Dynamics of Reconstruction Projects

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Abstract

Ongoing counterinsurgency operations in Iraq present a complex, dynamic environment in which traditional analytical methods struggle to explain the behavior over time. System Dynamics is extremely well suited to analyze this environment as the methodology focuses on understanding the structure of the system and the behavior it creates. This paper proposes a system dynamics model of reconstruction projects for essential services to examine one aspect of this operating environment. One of the many challenges that exist in this environment is determining the proper balance between the use of the Commander's Emergency Response Program (CERP) for small scale and major reconstruction projects. This paper attempts to mitigate this challenge by analyzing the structure of the system, modeling the behavior of the system over time, and proposing policy recommendations to improve the system behavior. Although the model is not calibrated to historical data, it produces behavior consistent with behavior described in Army doctrine. The causal relationships provide valuable insights into the dynamic behavior of reconstruction efforts and their impact on essential services. With further calibration of the model, leaders can develop and evaluate policy alternatives for capacity development to mitigate the impact of the insurgency.

Key Words: System Dynamics, Reconstruction, Counterinsurgency, CERP Funds

Introduction

Current operations in Iraq and Afghanistan have identified shortcoming in traditional analytical methods for dealing with the complex, dynamic combat environment our military faces today. A challenge that exists for commanders is determining the proper balance between the use of the Commander's Emergency Response Program (CERP) for small scale reconstruction projects and major reconstruction projects. This paper proposes an initial system dynamics model of reconstruction projects based on a literature review, interviews with subject matter experts, and current Army doctrine. The model is then used to evaluate different levels of reconstruction funding and the proportion of funds spent on large and small projects. With these insights, leaders can develop policy alternatives for capacity development within the host-nation to mitigate the impact of the insurgency.

Background

Since March of 2003, the Unites States has appropriated $61.64 billion for reconstruction efforts in Iraq (Special Inspector General for Iraq Reconstruction 2011). Of that amount, only a small fraction, $3.85 billion, is allocated to the Commander's Emergency Response Program funds. CERP funds began as a tool for commanders to stabilize their area of operations through the initiation of emergency relief and small scale reconstruction projects. Initially, funds were allocated from seized Ba'athist Party funds; however, judge advocates later ruled that Department of Defense (DoD) funds could be used for these projects (Martins 2005). Initially, commanders were able to spend up to $100,000 on reconstruction assistance defined by a Combined Joint Task Force order as:

> *"the building, repair, reconstitution, and reestablishment of the social and material infrastructure in Iraq. This includes but is not limited to: water and sanitation infrastructure, food production and distribution, healthcare, education, telecommunications, projects in furtherance of economic, financial, management improvements, transportation, and initiatives which further restore the rule of law and effective governance, irrigation systems installation or restoration, day laborers to perform civic cleaning, purchase or repair of civic support vehicles, and repairs to civic or cultural facilities"* (Commander, CJTF-7 2003)

As the war progressed, the initial limit of $100,000 increased to incorporate larger scale projects focused on developing essential services within Iraq.

Initially, the reconstruction efforts funded with CERP money became an outstanding success as more than 11,000 projects were completed between June and October 2003 (Martins 2005). These projects spanned the range of providing school supplies to children to cleaning major water supply systems. However, CERP Funds still comprise a very small portion of the overall reconstruction effort in Iraq to improve the essential services the country provides for its citizens. The System Dynamics model in this paper examines potential alternative policies which increase the percentage of funds allocated to the CERP. It attempts to determine if there is a tipping point at which allocating a different percentage of CERP funds to reconstruction efforts will improve the essential service level in the host nation.

Literature Review

The Army's new Field Manual 3-24, Counterinsurgency, provides an overview of modern insurgencies and counterinsurgency techniques to determine the underlying dynamics of reconstruction efforts. The manual presents the argument that the legitimacy of a nation is the underlying goal in any insurgency or counterinsurgency. Nation states attempt to gain legitimacy by improving their economic situation, essential services, and security within their borders. Additionally, they attempt to minimize the level of corruption to a level that is culturally acceptable to the people of the nation. In order to have a lasting, stable government it must be viewed as legitimate to a majority of the populace (Department of the Army 2006).

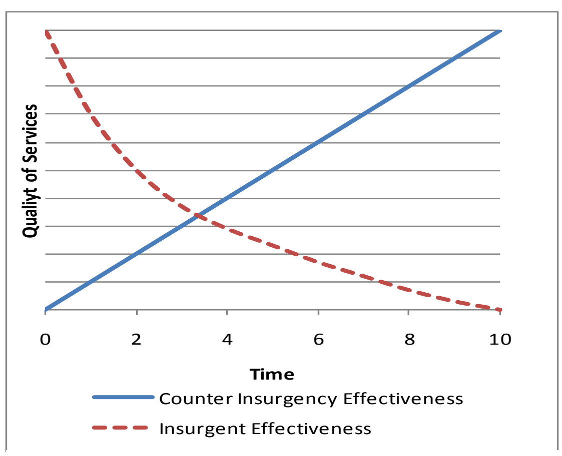

Figure 1: Essential Service Impact (Department of the Army 2006)

FM 3-24 also provides a theory as to how an increase in the quality of essential services provided by the host nation will impact the counterinsurgency and insurgent effectiveness. Figure 1presents an adaptation of the behavior over time FM 3-24 describes. As shown, with an increase in essential services, the insurgent effectiveness decrease at an increasing rate, similar to goal seeking behavior as the effectiveness of the counterinsurgency increases. This would suggest that essential services have a negative link to insurgent support and a positive relationship to the government's legitimacy. Additionally, Kilcullen describes an insurgency as a complex system that needs energy, in the form of acts of violence and grievances against the government, to sustain itself through several feedback structures (2004). This theory supports FM 3-24 assertion that an increase in essential services, which reduces the grievances against the government, will act to decrease the effectiveness of the insurgency. FM 3-24 provides additional insights into the behavior of reconstruction efforts and the components of the system dynamics model.

System Dynamics is a methodology to understand the dynamic behavior of complex systems through modeling and simulations. System Dynamics explains the behavior of systems over time as a direct result of the system structure. It also aims to adjust individuals' mental models of the system to implement policies to improve the system. Forrester described the potential for system dynamics as an approach that should help in the important high-level management problems (1961). He noted that solutions to small problems will only yield small results and that people get mediocre results by setting improvement goals too low. He suggests that the change must be at the enterprise level to achieve major improvement and that the goal should be to determine policies that lead to greater success (Forrester 1961).

Forrester describes a system as "a grouping of parts that operate together for a common purpose" (1968). He further classifies two types of systems: open systems, in which exogenous, or external, variables affect the system, or closed systems, in which all variables are endogenous, or internal to the system (Forrester 1961). The distinction between open and closed systems relies heavily on where the system boundary is drawn; however, a model of a system will provide a better understanding of the dynamics the closer it is to a closed system. Dynamics are the behavior of a system over time, which are generally complex and non-linear in nature (Forrester 1961). This complexity comes from feedback within the system, time delays between decisions and effects, and the learning process of the system (Sterman 2000).

Causal loops diagrams are a key element of the system dynamics approach which are signed diagrams that represent the reinforcing or balancing feedback within a system. Casual loops are different from discrete, event-oriented perspective of individual causes and effects in that they acknowledge that in a closed system any cause is an effect and any effect is a cause (Richardson 1991). In System Dynamics, the feedback loop diagrams indicate that one variable influences another through physical or information flows. One is able to describe the behavior of the system by talking through the loop to tell the story of the interactions within the system (Meadows, Randers and Meadows 2004).

System Structure

The structure of the reconstruction effort system is extremely complex with several individual feedback structures contributing to the dynamic behavior of the system. To understand the structure of this system, this paper presents three of the major feedback structures to include the desire to begin reconstruction projects, the security situation, and the maintenance of essential services. The first feedback structure presents how degradation in essential services will create the desire to begin reconstruction projects and how a population will desire a higher level of service based on their current situation. The second feedback structure describes how the security situation in the country impacts the project completion rate, corruption, and projects. The final feedback structure presented examines the impact of the difference in maintenance complexity between large and small projects and how this complexity leads to a decrease in essential services.

The first feedback structure within the reconstruction project system includes a balancing and a reinforcing feedback loop. First, the "Need for Projects" loop explains how projects will be started as a gap in essential services is felt by the nation. If the level of *Essential Services* decreases, then the *Essential Services Gap* will also increase. This will create a desire to improve the current situation by increasing the *Projects Started*. As more projects begin, the number of *Projects Completed* will also increase and then have the desired effect of increasing the level of the Essential Services. However, there is an interesting dynamic in that as people experience a certain level of *Essential Services* they will increase their *Desired Level of Essential Services*. This is shown in the "Have More, Want More" reinforcing loop. This loop creates the requirement for additional reconstruction projects as the population begins to expect an increases level of service.

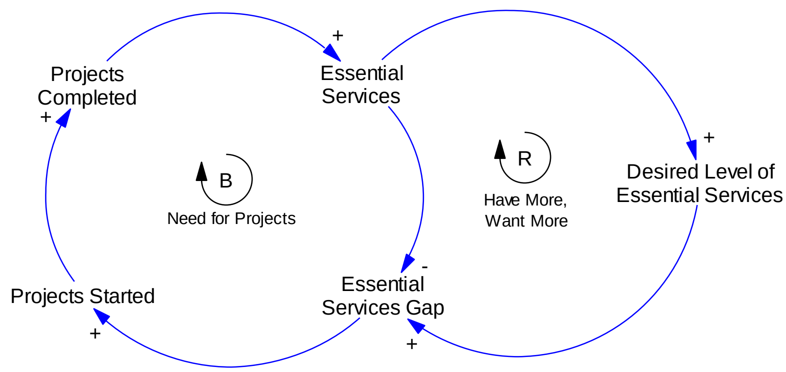

Figure 2: Desire to Start Projects

The second feedback structure focuses on the security situation in the country and the feedback with the reconstruction projects. This model does not attempt to model other counterinsurgency methods, such as direct action against insurgents, instead focusing on the impact reconstruction projects have on the overall system. The "Attacks on Projects" feedback loop explains how insurgents can directly impact reconstruction projects by attacking the projects themselves. If there is an increase in *Attacks on Projects*, the number of *Projects* will obviously decrease. This decrease also causes a lower level of *Essential Services*, which decreases the *Legitimacy of Government* and the overall *Security* in the country. As the security level decreases the overall number of *Acts of Violence* increases as does the number of *Attacks on Projects* (Choucri, et al. 2006). So, if this reinforcing loop begins to act in a negative manner it can have a profound impact on the essential services in the country. Additionally, this can impact the *Availability of Workforce* as the workforce may become intimidated by insurgent activity, which will decrease the *Project Completion* rate. Additionally, as the *Legitimacy of Government* is decreased the "Corruption" feedback loop may begin to impact the behavior of

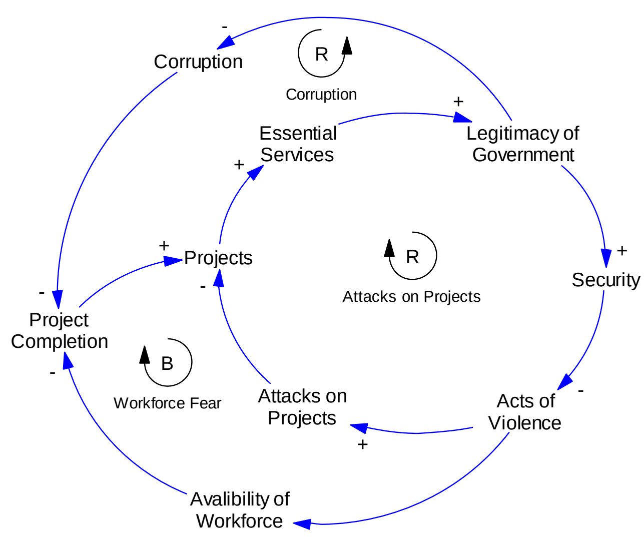

Figure 3: Security Situation

the system. *Corruption* within the country could decrease the *Project Completion* rate, which would then decrease the number of *Projects* and eventually decrease the *Legitimacy of Government* even further.

The final feedback structure explains the dynamics of the impact the different sized projects have on the maintenance complexity and the eventual degradation of essential services due to a lack of maintenance. The first feedback loop is a reinforcing feedback loop for "Large Project Maintenance." This loop describes how an increase in the *Essential Services Gap* creates an increased *Desire to Start Projects*, which leads to more *Large Projects*. However, with more projects come an increase in the *Maintenance Complexity* and an increase in the *Maintenance Gap* between the required level of maintenance and the *Maintenance Ability* of the country (McDonald 2011). As the *Maintenance Gap* increases, there is a *Degradation of Essential Services* which decreases the level of *Essential Services* and widens the *Essential Services Gap*. Thus, this loop reinforces the behavior to start additional projects. This is also visible in the "Small Project Maintenance" loop; however, not to the same extent as in large projects because the complexity of individual projects is much smaller. An additional reinforcing loop exists in the "Maintenance Ability" of the country. As the level of *Essential Services* increases, the *Legitimacy of Government* also increases. With a more legitimate government, the nation is able to increase its *Maintenance Ability* as is has resources to maintain the complex, large projects and decreases the *Maintenance Gap*.

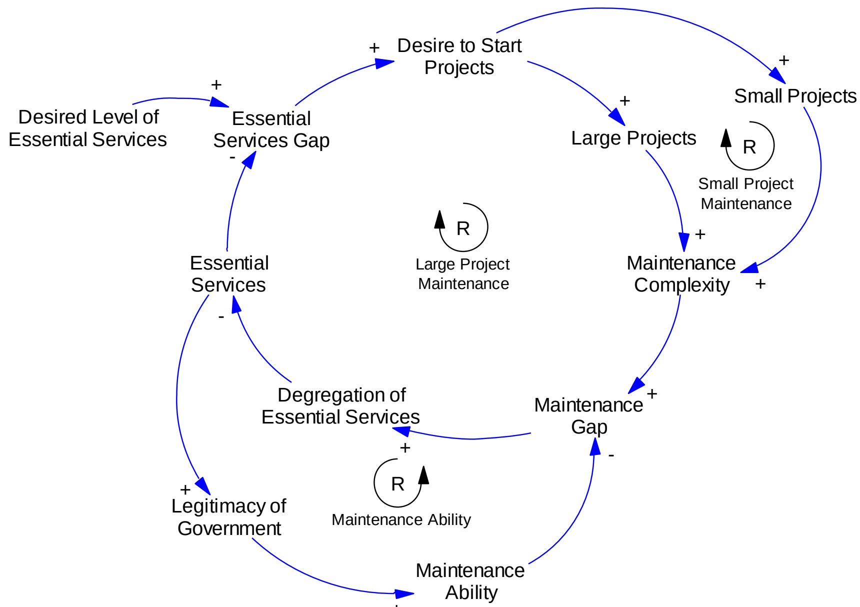

Figure 4: Maintenance Feedback Structure

System Dynamics Model

The system dynamics model of the reconstruction projects is composed of three different views; the essential services, security situation, and maintenance views. The feedback structure described above provides the basis for developing the model and the relationships between the different variables. The main components of the essential services view are the number of large and small projects and the level of essential services in the nation. In the security situation view, the major components include the level of government legitimacy, the security situation and acts of violence. Finally, the maintenance view includes the required level of maintenance complexity and the ability of the nation to conduct this maintenance.

The system boundary only included the reconstruction effort to improve the essential services within the nation. This includes both large scale projects and CERP projects, which the model represents as small projects, aimed at developing the country's essential services. Within the security view, the model does not include any kinetic counterinsurgency operations aimed at reducing the number of acts of violence. A more robust model could include kinetic operations as a potential leverage point to further improve system performance; however, it was not necessary to demonstrate the problematic behavior. Also, the model does not include an insurgent growth element to demonstrate how insurgents are recruited and trained, but just associates acts of violence with the security situation in the nation.

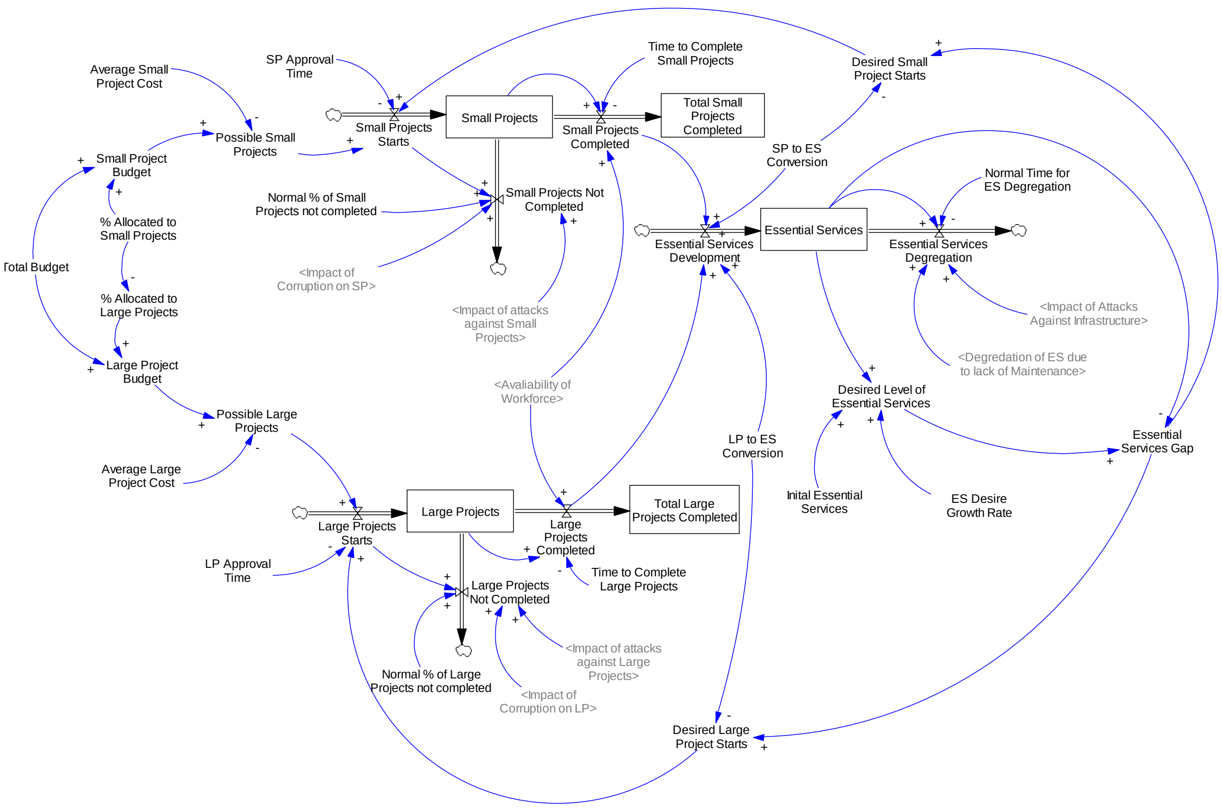

Figure 5: Essential Services Model View

Figure 5 presents the essential services model view of the overall reconstruction effort and includes the leverage points of the total budget and percent of funds allocated towards small projects. The structure of this portion of the model is a co-flow, which depicts an increase in the essential service level with the completion of both large and small projects. Also, the model accounts for any projects, both large and small, that are no completed due to insurgent attacks on the projects, intimidation of the work force, and corruption. These are all variables that can impact the overall project completion rate for any reconstruction projects (Special Inspector General for Iraq Reconstruction 2011). Additionally, the model accounts for the degradation of essential services over time due to normal degradation of projects, which can be impacted by a lack of maintenance ability and insurgent attacks against the infrastructure. The model also accounts for the population's increase in their desired level of essential services, as the higher this level, the more services they will come to expect from the government. So, this reinforces the number of projects that will be started to improve the nation's essential services.

Figure 6 presents the security situation view of the model, which includes the legitimacy of the government as the major stock in this portion of the model. The legitimacy of the government can change as the perception of the security situation and the essential services increases (Department of the Army 2006). Both of these variables will impact the normal change in legitimacy to determine the actual change in legitimacy. Like the essential services view, the model accounts for the growth in the desired level of legitimacy as the population will begin to desire a higher level of legitimacy as time progresses. The level of legitimacy of the government impacts the support for the government, which then drives the security situation in the country. Based on the level of security in the country, the model generates a number of acts of violence, which can be targeted against infrastructure, reconstruction projects, or the work force (Latawski 2006). Acts of violence against counterinsurgency forces were not included in this model as they did not directly impact the problematic behavior observed.

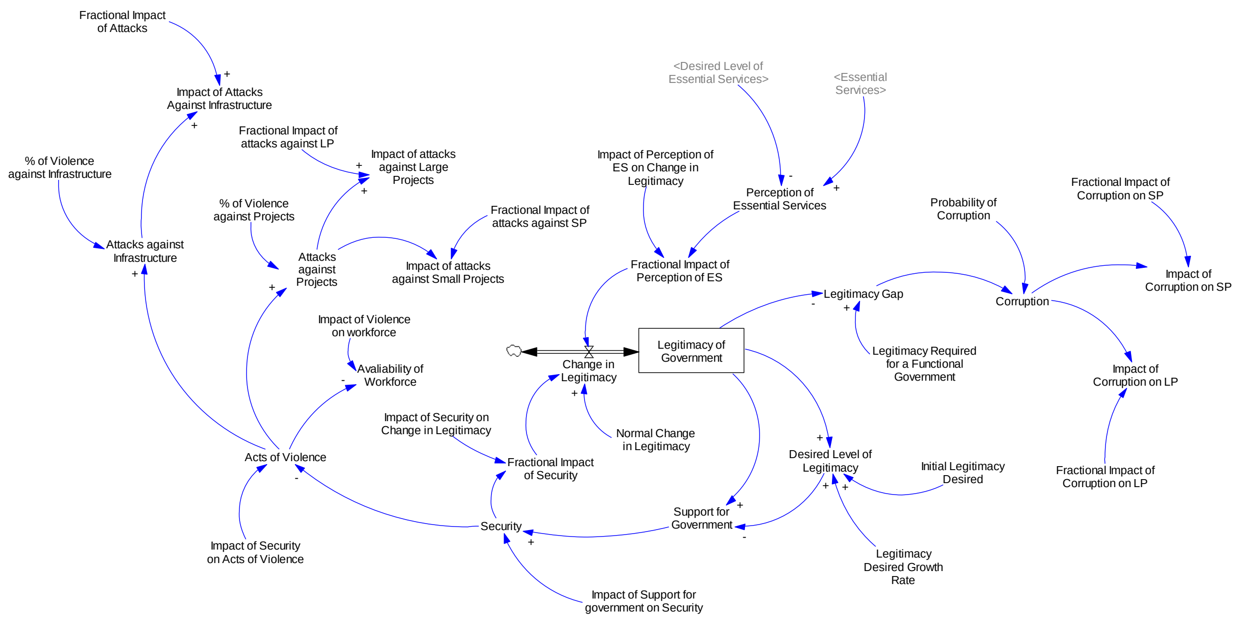

Figure 6: Security Situation Model View

Figure 7 presents the final view of the model, which includes the maintenance gap generated by a required level of maintenance complexity and the ability of the country to maintain essential services. The model asserts that there is a level of maintenance ability, based on the legitimacy of the government and the initial level of maintenance capacity of the nation. This is the country's ability to maintain infrastructure based on their education level, financial situation, and work force experience. The maintenance gap exists as projects add complexity to the infrastructure. It looks at the total percentage of large scale projects, which have a higher level of maintenance complexity, and adds this value to the maintenance complexity of small scale CEPR projects, which are much easier to maintain and have a lower maintenance complexity (Special Inspector General for Iraq Reconstruction 2007). The maintenance gap then increases the degradation of essential services because of a lack in maintenance.

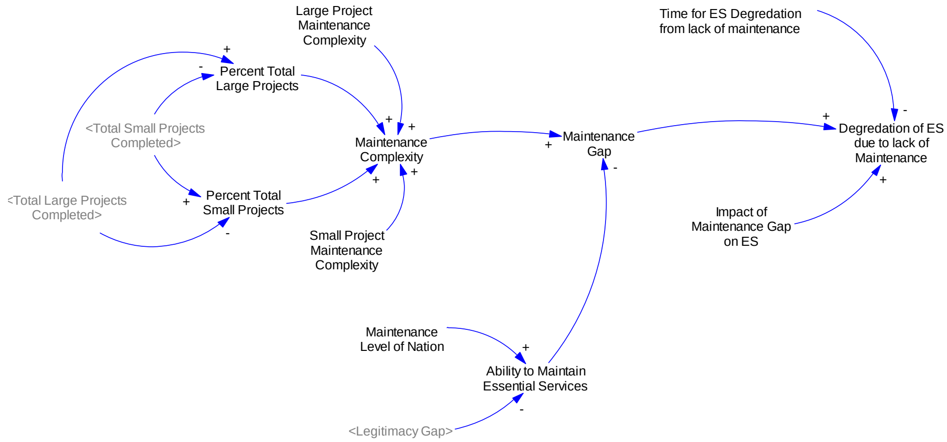

Figure 7: Project Maintenance Model View

Results of Proof of Concept Model

Without historical data to calibrate the model to, the initial simulation attempted to generate the behavior FM 3-24 presented. FM 3-24 proposes that as the essential services increase, the effectiveness of the counterinsurgency also increases and the effectiveness of the insurgency decreases (Department of the Army 2006). Figure 8 and Figure 9 present the essential services and the legitimacy of government output from the initial simulation. As shown in these figures, both are increasing after an initial decrease as the insurgency begins. This appears to be consistent with the behavior FM 3-24 presents for this aspect of an insurgency.

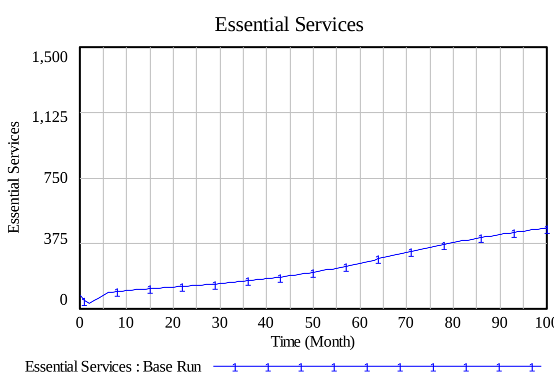

Figure 8: Essential Services - Base Run

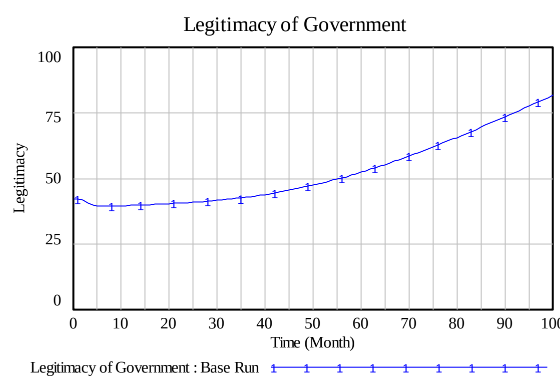

Figure 9: Legitimacy of Government - Base Run

The model does not have a specific variable for the effectiveness of the insurgency; however, the two variables *Acts of Violence* and *Corruption* serve as reasonable approximations of the insurgency's effectiveness. These are also similar to the variables Kilcullen presents in his paper as the requirements for an insurgency's success (2004). Figure 10 and Figure 11 present the acts of violence and corruption outputs from the base run of the simulation. Although these values initially increase, after about 10 months, they begin to decreases over time. Again, the model appears to generate a similar behavior to that of the theory in FM 3-24.

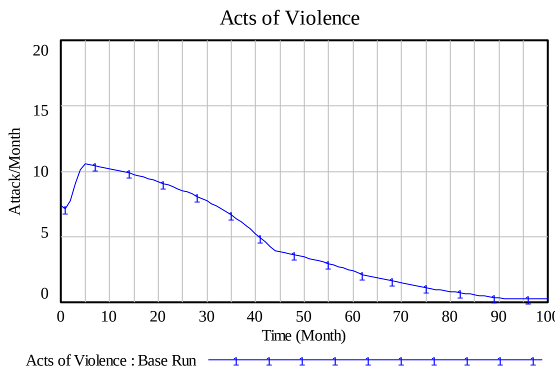

Figure 10: Acts of Violence - Base Run

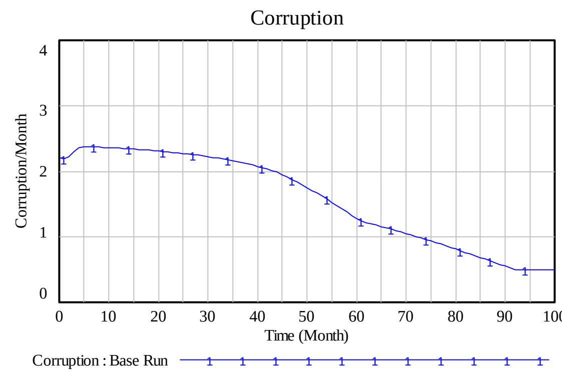

Figure 11: Corruption - Base Run

Although a thorough calibration of the model was not completed, the model generates behavior similar to that FM 3-24 proposes for the interaction of essential services, counter insurgency effectiveness, and insurgency effectiveness. For the purposes of this paper, the general trends in behavior provide insights into the performance of the system and potential policies for the application of reconstruction funds. Additionally, the model generated the predicted behavior during the extreme conditions tests. If the total budget decreases to about $10,000,000 the insurgency begins to dominate the system and the level of essential services decrease to a point in which it cannot recover. Also, the simulation does not improve past a point when additional funds are allocated to the total budget for reconstruction efforts.

Potential Policy Recommendations

Although a more detailed, calibrated model would be required to develop policies, this model demonstrates the predicted behavior for policy changes. The two major leverage points in the model are the percent of the projects that are small projects and the total budget variables. Changes to these two variables provide the inputs for the analysis of different policy alternatives. The first alternative analyzed the impact of increasing the percentage of small projects from 5 percent to 20 percent. The second alternative examined the impact of increasing the percentage of small projects to 35 percent and decreasing the budget to $300,000,000 per month. This reduces the overall budget for reconstruction projects by over 50 percent.

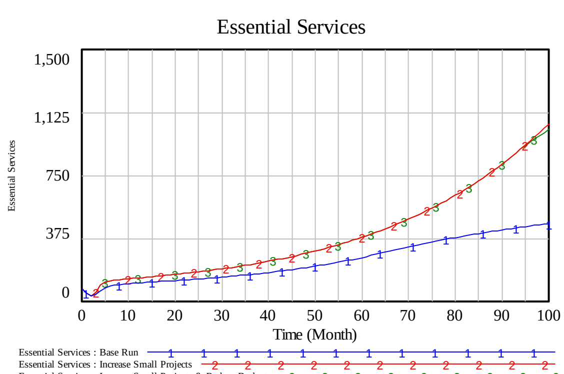

Figure 12: Essential Services - Alternatives

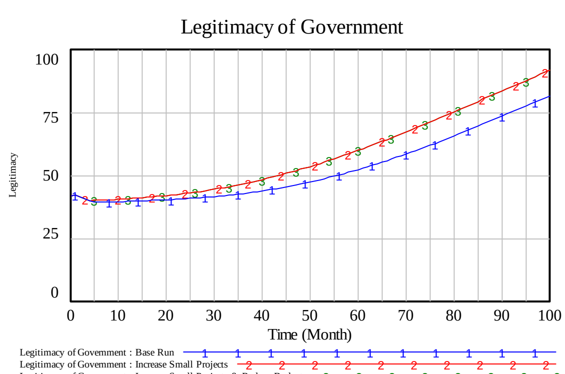

Figure 13: Legitimacy of Government - Alternatives

Figure 12 and Figure 13 present the essential service level and the legitimacy of government level for the two alternative policies and the base run. As shown, both alternatives generate improved performance from the base case and create the same pattern of behavior over time. Line 2 represents the increase in the percentage of small projects alone while the line 3 depicts the performance over time when the percentage of small projects increases and total budget decreases. The interesting dynamic in this system is that both alternatives are capable of generating the same pattern of behavior. So, the better alternative would be to decrease the total budget by over 50 percent and to increase the percentage of small projects to 35 percent. This increases both the essential services and legitimacy of government to a higher level than the base run and will cost less to implement the reconstruction efforts.

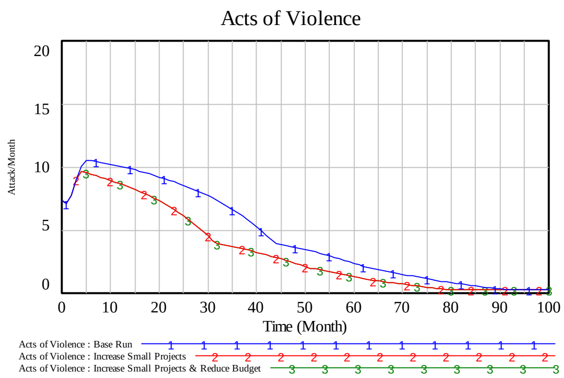

Figure 14: Acts of Violence - Alternatives

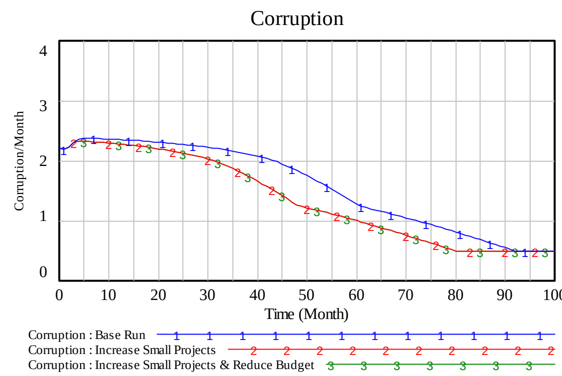

Figure 15: Corruption - Alternatives

Figure 14 and Figure 15 present the model output for the acts of violence and the corruption, respectively, for the two alternative policies. As shown, both policies demonstrate improved performance from the baseline. This output reinforces the policy recommendation do both increase the percentage of small projects and decrease the total budget for the reconstruction policies.

Conclusion

This paper presented a proof of concept model and initial simulation results of the impact reconstruction projects could have in a Counter-Insurgency environment. Although the model functions and provides output similar to the theoretical models that FM 3-24 provides, it is not calibrated to historical examples of counterinsurgency. Future research and work could be devoted to exploring how the model's outputs compares to these historical examples given those circumstances.

The major insight from this application of System Dynamics is that a better balance between the number of small projects funded from the Commander's Emergency Response Program and the number of large reconstruction projects could potential reduce the amount of funds required for reconstruction. Although the model only generated similar behavior to that FM 3-24 presents as typical behavior in an insurgency, the insights appear to be valid. Future work could include modifying the model to make more variables endogenous to the system. Additionally, a more detailed calibration of the model could be conducted to determine the exact funding levels and percent allocation to small projects to maximize the development of essential services in a given nation.

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