it as the

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<sup>14</sup> Iraqi Governing Council, retrieved July 25, 2005 from <http://www.globalsecurity.org/military/world/iraq/igc.htm>

<sup>15</sup> Iraqi Governing Council, retrieved July 25, 2005 from <http://www.globalsecurity.org/military/world/iraq/igc.htm>. According to this accord, the IGC would draft a transitional law by February 28, 2004 which would be a temporary constitution that would serve as a Supreme Law during the transition period until a permanent constitution could be written and approved by a general election. By May 31, 2004, the IGC would establish a transitional national assembly that would then elect an executive branch and appoint ministers by June 30, 2004. The agreement also set a specific timetable for holding elections to elect the delegates to a constitutional conference. Elections for a new government under that constitution would be held by December 31, 2005.

biggest political mistake ever made. Some of the discussions revolved around the following questions:

- Was Iraq ready for an election?
- Was Iraq secure enough to hold an election?
- Did all Iraqi candidates follow the proper campaign finance guidelines?
- Had foreign money been used to influence the elections?
- Did all the candidates jump through all necessary hoops to gain ballot access?
- Were illegal immigrants prevented from voting?
- Were all voters safe enough to vote?
- Were standards at a level seen in democratic countries (like Canada or Australia)?

A survey by the International Republican Institute prior to the election showed that 41.4% of Iraqis thought that they would vote for electing the president, while only 28.7% understood correctly they would vote for a Transitional National Assembly (TNA). The same survey indicated that 71.4% strongly intended to vote. It also showed that reluctance among the Sunni population was more common than for the other groups. One of the most important indicators that the survey revealed was that a large portion of people (40.4%) would boycott the elections if a respected organization called for boycott.<sup>16</sup>

Any Iraqi citizen who was 18 by December 31, 2004 and registered to vote could participate. Initial voter registration was prepared according to the Iraqi Public Distribution System. That list initially contained nearly 14 million Iraqi citizens. Citizens could be added and removed, or the information edited, up until December 15, 2004.<sup>17</sup>

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<sup>16</sup> Survey of Iraqi Public Opinion, International Republican Institute, November 24 – December 5, 2004.

<sup>17</sup> "Iraq Elections: Road to Democracy," U.S Department of State Bureau of International Information Programs. Retrieved July 20, 2005 from <http://usinfo.state.gov/products/pubs/iragelect/iragelect.pdf>

The Independent Electoral Commission of Iraq (IECI) was the official body responsible for organizing the elections, certifying the political entities (parties, associations, groups and individual candidates) and ruling as an arbiter of electoral disputes. The IECI hired about 6,000 Iraqis to be employed in voter and candidate registration. The commission established more than 5,000 polling centers and hired and trained more than 100,000 locals to work in them on Election Day.

Despite the controversy, the Iraqi people went to the polling stations to cast their votes on January 30, 2005. They elected a 275-member Transitional National Assembly, members of the 18 provincial councils and members of the Kurdish regional government. Approximately 300 terrorist attacks, all of which were outside the election areas, were reported on the Election Day.<sup>18</sup> It was a clever decision to close all roads to motor vehicles two days prior to the election to hinder terrorist attacks.

On February 17, 2005, the Independent Electoral Commission of Iraq announced the official results of the January 30 election. They declared that 94,035 out of 8,456,266 votes were invalid. Despite threats of violence and terrorist attacks, the turnout was slightly above 58%. The TNA consisted of 12 parties out of 111 political entities on the ballot. The United Iraqi Alliance, which is the Shia alliance backed by Shia Muslim clergy, gained 140 seats with 47.6% of the total votes. The Kurdistan Alliance List, which brought the two main Kurdish parties together, gained 75 seats in the assembly with 24.5% of the votes. The Iraqi List, led by then Prime Minister Ayad Allawi, received 40 seats. With these results, no single political party held the two-thirds majority in the assembly necessary to establish the three-member Presidency Council. Selecting the three-member Presidency Council was a breakpoint in post-war Iraq. Although it is hard to say that the election was completely democratic, this three-member council was the first elected body to rule over the Iraqi people after Saddam's removal from power.

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<sup>18</sup> Iraqi Insurgency Groups, retrieved July 26, 2005 from [http://www.globalsecurity.org/military/ops/iraq\\_insurgency.htm](http://www.globalsecurity.org/military/ops/iraq_insurgency.htm)

The primary task of the TNA is to draft a permanent constitution. The TAL called for the Assembly to propose the draft by August 15, 2005. The Iraqi people will go to a referendum to approve or disapprove the constitution on October 15, 2005. Additionally, the Iraqi people will elect the constitutional government in an election on December 15, 2005.

#### **D. A LEGACY ISSUE: SUNNI PARTICIPATION**

The results of the January 30 election showed that the Arab Shiite and Kurdish Iraqis are willing to vote. Did they see this as the quickest way to compel foreign troops out, or did they really want to use their new democratic rights? Another question pertains to the very low turnout of Arab Sunni voters. Why did they not also use this opportunity to gain representation in the constitutional assembly?

Iraqi Sunnis make up approximately 20% of the Iraqi population. Although Iraqi Kurds, which make up approximately 15% of the Iraqi population, are Sunni, they are not included in the Sunni category because they are more highly motivated by their ethnic interests than by religious ties. Therefore, the category "Iraqi Sunnis" implies "Iraqi Arab Sunnis."

Iraqi Sunnis are generally concentrated in Mesopotamia, which is bounded by the Tigris and Euphrates rivers. Specifically, they inhabit the so-called "Sunni triangle" circumscribed by Tikrit in the north, Al-Ramadi in the west and Baghdad in the east. Baghdad and Mosul are the most populated Sunni cities. Figure 3 shows the ethnic makeup of Iraq.

Why Sunni participation was low requires deeper analysis; however, it is beneficial to point out some of the most important factors that likely affected the turnout.



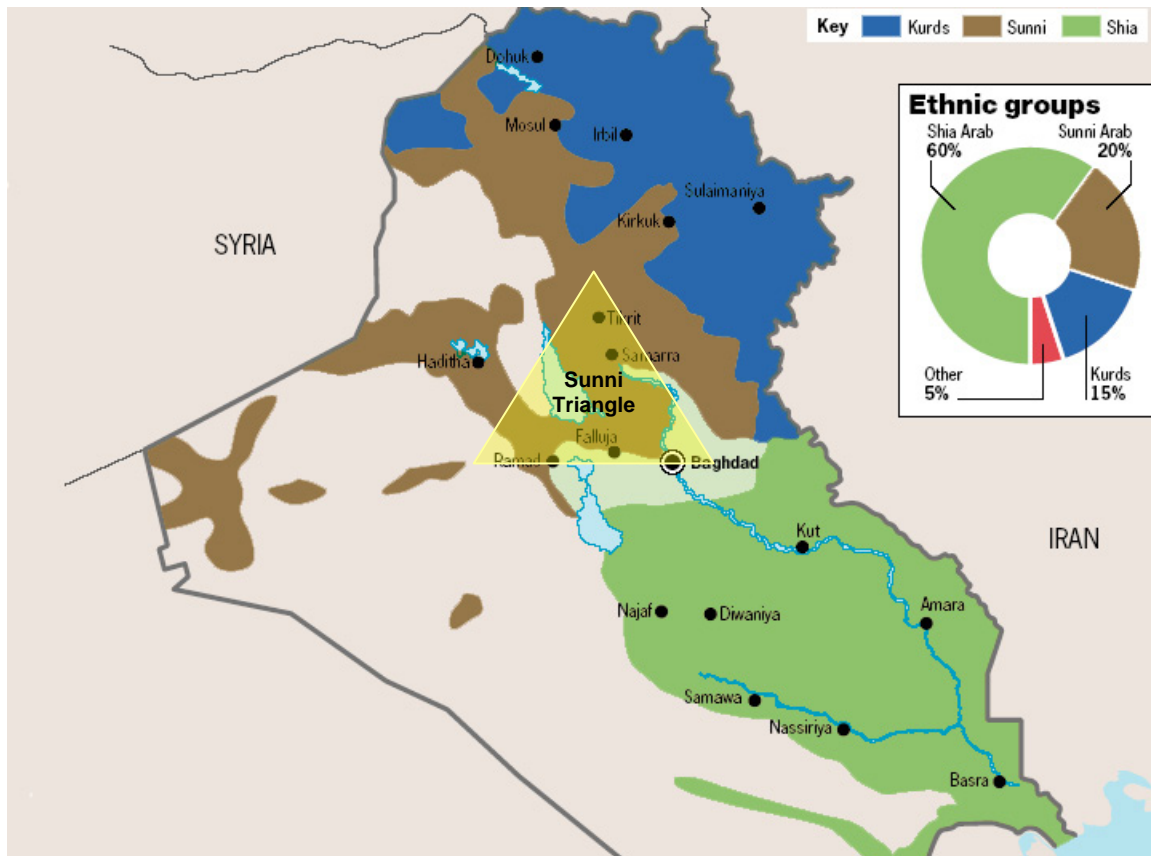


Figure 3. Ethnic Make-up of Iraq<sup>19</sup>

First, although they made up no more than 20% of the population, the Sunnis were the ruling population over Iraq not only during Saddam's reign but also during the British occupation and Ottoman rule. They enjoyed most of the privileges, like having jobs in state-owned businesses, high ranks in the army, and investments in the cities they inhabit, and so on. Not surprisingly, Coalition forces faced the most severe resistance during and after OIF in Sunni-populated areas. Approximately 80% of insurgencies occurred in Sunni-dominated central Iraq. The majority of those captured or killed were Iraqi Sunnis. Of the detainees, between 90 and 95% were Sunnis as well.<sup>20</sup>

<sup>19</sup> The map is taken after Guardian Unlimited Network, "Provisional Results," retrieved July 30, 2005 from [http://image.guardian.co.uk/sys-files/Guardian/documents/2005/02/14/Iraq\\_election\\_results.pdf](http://image.guardian.co.uk/sys-files/Guardian/documents/2005/02/14/Iraq_election_results.pdf). The Sunni triangle is superimposed.

<sup>20</sup> Anthony H. Cordesman, "The Developing Iraqi Insurgency: Status at End-2004" (Working Draft), (Washington D.C.: Center for Strategic and International Studies Publishers, 22 December 2004), 12.

Second, with approximately 60% of the majority, the Shiites were expected to dominate in an election. For Sunnis, who had ruled over Iraq for centuries, it would be devastating to lose the privilege of being the ruling class. Some might say that because it was a proportional representation formula, not “winner takes all,” they would not lose the privilege of ruling if everyone voted along sectarian lines. However, even assuming that all the Sunni population had voted and received proportional representation, this would mean sharing those privileges they had enjoyed for centuries. Furthermore, it would be too optimistic to expect Shiite and Kurdish representatives to treat the Sunnis democratically after long years of suffering. Therefore, boycotting the election might have seemed to them the only way out of this uncomfortable situation.

Third, there was a harsh intimidation campaign to persuade or scare Sunnis not to vote. As Abu Musab al-Zarqawi (Osama bin Laden's man in Iraq) stated, they started a fierce war against this election. “We have declared a fierce war on this evil principle of democracy and those who follow this wrong ideology.”<sup>21</sup> As shown in Figure 3, the drastic increase in the number of the daily attacks by insurgents after March 2004, when the TAL was approved, is an indication of the intimidation campaign.

Furthermore, the killings of civilians in a public market on March 28, 2003, and other incidents such as the disbanding of the former Iraqi Army and the firing of government employees, alienated the Sunni population from the US.

On October 15, 2005, the Iraqi people will hold a referendum to approve the new constitution. After four months they will elect the assembly. Because they boycotted the election to the Transitional National Assembly, Arab Sunnis are disproportionately under-represented in that body. They were brought into negotiations on the Iraqi Constitution after the fact.<sup>22</sup> The constitution itself was

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<sup>21</sup> CBS News, “Car Bomb Targets Allawi Party HQ” retrieved July 17, 2005 from <http://www.cbsnews.com/stories/2005/01/24/iraq/main668726.shtml>

<sup>22</sup> Hamza Hendawi, “Sunni Deal Reached on Drafting of Constitution”, Associated Press, retrieved June 16, 2005 from <http://www.harktheherald.com/modules.php?op=modload&name=News&file=article&sid=57572>

approved August 28, 2005, following several delays.<sup>23</sup> Unless Iraqi Sunnis participate in these upcoming elections, the future of democracy in Iraq will be jeopardized. For Sunnis to express themselves, representation in the assembly is the only way. Therefore Sunni participation is vital. Voting is not only a democratic right but also a responsibility for the Iraqi people on the way to democracy.

The term "democratization" is generally used to express the process of transition from an authoritarian or semi-authoritarian system to a democratic political system where government policies are determined by officials chosen for a certain period of time by means of free, fair and periodic elections in which a significant portion of adults can vote without distinction as to race, sex, belief or social status. Freedom of speech and the free expression of viewpoints, common suffrage, participation in the political process without any restriction or coercion, and protection of minorities' rights are among the prerequisites of democratic systems.

After Operation Iraqi Freedom, a democratization process for Iraq began. The aim is a system that will provide a free and contemporary environment for the Iraqi people, and a nation that will not be a threat to its neighbors and to global peace. Although the shift from a tyranny to a democratic system is very important and promising, there are some risks and challenges that the Iraqi people might confront on the way to democracy.

Historical records show that nations that begin institutionalizing democracy experience political and national violence during the transition process. In the early stages of democratization, as people start to enjoy some democratic rights such as voting and participating in the political process, ethnic conflicts become more likely. In most of the nations that take initial steps toward a democratic

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23 Associated Press Worldstream, "Iraqis Divided over Draft Constitution." Retrieved August 28, 2005 from [http://web.lexis-nexis.com.libproxy.nps.navy.mil/universe/document?\\_m=b05f0acb14cb13af044343f90eeeb86a&\\_docnum=9&wchp=dGLbVzb-zSkVA&\\_md5=e65b89d881ee0d53d0941a3e0909a10b](http://web.lexis-nexis.com.libproxy.nps.navy.mil/universe/document?_m=b05f0acb14cb13af044343f90eeeb86a&_docnum=9&wchp=dGLbVzb-zSkVA&_md5=e65b89d881ee0d53d0941a3e0909a10b)

system, such conflicts generally burst out shortly after initial civil improvements like holding elections.<sup>24</sup>

There are some countries, like Algeria and Nepal, which had not experienced any societal or ethnic war prior to their democratization process. Their initial democratization efforts triggered destructive armed conflicts. More interestingly, most of the countries that experienced serious ethnic and societal conflicts failed to establish rational regimes. Consequently, they remained either autocratic or semi-democratic.<sup>25</sup>

In multiethnic democratizing countries, nationalism starts to arise in the early stages of the transition. Political leaders find it easier to favor religious ties or ethnicity to gain popularity among their ethnic group rather than arguing about more complex urgent problems. Ironically, liberalization is often accompanied by a rise in sectoral conflicts.

Although democracy is not well-defined and different approaches point to different aspects of it, common suffrage and opportunity for representation of all groups are among the requirements that most academicians agree on. Anyone, regardless of religion, ethnicity, race, sex or status should be able to participate in the political process and all groups should have adequate representation. Even though the TAL guaranteed that anyone who carried Iraqi citizenship could vote, the lack of Sunni participation affected the legitimacy of the January 30 elections. Furthermore, during the preparation of the permanent constitution, Sunnis' views were generally ignored by the Shiite and Kurdish representatives in the assembly. There is potential for a long period of armed conflicts among these three groups.

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<sup>24</sup> Jack Snyder, "From Voting to Violence: Democratization and Nationalist Conflict" 2000.

<sup>25</sup> "Peace and Conflict 2005," Center for International Development & Conflict Management. Retrieved September 10, 2005 from [http://www.cidcm.umd.edu/peace\\_and\\_conflict.asp](http://www.cidcm.umd.edu/peace_and_conflict.asp)

### **III. MODELING TOOLS**

#### **A. INTRODUCTION**

The main actors in peace support operations are noncombatant civilians, rather than soldiers. They follow what their internal states (emotion, fear, anger, etc.) dictate rather than the orders of a superior. Their behavior is determined after the inputs—either from outside or inside - are evaluated by internal processes. Group dynamics, the presence of a leader they might listen to and his attitude, interactions between civilians and soldiers, and the presence of rival groups in the theatre are some of the most important external inputs that might influence an individual's behavior. Although they might be manipulated from outside, the internal processes of each individual are unique. Due to this uniqueness, individuals may respond differently to the same external influences, so individual behaviors are difficult or impossible to predict.

The agent-based approach is suitable for modeling the human behavior patterns because with agent based approach situations are more likely to be represented close to reality. In agent-based models, real entities are modeled as entities in the simulation as well.<sup>26</sup> Agents pursue their goals by sensing the environment and evaluating their interactions with other agents. Interactions may affect an agent's internal state as they do in real life.

The PAX modeling platform that we utilize in this study was developed by EADS Dornier for the German armed forces. The main difference between PAX and other agent-based models is that PAX focuses on modeling civilian behaviors<sup>27</sup>. It also allows us to examine MOEs like escalation, fear, and anger: these are more appropriate for gaining insight into PSOs than attrition-based MOEs commonly reported in agent-based combat models.

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<sup>26</sup> Gunther Schwarz, "Command and Control in Peace Support Operations Model PAX - Approaching new Challenges in the Modeling of C2." 2004.

<sup>27</sup> Gunther Schwarz & Hans-Joachim Mosler, "Investigating Escalation Processes in Peace Support Operations: An Agent-based Model about Collective Aggression", 2005.

## B. BUILDING THE MODEL

The election is held in an Iraqi town which is inhabited primarily by one ethnic group. In our model there are two civilian groups in the area. The main group consists of potential voters (i.e., those who have registered to vote), but we will simply call them **voters**. Voters are the agents colored purple at the beginning of the simulation in Figure 4. They may or may not cast their votes, but the admission control soldiers will allow them to enter the election area.

Agents in the other group, which we call **disturbers**, have not registered to vote and are kept from entering the election area by admission control. They are colored red at the beginning of the simulation (see Figure 4). Their main intentions are to cause havoc, threaten, and frighten the **voters** to keep them from casting their votes. They represent civilians from minority ethnic groups, as well as civilians from the majority ethnicity that oppose the elections. Their anger is high at the beginning of the simulation.

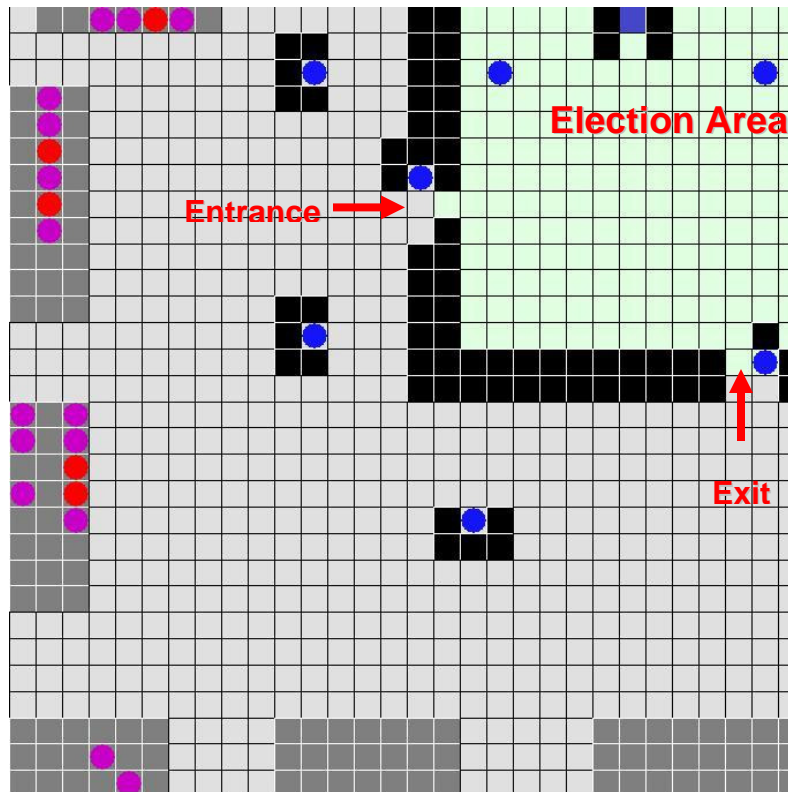


Figure 4. Basecase Election Scenario (Small Group)

There are 20 civilians in the “small group” basecase scenario—15 **voters** and 5 **disturbers**. In the “large group” basecase scenario there are 40 civilians, 30 of which are **voters**. The ratio of **disturbers** to **voters** is 1/3 in both instances.

There are three units of reserve soldiers outside of the election area. Because most of the civilians are coming from the east, two of the units are located on the east side of the election area. The other unit is located on the southeast side of the election area. At the beginning of the simulation, all the reserve soldiers are waiting at their posts.

The election area is located at the northeast side of the village. There are two gates. The gate on the west wing of the election area is the entrance; the one on the south wing of the election area is the exit. These are defined as unidirectional gates. Agents can neither use the “entrance” to exit the polling station, nor enter the election area through the “exit.” Each gate is guarded by admission control soldiers. Their mission is to guard the gates and manage the entrance and exits. The admission control on the entrance allows civilians belonging to the **voters** group to enter the election area.

The polling station is located on the north of the election area and guarded by two reserve soldiers. Their mission is to reduce any escalation in the election area, and guard the polling station.

The rest of this chapter provides step-by-step explanations of the modeling tools, including the PAX User Interface, the PAX Scenario Editor, and the PAX Experiment Editor.

### **C. PAX USER INTERFACE**

PAX is an agent-based modeling platform which focuses on peace support operations. It concentrates on modeling civilian behaviors and group dynamics, providing the opportunity for analysts to investigate the effect on civilian behaviors of different actions committed by soldiers in accordance with different rule sets.

After the PAX.bat file is invoked, either from the command prompt or by clicking directly on the batch file, the window in Figure 5 pops up. It provides all necessary means for running and analyzing a simulation with PAX. The user can create or modify a scenario, start and run a simulation or display and analyze the simulation. It has three drop-down menu options: *File*, *Options* and *?*.

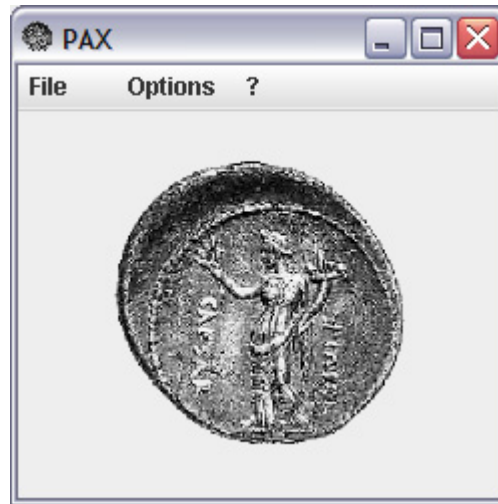


Figure 5. PAX-Start up

### 1. File Menu

When users click on the *File* menu, they can choose one of four options from the list displayed in Figure 6.

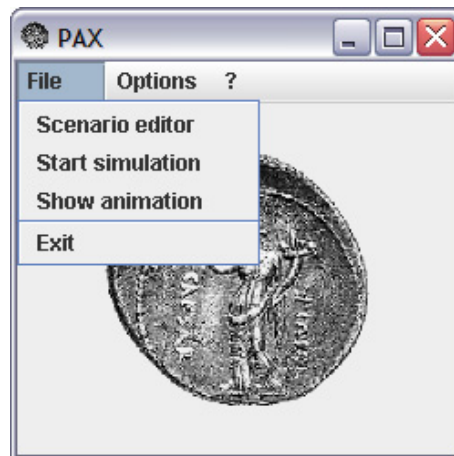


Figure 6. File Menu Items



**a. Scenario Editor:**

If this option is chosen, the editor called *PAX Scenario Editor* starts. Using this editor, users can create new scenarios or modify existing ones. Further information about the editor will be provided in Section D of this chapter.

**b. Start Simulation:**

In order to start a simulation, a scenario must be created beforehand. After clicking here, users are asked to choose an existing scenario file. After choosing the scenario, users are asked to specify a starting value for the random variables in the model and to start the simulation. It may take a few minutes for the simulation to run. After the simulation has finished, the animation window appears.

**c. Show Animation:**

The animation window shows the animation of the just-completed simulation. Only the most recently-executed simulation is stored. Each simulation overwrites the previous simulation. Further information about the animation window will be provided in Section E.

**d. Exit:**

This option exits the programs.

## **2. Options Menu**

Figure 7 shows the drop-down list for the *Options* menu. The option is limited to setting the language. Users can choose either English or German for the menu language.

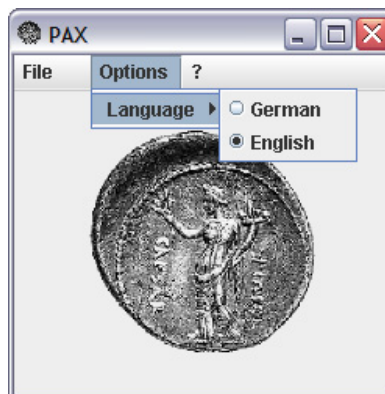


Figure 7. Option Menu Items

### 3. ? Menu

Figure 8 shows the ? menu options. The *Help* option provides an online manual for PAX. The *About* option provides information about the contributors to the project and the developer's contact information.

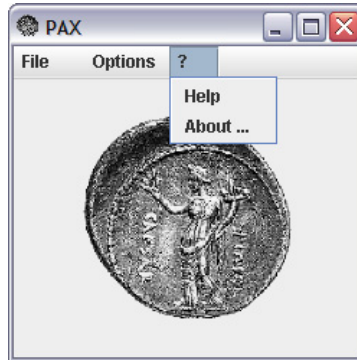


Figure 8. ? Menu Items

### D. PAX SCENARIO EDITOR

The PAX Scenario Editor allows the user to create a PAX scenario. In the scenario, the user can define the properties of the terrain, which is the playing field where the agents interact. The user also selects the types and initial locations of the agents, which can include civilians, soldiers and a service point (either a food distribution center or a polling station).

Once the editor is invoked, the window depicted in Figure 9 appears. It has three drop-down menu options: *File*, *Scenario* and ?.

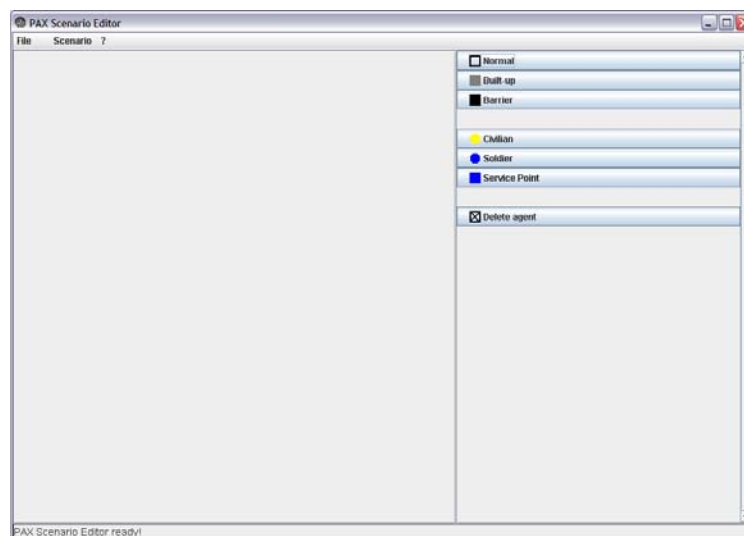


Figure 9. PAX Scenario Editor

## 1. File Menu

When users click on the *File* menu, they can pick one of the five options from the list shown in Figure 10. *Save* and *Save as* options are initially inactive, since no scenario is yet created or loaded.

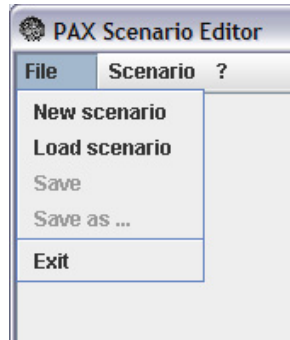


Figure 10. Scenario Editor File Menu Options

### a. New Scenario:

Users create a scenario from scratch. If this option is chosen, a window opens that asks for the dimensions of the scenario. Figure 11 shows the *Scenario Dimensions* window. Each square is identified by a coordinate system (x,y). The coordinate of the bottom left square is (0,0). The x value increases towards the right side along the horizontal axis, and the y value increases upwards along the vertical axis. Methods for setting up the terrain and defining the agents and their will be explained in a later section.

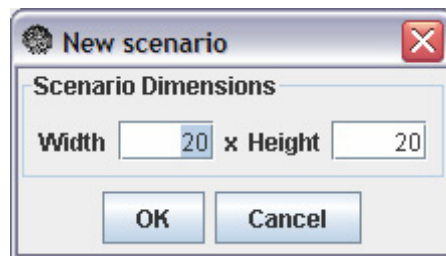


Figure 11. Scenario Dimensions

**b. Load Scenario:**

By choosing this option, users can open a previously created scenario to edit or simply to run.

**c. Save:**

This option saves a scenario created or edited by a user to disk, rewriting the existing scenario file.

**d. Save As:**

Users can save the scenario they created or edited to disk with a new name or format.

**e. Exit:**

Leave the editor

**2. Scenario Menu**

When users click on the *Scenario* menu, they can pick one of the two options from the list shown in Figure 12.

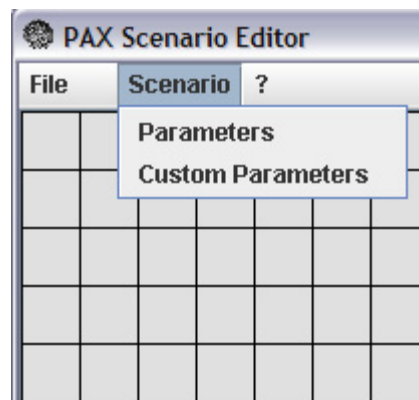
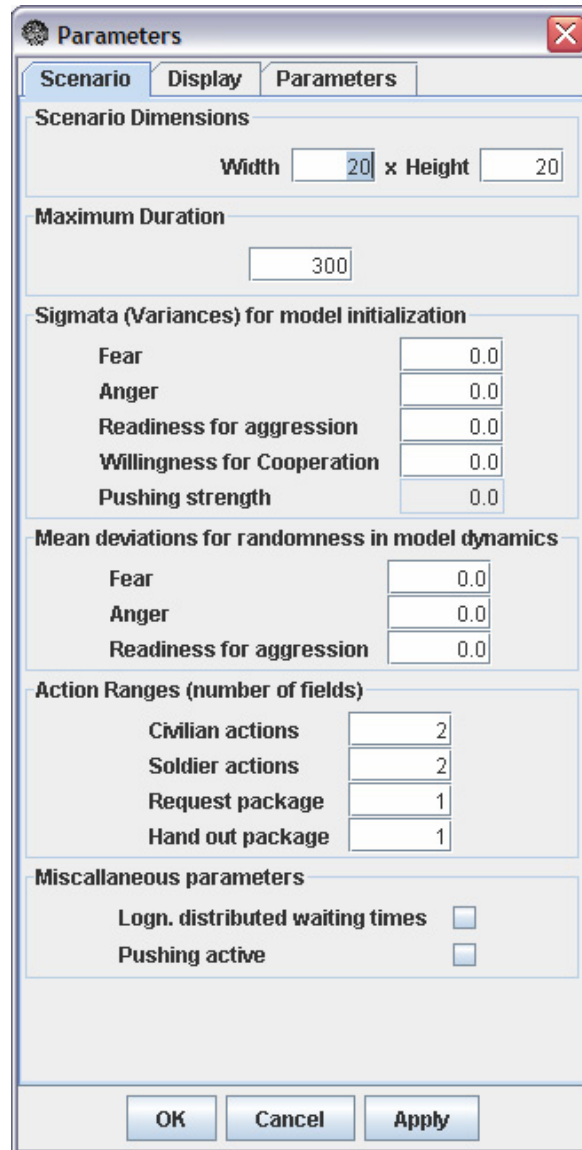


Figure 12. Scenario Editor Scenario Menu Items

**a. Parameters:**

Apart from the model variables of each agent and cell, PAX defines a set of global parameters valid for either the whole scenario or for all civilian agents. It lets users edit global parameters (such as playfield dimensions or randomness settings), change the appearance of the playfield, and select which parameters are visible on the *Selection* pane. As Figure 13 shows, there are three tabs in the *Parameters* window.



The Parameters Window is a dialog box with a title bar containing a gear icon, the text "Parameters", and a close button. It has three tabs: "Scenario", "Display", and "Parameters", with "Parameters" currently selected. The window is divided into several sections, each with a title and a set of controls.

- Scenario Dimensions:** Contains two input fields: "Width" (set to 20) and "Height" (set to 20), separated by an "x" symbol.
- Maximum Duration:** Contains a single input field set to 300.
- Sigmata (Variances) for model initialization:** A list of five parameters, each with a corresponding input field set to 0.0:
  - Fear
  - Anger
  - Readiness for aggression
  - Willingness for Cooperation
  - Pushing strength
- Mean deviations for randomness in model dynamics:** A list of three parameters, each with a corresponding input field set to 0.0:
  - Fear
  - Anger
  - Readiness for aggression
- Action Ranges (number of fields):** A list of four parameters, each with a corresponding input field:
  - Civilian actions (set to 2)
  - Soldier actions (set to 2)
  - Request package (set to 1)
  - Hand out package (set to 1)
- Miscellaneous parameters:** Two checkboxes:
  - Logn. distributed waiting times (unchecked)
  - Pushing active (unchecked)

At the bottom of the window are three buttons: "OK", "Cancel", and "Apply".

Figure 13. Parameters Window

(1) *Scenario Pane*: Users can set the size of the currently edited scenario in the **Scenario Dimensions** area. When resizing the playfield, the cells are added to or reduced from the top and right. Any agents located on cells that are cleared will also be cleared. To resize the playfield to its original dimensions, the editor adds only cells. In other words, any agents who were previously cleared are lost; the user must recreate them if they are needed.

The **Maximum Duration** defines the maximum simulation duration if none of the natural criteria for stopping the simulation are fulfilled. The

simulation is stopped naturally if all the food packages are distributed in food distribution scenarios, and if all the civilians have voted in election scenarios.

The **Sigmata (Variances)** section lets users specify a standard deviation for the starting conditions *fear*, *anger*, *readiness for aggression*, *willingness for cooperation* (in case of a leader) and *pushing strength* of each civilian. The users cannot specify the standard deviation for each civilian individually or each group separately, but just for all of them in common. Just before the simulation run begins, the model changes each civilian's value of *fear*, *anger*, *readiness for aggression*, *willingness for cooperation* (if the agent is a leader), and *pushing strength* according to random draws from a normal distribution with the specified standard deviation. The results depend on the random seed provided to the model. This is to reduce the possibility that many or of the civilians will change their internal state simultaneously. (Otherwise, since they all start off with exactly the same parameterization, they might all change their internal state the same way due to very similar influences from their environment).

The user can specify a **mean deviation for randomness in model dynamics** for the parameters *fear*, *anger* and *readiness for aggression*. These values influence the simulation runs so that whenever an action is selected by an agent, the relevant factors are manipulated according to uniform distributions with the mean deviations specified here. For example, a mean deviation of 4.0 for anger implies that the anger value used to determine an agent's action can differ from the agent's actual anger by at most 8.0. This means that before making certain decisions (such as whether to threaten or attack a soldier) the values of *fear*, *anger* and *readiness for aggression* can be slightly altered so that certain model thresholds are smoothed. For example, if a civilian's *readiness for aggression* is just below 30 he will not attack a soldier despite being angry. If, however, an agent is angry and his *readiness for aggression* is over 30, he is going to attack the soldier. The randomness effect is meant to avoid having a rigid threshold: civilians with slightly lower or higher values of *readiness for aggression* may sometimes violate expectations.

The **Action Ranges** section defines the ranges in which agents can perform certain actions during a simulation.

In the **Miscellaneous Parameters** section, agents' waiting times can be set so they are drawn randomly from a log-normal distribution. Otherwise, waiting times are always exactly one time unit. In some situations, some agents' internal states may be so low that they can barely act, causing problems such as blocking an entrance or exit, or hindering other agents from accessing the food distribution center or polling station. In such cases, stronger agents may push through and change positions with weaker agents. Strength is defined by physical strength and motivational power. Checking or unchecking the *Pushing active* box will activate or deactivate this feature. If pushing is deactivated, then the strength for pushing cannot be altered.

(2) *Display Pane*: Figure 14 shows the display pane. Here users can change the *display* size of the playfield. The actual size (in cells) of the playfield is *not* affected by this setting. Automatic handling adjusts the display size so that it fits best into the editor's draw panel. However, this default behavior can be changed and the size can be set manually.

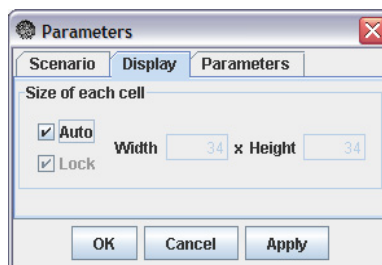


Figure 14. Display Pane

(3) *Parameters Pane*: In order to improve clarity in the selection panel to the editor's right, users can show or hide some of the agent's and cell's parameters. Such hidden parameters can no longer be set for any agent or cell, but they remain present and any values previously set for the existing agents and cells are preserved. Moreover, any *new* agents and cells are parameterized with the last values parameters had prior to being hidden. Figure 15 shows the parameters pane.



Figure 15. Parameters Pane

**b. Custom Parameters:**

Some model parameters are, by default, not yet editable when a new scenario is created. The *Custom parameters* option lets users define these custom parameters. The complete path to the model parameter (in the underlying code) must be specified. For example, if we want specific groups to be allowed to enter the election area, we need to type this in the parameter field as "Soldat[i]/S\_Cognition/Akzeptierte\_Groupen[k]" where i stands for the soldier



ID and k for the group. The corresponding value should be “true,” as shown in Figure 16.

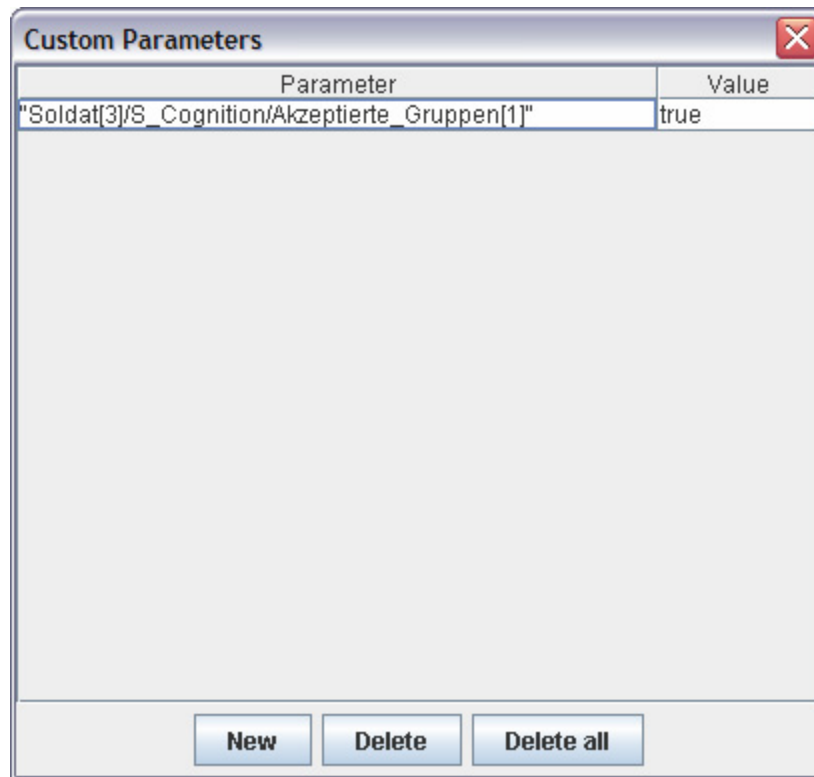


Figure 16. Custom Parameters Window

### 3. ? Menu

Figure 17 shows the ? menu options. Just as the corresponding menu in the *PAX Startup* window, the *Help* option provides an online manual for PAX Scenario Editor. The *About..* option provides information about the contributors to the project and the developer's contact information.

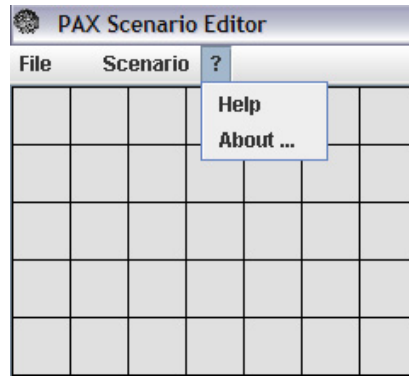


Figure 17. ? Menu Options

A scenario created by PAX Scenario Editor can be used for different purposes. First, it can be used as a direct input file for single runs of a PAX model. After running the single simulation, users can see the results and replay the simulation. Second, it can be used as an input file for running the model PAX using the so-called *PAX Wrapper*. Comma-separated output files are generated by the PAX Wrapper. It is implemented as another layer wrapped around the model itself so that users can perform a single model run with an XML input file and CSV output. Finally, the scenario file created by the PAX Scenario Editor can be used as a base scenario for creating an experiment with the PAX Experiment Editor. Further information about the PAX Experiment Editor will be provided in Section F.

The Scenario Editor can save files in two output formats: the PAX-specific XML format and the editor-specific XML format. Saved scenarios can be read in again from both of these formats, and both formats are suitable for performing studies with the Project Albert software *OldMcData*.

#### 4. Setting cells

The Scenario Editor consists of two main parts. The playfield of the scenario being created is displayed on the left of the editor. The selection panel for choosing, modifying and deleting the agents and different types of fields is on the right side. The playfield on the left is initially filled with normal cells by default. To change the appearance of the environment, or to place agents onto the cells of the playfield, users must select the appropriate cell or agent type in the selection panel to the right of the editor.

Setting a number of cells to a specific cell type can be done either by setting the cells one at a time or by drawing a rectangle with the left mouse button pressed. Users need to first select the type of cell they want to set from the selection panel. There are three forms of cell types possible, as Figure 18 shows.



Figure 18. Cell Types

**a. Normal:**

Normal cells are the cells that all kind of agents can traverse. Every cell belongs to a certain *area type*, where *area types* 0, 1, 2, and 3 are represented by light-grey, light-blue, pink, and light-green colors, respectively. All cells initially belong to area 0 when a new scenario is created. For normal cells we can define **portals** between different area borders. Portals are gateways that enable passages back and forth between area borders. Unless a portal is defined, agents cannot traverse from one area to another. Portals between cells in the same area are meaningless. Figure 19 shows the portals pane. The space at the center represents the cell from which the portal will be defined. In order to define a portal, users simply click to check the box (or boxes) that represent surrounding cells. More than one portal can be defined for a particular cell. Furthermore, a portal can be either unidirectional or bidirectional. The model is capable of reporting the measures of effectiveness for different areas, such as total escalation in the election area.



Figure 19. Portals Pane

**b. Built-up:**

Built-up cells represent shelters or refuge for civilian agents who are frightened, have already received supply packages, or have cast their votes. Built-up cells, like normal cells, belong to a certain *area type*. It is important to remember that agents cannot traverse the border between a normal cell and a built-up cell of a different area. In other words, in order to have built-up cells work as intended, the *area type* of the built-up cells must be the same as the normal fields surrounding the built-up cells. If an existing cell is occupied by a soldier or service point, setting a built-up cell there causes the agent or service point to be removed.

**c. Barrier:**

Barrier cells represent obstacles that no agents can traverse. These can model either natural barriers like rivers, or artificial barriers like walls and barbed wire.

## 5. Setting Agents

The playfield is a backdrop for the agents in the simulation. There are three types of agents that users can define. Figure 20 shows these types and their symbols. A civilian's color can change during the simulation, but soldier and service point agents always appear blue.



Figure 20. Types of Agents

Agents can be set simply by clicking or drawing a rectangular region on the playfield. Whether an agent can be set on a specific position depends on the type of cell at that position. If a cell is designated as a barrier, no agent can be put on that cell. Only civilian agents can be placed on built-up cells. There are no limitations to setting agents on normal areas. To set an agent's initial position to

a particular cell, users select the type of the agent they wish to set from the selection panel. Once an agent is selected, the parameters currently editable for this type of agent are shown in the lower part of the selection panel.

**a. Civilian:**

As described above, civilian agents can be set on normal or built-up types of cells. Civilians' parameters in the current version of PAX include *fear*, *anger*, *need*, *readiness for aggression*, *group cohesion*, *norms for anti-aggression*, *status* (leader or normal), *willingness for cooperation*, *group*, *elective motivation*, personality constants for initial *fear*, personality constants for initial *anger*, *decrease of anger on success* and *pushing strength*. However, the personality constants for *fear*, *anger*, *decrease of anger on success*, and *pushing strength* are hidden by default. The *Parameters Pane* section earlier in this Chapter explains how to make them visible. Figure 21 shows the editable parameters of the civilian agents.

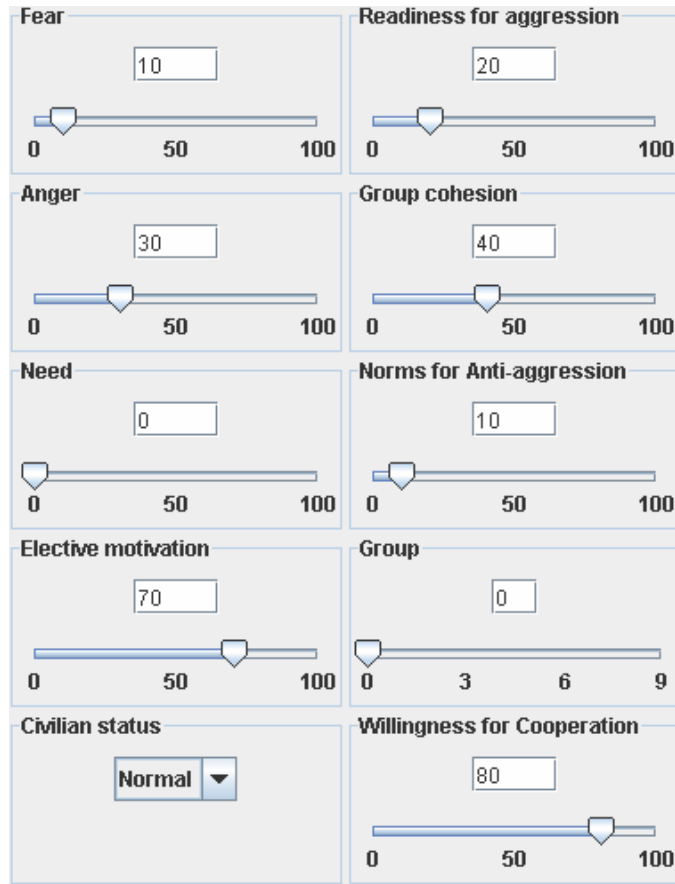


Figure 21. Editable Parameters of Civilians

The parameters of a civilian agent can be chosen from the range 0 to 100. A civilian agent's type can be set either as normal or as a leader. The parameter *willingness for cooperation* does not have any meaning for a normal civilian. It is a parameter for a leader, indicating how much he is willing to obey or get along with the soldiers. The parameter *need* corresponds to a need for food, and is not used in election scenarios. Civilians can be set as belonging to a particular *group* (or ethnicity) that enables reporting measures of effectiveness by groups.

Civilian agents are represented with colored dots in the simulation. Different colors represent different internal states. These colors change during the course of the simulation as the agents' internal states change. An agent's

dominant internal state at a specific point in time becomes the leading motive. The color codes used in the simulation are as follows:

- Green Fearful
- Yellow Needy (Hungry)
- Orange Angry
- Red Ready for Aggression
- Brown Obedient
- Purple Willing to vote
- White Neutral

**b. Soldier:**

Soldier agents can only be associated with normal cells. A soldier agent's type can be set either to admission control or reserves. Admission control soldiers guard and manage entrances and exits. They do not move. If a soldier is set to admission control, the cell controlled by that admission control agent should be set as well. Reserve soldiers are capable of limited movement. The only movement currently implemented is that reserve soldiers will move towards the civilians if the escalation becomes high. The only common parameter for both types of soldier agents is the rule set. Ten rule sets can be set in the editor. Only the first six rule sets have been implemented so far. Figure 22 shows the types of the soldier agents and rule sets selection slider.

The screenshot shows a user interface for configuring a soldier agent. It is divided into two main sections: 'Soldier status' and 'Cell controlled by this soldier'. The 'Soldier status' section contains a dropdown menu with 'Admission control' selected, and a list box showing 'Admission control' and 'Reserves'. The 'Cell controlled by this soldier' section contains a dropdown menu with 'NorthWest' selected. Below these sections is a 'Rule set' section with a text input field containing the number '1' and a slider control with a shield icon on the left and a range from 1 to 10.

Figure 22. Soldiers' status and rule sets

**c. Service Points:**

Service points can only be associated with normal cells. The types of service points available are supply vehicles or polling stations. The number of packages refers to the number of food packages that can be distributed in food distribution scenarios. In election scenarios it is not meaningful. Users can also set the amount of time that the service point needs to distribute one package or that an agent needs to cast his or her vote. Figure 23 shows the *Service Point Parameters* window.

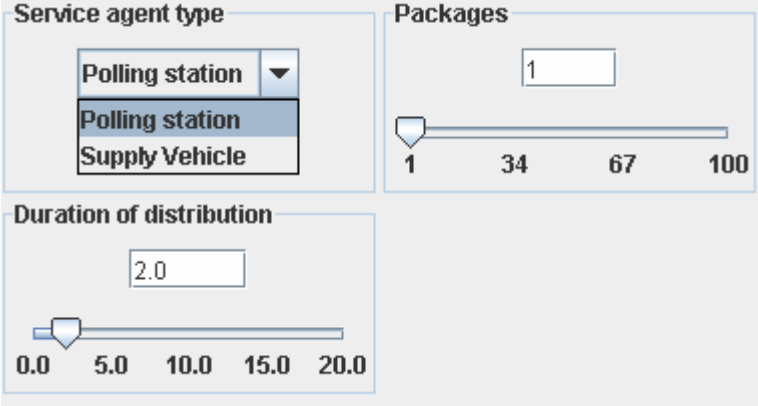
The image shows a software window titled "Service Point Parameters". It is divided into two main sections. The left section contains two controls: a dropdown menu labeled "Service agent type" with "Polling station" selected, and a slider labeled "Duration of distribution" with a value of 2.0. The right section contains a text input field labeled "Packages" with the value 1, and a corresponding slider below it with tick marks at 1, 34, 67, and 100.

Figure 23. Service Point Parameters

**d. Delete Agents:**

To delete agents, click on the tab shown in Figure 24 and then simply click on the agent to be deleted. Users can delete agents one by one as well as more than one at a time by dragging the mouse over the agents they want to delete.

The image shows a single button with a blue gradient. On the left side of the button is a small square icon containing a white 'X'. To the right of the icon is the text "Delete agent".

Figure 24. Delete Agent

One agent can replace another. Simply specify the type of agent you wish to include, and then click the agent to be replaced in the draw panel.



## E. PAX ANIMATION WINDOW

The PAX animation window enables users to review the course of a previous simulation. It serves as PAX's playback tool. It presents different model elements recorded during the simulation run. Users can have information about the status of the agents at a specified time. Figure 25 shows a screen shot of the animation window.

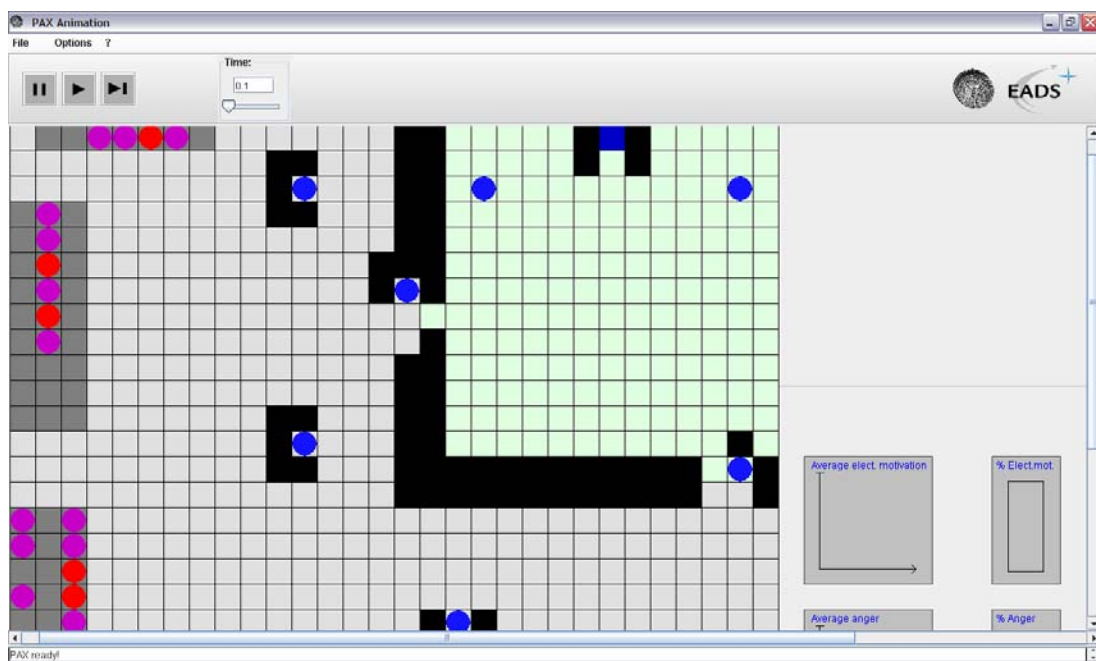


Figure 25. Animation Window

### 1. File Menu

The only option is to exit the animation window.

### 2. Options Menu

#### a. *Reset:*

It resets the animation to the starting time.

#### b. *Configuration Settings:*

Choosing "Configuration Settings" in the animation window's "Options" menu brings up a configuration dialog. Figure 26 shows the

configuration dialog. Users can adjust the configurations under three sections: animation speed, field information, and other options.

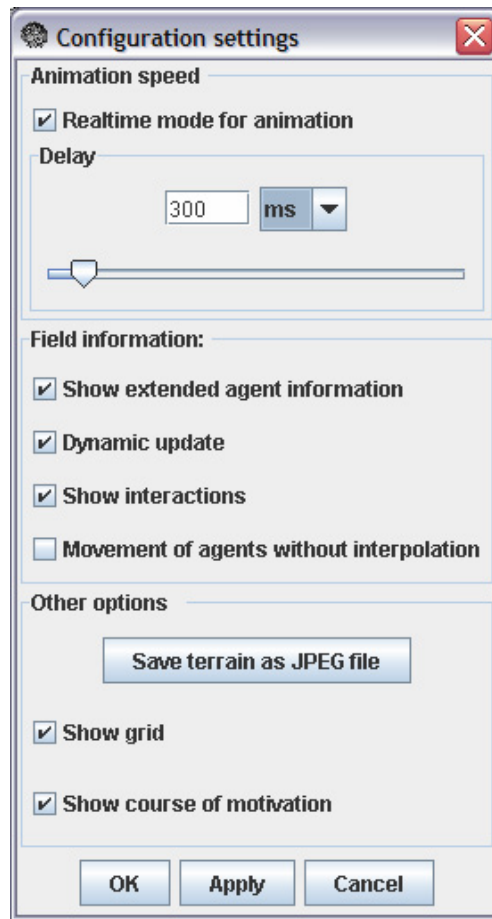


Figure 26. Configuration settings

(1) *Animation Speed*: To have the animation displayed so that every time unit takes the same amount of time regardless of how many events have occurred at that point in time, users should check **Realtime mode for animation**. They can define a **Delay** to pause the animation after each time step, making the animation more traceable on fast machines.

(2) *Field Information*: The information about agents' deindividuation<sup>28</sup> and readiness for aggression are hidden by default. Users can

---

<sup>28</sup> Prentice-Dunn, S. & Rogers, R. W, "Deindividuation and the Self-Regulation of Behavior". In P. B. Paulus (Ed.), *Psychology of Group Influence*, Hillsdale: Lawrence Erlbaum Associates. 1989.

make them visible (as part of the agent information dialog box) by selecting **Show extended agent information**. In order to see the information about an agent, simply click on that agent on the play field. Figure 27 shows an information dialog for a civilian agent. The **show results** button on the right bottom of the information dialog is initially invisible. Once one of the **record X** check boxes is activated, it becomes visible. Information about soldiers and field can be similarly displayed. **Dynamic Update** defines whether the information in the currently open information dialog is dynamically updated. If it is not checked, the information is not updated dynamically. The **Show interactions** check box enables the user to switch between displaying and hiding the interactions between agents. It is a good practice to see the interactions among the agents; it gives better insight into the overall situation. In the underlying model agents jump from cell to cell, and the computations to determine their actions are time consuming. The default animation mode is an idealization of the model behavior that makes it easier for the analyst to track a specific agent and its behavior, in that agents' movements are interpolated as continuous. This can be deactivated by deselecting **Movement of agents without interpolation** so that the agents jump from cell to cell like they do in the model.

Agent on field: (11/23)

Agent type:	Civilian
ID:	3
Group	0
Strength	36
Action:	Moving
Communication:	Waiting

---

Leading motive:	Fear
Aim of Command:	None
Need:	0
	<input checked="" type="checkbox"/> Record need
El. motivation:	80
	<input checked="" type="checkbox"/> Record elective motivation
Anger:	48
	<input checked="" type="checkbox"/> Record anger
Fear:	86
	<input checked="" type="checkbox"/> Record fear
Obedience	0
	<input checked="" type="checkbox"/> Record Obedience

---

Deindividuation	0
	<input checked="" type="checkbox"/> Record de-individuation
Readiness for aggression	0
	<input checked="" type="checkbox"/> Record aggressiveness

---

☐ Display plan of actions

Show results

Figure 27. Information about agent on grid (14/20)

(3) *Other Options:* Users can save a snapshot of the situation currently displayed in the animation window with **Save terrain as JPEG file**. The grid underlying the animation can be displayed or hidden by choosing the appropriate **Show grid** setting. Deactivate the graphs to the right side of the animation window by deselecting **Show course of motivation**. Figure 28 shows the graphs that can be hidden.

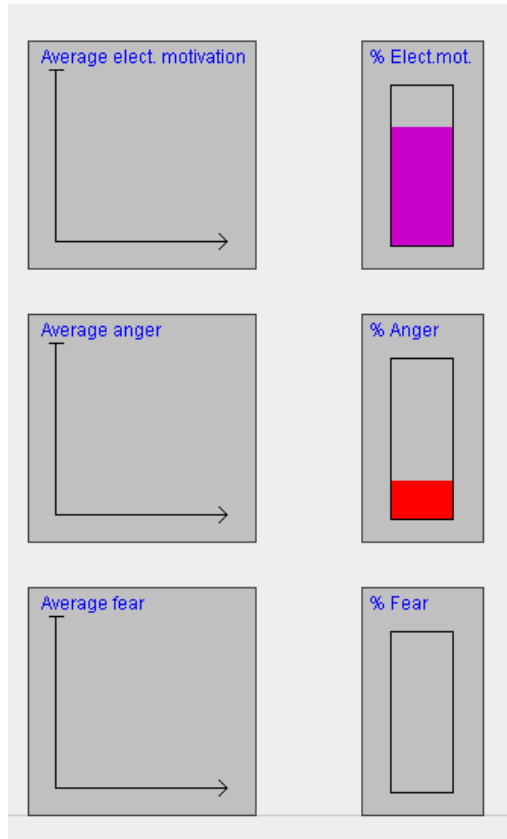


Figure 28. Course of motivation

**c. Show Results:**

This presents a summary of the current run.

**3. ? Menu**

As before, the *Help* option provides an online manual for PAX Animation Window. The *About..* option provides information about the contributors to the project and the developer's contact information.

**4. Button Panel**

A PAX Animation window has buttons that can be used to start, pause and rerun the simulation. Figure 29 shows the button panel.



Figure 29. Button Panel

Clicking on the pause button will pause the animation. The play button starts or continues the animation. By clicking the step button, a single animation step (0.1s) is performed. In the time panel the animation can be set to a certain point in time either directly or by using the slider.

## 5. Result Presentation and Statistical Graphics

On the right side of the playfield, the PAX Animation window provides some useful graphics about the course of simulation over time. This allows users to get a sense of the situation before starting further analysis. Figure 30 shows the graphics displayed on the right side of the playfield.

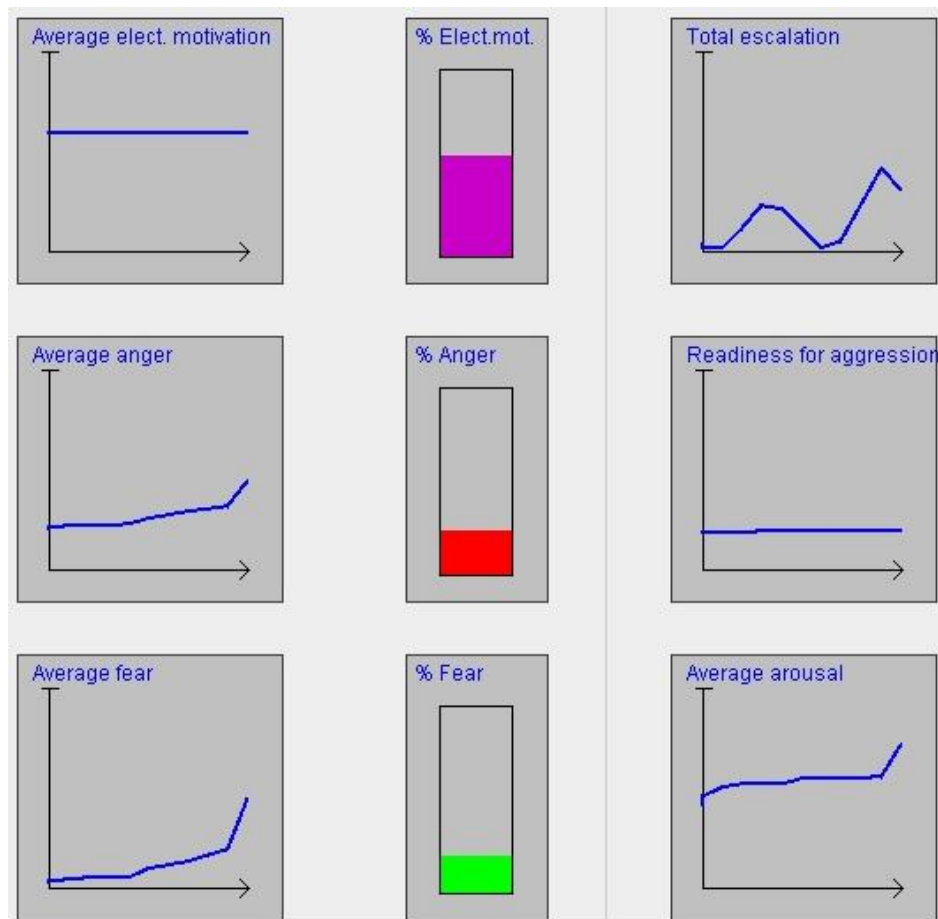


Figure 30. Statistical Graphics

In addition to the statistical graphics on the right side of the playfield, a general summary of the simulation run is available from the menu item **Show**

**results** under the **Options** menu. This option is not active until the animation has run from the beginning to the end of the simulation at least once. The summary is shown in a separate window. An example of a summary window is displayed in Figure 31.

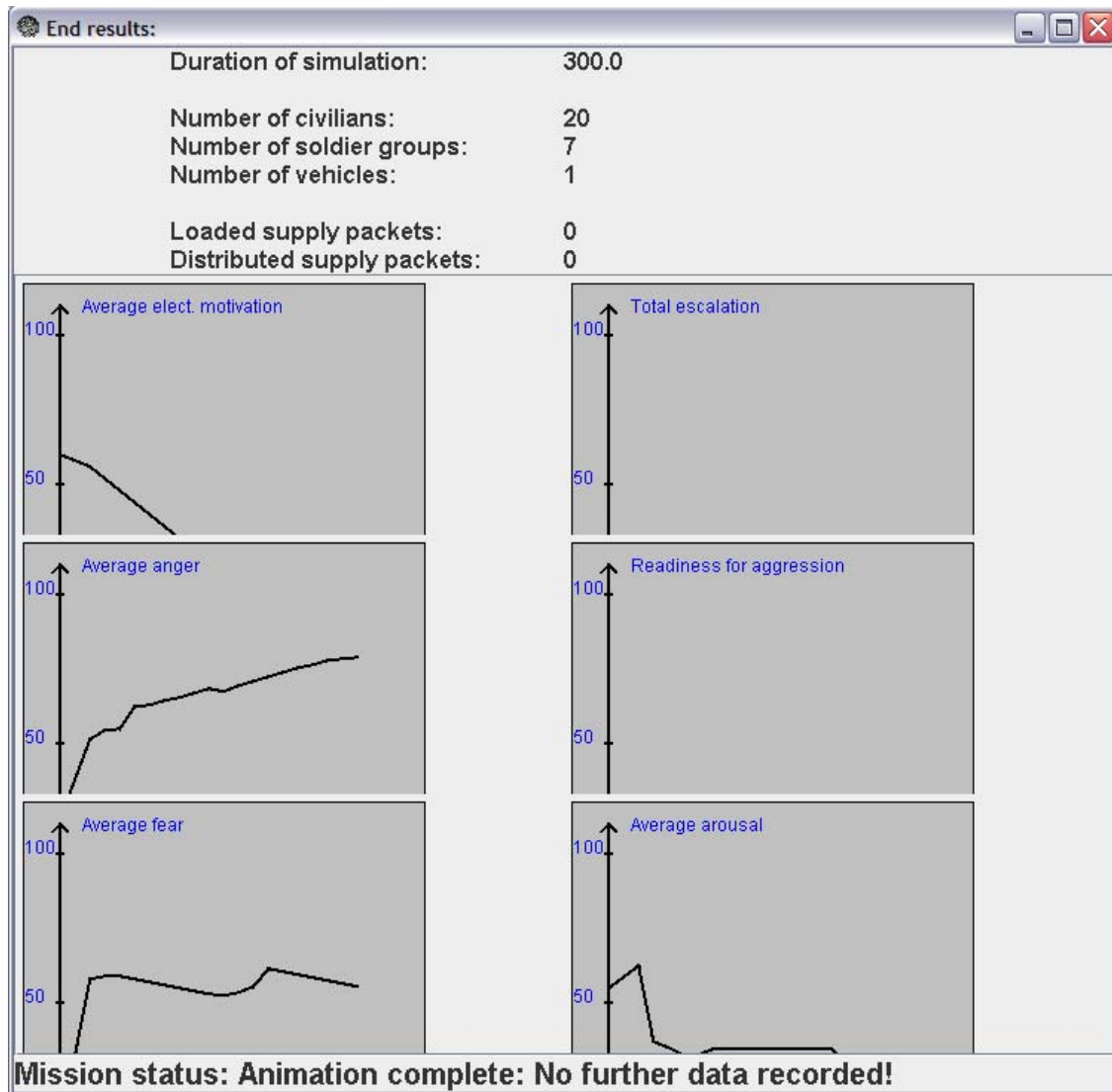


Figure 31. General Summary of the Simulation Run

Detailed statistics about a particular agent are available as well. If an agent's parameters have been recorded, they can be displayed by selecting the *Show results* button in the agent's information dialog shown in Figure 27. The previously recorded course of the parameters is shown in a separate window; an example is displayed in Figure 32.

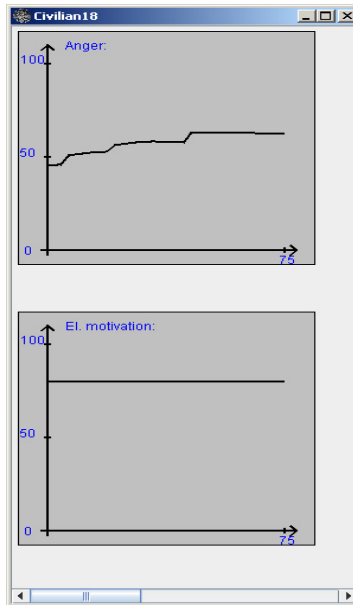


Figure 32. Recorded Parameters of Civilian 18

## F. PAX EXPERIMENT EDITOR

The PAX Experiment Editor provides a graphical user interface (GUI) that lets users create a PAX experiment with multiple excursions which can be run using the *OldMcData* software created by MITRE Corporation. It allows more than two parameters at a time to be varied. Once the experiment editor is invoked, a graphical interface similar to scenario editor opens.

### 1. File Menu

When users click on the *File* menu, they can pick one of the six options from the list. *Save* and *Save as* options are initially inactive because no experiment has been created or loaded yet. Figure 33 shows the *File* menu options.



Figure 33. PAX Experiment Editor File Menu Options



**a. New Experiment:**

The **New Experiment** option let users create a new experiment from scratch. Once they chose this option, a dialog window appears asking for the name of the scenario which will serve as the base case for the experiment. Therefore, the user must create a scenario before creating an experiment. However, if there are no preexisting scenarios, users can invoke the PAX Scenario Editor from PAX Experiment Editor by choosing the **New scenario** option from *File* menu. This opens the Scenario Editor previously described in Section E. With the basecase scenario loaded, the window looks like similar to Figure 34. The left side is called the selection panel and the right side is called the parameterization panel. Unlike in the scenario editor, the playfield on the left *cannot* be edited. That means neither agents nor cells can be added or deleted, and the positions of the agents and cells on the playfield cannot be changed. The left part of the editor simply shows the playfield with all of its objects waiting for parameterization, and serves as the selection panel for performing this parameterization.

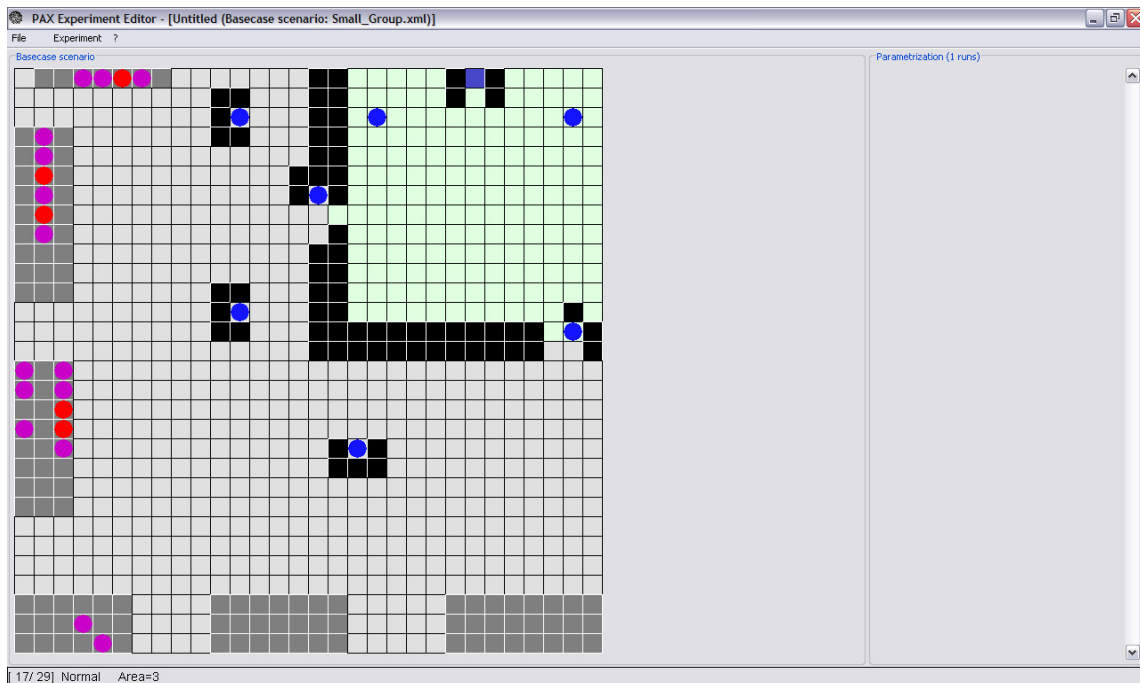


Figure 34. Experiment Editor

**b. Load Experiment:**

By choosing **Load experiment** from the *File* menu, users can open a previously saved experiment description file. After they have chosen an experiment description file, the editor reads the name of the associated basecase scenario file and tries to open it. If the experiment description file and the basecase scenario file are not located in the same directory, which is called the *study directory*, a message dialog similar to Figure 35 will warn that the basecase is not found.

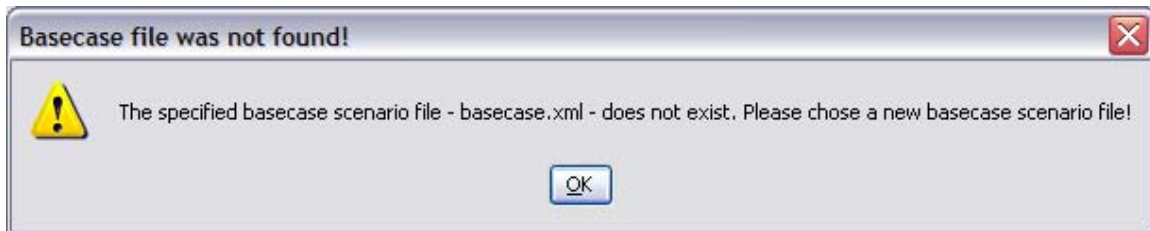


Figure 35. Basecase File Not Found Warning

Once the user hits the **OK** button in Figure 35, another dialog box will pop up to enable the user to locate the basecase file manually. If the selected basecase contains a scenario which is in some way incompatible with the experiment, the editor still tries to locate and group all agents and cells to be varied in that basecase scenario. Any warnings that occur during this process appear in another dialog window. Figure 36 shows examples of these warnings.

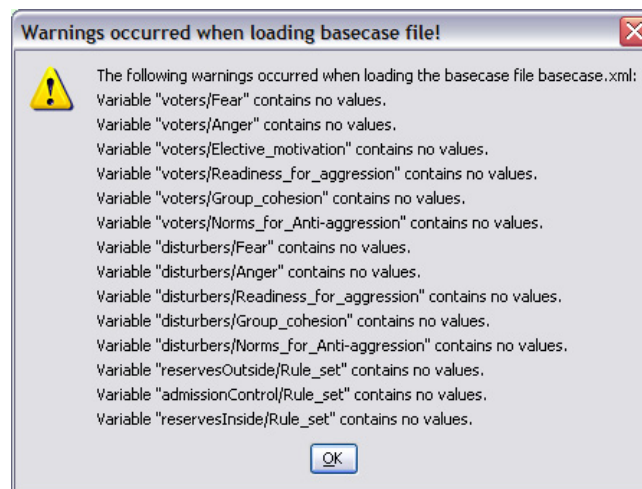


Figure 36. Warnings Occurred When Loading Basecase File

After the experiment loads successfully, the playfield shows on the editor's selection panel, while the groups and varied parameters are displayed on the parameterization panel on the right.

**c. Save:**

When saving the experiment, the editor automatically saves the basecase scenario into the same directory as the experiment file. The basecase scenario defines the values of all variables in the model, while the experiment description file specifies a set of parameters that are being parameterized differing from that variable's default value. Thus the experiment description file drives a process in which OldMcData creates a scenario for each parameter variation by changing the default values of the basecase scenario appropriately and performing a simulation run based on that scenario. The name of the basecase file can be specified in the *Experiment* settings. The basecase scenario is always saved in XML format regardless of its file name. If a file with that name already exists it is overwritten without warning. It is generally recommended that an experiment be saved to a designated empty folder since OldMcData writes all input and output files of the experiment, as well as logging and error files, to that folder.

**d. Save As:**

Users can save the created or edited experiment to disk with a new name or format.

**e. Exit:**

This leaves the experiment editor.

**2. Experiment Menu**

The *Experiment* menu basically lets users change or adjust experiment settings. Figure 37 shows the *Experiment* menu options.

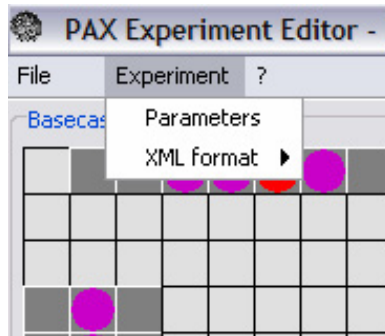


Figure 37. PAX Experiment Editor Experiment Menu Options

**a. Parameters Dialog:**

The global settings can be set in the parameter dialog which opens when **Parameters** is selected in the *Experiment* menu. These parameters have impact on the execution of the experiment. The **Parameter** dialog box has three tabbed panes with settings, as Figure 38 shows.

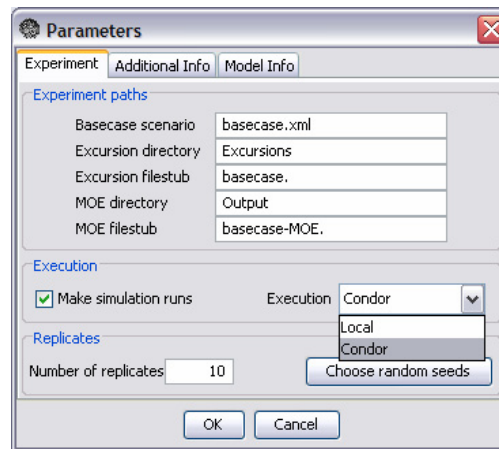


Figure 38. PAX Experiment Editor Parameters Dialog

(1) *Experiment*: The settings in the *Experiment paths* section determine which files and folders are accessed by *OldMcData* when executing the experiment. The *Basecase scenario* specifies the name of the basecase scenario file. This name can be freely chosen and the basecase scenario of the current experiment is automatically saved under this name in the study directory when saving the experiment. The *Excursion directory* specifies the name of the

folder to store the excursions created by *OldMcData*. The *Excursion filestub* specifies the first part of the excursions name to be created. The *MOE directory* is the directory to store the output files to which the results of the simulations are saved. They are used by the PAX Post Processor to create the .csv file used for data analysis purposes. The *MOE filestub* specifies the names of output files stored in the MOE directory. It is recommended that users leave those settings untouched or use the same naming convention if changes are desired.

There are two types of executions. The pull-down menu **Execution** permits a choice between *Local* and *Condor*. *Local* let users conduct the experiment on their local machine while *Condor* enables the runs to be conducted on a Condor pool. By deactivating the *Make simulation runs* switch, users simply tell *OldMcData* to prepare the experiment and create all files and folders needed to execute the experiment, without actually running it.

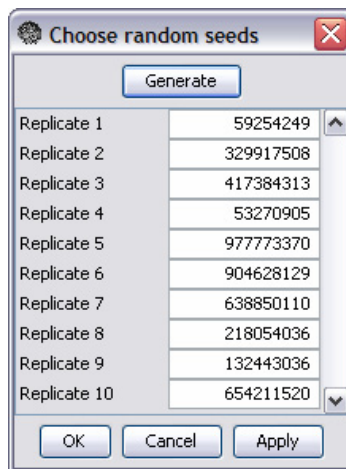
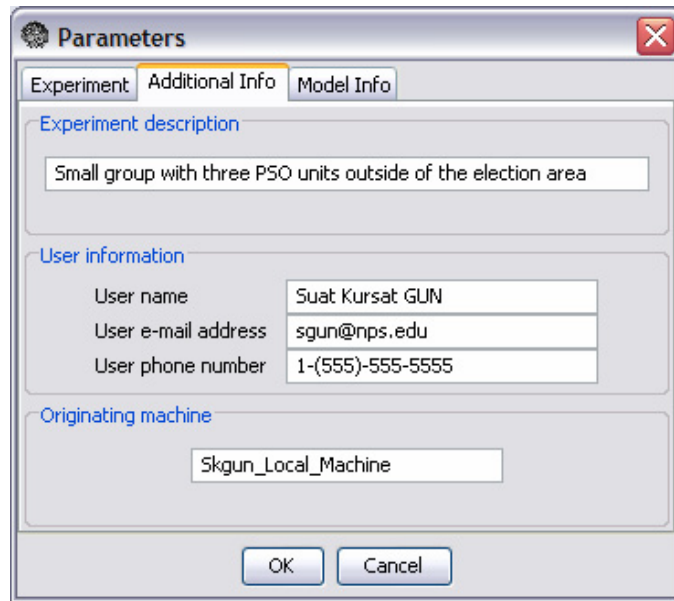


Figure 39. Choose Random Seeds

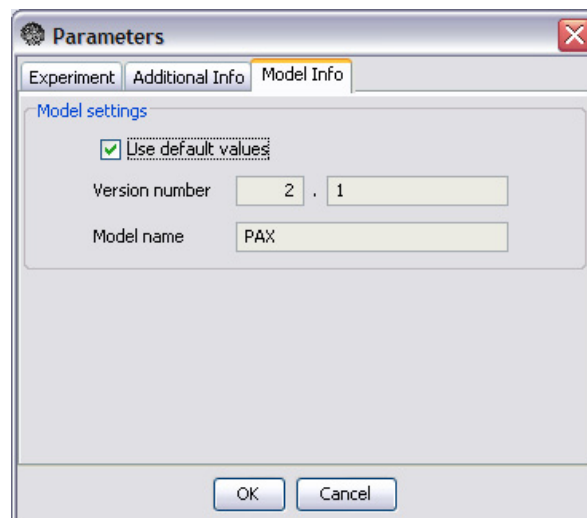
(2) *Additional Info*: This pane's settings are only for information purposes and do not affect the course of an experiment. It is possible to provide a short description of the experiment and information about the user. Figure 40 shows the additional info pane.



The 'Parameters' dialog box has three tabs: 'Experiment', 'Additional Info' (selected), and 'Model Info'. The 'Additional Info' pane contains three sections: 'Experiment description' with a text box containing 'Small group with three PSO units outside of the election area'; 'User information' with three fields: 'User name' (Suat Kursat GUN), 'User e-mail address' (sgun@nps.edu), and 'User phone number' (1-(555)-555-5555); and 'Originating machine' with a text box containing 'Skgun\_Local\_Machine'. At the bottom are 'OK' and 'Cancel' buttons.

Figure 40. Additional Info Pane

(3) *Model Info*: If there is more than one version of the model PAX registered with *OldMcData*, users can define which version is being used in this pane. The version defined on this pane must match the settings in *OldMcData*. These are quite sensitive settings; therefore it is recommended that users not change the default value unless they have loaded a basecase scenario created by an old version of PAX. From a practical point of view, it is highly recommended that the basecase scenario be created with the same version. Figure 41 shows the *Model Info* pane.



The 'Parameters' dialog box has three tabs: 'Experiment', 'Additional Info', and 'Model Info' (selected). The 'Model Info' pane contains a 'Model settings' section with a checked checkbox 'Use default values'. Below this are two fields: 'Version number' (2 . 1) and 'Model name' (PAX). At the bottom are 'OK' and 'Cancel' buttons.

Figure 41. Model Info Pane

### 3. ? Menu

Once again, the *Help* option provides an online manual for PAX Experiment Editor. The *About...* option provides information about the contributors to the project and the developer's contact information.

### 4. Grouping Agents

Before agents can be parameterized, they must be grouped. Agents must be selected on the selection panel before they can be grouped. Selecting an agent is done by simply clicking on it. In order to select all agents located in a particular region of the playfield, drag the mouse over that region and release the mouse when all the desired agents are selected. Selected agents icons are tinged with a dark blue overlay. Figure 42 shows two rows of agents. The agents on the upper row are normal; those on the lower row are selected.

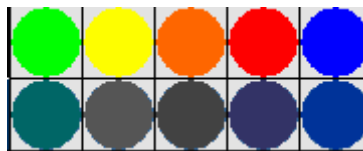


Figure 42. Selected Agents

To add agents to an existing selection, simply click on the agent or agents while pressing the *Ctrl* key. Similarly, to remove an agent from a selection, click on that agent while keeping the *Ctrl* key pressed. After agents are selected they can be grouped via a popup menu by right-clicking on the selected agents. Figure 43 shows the pop up menu for grouping agents.



Figure 43. Grouping Agents

Once users select the menu item *Group*, the agents currently selected are placed into a new group that shows up on the parameterization panel. Users can give the newly created group a name that represents the group's main characteristic. As seen in Figure 44, the number of agents in the group is reported to the right of the group's name.

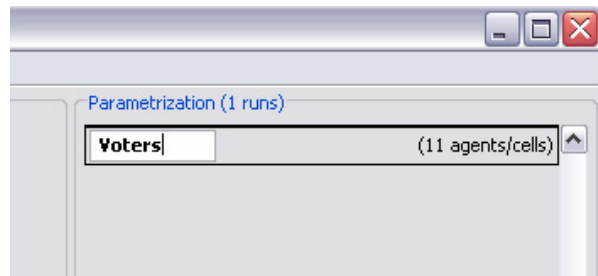


Figure 44. Naming Groups

To add an agent to an existing group, simply right-click on the agent and choose the *Add to group* option from the pop up menu shown in Figure 43. This option will show all the groups to which agents can be added, and the appropriate group can be selected. The experiment editor allows users to add an agent who has parameters that differ from those of the selected group. For example, a soldier can be added to a group of civilians. However, in such cases the agents have different sets of parameters, so no parameters can be varied during an experiment. If an agent who already belongs to one group is added to a different group, it is automatically removed from its original group.

Removing an agent from a group is done in similar fashion. After right clicking on the related agent, choose the *Release from group "group\_name"* from the pop up menu that is seen in Figure 45.

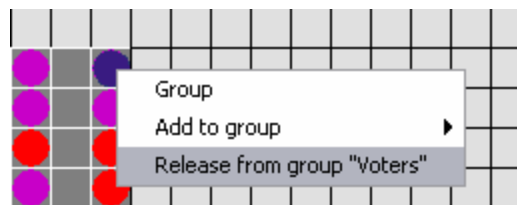


Figure 45. Release from Group



To delete an entire group, right click on the group's name on the parameterization panel. Then choose the *Remove group "group\_name"* option from the pop up menu displayed in Figure 46.

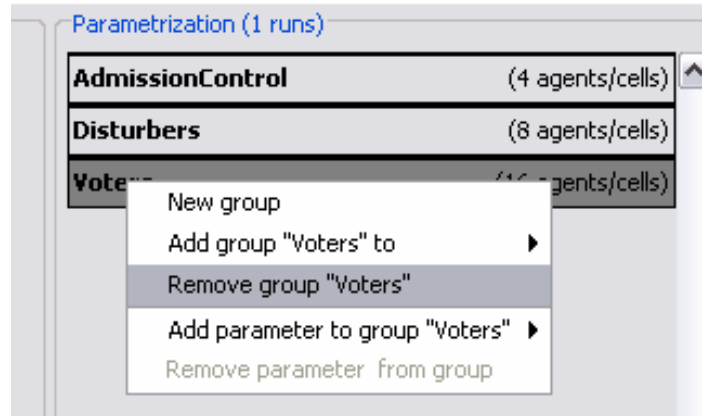


Figure 46. Remove Group

By choosing the *Add group "group\_name" to* option, users can add all the agents in one group to a different group that has been already created. This will automatically remove the previous group as well. The other possibility is to create a new group by selecting *New group* option.

## 5. Parameterizing Groups

It is not too bold to say that the PAX Experiment Editor is all about parameterizing the groups. Parameterization is its main focus. A set of values can be defined for the parameters of the agents which are varied in the experiment. As stated previously, to parameterize a group, all the agents in that group should support the same parameters. First, a parameter to be varied must be added to a group by right clicking on the group's name in the parameterization panel and selecting *Add parameter to group <group\_name>* (Figure 46). Once this option is selected, all parameters that can be varied appear as shown in Figure 47. Previously parameterized variables do not show up in the list.

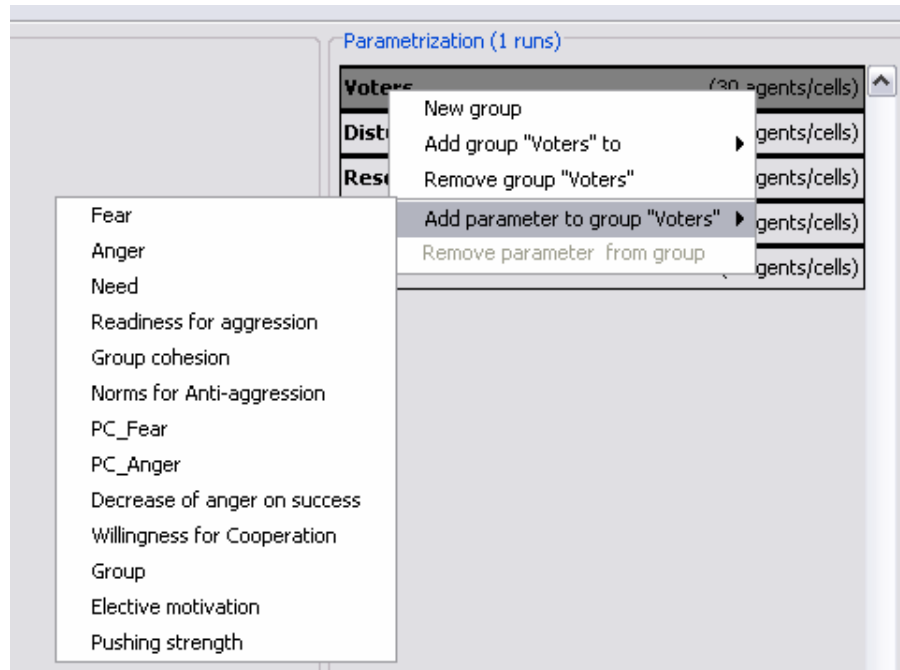


Figure 47. Parameters to Vary

Once the desired parameters are added, they appear in a new region of the window as in Figure 48 with a title, an input field, and a set of editable value fields under the group's name in the parameterization panel.

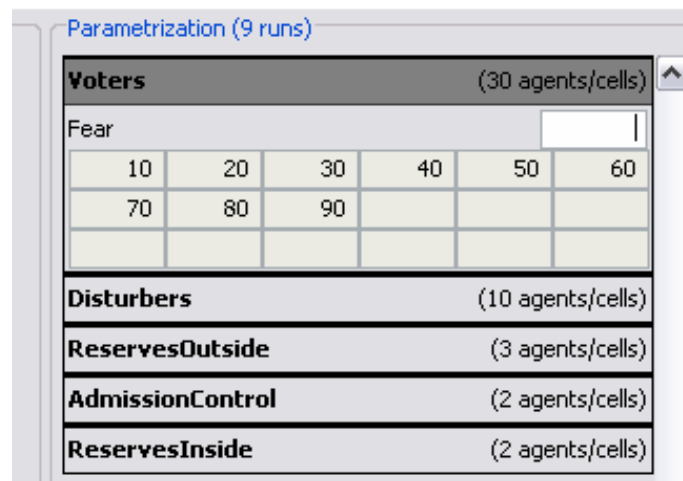


Figure 48. Value Inputs for Parameters

The parameter area initially contains 18 empty value fields. The number of fields increases automatically once the number of values for the parameter exceeds 18. The white cell on the right of the parameter's name is for inputting

values. However, the values can also be typed directly into the value fields. Clicking on one of the value fields makes it editable. Typing a new value overwrites the old one. The order of the values is ascending.

Values can be deleted by right-clicking the corresponding value field and then using the popup menu to delete them. It is possible to delete more than one value field simultaneously by first pressing the *Ctrl* key while clicking on the corresponding value fields. Users can select a whole range of values by clicking the first value and then the last value in the range while depressing the *Shift* key. To remove a parameter from the experiment, select the menu item *Remove parameter* "*parameter\_name*> from group <*group\_name*>from the pop up menu.

## **6. Reading Values from a File**

In large scale experiments, values for parameters are generally created by experimental designs like Nearly Orthogonal Latin Hypercube Designs<sup>29</sup>. In such cases, the *Experiment* option should read the values from the files created by design tools. Unfortunately, the PAX Experiment Editor is currently unable to do this. However, users can accomplish this manually by editing the .xml file created by the PAX Experiment Editor.

If the values are read from a file, users do not enter values for the parameters. After all the parameters to be varied are added to the groups' parameters list, the user should save the experiment without adding any values. This will produce a warning similar to the one shown in Figure 49. Save the experiment while ignoring the warning message. This creates the .xml paths of the parameters correctly.

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<sup>29</sup> Susan M. Sanchez, "Excel Spreadsheet for Generating Nearly Orthogonal Latin Hypercube Designs", retrieved September 16, 2005 from <http://diana.cs.nps.navy.mil/seedlab/NOLHdesigns.xls>. This spreadsheet is based on the study of Cioppa, T. M. and T. W. Lucas, "Efficient Nearly Orthogonal and Space-Filling Latin Hyper cubes"

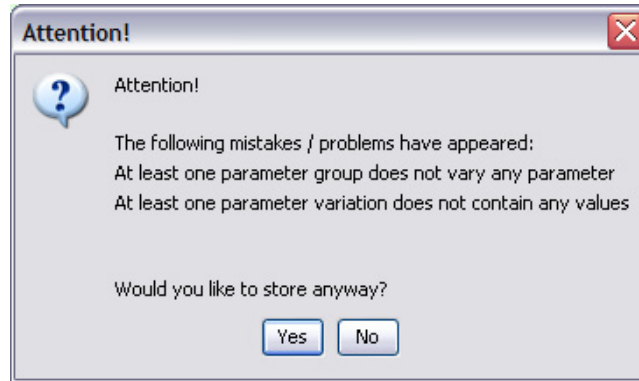


Figure 49. Attention Message

Upon saving the experiment, the PAX Experiment Editor will create two .xml files as previously described. Users need to edit the study file (not the basecase file) by using a word editor. Replace the lines

```
<GeneratorAlgorithm type="CartesianProduct" name="CartesianProduct"
classname="oldmcdata.generators.CartesianProductGenerator">
<Parameters/>
```

with

```
<GeneratorAlgorithm type="File" name="File"
classname="oldmcdata.generators.RunDataFromFileGenerator
<Parameters>
<FileName>C:\SKGUN\NOLHdesigns_For_Elections.csv</FileName>
<NumberOfLinesToSkip>...</NumberOfLinesToSkip>
</Parameters>
```

The filename “C:\SKGUN\NOLHdesigns\_For\_Elections.csv” is an example of the name of the file to read with its full path. After saving this revised .xml file, the experiment is ready to run using *OldMcData*.<sup>30</sup> Instructions for *OldMcData* are available.

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<sup>30</sup> OldMcData is a data farming tool developed by Project Albert Group. Information about the Project Albert Group can be found on [www.projectalbert.org](http://www.projectalbert.org)

## **IV. ANALYSIS OF THE COLLECTED DATA**

### **A. CHAPTER OVERVIEW**

This chapter begins with a brief introduction to linear regression and regression tree techniques used for analysis purposes. It then explicitly presents the questions to be addressed, the factors to be varied, and MOEs. Later in the chapter the analysis of the data collected from the experiments is provided. Regression models are developed to identify critical or significant factors that could be important in election scenarios.

### **B. LINEAR REGRESSION ANALYSIS**

Regression analysis is a statistical analysis technique used to examine and model the relations between variables, which are generally called the response variable (Y) and one or more regressors or predictors (X's). A predictor or regressor can be defined as a variable that is used to explain some characteristics of the response variable. Regressors can also be functions of explanatory variables. For example,  $X_1^2$  is a quadratic regressor and  $X_1X_2$  is a two-way interaction. A regression model which involves only one predictor is called Simple Linear Regression Analysis. Linear regression tries to explain the relationship with a straight line that fits the data set. The equation of that straight line is generally used to describe the data, estimate the parameters, or predict and estimate values for data points out of the data set. Not surprisingly, the term Multiple Linear Regression is used to describe regression models involving more than one predictor variable.

One measure of the value of a multiple regression model is its statistical significance. If the overall p-value from the regression is small (less than some pre-specified  $\alpha$ , typically  $\alpha = 0.05$ ), this means it is unlikely that there truly is no relationship between the regressors and the response variable. Once statistical significance is established, the coefficient of determination ( $R^2$ ) measures the proportion of variation in Y explained by the regressor variables in the model.  $R^2$  is a number between 0 and 1.  $R^2$  values that are close to 1 indicate that most of

the variability in the response is explained by the regression model, whereas values close to 0 imply that the model fails to explain most of the variability in the response. Adding variables to the model will never decrease the  $R^2$  value.

It is almost always impossible to explain all characteristics of the response. Adding all the variables and trying to fit the regression model might sound right at first; however, that could make the model overly complicated and expensive, and therefore unusable. There are often tradeoffs involved when deciding whether to add variables (or quadratic or interaction terms) to the model.

Evaluating all possible regression models and deciding on a fairly good model is generally a time-consuming task. In order to mitigate this problem, some useful techniques have been developed. One of the most commonly used is the stepwise regression method. Stepwise regression is an approach that selects a subset of factors for a regression model by adding and removing factors one at a time. The stepwise regression method generally adds or removes the model terms by adopting forward selection, backward elimination, or a mixture of these procedures. Forward selection starts without any terms in the model and adds the most significant term to the model at each step until there are no significant terms left. On the other hand, backward elimination starts with a model that includes all of the potential terms, and removes the least significant term from the model at each step until all of the terms remaining in the model are significant. The most significant term is the term with the highest partial F statistic or lowest p-value. This study adopts stepwise regression with mixed elimination where, at each step, the most significant term enters the model and then the least significant term leaves the model if its p-value is large.

Sometimes the equation of a straight line is not enough to explain the relation between response and predictors. The behavior of the response might be represented by a curve. Interactions among predictors and powers of predictors to the model can be added to explain the behavior of the response.

### **C. REGRESSION TREES**

Regression trees are nonparametric models that recursively partition the data in accordance with the relation between response and predictors. A regression tree consists of nodes and branches. A node is a decision point where the data set is split. Regression trees are created by binary recursive partitioning. The data set is divided into two partitions and then further divided into partitions on each of the branches. One of the advantages of regression trees is that predictors can be a mixture of categorical and continuous variables (ordinal and nominal). If the predictor is a continuous variable, the partition is created on a certain value. For example, one branch might correspond to  $X \leq 4$  and the other branch to  $X > 4$ . If the predictor is a categorical variable, the data set is divided into groups of levels. For example, one branch might correspond to  $X = \text{group A or C}$ , and the other branch to  $X = \text{groups B, D, and E}$ .

The number of partitions is a matter of interest. The analyst must choose between accuracy and generalization. Too many partitions may mean the data set is over-fit, while a small tree may fail to capture the overall structure of the data.

### **D. RUNNING THE EXPERIMENTS AND COLLECTING THE RESULTS**

Eight experiments are conducted. Each experiment has 65 design points with 30 replications at each design point. The categories of group size, presence of the duty posts and the ratio of the number of disturbers to the number of voters require different base-case scenario files to be set up. All combinations of these categories are investigated. The experiments are listed below:

- EXPERIMENT\_I - BasecaseLargeGroup: The number of civilians is 40. The duty posts are present. The ratio of the number of disturbers to the number of voters is 1/3.
- EXPERIMENT\_II - BasecaseSmallGroup: The number of civilians is 20. The duty posts are present. The ratio of the number of disturbers to the number of voters is 1/3.

- EXPERIMENT\_III - NoDutyPostLargeGroup: The number of civilians is 40. The duty posts are not present. The ratio of the number of disturbers to the number of voters is 1/3.
- EXPERIMENT\_IV - NoDutyPostSmallGroup: The number of civilians is 20. The duty posts are not present. The ratio of the number of disturbers to the number of voters is 1/3.
- EXPERIMENT\_V - EqualSizeLargeGroup: The number of civilians is 40. The duty posts are present. The number of disturbers is equal to the number of voters.
- EXPERIMENT\_VI - EqualSizeSmallGroup: The number of civilians is 20. The duty posts are present. The number of disturbers is equal to the number of voters.
- EXPERIMENT\_VII - NoDutyPostEqualSizeLargeGroup: The number of civilians is 40. The duty posts are not present. The number of disturbers is equal to the number of voters.
- EXPERIMENT\_VIII - NoDutyPostEqualSizeSmallGroup: The number of civilians is 20. The duty posts are not present. The number of disturbers is equal to the number of voters.

## 1. Questions Under Investigation

These experiments aim to answer the questions listed below:

- What are the impacts of rule sets used by admission control soldiers and reserve soldiers located inside and outside of the election area on number of votes at the end of simulation?
- What are the impacts of rule sets used by admission control soldiers and reserve soldiers located inside and outside of the election area on overall escalation at the end of simulation?
- What are the impacts of the angry group on the number of votes at the end of the simulation?



- What are the impacts of the angry group on the overall escalation at the end of the simulation?
- Does the presence of the duty posts outside the election area have an impact on overall escalation and the security of PSO units?
- What are the impacts of different ratios of disturbers to civilians?

In order to answer these questions, some of the MOEs provided by the agent-based modeling platform PAX are investigated. They include:

- Aggregated escalation (Agg\_esc)
- Escalation at the end of the simulation (Esc\_end)
- Escalation outside the election area at the end of the simulation (Esc\_out)
- Escalation inside the election area at the end of the simulation (Esc\_in)
- Ratio of number of votes to number of voters (Ratio\_Votes)
- Number of attacks conducted by civilians against civilians (Attacks\_civ\_civ)
- Average readiness for aggression among all civilians (Avg\_RFA)

## **2. Parameters to Vary**

In these experiments, the factors that are varied are listed below:

- Initial fear level of voters (Voter/Fear)
- Initial anger level of voters (Voter/Anger)
- Elective motivation of voters (Voter/EM)
- Readiness for aggression of voters (Voter/RFA)
- Group cohesion of voters (Voter/GC)
- Norms for anti-aggression of voters (Voter/NFAA)

- Initial fear level of disturbers (Dist/Fear)
- Initial anger level of disturbers (Dist/Anger)
- Readiness for aggression of disturbers (Dist/RFA)
- Group cohesion of disturbers (Dist/GC)
- Norms for anti-aggression of disturbers (Dist/NFAA)
- Rule sets used by reserve soldiers outside the election area (RO/RS)
- Rule sets used by admission control soldiers (AC/RS)
- Rule sets used by reserves soldiers inside the election area (RI/RS)

In these experiments, the NOLHDesigns spreadsheet<sup>31</sup> is used. This is an efficient way to collect data to explore how the MOEs are affected by all factors simultaneously. For the basecase scenario, which is a 14-factor experiment, 65 design points are generated. Figure 50 shows a sample of the spreadsheet.<sup>32</sup>

Once the factors are selected, appropriate ranges for each of the factors must be chosen. The environment created for the agent-based model reflects the environment faced by many Iraqi civilians. Iraqi civilians experienced wars like the Iran-Iraqi War (1980-88) and the Gulf War I (1991). For the last two years, suicide attacks, car bombs, and insurgencies have become part of their daily lives. Therefore it is realistic to assume that the civilian norms for anti-aggression are low. For the voters, levels of 40 and below were chosen, and for the disturbers, 30 and below.

The disturbers represent a group of people aged between 18 and 30, generally male and full of anger against the Western presence and influence in

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31 Susan M. Sanchez, "Excel Spreadsheet for Generating Nearly Orthogonal Latin Hypercube Designs", retrieved September 16, 2005 from <http://diana.cs.nps.navy.mil/seedlab/NOLHdesigns.xls>. This spreadsheet is based on the study of Cioppa, T. M. and T. W. Lucas, "Efficient Nearly Orthogonal and Space-Filling Latin Hyper cubes"

32 For more discussion of issues involving simulation experiments see Kleijnen, J.P.C., S.M. Sanchez, T.W. Lucas, T.M. Cioppa. 2005. A user's guide to the brave new world of designing simulation experiments. *INFORMS Journal on Computing*, 17(3): 263-289.

the region. Initial anger levels of 70 and above are appropriate for these purposes because this makes them really angry. Their initial fear is kept under a certain level in order to make anger their leading motive. In this case, it was set to 60 and below, so the highest initial fear is lower than the lowest initial anger level.

	low level															
	30	0	0	0	0	0	0	70	0	0	0	1	1	1	0	0
	high level															
	100	100	100	100	100	40	60	100	100	100	30	6	6	6	0	0
factor name	InitialFear	InitialAnger	electMotive	RFA	GroupCoh	NFAA	DistInitialFear	DistInitialAnger	DistRFA	DistGroupCoh	DistNFAA	reservesOutsideRuleSet	admissionControlRuleSet	reservesInsideRuleSet		
	80	5	36	33	13	31	48	85	97	72	16	6	2	4	0	0
	97	72	11	42	34	10	33	93	72	92	23	3	2	3	0	0
	92	36	95	22	30	34	9	84	41	58	24	5	3	4	0	0
	75	89	72	45	6	17	16	78	13	98	27	4	1	2	0	0
	95	47	19	2	9	6	15	88	61	48	2	5	4	4	0	0
	67	92	23	48	16	26	8	96	89	11	12	5	5	1	0	0
	84	19	53	3	25	13	53	83	16	44	10	6	6	5	0	0
	87	77	92	31	38	37	42	70	25	31	0	4	5	1	0	0
	78	3	2	81	41	24	23	73	80	30	25	3	3	2	0	0
	98	69	48	77	0	11	55	81	67	0	20	1	3	5	0	0
	66	2	97	53	20	18	19	91	2	23	22	2	2	1	0	0
	99	52	69	92	17	3	23	94	31	38	16	2	3	4	0	0
	68	22	33	64	39	19	11	78	95	95	4	1	6	2	0	0
	85	55	42	89	27	39	3	70	52	53	8	2	4	4	0	0
	70	33	78	95	44	9	28	98	14	83	0	3	6	2	0	0
	77	58	55	72	14	38	60	87	45	81	11	2	4	6	0	0
	90	44	39	13	67	40	47	99	58	59	9	2	3	4	0	0

Figure 50. A Sample of NOLHDesigns Spreadsheet

The voters faced an intimidation campaign before the January 30 election. They had been told that anyone who participated in the election would pay for their actions. This author predicts that a similar intimidation campaign will be launched in coming elections. Therefore, the voters will have some fear. Furthermore, they will be confronting soldiers from a different country, which would make the voters more fearful. In order to make the model voters start with some amount of fear, 30 was chosen for the lowest fear level.

All other factors related the civilian group range from 0 to 100 to see the impact of the different levels on the outcome.

The only parameter varied in the NOLHDesigns spreadsheet related to PSU soldiers is the rule set. There are six implemented rule sets in model PAX. The first rule set is based on the PSU Manual. Rule set 4 is known as the “Gandhi Strategy”. According to Rule set 4, soldiers always pacify civilians regardless of their actions. According to Rule set 6, known as “Zero Tolerance,” soldiers always defend no matter what the civilians do. Rule sets 2 and 3 dictate actions between the extremes. All of these are investigated.

## **E. ANALYZING THE RESULTS**

The experiments are run using OldMcData software. OldMcData is an application for small-scale data farming. It can handle multiple replications of a single excursion on a single machine. Each experiment is run separately. The experiments with large groups take more than one week to run. After each run, the results are written into a comma separated file (.csv) with the help of OldMcData. The results are combined into a big output file for data analysis purposes.

### **1. Investigation of Aggregated Escalation**

It is very important to carry out peace support operations in peace, as the name indicates. After a specific operation, whether it is a “food distribution” operation, “election” support, or some other stability operation, the PSU generally continues its mission. The aggregated escalation at the end of the simulation is an appropriate MOE for investigating the peacefulness of the process.

The stepwise regression produces a model with 36 terms, 19 of which are main effects. The  $R^2$  is 0.882, which means that nearly 90% of the variability is explained by the model. However, a model with 36 terms is so hard to explain it is unusable. At this point, the dilemma is choosing between a model that accounts for more of the variability or one that is simpler. After removing some of the terms, a simpler model that contains ten terms, six of which are main effects, is settled on. The  $R^2$  of the new model is 0.779. Figure 51 shows the factors, along with their slope estimates, standard errors, t-ratios, and p-values.

Parameter Estimates				
Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	-476.7889	138.8359	-3.43	0.0006
CivSize	23.657022	2.181817	10.84	<.0001
DutyPosts[No]	101.17766	21.81817	4.64	<.0001
DistRatio	935.00108	256.6843	3.64	0.0003
Voters/RFA	6.4519587	0.758121	8.51	<.0001
Dist/RFA	10.452086	0.75655	13.82	<.0001
RO/RS{6&2&1&5&3-4}	-975.432	28.62026	-34.08	<.0001
DutyPosts[No]*(RO/RS{6&2&1&5&3-4}-0.6)	-185.9881	27.27271	-6.82	<.0001
(DistRatio-0.415)*(Dist/RFA-50.0308)	47.587565	8.761021	5.43	<.0001
(Voters/RFA-50.0308)*(RO/RS{6&2&1&5&3-4}-0.6)	-7.404143	1.071498	-6.91	<.0001
(Dist/RFA-50.0308)*(RO/RS{6&2&1&5&3-4}-0.6)	-14.10791	0.896994	-15.73	<.0001

Figure 51. Parameter Estimates for Aggregated Escalation

The p-values for all 10 terms are low. This means that further removal of the terms would leave a significant term out of the model. The terms RO/RS{6&2&1&5&3-4} and DistRatio stand out as the most important effects. RO/RS stands for the rulesets adopted by reserve soldiers located outside the election area. DistRatio stands for the ratio of the number of disturbers to the number of voters. JMP automatically concatenated the {6&2&1&5&3-4} naming convention to RO/RS, showing that Ruleset 4 (which is the Gandhi Strategy) is different than the other rule sets. Under the Gandhi Strategy, the soldiers always try to pacify the civilians regardless of their actions. As seen in Figure 51, the coefficient of the term RO/RS{6&2&1&5&3-4} is -975.4. This means that adopting any rule sets other than 4 for reserve soldiers located outside of the election area would decrease the escalation by as much as 975. On the other hand, adopting the Gandhi Strategy for reserve soldiers located outside of the election area would increase the escalation as much as 975.

Another controllable variable revealed by the model is DutyPosts[No]. This means that no duty posts are built in the theater. The absence of duty posts makes the aggregated escalation increase.

JMP provides a feature called the Prediction Profiler. It shows the changes in the response predicted by the regression model as one variable changes while the others stay constant. The Prediction Profiler is particularly effective when used interactively. To convey the information, several snapshots of the

prediction profiler diagram are provided. Figure 52 shows the prediction profiler diagram when the Gandhi strategy is not adopted, duty posts are not present, the DistRatio is 0.333, and the initial readiness for aggression of both voters and disturbers are at their middle levels. As shown at the left of the diagram, a 95% confidence interval for the mean aggregated escalation is 438.5 +/- 80.3. The slopes, other than that of Rulesets, are relatively flat. This means that changing any single factor other than the Ruleset will not make a very big difference in aggregated escalation.

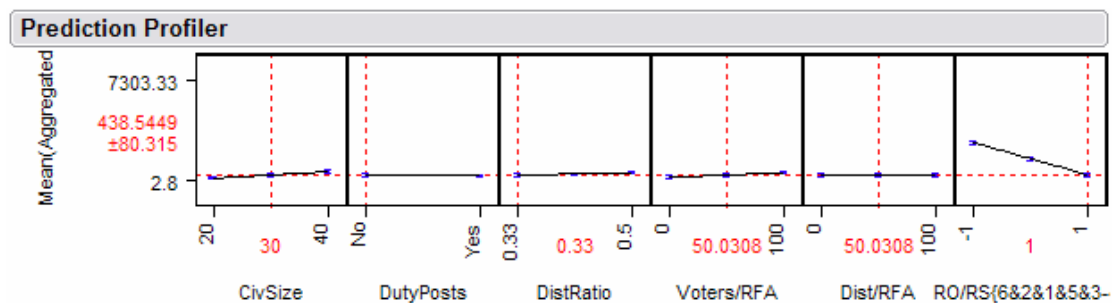


Figure 52. Aggregated Escalation When Rule Set = 6&2&1&5&3 and DistRatio = 0.333

Figure 53 shows that the aggregated escalation increases to 2764.2 if Gandhi Strategy is adopted and DistRatio is 0.333. Unlike Figure 52, the slopes in Figure 53 are steeper, particularly for Voter/RFA and Dist/RFA. This reveals the interactions between RFA terms and Ruleset 4. If Ruleset 4 is adopted, RFA terms become more important in the model.

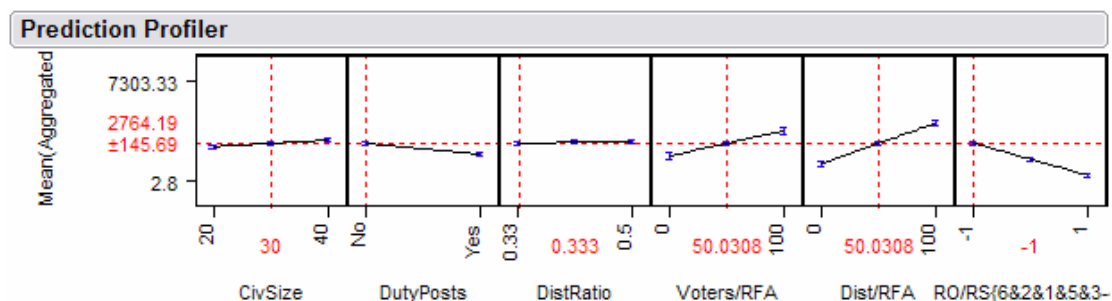


Figure 53. Aggregated Escalation When Rule Set = 4 and DistRatio = 0.333

The diagrams on the prediction profilers in Figure 54 and 55 show the levels of escalation when DistRatio is 0.5. If any ruleset other than the Gandhi

Strategy is adopted, the aggregated escalation decreases to 597.5. If the Gandhi Strategy is adopted, the escalation increases to 2920.3. The ruleset adopted by the reserve soldiers located outside the election area has the biggest impact on escalation regardless of the DistRatio. However, smaller DistRatios always reduce the average escalation by some amount.

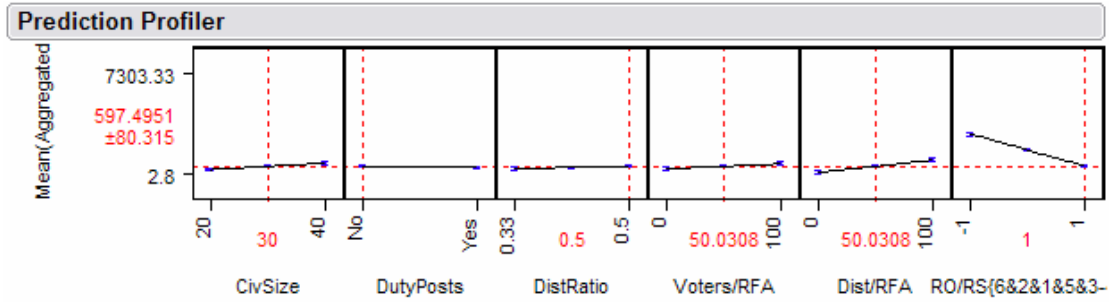


Figure 54. Aggregated Escalation When Rule Set = 6&2&1&5&3 and DistRatio = 0.5

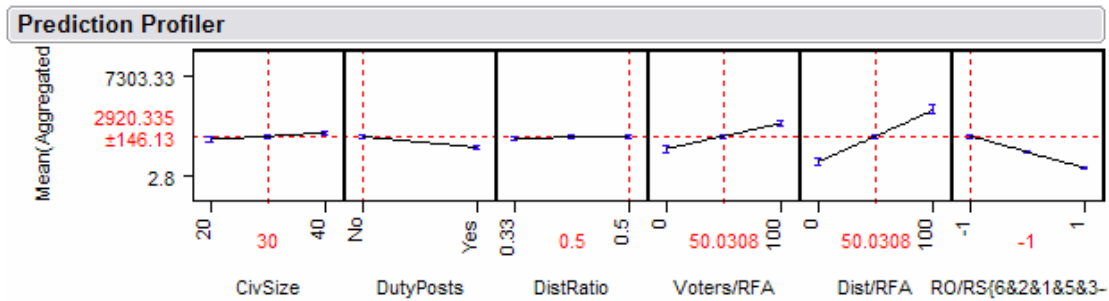


Figure 55. Aggregated Escalation When Rule Set = 4 and DistRatio = 0.5

The aggregated escalation model may be represented as

$$\begin{aligned} \text{Agg\_esc} = & -476.7889 + 23.657022 \cdot x_1 + 101.17766 \cdot x_2 + 935.00108 \cdot x_3 + \\ & 6.4519587 \cdot x_4 + 10.452086 \cdot x_5 - 975.432 \cdot x_6 - 185.9881(x_2 \cdot (x_6 - 0.6)) + \\ & 47.587565((x_3 - 0.415) \cdot (x_5 - 50.0308)) - 7.404143 \cdot ((x_4 - 50.0308) \cdot (x_6 - 0.6)) - \\ & 14.10791 \cdot ((x_5 - 50.0308) \cdot (x_6 - 0.6)) \end{aligned}$$

where:  $x_1 = \text{CivSize}$

$x_2 = \text{DutyPosts[No]}$

$x_3 = \text{DistRatio}$

$$x_4 = \text{Voters/RFA}$$

$$x_5 = \text{Dist/RFA}$$

$$x_6 = \text{RO/RS}\{6\&2\&1\&5\&3-4\}$$

The regression tree analysis produces results that are parallel to the results from the stepwise regression model. As seen in Figure 56, the mean aggregated escalation is 498.0 when rulesets other than Gandhi Strategy are used, while the mean aggregated escalation rises to 2227.2 if the Gandhi Strategy is adopted. Apparently, Ruleset 4, which always tries to pacify regardless of the civilians' actions, is not an appropriate policy if the PSU wants to keep the escalation low.

The absence of duty posts produces the worst case if Ruleset 4 is adopted and disturbers' readiness for aggression is above a certain level ( $\text{Dist/RFA} \geq 28$ ).

The models produced by both of the techniques are satisfactory in two aspects. First of all, both models explain almost 80% of the variability in aggregated escalation while using a relatively small number of terms. Secondly, the factors that stand out as important in the models are mainly controllable variables. Rulesets, the presence of duty posts, homogeneity and the size of the group are factors that can be changed. The PSUs can definitely choose the appropriate rulesets for the soldiers and train them accordingly. They can build as many duty posts as they wish, and wherever they like. At the first sight, it is not intuitive how the homogeneity and size of the civilian group can be affected. However, building more polling stations and assigning fewer people to vote in each station would decrease the number of people that show up in each station. If building more polling stations is expensive, perhaps the election could be carried out in more than a single day, and the time windows when people can vote might be coordinated. When planning who will vote at which station, ethnicity, religion and other factors might be taken into consideration to keep the groups homogeneous.



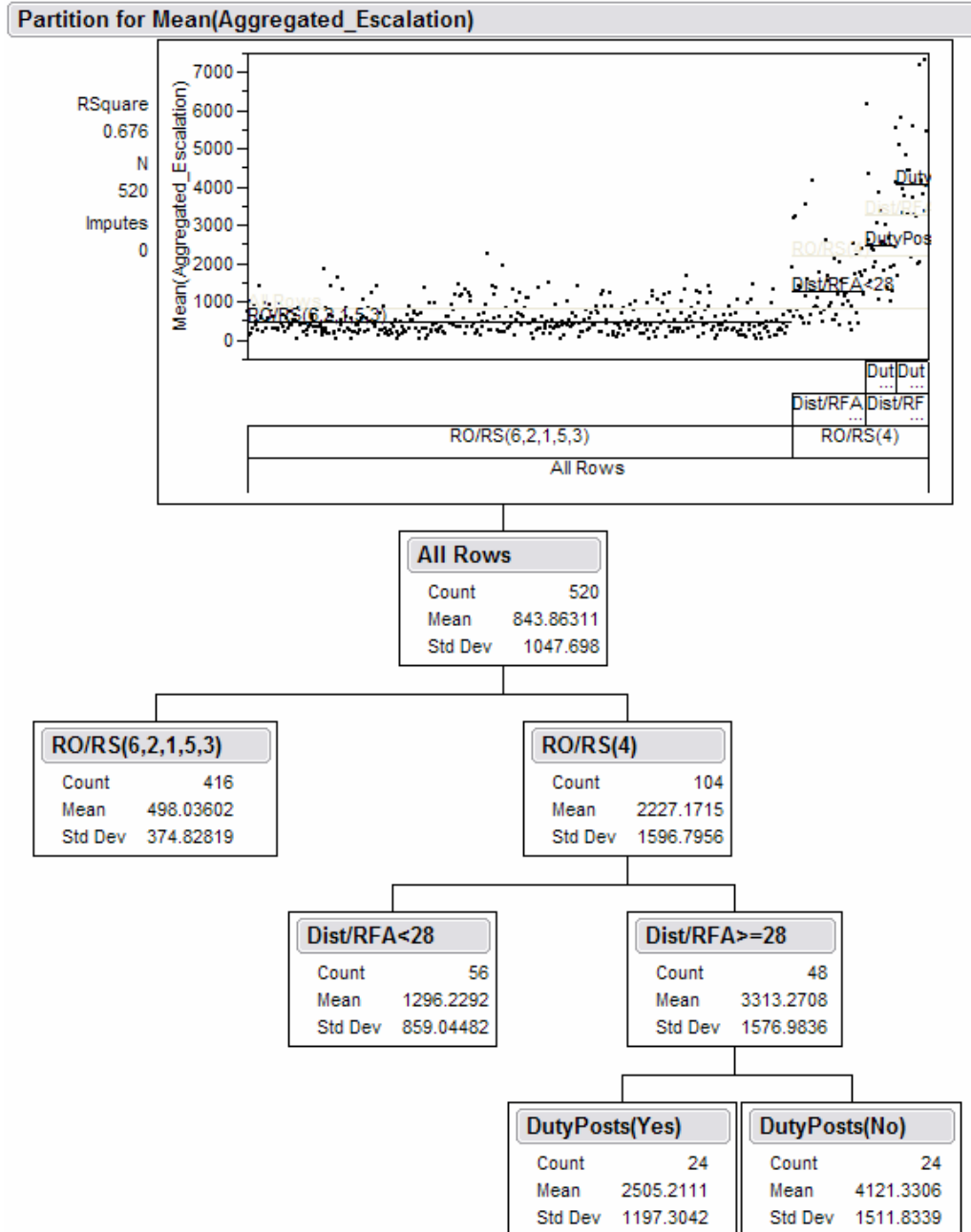


Figure 56. Aggregated Escalation Regression Tree

## 2. Investigating the Escalation at the End of the Simulation

The aggregated escalation is the accumulated escalation during the simulation. PAX also provides escalation levels according to groups and areas.

However, these correspond to the escalation levels at the end of the simulation. Before making comparisons between groups and areas, it is useful to investigate the total escalation at the end of the simulation.

The stepwise regression produces a 31 term model with  $R^2 = 0.868$ . After removing many of the terms, a seven term model with  $R^2 = 0.767$  is selected. This final model has four main and three interaction terms. Having  $R^2$  drop 0.1 as the penalty for removing 13 terms from the model is affordable. Figure 57 shows the parameter estimates for the escalation at the end of the simulation.

The term RO/RS{6&2&1&5&3-4} is once again the most important factor. However, rulesets for reserve soldiers located *inside* the election area, and rulesets for admission control soldiers, do not appear in the final model. This clearly shows that special attention should be paid to activities outside the election area. By not using Ruleset 4 for reserve soldiers located outside the election area, the escalation might be dropped as much as 8.272. The next most important factor in the model was the absence of the duty posts. Building duty posts would decrease the escalation as much as 0.699.

Parameter Estimates				
Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	7.4651364	0.694948	10.74	<.0001
CivSize	0.1331315	0.018965	7.02	<.0001
DutyPosts[No]	0.698751	0.189651	3.68	0.0003
Voters/Anger	-0.036911	0.006493	-5.68	<.0001
RO/RS{6&1&2&3&5-4}	-8.272307	0.237498	-34.83	<.0001
(CivSize-30)*(RO/RS{6&1&2&3&5-4}-0.6)	-0.1336	0.023706	-5.64	<.0001
DutyPosts[No]*(RO/RS{6&1&2&3&5-4}-0.6)	-1.802664	0.237063	-7.60	<.0001
(Voters/Anger-50.0308)*(RO/RS{6&1&2&3&5-4}-0.6)	0.1098718	0.007698	14.27	<.0001

Figure 57. Parameter Estimates for the Escalation at the End of the Simulation

The model for the escalation at the end of the simulation can be written as

$$\text{Esc\_end} = 7.4651364 + 0.1331315 * x_1 + 0.698751 * x_2 - 0.036911 * x_3 - 8.272307 * x_4 - 0.1336 * ((x_1 - 30) * (x_4 - 0.6)) - 1.802664 * (x_2 * (x_4 - 0.6)) + 0.1098718 * ((x_3 - 50.0308) * (x_4 - 0.6))$$

where:  $x_1 = \text{CivSize}$

$$x_2 = \text{DutyPosts[No]}$$

$$x_3 = \text{Voters/Anger}$$

$$x_4 = \text{RO/RS}\{6\&2\&1\&5\&3-4\}$$

The regression tree produces parallel results. As seen in Figure 58, the rulesets for reserve soldiers shows up as the most important effect. The mean escalation at the end of the simulation drops to 1.344 when Ruleset 4 is not adopted by reserve soldiers located outside the election area, and rises to 18.333013 if Ruleset 4 is adopted.

Another interesting result is that if voters are really angry, the ruleset that reserve soldiers uses does not matter that much. As seen in Figure 58, even though Ruleset 4 is chosen, if the voters' initial anger level is very high (above 89), then the mean of the escalation at the end becomes 6.506. That means if the voters are really angry Ruleset 4 works to keep the escalation low, too. However, it makes escalation higher than the other rulesets. In the worst case in which Ruleset 4 is used, when the voters' initial anger is below 89, the mean of escalation rises to 26.728. The prediction profiler supports this statement as well. As seen in Figure 59 and 60, using Ruleset 4 decreases the escalation when voters' anger is higher than 87.

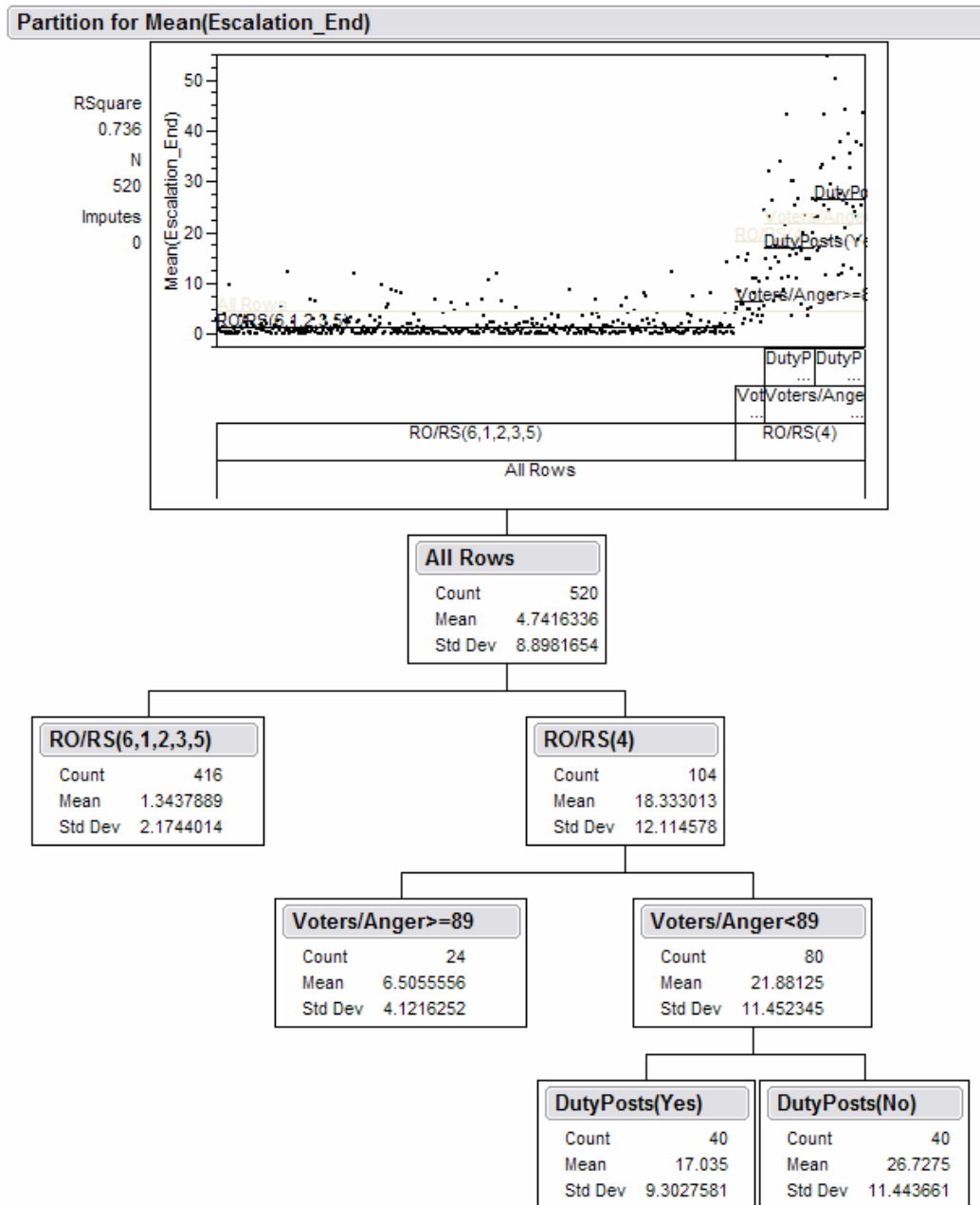


Figure 58. Regression Tree for the Escalation at the End of the Simulation

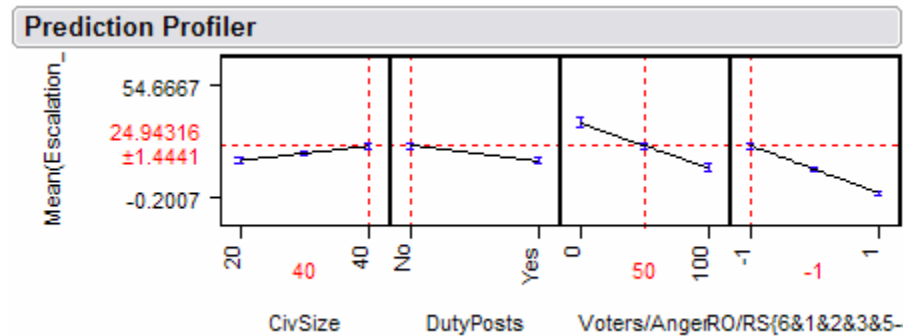


Figure 59. Escalation at the End When Voters/Anger = 50 and Rule Set = 4

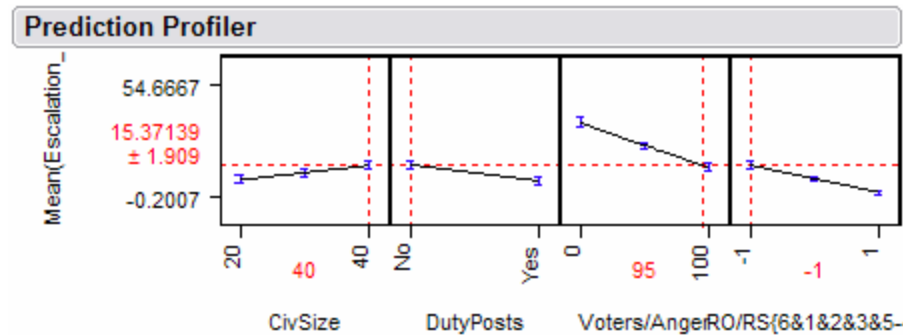


Figure 60. Escalation at the End When Voters/Anger = 95 and Rule Set = 4

### 3. Investigating Escalation Outside of the Election Area

Civilians enter polling stations through security check points. They face the reserve soldiers outside the election area before they go through checkpoints. Furthermore, they meet other civilians from either an opposing group or a friendly group. During this process they might become more (or less) agitated, scared or angry. Their actions in the election area might be affected by this process. Therefore, the pattern of escalation outside the election area is investigated more deeply.

The stepwise regression produces a model with 24 terms, including ten main effects. The  $R^2$  is 0.838. Manually removing some terms produces a 12 term model, involving six main effects, with  $R^2 = 0.793$ . Figure 61 shows the factors and the estimates, respectively.

Similar to the aggregated escalation model, the terms RO/RS{6&2&1&5&3-4} and DistRatio stand as the most important factors.

Ruleset 4 is again the worst choice. A large DistRatio, a large group, and absence of duty posts trigger the escalation outside the election area.

Parameter Estimates				
Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	3.3475689	1.060707	3.16	0.0017
CivSize	0.1211714	0.016768	7.23	<.0001
DutyPosts[No]	0.6088934	0.167676	3.63	0.0003
DistRatio	5.3429392	1.972657	2.71	0.0070
Voters/Anger	-0.02427	0.005916	-4.10	<.0001
Dist/RFA	0.0246165	0.005987	4.11	<.0001
RO/RS{6&1&3&2&5-4}	-8.238161	0.221677	-37.16	<.0001
(CivSize-30)*(RO/RS{6&1&3&2&5-4}-0.6)	-0.129657	0.020959	-6.19	<.0001
DutyPosts[No]*(RO/RS{6&1&3&2&5-4}-0.6)	-1.726212	0.209595	-8.24	<.0001
(DistRatio-0.415)*(Dist/RFA-50.0308)	0.3451086	0.068187	5.06	<.0001
(DistRatio-0.415)*(RO/RS{6&1&3&2&5-4}-0.6)	-13.39954	2.497211	-5.37	<.0001
(Voters/Anger-50.0308)*(RO/RS{6&1&3&2&5-4}-0.6)	0.0695162	0.007557	9.20	<.0001
(Dist/RFA-50.0308)*(RO/RS{6&1&3&2&5-4}-0.6)	-0.053035	0.007646	-6.94	<.0001

Figure 61. Parameter Estimates for Escalation outside Election Area

The model for escalation outside the election area is similar to the model for aggregated escalation. Nearly the same factors appear in the model. The only factor that differs from the aggregated escalation model is the Voter/Anger, which replaced the term Voter/RFA. The model can be summarized as

$$\begin{aligned} \text{Esc\_out} = & 3.3475689 + 0.1211714 * x_1 + 0.6088934 * x_2 + 5.3429392 * x_3 \\ & - 0.02427 * x_4 + 0.0246165 * x_5 - 8.238161 * x_6 - 0.129657 * ((x_1 - 30) * (x_6 - \\ & 0.6)) - 1.726212 * (x_2 * (x_6 - 0.6)) + 0.3451086 * ((x_3 - 0.415) * (x_6 - 0.6)) - \\ & 13.39954 * ((x_3 - 0.415) * (x_6 - 0.6)) + 0.0695162 * ((x_4 - 50.0308) * (x_6 - 0.6)) - \\ & 0.053035 * ((x_5 - 50.0308) * (x_6 - 0.6)) \end{aligned}$$

where :  $x_1 = \text{CivSize}$

$x_2 = \text{DutyPosts[No]}$

$x_3 = \text{DistRatio}$

$x_4 = \text{Voters/Anger}$

$x_5 = \text{Dist/RFA}$

$x_6 = \text{RO/RS}\{6\&2\&1\&5\&3-4\}$

The regression tree for the escalation outside the election area produces parallel results to stepwise regression. As shown in Figure 62, adopting any ruleset other than 4 would keep the escalation very low. Mean escalation rises to 0.9889634 if Ruleset 4 is not adopted. If so, mean escalation rises to 16.727. As evidenced one more time, Ruleset 4 is not appropriate if lower escalation is desired.

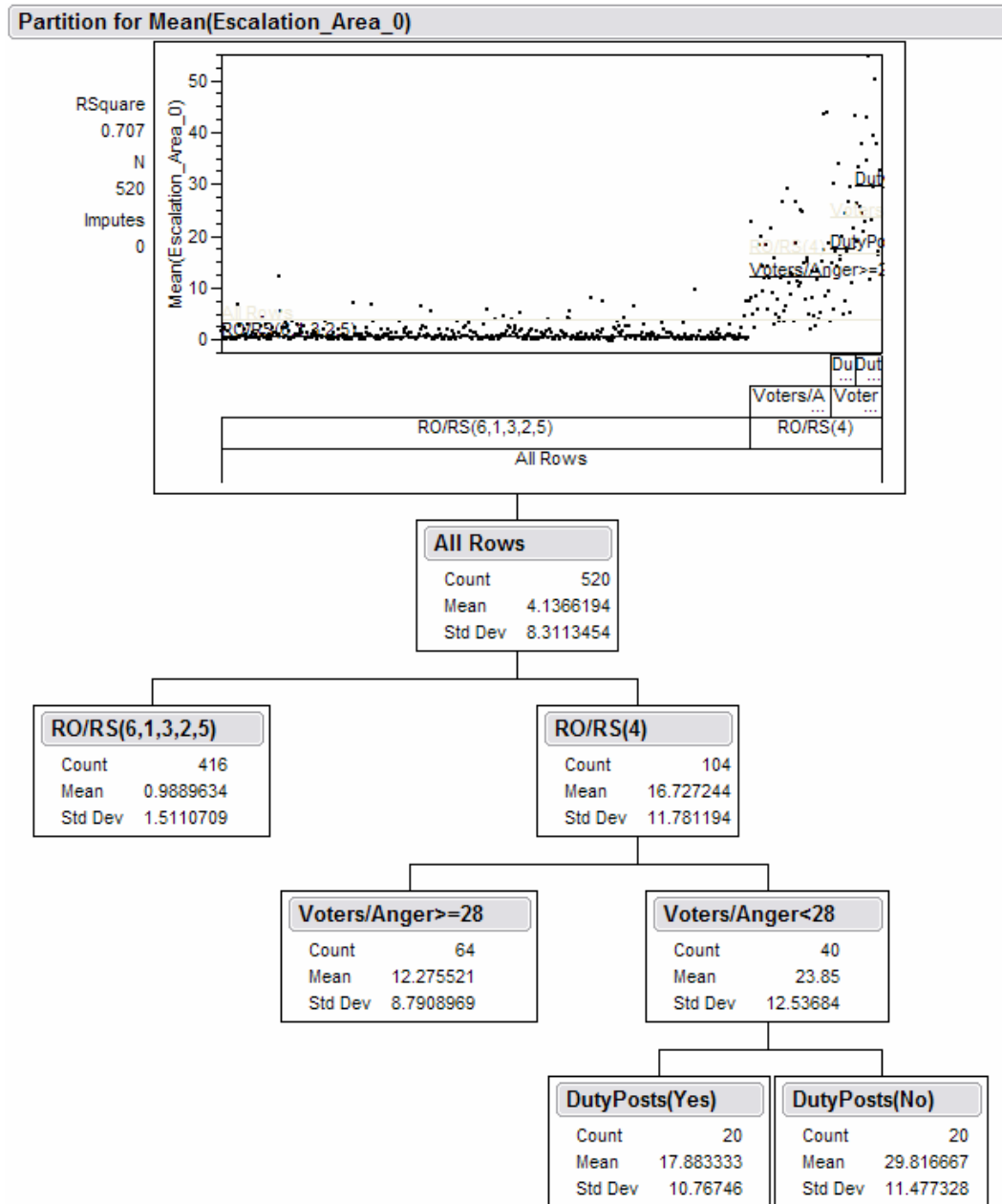


Figure 62. Regression Tree for the Escalation Outside of the Election Area.

#### 4. Investigating Escalation Inside the Election Area

The election area is where the polling booths are established. It is the last location where civilians can interact with each other and with PSU soldiers. Any incidents that occur in this area could jeopardize the voting process, so special attention should be paid to the activities in the election area. In particular, escalation might scare the voters and make them leave without voting. Therefore, it is appropriate to look more deeply into the escalation level within the election area.

The stepwise regression produces a model with  $R^2$  of 0.790. The model includes eight main terms and six interaction terms. The ruleset for reserve soldiers located inside the election area to watch the election process stands as the most important factor. Ruleset 4 was the worst choice one more time. Any ruleset other than 4 lowered the escalation in the election area. Figure 63 shows the parameter estimates for escalation in the election area.

Parameter Estimates				
Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	5.5676626	0.364956	15.26	<.0001
DistRatio	-2.152505	0.611202	-3.52	0.0005
Voters/Fear	-0.031726	0.003145	-10.09	<.0001
Voters/EM	0.0066897	0.001855	3.61	0.0003
Dist/GC	-0.01499	0.002251	-6.66	<.0001
AC/RS{6&3&2-4&5&1}	0.0814076	0.05745	1.42	0.1571
AC/RS{4-5&1}	0.2232854	0.084274	2.65	0.0083
AC/RS{5-1}	0.5171295	0.101214	5.11	<.0001
R/RS{2&6&5&3&1-4}	-2.158215	0.088205	-24.47	<.0001
(DistRatio-0.415)*(R/RS{2&6&5&3&1-4}-0.6)	4.414488	0.764003	5.78	<.0001
(Voters/Fear-65.0154)*(R/RS{2&6&5&3&1-4}-0.6)	0.0810541	0.004648	17.44	<.0001
(Voters/EM-50.0308)*(R/RS{2&6&5&3&1-4}-0.6)	-0.013283	0.002553	-5.20	<.0001
(Dist/GC-50.0308)*(R/RS{2&6&5&3&1-4}-0.6)	0.0370481	0.004274	8.67	<.0001
(AC/RS{4-5&1}+0.10769)*(R/RS{2&6&5&3&1-4}-0.6)	-0.567198	0.11809	-4.80	<.0001
(AC/RS{5-1}-0.09231)*(R/RS{2&6&5&3&1-4}-0.6)	-1.271246	0.142734	-8.91	<.0001

Figure 63. Parameter Estimates for Escalation Inside the Election Area

The fear level of the voters has an important impact on the escalation inside. If the civilians begin the day more fearful, then they tend to run away from the soldiers and find a shelter for safety. Therefore not many interactions happen between civilians and soldiers. This actually explains the impact of the voters' fear level. As the fear level increases, the escalation tends to decrease.



Although it is not one of the driving forces, the ratio of disturbers shows up in this model as well. Unlike the other models, a high ratio of disturbers works to keep the escalation in the election area down. In fact, this is not surprising, because the admission control soldiers do not allow disturbers to enter into the election area. If there are more disturbers in the theater, there will be more people left outside. The fewer the people in the election area, the lower the escalation.

Another point is that even in one of the worst case scenarios, which is adopting Ruleset 4 when the voters are not that fearful, the escalation inside rises to a maximum value of 10.812, as shown in Figure 64. Compared to the escalation level at the end of the simulation with the worst case of 26.728, it is clear that most of the interactions took place outside the election area. This supports an earlier statement that special attention should be paid to the outside of the election area.

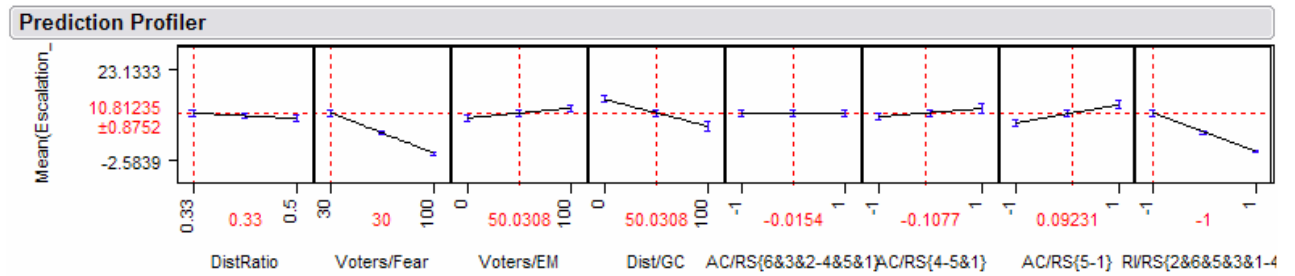


Figure 64. Escalation Inside Election Area When Rule Set = 4 and Voters are Not Fearful

The model for escalation inside the election area can be written as

$$\begin{aligned} \text{Esc\_in} = & 5.5676626 - 2.152505 * x_1 - 0.031726 * x_2 + 0.0066897 * x_3 - \\ & 0.01499 * x_4 + 0.0814076 * x_5 + 0.2232854 * x_6 + 0.517195 * x_7 - 2.158215 * x_8 \\ & + 4.414488 * ((x_1 - 0.415) * (x_8 - 0.6)) + 0.0810541 * ((x_2 - 65.0154) * (x_8 - 0.6)) - \\ & 0.013283 * ((x_3 - 50.0308) * (x_8 - 0.6)) + 0.0370481 * ((x_4 - 50.0308) - 0.567198 * \\ & ((x_6 + 0.10769) * (x_8 - 0.6)) - 1.271246 * ((x_7 - 0.09231) * (x_8 - 0.6)) \end{aligned}$$

where:  $x_1 = \text{DistRatio}$

$x_2 = \text{Voters/Fear}$

$$x_3 = \text{Voters/EM}$$

$$x_4 = \text{Dist/GC}$$

$$x_5 = \text{AC/RS}\{6\&3\&2 - 4\&5\&1\}$$

$$x_6 = \text{AC/RS}\{4 - 5\&1\}$$

$$x_7 = \text{AC/RS}\{5 - 1\}$$

$$x_8 = \text{RI/RS}\{6\&2\&1\&5\&3-4\}$$

## 5. Investigating the Ratio of Votes

The main focus of this work is to evaluate the participation of the Sunni population in an election. It is expected that in a large group, the turnout (in number of votes) would be larger. The more potential voters who show up in election area, the more votes are expected. In order to avoid having this situation mask the most important effects, the MOE is the ratio of votes to the number of voters, instead of the number of votes.

The final model includes 17 terms: 13 main terms and four interaction terms. The  $R^2$  value is 0.834. Figure 65 shows the parameter effects and the estimates, respectively.

Not surprisingly, the initial anger level (Voters/Anger) and election motivation (Voters/EM) stand out as the two most important factors. If a civilian starts with a high election motivation he tends to end up voting. The higher the initial anger level, the lower the turnout. Although these two factors are considered uncontrollable variables, it might be possible to affect them by long-term efforts before Election Day. Gaining the trust of the population, explaining the virtues of democracy, making them believe that the election is for their own good, and treating them in a friendly manner could increase the election motivation and decrease the anger level on the day of the election.

### Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	0.439416	0.018039	24.36	<.0001
CivSize	-0.007301	0.000419	-17.41	<.0001
Voters/Anger	-0.004	0.000208	-19.26	<.0001
Voters/EM	0.0039616	0.000151	26.24	<.0001
RO/RS{5&3-1&4&6&2}	-0.011629	0.00482	-2.41	0.0162
RO/RS{1&4&6-2}	-0.027221	0.007133	-3.82	0.0002
RO/RS{1&4-6}	0.0119722	0.008133	1.47	0.1416
RO/RS{1-4}	0.0442379	0.008499	5.21	<.0001
AC/RS{1&5&3&4-2&6}	-0.030354	0.006452	-4.70	<.0001
AC/RS{1&5-3&4}	0.0219543	0.006769	3.24	0.0013
RI/RS{3&2-6&5&1&4}	-0.017668	0.004723	-3.74	0.0002
RI/RS{6&5&1-4}	-0.019527	0.006733	-2.90	0.0039
RI/RS{6-5&1}	-0.020061	0.008239	-2.43	0.0152
RI/RS{5-1}	0.0342497	0.009342	3.67	0.0003
(CivSize-30)*(Voters/Anger-50.0308)	0.0001291	0.000014	9.02	<.0001
(Voters/Anger-50.0308)*(Voters/EM-50.0308)	-0.000059	0.000005	-11.73	<.0001
(Voters/Anger-50.0308)*(RO/RS{1-4}+0.09231)	-0.002896	0.000268	-10.80	<.0001
(AC/RS{1&5-3&4}+0.07692)*(RI/RS{5-1}-0.09231)	-0.06666	0.010944	-6.09	<.0001

Figure 65. Parameter Estimates for Escalation Outside the Election Area

Among the controllable variables that show up in the model, civilian size has the biggest impact on the turnout. In a relatively large group, agents tend not to cast their votes as often as they do in smaller groups. As seen in Figures 66 and 67, in a large group 13.43% of the voters vote. The turnout rises to 28.03% in a small group. Just by adjusting the group size, the turnout more than doubles.

### Prediction Profiler

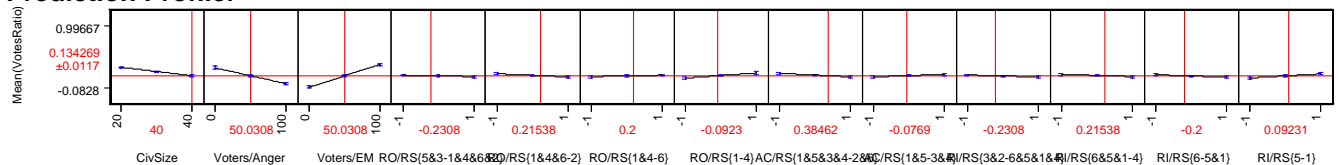


Figure 66. Ratio of the Votes in a Relatively Larger Group

### Prediction Profiler

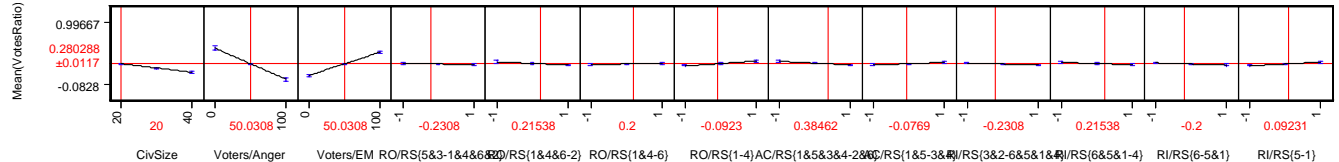


Figure 67. Ratio of the Votes in a Small Group

As seen in the prediction profiles in Figures 66 and 67, the slopes in the first three cells are steeper. These correspond to civilian size, anger level and the election motivation of the voters. This shows that the first three terms have the biggest effects on the turnout. Actually, when the model is fit by just adding these three terms, the  $R^2$  is 0.741. These three terms alone explain nearly 75% of the variability in the ratio of the votes to the number of voters.

The only term with a relatively high p-value in the model is RO/RS{1&4-6}. JMP divides the rulesets of the reserve soldiers outside the election area into four groups. In order to have the rulesets that show up in later partitions, the RO/RS{1&4-6} had to be included because further removal of the rulesets that showed up in later partitions causes the  $R^2$  to drop significantly. Furthermore, including rulesets separately in the model helps in investigating the impact of the each ruleset separately.

At the first partition, JMP divided the rulesets of reserve soldiers that were located outside the election area into two groups. Rulesets 5 and 3 formed the first group. Rulesets 1, 4, 6 and 2 formed the other group. At first glance, employing Ruleset 5 or 3 appeared to be the worst choice. However, by looking at the aggregate effect after considering all ruleset terms, Ruleset 4 appears to be the worst choice one more time. Adopting Ruleset 4 drops the ratio of votes cast by as much as 0.044. On the other hand, Ruleset 1 (based on rules of engagement from the UN Peace Operation Manual) shows up as the best choice. Ruleset 2 also has a positive effect on the turnout ratio. Using Ruleset 1 or 5 for admission control soldiers, and Ruleset 5 for reserve soldiers located in the election area, produces positive impacts on the ratio of votes. The effects of all terms can be seen in the scaled estimates displayed at the bottom of Figure 68.

### Scaled Estimates

Continuous factors centered by mean, scaled by range/2

Term	Scaled Estimate	Std Error	t Ratio	Prob> t
Intercept	0.2072785	0.00421	49.23	<.0001
CivSize	-0.073009	0.004194	-17.41	<.0001
Voters/Anger	-0.200002	0.010385	-19.26	<.0001
Voters/EM	0.1980803	0.007549	26.24	<.0001
RO/RS{5&3-1&4&6&2}	-0.011629	0.00482	-2.41	0.0162
RO/RS{1&4&6-2}	-0.027221	0.007133	-3.82	0.0002
RO/RS{1&4-6}	0.0119722	0.008133	1.47	0.1416
RO/RS{1-4}	0.0442379	0.008499	5.21	<.0001
AC/RS{1&5&3&4-2&6}	-0.030354	0.006452	-4.70	<.0001
AC/RS{1&5-3&4}	0.0219543	0.006769	3.24	0.0013
RV/RS{3&2-6&5&1&4}	-0.017668	0.004723	-3.74	0.0002
RV/RS{6&5&1-4}	-0.019527	0.006733	-2.90	0.0039
RV/RS{6-5&1}	-0.020061	0.008239	-2.43	0.0152
RV/RS{5-1}	0.0342497	0.009342	3.67	0.0003
(CivSize-30)*(Voters/Anger-50.0308)	0.0645471	0.007158	9.02	<.0001
(Voters/Anger-50.0308)*(Voters/EM-50.0308)	-0.146713	0.012504	-11.73	<.0001
(Voters/Anger-50.0308)*(RO/RS{1-4}+0.09231)	-0.144821	0.013414	-10.80	<.0001
(AC/RS{1&5-3&4}+0.07692)*(RV/RS{5-1}-0.09231)	-0.06666	0.010944	-6.09	<.0001

Figure 68. Scaled Estimates for Ratio of Votes

The final model can be written as

$$\begin{aligned} \text{Ratio\_Votes} = & -0.39416 - 0.007302 * x_1 - 0.004 * x_2 + 0.0039616 * x_3 - \\ & 0.011629 * x_4 - 0.027221 * x_5 + 0.0119722 * x_6 + 0.0442379 * x_7 - 0.030354 * x_8 \\ & + 0.0219543 * x_9 - 0.017668 * x_{10} - 0.019527 * x_{11} - 0.020061 * x_{12} + 0.0342497 \\ & * x_{13} + 0.0001291 * ((x_1 - 30)*(x_2 - 50.0308)) - 0.000059 * ((x_2 - 50.0308) * (x_3 - \\ & 50.0308)) - 0.002896 * ((x_2 - 50.0308) * (x_7 + 0.09231)) - 0.06666 * ((x_9 + \\ & 0.07692) * (x_{13} - 0.09231)) \end{aligned}$$

where :  $x_1 = \text{CivSize}$

$x_2 = \text{Voter/Anger}$

$x_3 = \text{Voter/EM}$

$x_4 = \text{RO/RS}\{5\&3-1\&4\&6\&2\}$

$x_5 = \text{RO/RS}\{1\&4\&6-2\}$

$x_6 = \text{RO/RS}\{1\&4-6\}$

$x_7 = \text{RO/RS}\{1-4\}$

$x_8 = \text{AC/RS}\{1\&5\&3\&4-2\&6\}$

$x_9 = \text{AC/RS}\{1\&5-3\&4\}$

$$x_{10} = RI/RS\{3 \& 2 - 6 \& 5 \& 1 \& 4\}$$

$$x_{11} = AC/RS\{6 \& 5 \& 1 - 4\}$$

$$x_{12} = AC/RS\{6 - 5 \& 1\}$$

$$x_{13} = AC/RS\{5 - 1\}$$

The regression tree gives almost the same results. As seen in Figure 69, if agents start with an election motivation less than 17, hardly anyone casts a vote. If agents are willing to vote, they end up voting more enthusiastically in smaller groups. In a large group, 27.5% of the voters actually cast votes. The ratio is 55.28% in a relatively small group.

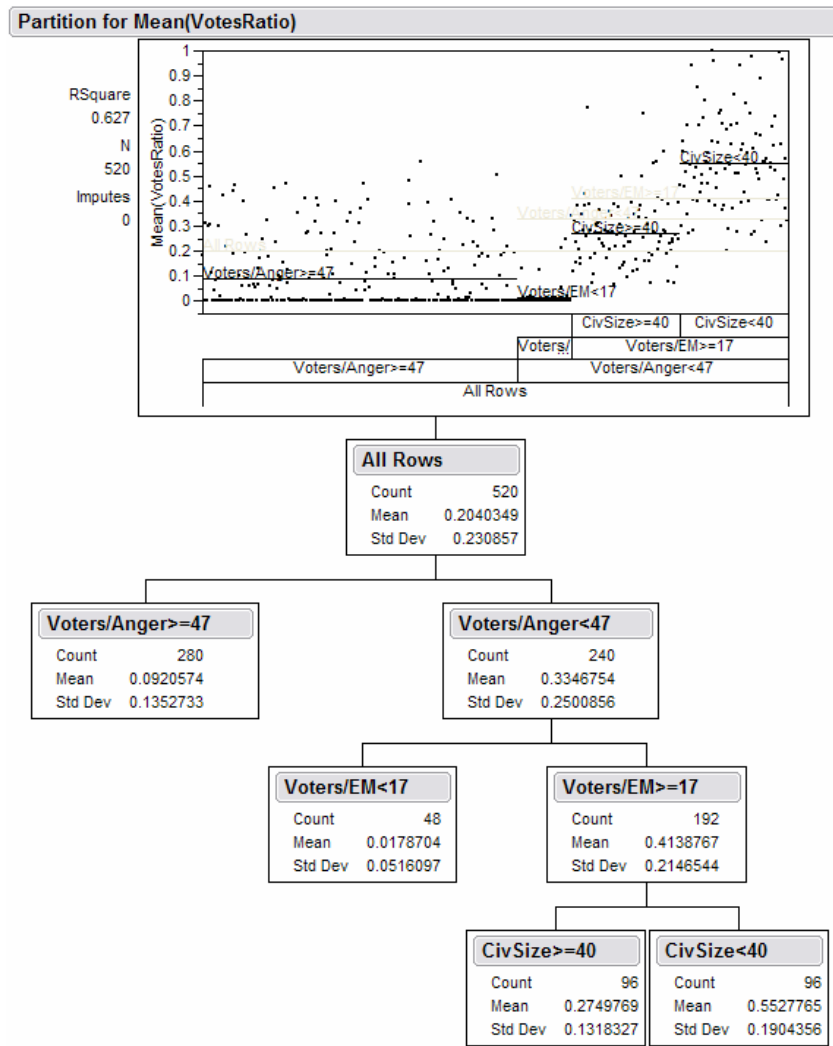


Figure 69. Regression Tree for Ratio of Votes

## 6. Investigating Attacks Against Civilians Conducted by Civilians

Although PAX does not provide the number of attacks conducted by groups separately, it reports the total number of attacks conducted by civilians regardless of the groups. The attacks conducted by civilians comprise most of the escalation. If they can be prevented, escalation can be kept at low levels.

The final model includes six main and five interaction terms. The  $R^2$  value is 0.775. It is very rewarding to observe that the rulesets of reserve soldiers

located outside, which is a controllable variable, has the biggest impact in the model. Figure 70 shows the parameter estimates of the model.

Parameter Estimates				
Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	-52.90878	13.37153	-3.96	<.0001
CivSize	1.5886619	0.210135	7.56	<.0001
DutyPosts[No]	9.8813623	2.101346	4.70	<.0001
DistRatio	66.614821	24.72171	2.69	0.0073
Voters/RFA	0.7063195	0.073016	9.67	<.0001
Dist/RFA	1.1801725	0.072865	16.20	<.0001
RO/RS{6&2&1&5&3-4}	-87.62491	2.756467	-31.79	<.0001
(CivSize-30)*(Dist/RFA-50.0308)	0.0329141	0.007172	4.59	<.0001
DutyPosts[No]*(RO/RS{6&2&1&5&3-4}-0.6)	-17.64707	2.626682	-6.72	<.0001
(DistRatio-0.415)*(Dist/RFA-50.0308)	4.9428296	0.843789	5.86	<.0001
(Voters/RFA-50.0308)*(RO/RS{6&2&1&5&3-4}-0.6)	-0.845807	0.103198	-8.20	<.0001
(Dist/RFA-50.0308)*(RO/RS{6&2&1&5&3-4}-0.6)	-1.540822	0.086391	-17.84	<.0001

Figure 70. Parameter Estimates for Attacks on Civilians by Civilians

Any ruleset other than Ruleset 4 results in a low number of attacks. Ruleset 4 shows up as the worst policy yet again. As seen in the prediction profilers displayed in Figures 71 and 72, rulesets other than 4 caused a low number of attacks (around 32). Ruleset 4 increased that number to 243.

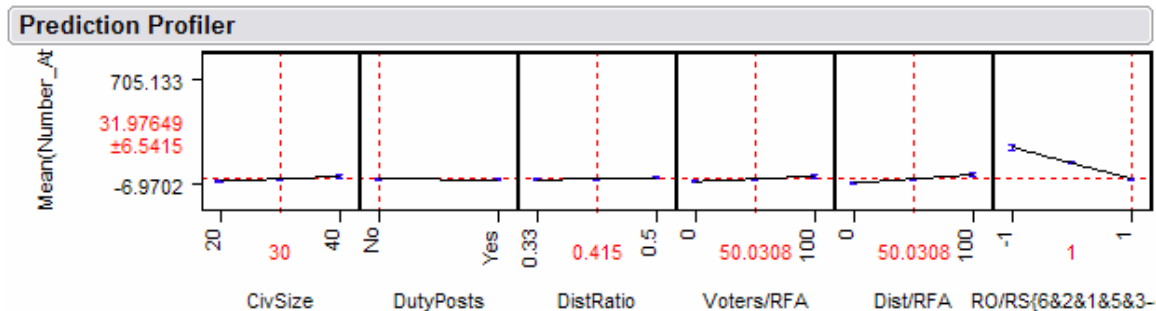


Figure 71. Number of Attacks to Civilians by Civilians when Rule Set = 6&2&1&5&3

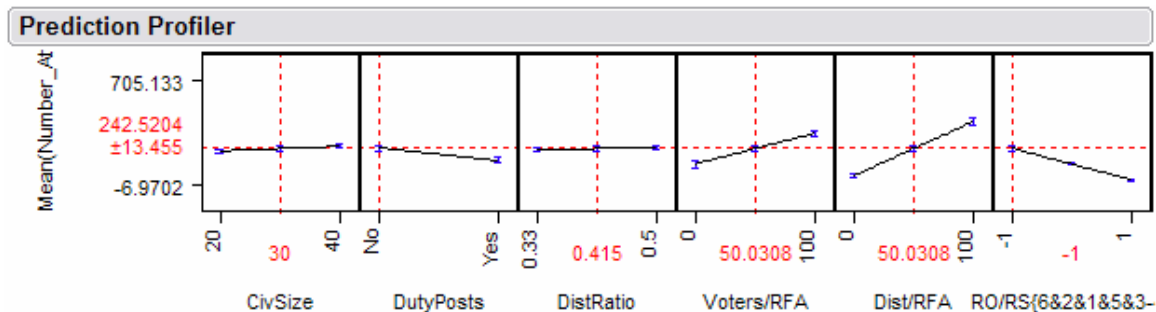


Figure 72. Number of Attacks on Civilians by Civilians when Rule Set = 4



The other controllable variables—civilian size, absence of duty posts and ratio of disturbers—also show up in the final model, although they have minor effects. While large group and a large ratio of disturbers increase escalation, building duty posts for the reserve soldiers decreases the number of attacks. The model can be written as

$$\begin{aligned} \text{Attacks\_civ\_civ} = & -52.90878 + 1.58866619 * x_1 + 9.8813623 * x_2 + \\ & 66.614821 * x_3 + 0.7063195 * x_4 + 1.1801725 * x_5 - 87.62491 * x_6 + 0.0329141 * \\ & ((x_1 - 30) * (x_5 - 50.0308)) - 17.64707 * (x_2 * (x_6 - 0.6)) + 4.948296 * ((x_3 - 0.415) \\ & * (x_5 - 50.0308)) - 0.845807 * ((x_4 - 50.0308) * (x_6 - 0.6)) - 1.540822 * ((x_5 - \\ & 50.0308) * (x_6 - 0.6)) \end{aligned}$$

where:  $x_1 = \text{CivSize}$

$x_2 = \text{DutyPosts[No]}$

$x_3 = \text{DistRatio}$

$x_4 = \text{Voters/RFA}$

$x_5 = \text{Dist/RFA}$

$x_6 = \text{RO/RS}\{6\&2\&1\&5\&3-4\}$

## 7. Investigating Average Readiness for Aggression

Leaving people unsatisfied, angry and ready for aggression contradicts the long term goals of the PSU. First of all, having a large number of people who are angry and ready for aggression is a threat to the security of PSU itself. Secondly, these kinds of people are more likely to cause problems for other civilians. Therefore, it is desirable that as few people as possible be left angry at the end of the operation. Discussion now turns to an investigation of the level of readiness for aggression at the end of the simulation.

The final model accounts for almost all of the variability in average readiness for regression. The  $R^2$  term is 0.97. Moreover, the model is simple: it include just five terms, three of which are main effects and two of which are interaction terms. However, it is apparent that the PSU unit has little ability to

decrease the readiness for aggression. The terms that have the biggest impact in the model are the initial readiness for aggression of the voters and the initial readiness for aggression of the disturbers, both of which are uncontrollable variables. The only controllable variable that shows up in the model is the ratio of the disturbers, and it has only a minor effect. Figure 73 shows the scaled estimates.

Scaled Estimates					
Continuous factors centered by mean, scaled by range/2					
Term	Scaled Estimate		Std Error	t Ratio	Prob> t
Intercept	45.505224		0.173225	262.69	0.0000
DistRatio	0.3657625		0.173225	2.11	0.0352
Voters/RFA	29.747981		0.295624	100.63	0.0000
Dist/RFA	17.39563		0.295624	58.84	<.0001
(DistRatio-0.415)*(Voters/RFA-50.0308)	-6.196329		0.295624	-20.96	<.0001
(DistRatio-0.415)*(Dist/RFA-50.0308)	6.2303013		0.295624	21.08	<.0001

Figure 73. Scaled Estimates for RFA

The model can be represented as

$$\text{Avg\_RFA} = -3.4518 + 4.3030879 * x_1 + 0.5949596 * x_2 + 0.3479126 * x_3 - 1.45796 * ((x_1 - 0.415) * (x_2 - 50.0308)) + 1.4659532 * ((x_1 - 0.415) * (x_3 - 50.0308))$$

where :  $x_1 = \text{DistRatio}$   
 $x_2 = \text{Voter/RFA}$   
 $x_3 = \text{Dist/RFA}$

The regression tree produces almost the same result. As Figure 74 shows, the voters' initial readiness for aggression and the disturbers' initial readiness for aggression are the only two factors that appear.

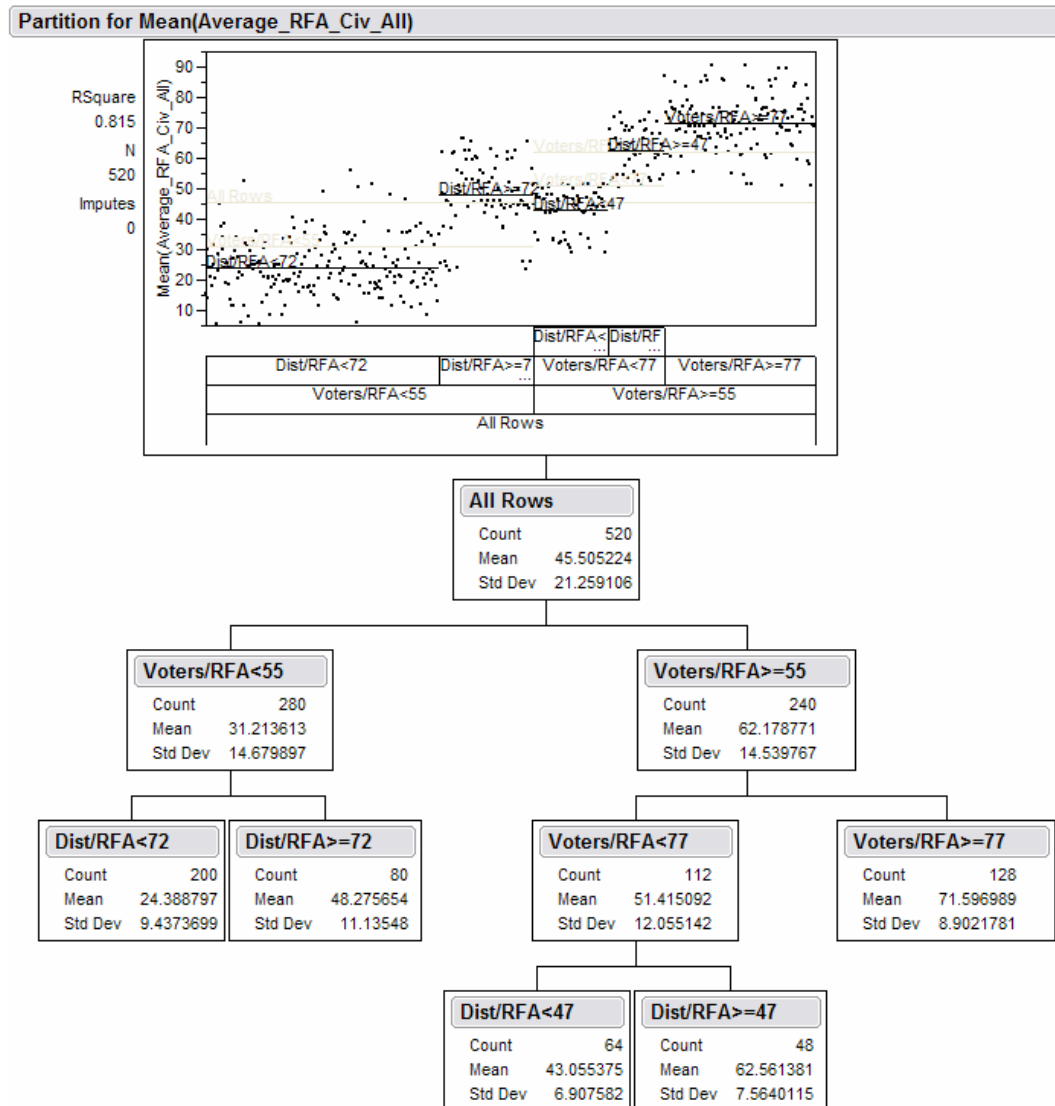


Figure 74. Regression Tree for RFA

## F. A COMPARISON BETWEEN TWO CASES

So far, in our analysis we have seen that large civilian sizes, high disturber ratios and absence of duty posts yield undesired results. To give more tangible insights to the reader we take a birds-eye view of two cases: a good case and a not-so-good case. In the former, a small group of relatively homogeneous civilians go to the polls (DistRatio is low). Additionally, PSU soldiers are protected by duty posts. Conversely, for the bad case the PSU deals with a larger group and does not have the protected duty posts. There is a higher proportion of disturbers as well. We will compare the *changes* in average readiness for

aggression, average anger and average fear among all civilians during the course of the simulation. Ideally, the change in average values would be negative for RFA, fear, and anger. This might improve the prospects of successful peace support operations in the future.

Although PAX does not report average initial RFA, average initial anger, and average initial fear among all civilians, we can represent these values by adding three more columns to the output data set. Multiplying the initial RFA of disturbers, the civilian size, and the disturbers' ratio gives the total initial RFA for disturbers. Similarly, the product of the initial RFA of voters, the civilian size, and voters' ratio (equal to  $1 - \text{the disturbers' ratio}$ ) gives the total initial RFA among voters. Dividing the sum of the total initial RFA of disturbers and the total initial RFA of voters by civilian size gives the average initial RFA among all civilians. Finally, the difference between the average RFA at the end of the simulation and the initial average RFA gives the change in average RFA among all civilians. Changes in average anger and fear are acquired in a similar manner.

As we see in Figures 75 and 76, in both the good and bad cases the change in average RFA is generally below zero. This means that average RFA among all civilians at the end of the simulation tends to be lower than the average initial RFA. In other terms, RFA tends to decrease during the simulation. However, unlike average RFA, average fear and average anger tend to increase during the simulation. The dark shaded columns in each of the graphs represent the positive changes – the increases in average RFA, average anger and average fear. Although both cases seem to produce similar results, there are some differences worth mentioning.

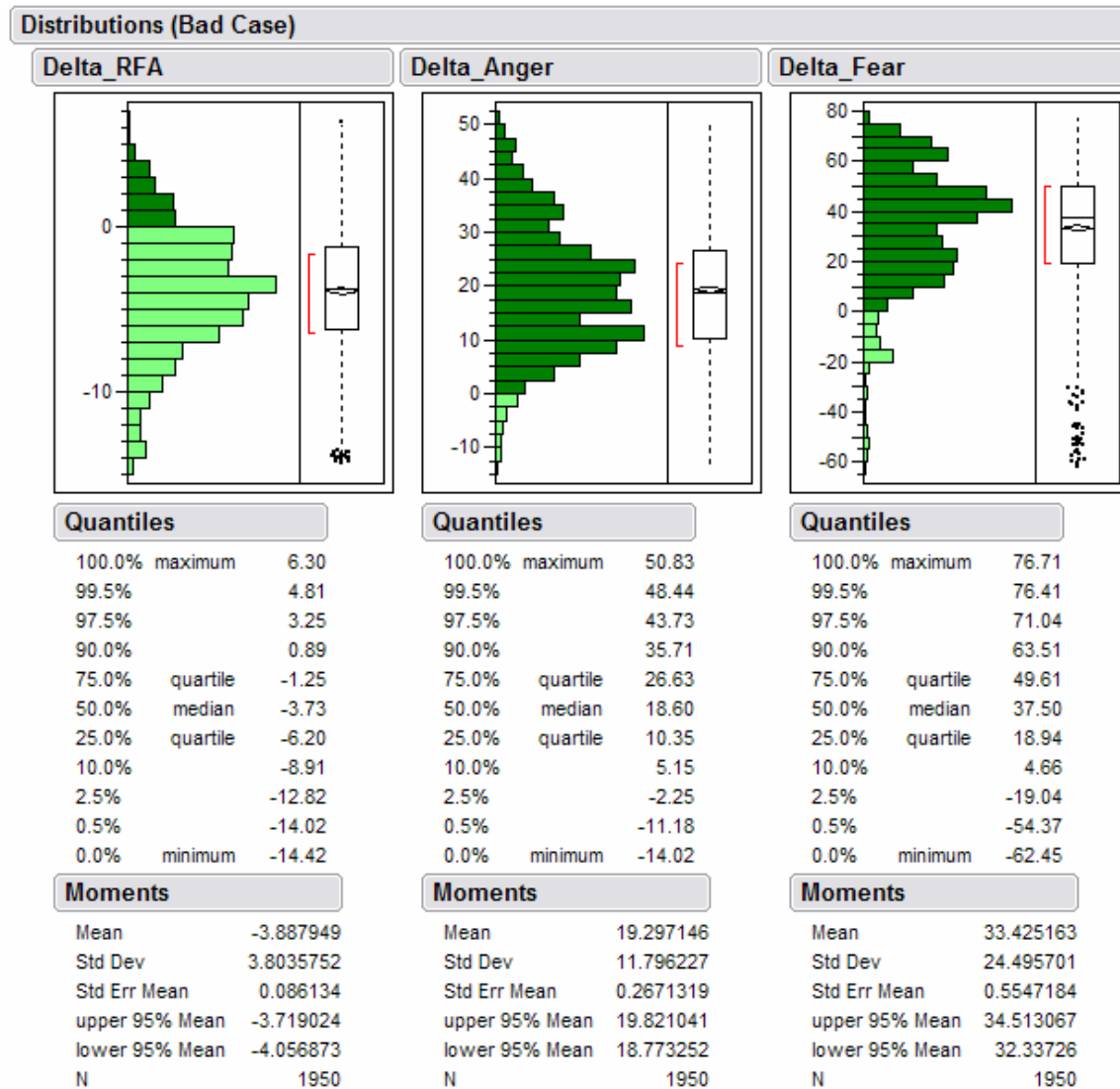


Figure 75. Change in RFA, Anger and Fear (Bad Case)

The mean of the change in RFA in the bad case is -3.888 while it is -5.255 in the good case. This difference may be minor. However, the mean of the changes in average anger and fear in the bad case are almost double the corresponding values in the good case: 19.927 vs. 9.907 for the change in average anger, and 33.425 vs. 17.219 for the change in average fear. The average anger decreased for more than 25% of the observations in the good case. On the other hand, it increased for more than 90% of the observations in the bad case. Furthermore, the increase in average anger is over 10 for more

than 75% of the observations in the bad case, while it is less than 10 in more than 50% of the observations in the good case.

Similar to the change in average anger, the change in average fear increases for more than 90% of the simulation runs in the bad case. While the ranges of potential changes in fear are essentially the same, many more situations (over 25%) resulted in decreased fear for the good case.

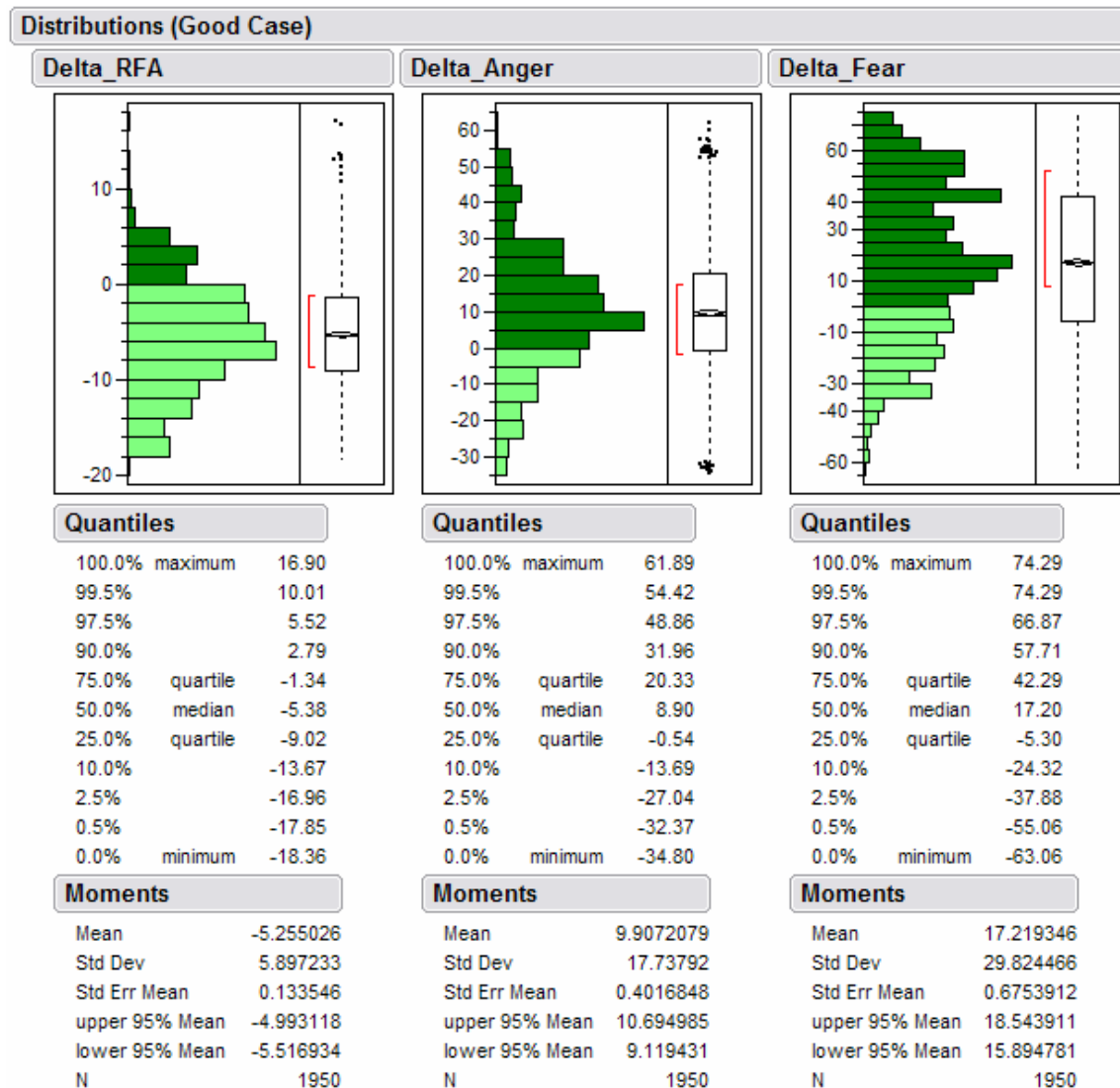


Figure 76. Change in RFA, Anger and Fear (Good Case)

One could argue that if the situation may be bad in either case, why should the PSU worry too much about how to safeguard the election?

Considering the situation in Iraq, there are a lot of things to worry about. Since the start of the Operation Iraqi Freedom, thousands of people lost their lives - most of whom are innocent civilians. The ones who managed to survive are living in miserable conditions and worrying about their own and their beloveds' lives. It is obvious that the more angry and fearful the people are, the more aggressive they may become. Any measure that can save a life, hinder an attack or lessen the aggressiveness is worthwhile, regardless of how much it costs. The results of our simulation study show that PSU rule sets and other measures can improve the situation. Follow-on work may reveal additional tactics, techniques, or procedures that can lead to further improvements. The results also emphasize the importance of efforts to influence civilian behavior before the Election Day. For example, some civilian leaders might be able to reduce the anger or fearfulness of their group, increase their groups' norms for anti-aggression, or keep potential disturbers farther from the polling areas. Our results show that the results of these actions would be a safer election with a higher proportion of potential voters casting their votes.

## **G. SUMMARY OF RESULTS**

In this chapter, several MOEs are investigated to gain insights about how they can be influenced by the tactics and procedures of the PSU, the number of civilians present, the presence or absence of duty posts, and different ratios of the number of disturbers to the number of voters. For each MOE investigated, models were built using stepwise regression and regression tree techniques. The MOEs investigated are:

- aggregated escalation,
- escalation at the end of the simulation,
- escalation outside the election area at the end of the simulation,
- escalation inside the election area at the end of the simulation,
- ratio of number of votes to the number of voters,

- attacks conducted by civilians against civilians, and
- average readiness for aggression among all civilians.

The models are satisfactory. In each model, most of the variability of the response is explained by the regressors in the model. For instance, the model for average RFA among all civilians covers almost 97% of the variability. The model that has the lowest  $R^2$  is the model for escalation inside the election area. The  $R^2$  value for that model is 0.77, which is still a high value. Main effects, quadratic effects and interaction terms were added to the models before running stepwise regression. However, quadratic effects never show up in the final models. Generally, the final models contain main effects and a small number of interaction terms.

The other satisfactory side of the models is that in all models but Avg\_RFA, the controllable variables stand as the most important factors. This means it is possible to simultaneously increase the ratio of the votes and keep escalation low by adopting particular policies or strategies.

Table 1 gives a summary of the effects in each model. A plus sign (+) means the corresponding factor has a positive effect on the model, whereas a minus sign (-) implies the opposite. For example, while it is desirable for the ratio of votes to be high, the escalation should be low. If a factor has a “+” in both columns, this means that factor helps to keep the ratio of votes high and the escalation low.

The larger civilian group size, appearing in five of the seven models, always has a negative effect on the MOEs. This means that situations involving larger groups tend to be worse than those involving relatively small groups. For example, civilians tend to vote at higher rates in smaller groups. The ratio of votes increased two times in smaller groups compared to larger groups. Although the impact of civilian group size is not as dramatic for the escalation model, it is still beneficial. Smaller group sizes tend to keep the escalation substantially lower.



The presence of duty posts has positive effects in all models where it appears. It shows up in four of the seven models. In situations where duty posts were built, escalation decreased drastically. Although this thesis did not investigate where and how many duty posts should be built, their presence clearly helps keep the escalation down.

A large ratio of disturbers has negative effects in all but one of the five models in which it appears. It decreases the escalation, except for escalation inside the election area. In scenarios that include more people from opposing groups, attacks from one group on another rose significantly. Lower ratios of disturbers caused low levels of RFA for all civilians, which can be used as an indicator of long term effect. There is a reasonable explanation for its positive effect on escalation inside election areas. Disturbers were not allowed to enter to election areas by admission control soldiers. In groups with large ratios of disturbers, more people were left outside the election area. Because they were outside, they could not create havoc inside.

	Agg_Esc	Esc_End	Esc_Out	Esc_In	Ratio_Votes	Attacks_civ_civ	Avg_RFA
R2	0.779	0.767	0.793	0.790	0.834	0.776	0.966
CivSize	-	-	-		-	-	
DutyPosts	+	+	+			+	
DistRatio	-		-	+		-	-
RO/RS{6&2&1&5&3-4}	+	+	+			+	
RO/RS{5&3}					-		
RO/RS{2}					+		
RO/RS{4&6}					-		
RO/RS{1}					+		
RI/RS{6&2&1&5&3-4}						+	
RI/RS{3&2}					-		
RI/RS{4}					+		
RI/RS{6}					-		
RI/RS{1}					-		
RI/RS{5}					+		
AC/RS{1&5&3&4 – 2&6}					-		
AC/RS{6&3&2}				-			
AC/RS{4}				-			
AC/RS{5}				-			
AC/RS{1}				+			
AC/RS{1&5 - 3&4}					+		
Voters/Anger		+	+		-		
Voters/Fear				+			
Voters/EM				-	+		
Voters/RFA	-					-	-
Dist/RFA	-		-			-	-
Dist/GC				+			

Table 1. Summary of the effects in all models

Rulesets used by PSU soldiers show up in all models except for Average RFA among all civilians. Rulesets for reserve soldiers located outside of the election area play more important roles than those for other soldiers. The term RO/RS{6&2&1&5&3-4} has positive effects in all models of escalation, which means rulesets other than Ruleset 4 (Gandhi Strategy) do a better job of keeping escalation low. This means that means adopting any ruleset other than 4 produces better results. Considering the ratio of votes, Ruleset 1 (built on the Peace Support Operation Manual) turns out to be the most appropriate choice. Ruleset 2 also improves the proportion of votes cast. However, the rest of the rulesets have negative effects on the ratio of votes. Rulesets for admission control and reserve soldiers located inside the election area do not matter so much. They have very small effects on the escalation inside the election area, or on the ratio of votes.

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## **V. CONCLUSIONS AND RECOMMENDATIONS**

In this thesis, a representative Iraqi town was created using the agent-based model PAX. The peace support operation examined in this thesis was safeguarding the operation of elections. Eight scenarios were developed and run with the help of OldMcData, data farming software created by the MITRE Corporation. After each run, OldMcData provided an output file of the simulation. The output files were concatenated into one output file. The results have been analyzed by statistical software JMP.

This author does not predict what will happen in an election held in Iraq. But some useful insights might be provided to decision makers as a result of the analysis done here. Additionally, the experience of conducting these experiments and some of the problems that occurred during the research process allows some useful feedback to be provided to the developers of model PAX.

### **A. RECOMMENDATIONS TO DECISION MAKERS**

Peace support operations are different in character than conventional war. Therefore the modeling tools should be used wisely. Attrition-based models that were primarily developed to model traditional combat may not be suitable to represent the most important aspect of peace support operations. The first and most important distinguishing characteristic of peace support operation is that there is no enemy to kill and the people the soldiers are dealing with are civilians. Although a relatively new model and still under development, the PAX model is an important step toward representing peace support operations.

Because the participants are not armed forces, special tactics and procedures must be followed. As this study shows, different tactics and procedures have different impacts on the outcomes. A tactic that is suitable for one scenario may not work well in another.

Decision makers do not have many parameters that they can control. Most of the parameters are human related. However, as this study demonstrates,

these controllable variables, though limited, may play significant roles in peace support operations. Smaller groups sizes give better results; in particular, small group sizes produce less escalation and higher turnouts. Although it does not affect the number of votes, the presence of duty posts decreases the escalation significantly. Additionally, keeping the civilian groups homogeneous helps the PSU to establish security more easily.

The PSUs can definitely choose the appropriate rule sets for the soldiers and train them accordingly. They can build as many duty posts as they wish, and wherever they like. At the first sight, it is not intuitive how the homogeneity and size of the civilian group can be affected. However, building more polling stations and assigning fewer people to vote in each station would decrease the number of people that show up in each station. If building more polling stations is expensive, perhaps the election could be carried out in more than a single day, and the time windows when people can vote might be coordinated. When planning who will vote at which station, ethnicity, religion and other factors might be taken into consideration to keep the groups homogeneous.

## **B. RECOMMENDATION TO PAX DEVELOPERS**

PAX is a model that was developed for peace support operations after it was recognized that such operations are not suitably simulated in current attrition-based models. It takes human behavioral patterns into consideration, making it unique. It is a relatively new model and its development process is ongoing. In the 10<sup>th</sup> Project Albert International Workshop, the developers introduced a new, stochastic version of PAX. The new version also includes some other features, such as pushing/shoving, and reporting the MOEs according to the groups and areas. However, the model still needs enhancement. All models are abstractions, and no model can simulate an operation perfectly. But for PAX to be useful for broad investigations into peace support operations, it should offer users some additional features. Some problems confronted during the experiments reported in this thesis are listed below for the benefit of the PAX developers.

## **1. Different Agent Types**

In PAX, there are three agent types that can be assigned: civilian, soldier and service point. Although these are the main actors in peace operations, there are other entities that play important roles. Before the 30 January elections, more than 500 nongovernmental organizations (NGOs) emerged in Iraq to deal with just women's issues.<sup>33</sup> Of course, it is impossible to model all types of entities. However, some important organizations and agencies, like health organizations and the media and press, should be taken into consideration.

## **2. Leader Situation**

In group dynamics, a leader's presence and attitude have considerable impact on individual behaviors. PAX provides the opportunity to investigate the presence of a civilian leader. Initially, this researcher intended to explore the different attitudes of the leader. A question of particular interest was if participation could be increased by persuading a leader to support (or at least not hinder) the election. But the interaction between soldiers and leaders is limited. If escalation reaches a certain threshold, soldiers will approach the leader and ask him to encourage his men to leave the area. Whether this is successful will vary according to the situation, since each individual will decide whether they will obey the leader or refuse his proposal. So if the group causing problems has a civilian leader, the leader may help deescalate the situation within the election area.

In PAX, one is able to model more than one group of civilians. Each group may have a leader. In these experiments, however, the voters are the only group with a leader. If escalation occurs, the soldiers will approach this leader and request that he tell his men to leave the area, even if the trouble was caused by another group. This is not optimal. If a group is associating with soldiers and doing well, it is desirable that they continue doing so. In such cases, the soldiers

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<sup>33</sup> Iraq Elections: Road to Democracy, p 24. *U.S Department of State Bureau of International Information Programs*, Retrieved July 20, 2005 from <http://usinfo.state.gov/products/pubs/iragelect/iragelect.pdf>

should be encouraging the leader to ask his men to vote, not to ask his men to leave.

PAX currently reports MOEs according to groups and areas. This means it tracks which group is causing problems (i.e., which group is threatening or attacking the soldiers). Therefore, it should be relatively easy to have the soldiers seek out the leaders of the disturbing group. Allowing the soldiers to use different types of communications for leaders of different groups would also be useful.

### **3. Escalation and Closing the Gates**

Civilians enter the election area if their leading internal state is motivation to participate in the election and if they belong to a group that is allowed to enter. There are no mechanisms to control flow into or out of the election area. In the model simulations, situations arose where agents kept entering the election area even when there was a lot of escalation. In a real situation, if escalation goes way up, one of the first things that the PSU commander would do is to close the gates and wait for the escalation to abate. If the flow could be controlled, the situation would be more realistically represented.

### **4. Custom Parameters**

Advanced features, like enabling groups to enter the election area, and tracking the number of civilians who passed the check points, and when they do so, can be edited by using the Custom Parameters option. This option allows users to exploit the advanced features of PAX. However, it is not clear how the custom parameters options can be implemented. The online manual does not say anything about this topic. Furthermore, the fields must be entered in German. These problems make the Custom Parameters option impractical for non-German speakers. Fortunately, the developers were able and willing to help in the use of these advanced features, but if they could be selected from a menu, like other features, then more users could benefit from them more easily. In



addition to or instead of these enhancements, updating the online manual would help users to understand and use the advanced features.

### **C. FUTURE WORK**

Follow-on work may reveal additional tactics, techniques, or procedures that can lead to further improvements. The results also emphasize the importance of efforts to influence civilian behavior before the Election Day. For example, some civilian leaders might be able to reduce the anger or fearfulness of their group, increase their groups' norms for anti-aggression, or keep potential disturbers farther from the polling areas. Our results show that the results of these actions would be a safer election with a higher proportion of potential voters casting their votes.

As stated above, the controllable parameters are limited. Future work should focus on the effects of different levels of controllable parameters. The controllable variables can be summarized as

- Different tactics and procedures (rulesets) of soldiers
- Number and location of PSU soldiers
- Number and location of duty posts
- Different ratios of number of disturbers to number of voters

In addition to a more detailed study of these controllable variables, the presence of leaders and their attitudes could be investigated more deeply if the developers update the model PAX accordingly.

### **D. SUMMARY**

What we once thought of as purely civilian considerations are today increasingly significant in conflict situations. Conflicts within states and engagements that involve urban encounters make civilian considerations particularly worthy of military attention. The international community has reached a consensus on democracy as form of government, but new democracies tend to

be unstable. It is particularly vital that international actors assisting societies in transition help those nations to choose their own democratic government structures and leadership.

For these reasons, the techniques militaries use must change. Stability operations are an application of military power to influence the political and civilian environment. Often these stability operations take the form of peacekeeping or peace support operations. Peace Support Operations (PSO) are military operations to support and sustain a long-term political settlement. PSO and conventional war have different characteristics. The main purpose of conventional war can be generalized as “defeat the enemy,” whereas peacekeeping attempts to “win the peace.” At the level of tactics, the goals of peacekeeping missions are to help and protect civilians, avoid violence and escalation, ensure the safety of the public, and so on. Stability operations are executed in a more diverse range of environments than are the operations of conventional war. Finally, depending upon the mandate, the engagement rules for soldiers are different when they interact with civilians in a stability operation as opposed to in combat. This thesis demonstrated an example of how ABMs can be used to provide insights to PSUs about appropriate tactics for successful peace support operations. Future work may reveal additional tactics, techniques, or procedures that can lead to further improvements.

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