Exploring Policy and Initiative Decision Making in a Dynamic Conflict Environment

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Abstract
The need to provide resources to tactical forces requires a long and often vulnerable logistics tail, which draws forces from forward operating areas and exposes support units to hostile action. The additional requirement of securing and transporting resources to tactical forces effectively increase costs, delivery times and challenges the decision making of leaders. This model allows those leaders to investigate energy and infrastructure considerations in a red vs. blue simulated conflict environment. This approach is important as often operations oriented wargames and models discount the requirements for logistics, providing an incomplete examination of the tactical or operational problem. By using System Dynamics, the logistician can investigate those factors that influence and limit operations and identify possible solutions and test initiatives applicable to the logistical problem. The goal of this paper is to outline how a system dynamics model may adequately simulate the battle space such that users may then experiment with logistics policy and initiatives in a gaming environment.

Introduction

The concept of red vs. blue "wargaming" has existed in multiple forms since the first simple strategy games were devised centuries ago in the form of chess, checkers, go, etc. These strategy based "wargames" in simple terms represent a field of battle occupied by units with special capabilities guided by rules of engagement that determine how units may operate and defeat opponent units. These centuries' old "wargames" represent limited levels of complexity that mimicked the battlefield at the time of their inception when battles were more of hand to hand endeavors and tactics and strategy were less complex. In recent history technology has allowed the growth in complexity of the wargame to essentially parallel the development in the materiel of warfare (Amico 1973) and actually impacted the training of forces and leadership staff.

Armed Conflict has evolved over the centuries from simply throwing rocks, shooting arrows, carrying swords and shields in armed forces that lived off the land as self-sufficient, independent entities with limited communication and guidance from their home countries. The invention of gunpowder influenced the use of pistols, rifles, and canons in warfare, while influencing tactics and strategy that separated forces on the battlefield. The development of aircraft, tanks and electronics further influenced the impersonal and long rang tactics of conflict by establishing long range bombing, aerial combat, radar, and long range communications. Eventually, armed conflict evolved into its current form using mechanized forces, aircraft and missile systems operated by distributed forces requiring a large complicated web of distributed logistics and a network of (Intelligence, Surveillance, Reconnaissance) ISR and communication systems that allow forward operating areas to stay connected with military command and control and political leadership at home.

The increasing complexity of conflict doesn't diminish the need to develop "wargames" that replicate these tactics, strategies, and capabilities. The difference is that today "wargaming" is used for learning as well as entertainment. Most analytical wargames take on seminar form to manage the intricate details of specific problems. In the rare case that a wargame is modeled with computer technology, the level of complexity necessary to simulate each individual mission within the area of operation and track the web of necessary logistical support are so complex, it takes significant amounts of time to run scenarios and analyze the results. For faster and simpler wargaming, operators have a tendency to assume that the logistics will support any operational decision they make such that they do not fully understand or see the entire picture or implications logistics management can have on their future operational goals.

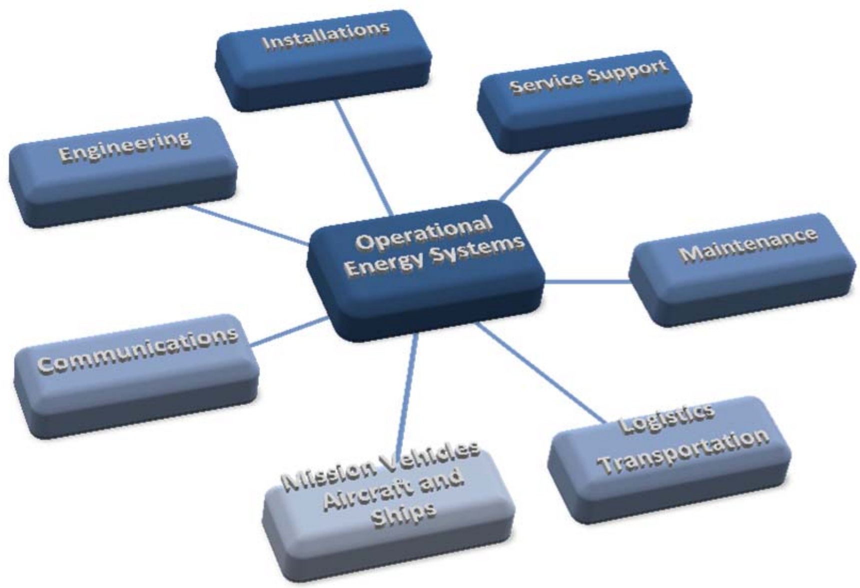

Figure 1: Supporting missions to be considered to maintain typical operations

The BATTLESPACE model is a customized wargaming platform for logistics management while assuming continuous operational goals will continue to drive demand in a conflict environment. The continuous nature of operations and logistics and each capable of impacting the other through feedback made system dynamics methodologies (Sterman 2000) well suited to the development of this model. It allows major stakeholders including operators and logisticians to stress the environment of the forward operating area and analyze and assess the impact it has on the things like storage capacities, distribution methods, delay times, etc. to individual bases and how that in turn affects operational capability. BATTLESPACE provides quantitative answers to challenging questions:

- Which policy or initiatives are most effective during steady state, conflict, or crisis response operations?
- What are the logistic challenges faced during steady state, conflict, or crisis response operations?
- What is prioritized as most critical and how does it influence operational capability?
- What are the primary considerations in choosing or developing new initiatives or policies?

Purpose

The purpose of the BATTLESPACE model is to establish a game platform that allows stakeholders to investigate the often overlooked logistics involved in supporting forward operating bases. The model reasonably simulates operations to drive logistics with a number of mission types based on the available force structure. It has the ability to affect operations and logistics based on conflict, natural disasters, training, and the need for ISR capabilities. Eventually, stakeholders will be able to enter any force structure whether it includes aircraft, naval ships, missiles, etc. which will drive simulation complexity of operational capability.

While applicable for investigating all levels and variants of logistics, the current case study investigates the distribution and consumption of energy based on supporting aircraft operations at multiple forward operating bases. In today's energy dependent environment, there is a priority to investigate more efficient, cost effective, and secure energy alternatives. (Force 2008) The goals of the case study and analysis of energy based scenarios include:

- Improving Operational Capabilities
- Reducing or Controlling Operating Costs
- Enhancing Energy Security
- Lower Energy Consumption

Model Description

The BATTLESPACE model reasonably simulates and is capable of stressing the logistical chain supporting any number of individual forward operating bases overseas. It models the distribution to and consumption of logistical resources at the bases as it relates to the operational stress. For example, a base supports multiple types of missions whether in conflict or not, consuming generated electricity, fueling vehicles and aircraft, shipping cargo and munitions, etc. The more bases included in the model, the more complex the logistical web becomes furthering the need of a model to account for where everything is going and how it is being consumed. The central driver for all of the model behavior is the operational tempo (OPTEMPO) each base must maintain to complete its assigned missions. OPTEMPO is defined by the intensity and number of missions within the defined area of operations. (Garamone, 1999) For the purposes of this model, OPTEMPO of the blue force is determined by the training of forces, ISR, response to natural disasters and the conflict environment between red and blue forces.

The conflict environment is developed by the interaction between the reinforcing loops and balancing loop depicted in Figure 1. The behavior of the conflict reinforcing loop drives the interaction between red and blue forces. As the level of conflict increases, the number of possible missions increases and is further defined by the level of aggression set for blue forces, adjusting OPTEMPO. The increased OPTEMPO increases the likelihood of an interaction between red and blue forces which, in turn, increases the level of conflict. The conflict environment also directly affects the level of attrition (Bull 2010) in the form of a balancing loop which determines the availability of assets supporting sorties that determine OPTEMPO. However, as indicated in real life, the forces would replace the lost assets from attrition with reinforcements. This means the attrition loop only serves as a delay to the reinforcing behavior of the conflict unless the forces are completely exhausted, which is unlikely given the timeframe and scenarios being tested.

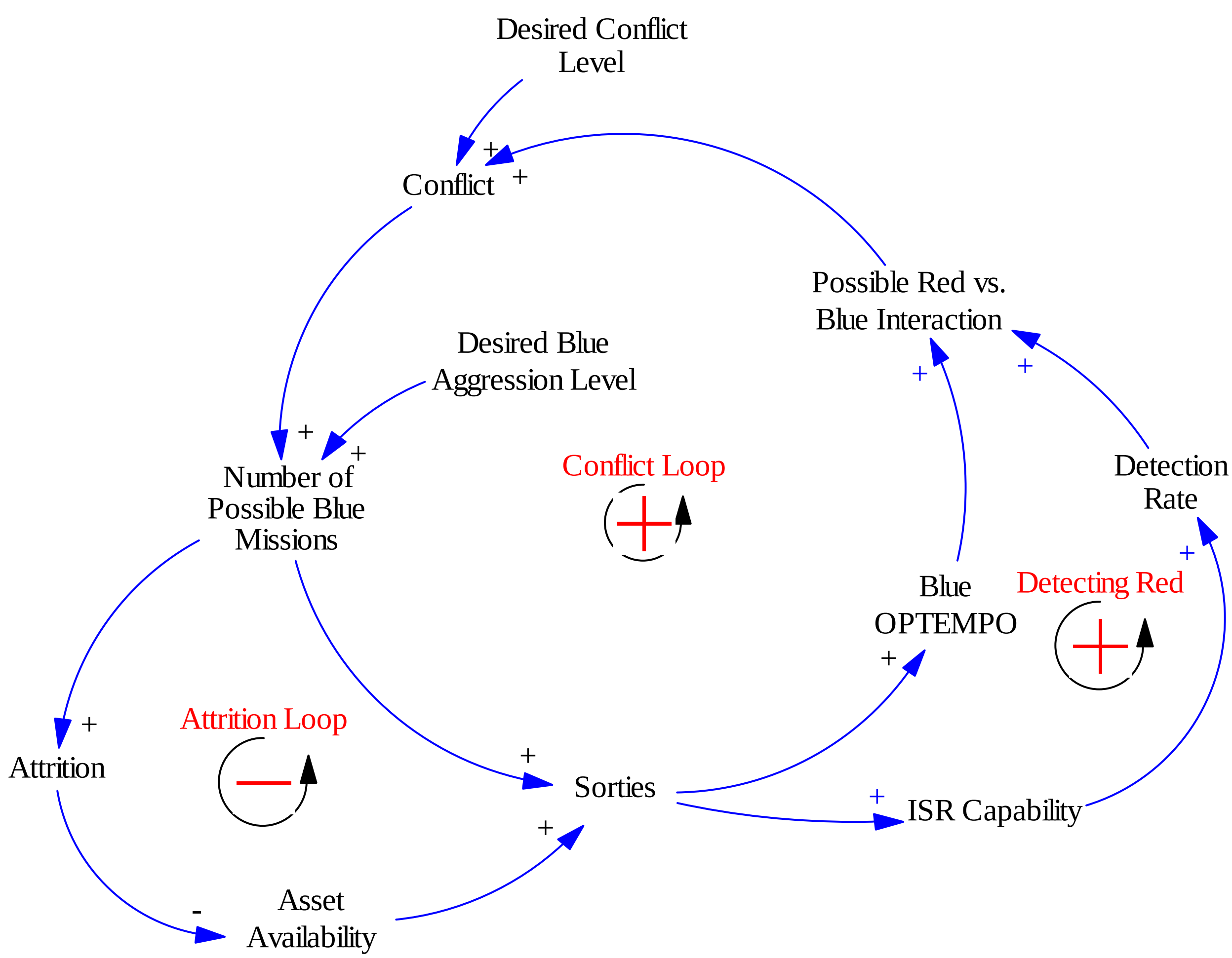

Figure 2: Causal Loop Diagram of Conflict Impact on OPTEMPO

Initially, the reinforcing behavior of the conflict is unchecked and may continue to grow exponentially until the balancing loop limits the conflict level by reducing the number of assets available to the blue force. This is confirmed by the premise that threatening and retaliatory action just breeds more and more conflict until resources are depleted or forces are completely destroyed. From the model perspective, there is no insight into the red force strategy, assets, or logistics and blue only registers red presence based on its ISR detection rate. Each asset that takes off has a certain level of ISR capability, but some assets specialize in ISR operations so the number and mix of assets employed affects the detection rate.

To manage the unrestricted growth in conflict, the reinforcing loop was turned into a goal seeking behavior by allowing the model user to set a conflict factor and the level of aggression of the blue force. The result is a quantitative measure of conflict from zero to one hundred percent that is constrained by resources and impacts behavior. Blue aggression is also a measure between zero and one hundred percent to determine if the blue force is on the offensive or defensive and at what intensity. These two metrics work together to determine the level of conflict that employs assets to achieve OPTEMPO without getting into specific mission planning. These metrics also allow for the assumption of outside forces that impact conflict but are not seen from the perspective of the model (diplomacy, economics, media, etc.)

Secondary to the conflict environment but primary to the purpose of the model and its underlying use are the effects of distribution and consumption of fuel, munitions, cargo, and other resources as it relates to the management of logistics. The delay in providing these resources to forward operating areas constrains operational capability such that it becomes critical to understand the balance between onsite capacities, travel time and delivery method alternatives. The cyclical dynamics involved (Morecroft 2007) stem from the interaction of feedback loops in Figure 2.

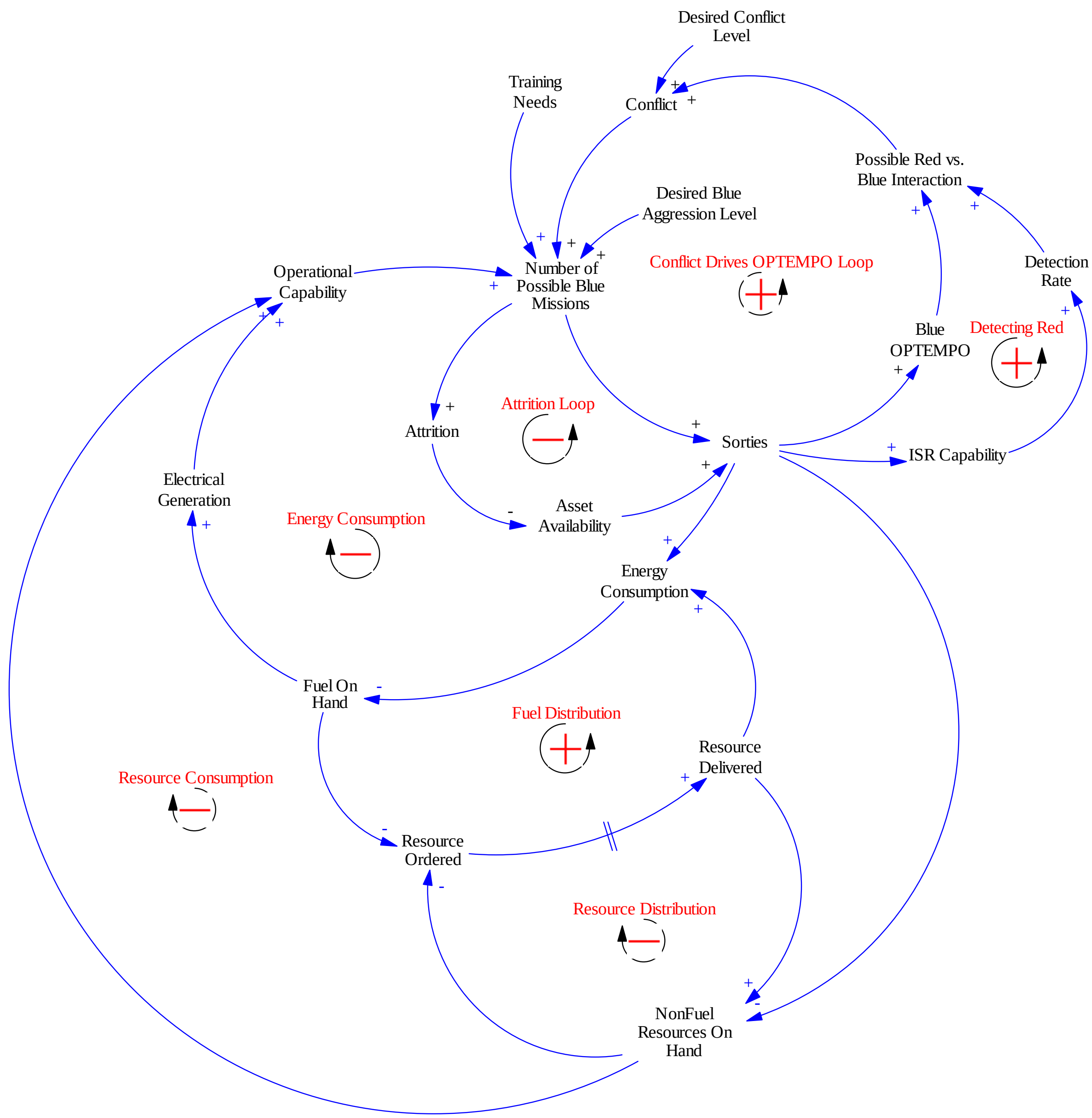

Figure 3: Feedback from Resource Consumption and Distribution

The complex interaction of the resource consumption and distribution feedback loops is compounded by the delay between order and delivery time. The resources are subdivided into fuel and nonfuel feedback to account for the additional complexity of both types drawing on available energy to maintain their relative distribution networks.

The model is dependent on a custom input sheet that initializes many variables that affect behavior within the model. The data will primarily be populated with force statistics and model assumptions dictated by the white team that develops and manages the wargame scenarios being tested. The final data entry is dependent on the wargame participants to choose the force structure they wish to simulate and affect logistics given the scenario parameters.

The model generates random missions according to the scenario parameters (conflict, crisis response, aggression, etc.) and tracks operational assets as they are employed to accomplish missions. The assets are all categorized under a capability type that can then be assessed based on operational capability and energy consumption. Operational Assets are currently divided into the following capability categories:

- Air Superiority
- Precision Attack
- Global Rapid Mobility
- Command and Control
- ISR

The simulated resource storage and distribution tracks several types of fuel, cargo, and munitions from multiple origination points using several transportation methods. Base characteristics and policy are pivotal to accurately capturing the behavior that is impacted by capacities, thresholds, and delay time.

Analysis

The actual results of the analysis are not included in this report due to the sensitive nature of the information. This information was provided to the client only and is released at their discretion. A small selection of generic output was generated to demonstrate the wargame applications and data impact had on participant discussions and decisions.

To test the viability of the model to help make decisions that will positively impact logistical capabilities and support the operational environment, BATTLESPACE was used to investigate distribution, storage and energy consumption supporting aviation operations. The case study compared baseline force capabilities and a reasonable approximation of what energy consumption in the conflict environment looks like in stressed conditions as well as more relaxed alternatives. Additionally, scenarios investigated future force capabilities by allowing the selection of future platforms, alternative energies and more efficient initiatives. Below is an overview of some of the scenarios the model will simulate to highlight logistical challenges:

- Conflict: A range metric from zero to one hundred that generates aggression by red force that blue must respond to
- Aggression: Another factor of conflict that sets the level of aggression the blue force will engage in outside of responding to red aggression
- Natural Disaster: A range of intensity that can impact the based directly halting operations or indirectly by generating the need for crisis response and humanitarian aid
- Initiative Selection: Various new and upgrade technology to add to or improve capability and efficiency of assets, facilities, storage, transportation, security, and more

The participants then proceeded to plan the procurement and implement energy policies with a full understanding of the scenarios affecting their “current force”. Given budget constraints and a projected timeline, the participants selected initiatives for the expressed purpose of affecting the energy concerns of their “future force”. Discussion included cost tradeoffs, viability of specific initiatives under certain conditions, and relative security concerns. The range of initiatives ran the gauntlet of inventing new technologies to changing the culture of the force.

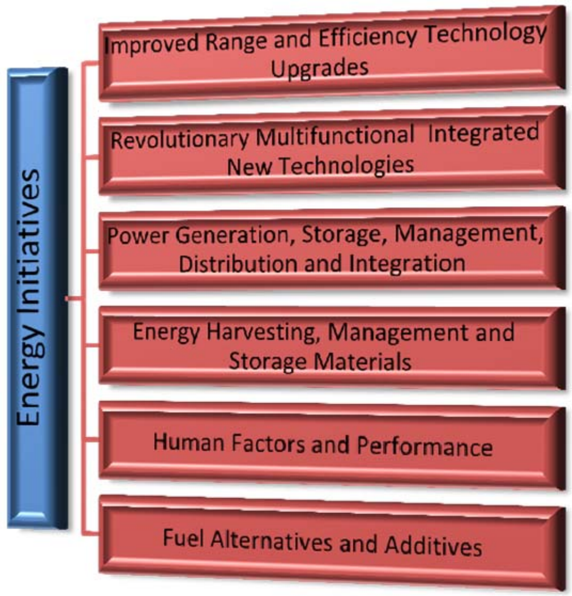

Figure 4: Energy Initiative Categories

As a quick example of how a turn in a seminar game may play out, a conflict value was set and maintained throughout the comparison of three runs. In the first scenario, participants conduct a facilitated discussion to choose a force structure that adequately estimates today's capabilities. For the second scenario, facilitated discussion focuses on initiatives that would adequately upgrade the force structure such that it would be more efficient in the face of a similar conflict. Finally the third scenario envisioned encountering similar conflict 20 years in the future, focusing discussion on reevaluating the force structure to encompass new platform technologies.

The output in Figure 5 clearly shows that the decisions made in each subsequent scenario reduce the fuel consumption at the base. Each simulation stimulated in depth discussion, a chance to review the previous results, and assessment of the likelihood of adopting proposed initiative. The benefits of the learning involved during these scenario runs were aided by the quantitative results to support the decisions of the participants.

Figure 5 shows the fuel consumption distributed by platform capability. The high level of consumption in the category of precision attack confirms the OPTEMPO set in the conflict environment. The OPTEMPO drives demand for logistics which is high based on the amount of fuel consumed in the Rapid Global Mobility category.

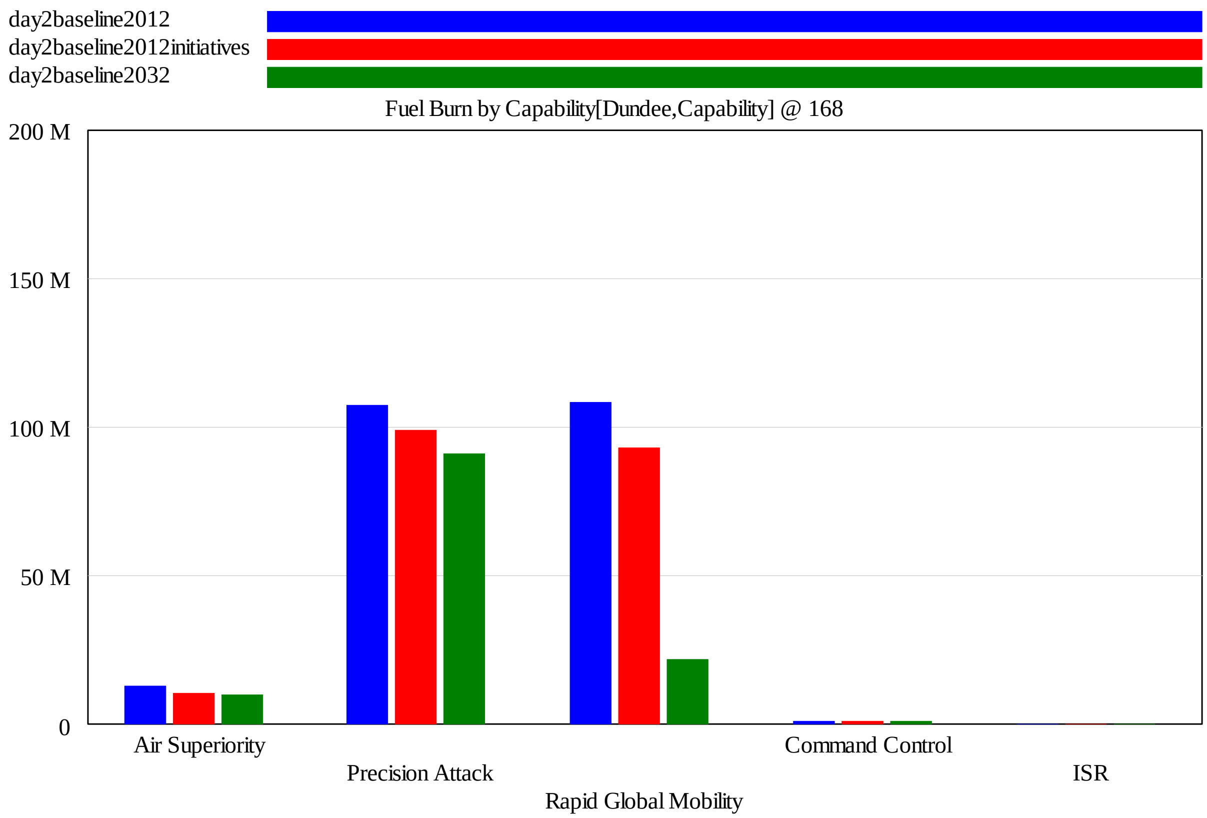

Figure 5: View of Fuel Consumption based on Capability

The output of the graph above confirms the subsequent reduction in fuel consumption relative to capability. This output also indicates that as the efficiency of these platforms increase do to selection of new or upgraded technology initiatives, the same OPTEMPO was maintained with less reliance on fuel. The result was less dependence on logistics needed to supply that fuel and a significant drop in fuel consumption in the category of Rapid Global Mobility which includes transport and air refueling operations.

The quick turn adjudication of participant decisions allowed multiple “what-if” scenarios to play out with easy force structure changes and without having to spend considerable time altering mission plans. To focus discussion and facilitate understanding of the impact of their decisions, wargame participants have access to a variety of output. In each case they may see a breakout of the assigned sorties by platform compared to their relative fuel consumption which may drive decisions about which initiatives are chosen.

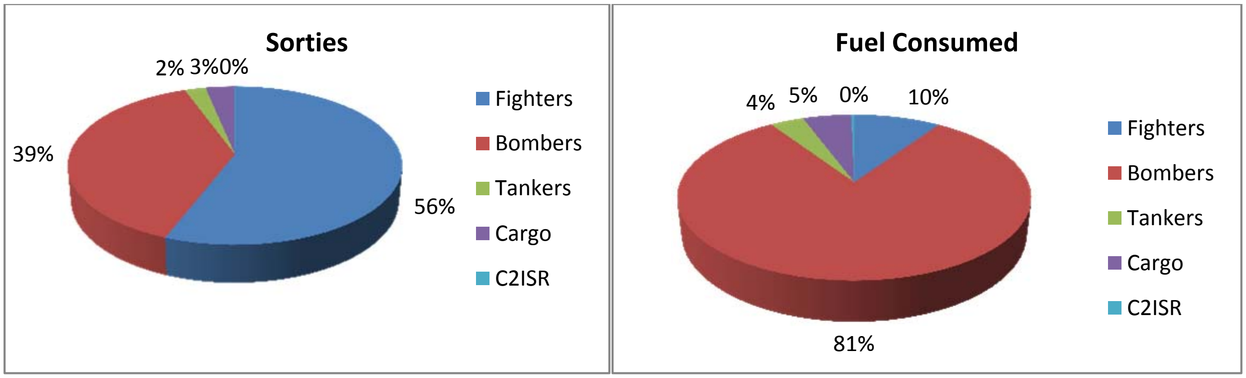

Figure 6: Comparison of sorties to fuel consumption

In addition, participants may assess the energy security of the force and their associated bases and to better understand their choices about alternative energy initiatives. It is typical during seminar wargames to divide participants into separate teams and compare how different choices are made. In these cases, it is possible to compare the results and gain an understanding of what drove these differences in decisions and assess the underlying impacts to cost, security, and operations.

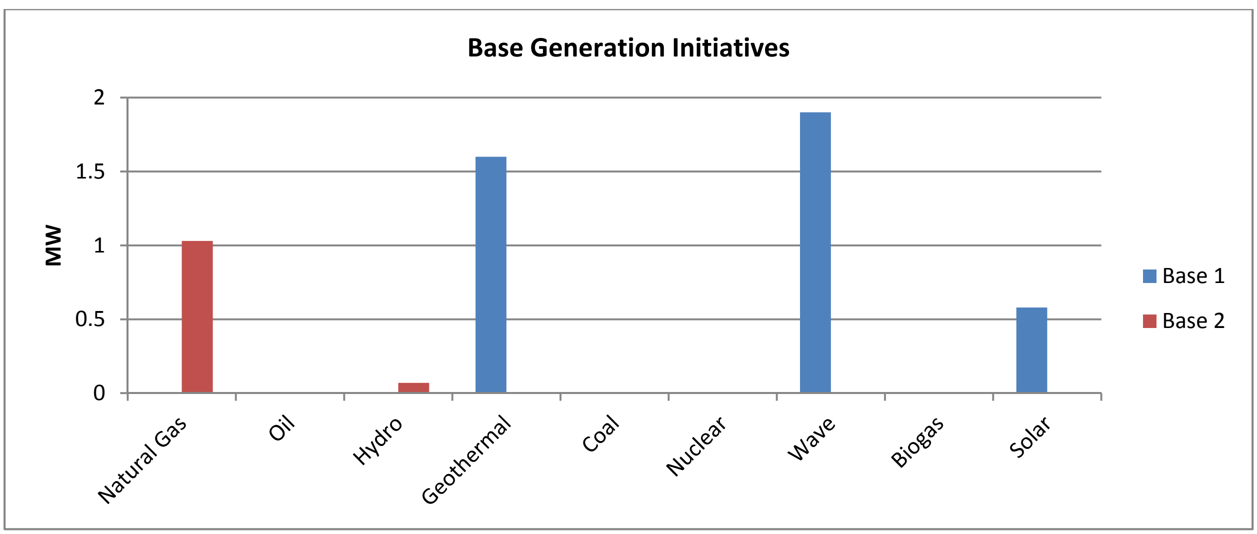

Figure 7: Comparison of energy generation initiatives of two separate teams

As demand on energy is constantly growing as populations rise and new technology is invented continuing unchecked unless policy is put in place an alternatives are successfully implemented. To ensure that wargame participants understand these impacts for the future force, typically a baseline is run that ages the force and a shows a steady growth in energy demand to account for new base, new platforms, and additional force. That baseline is then compared to the overall impact of their energy initiatives as they chose to implement them, allowing for the comparison of possible future outcomes.

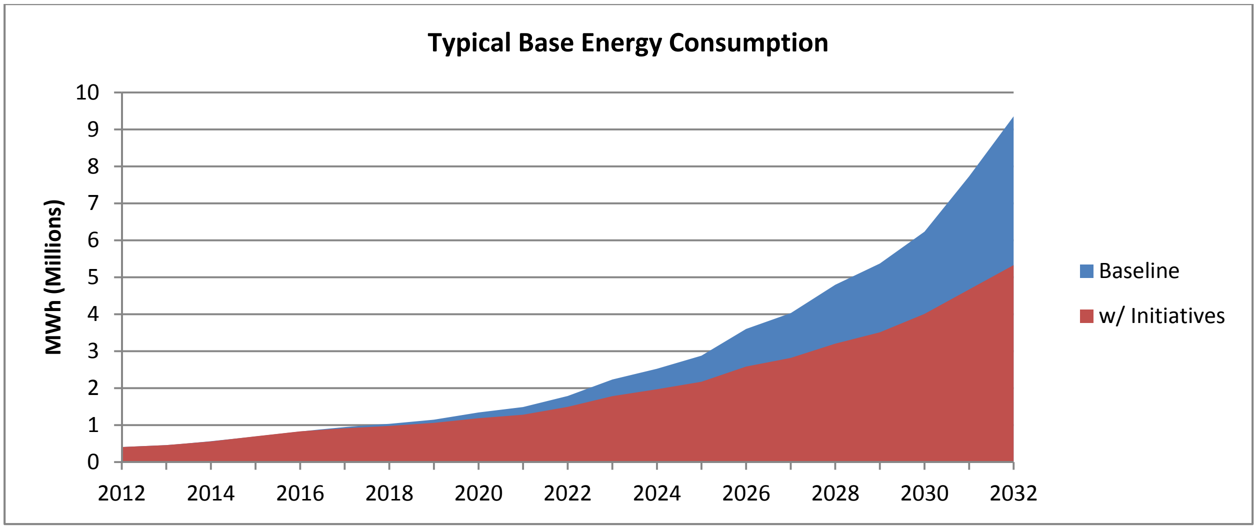

Figure 8: Comparison of energy consumption over time

Conclusion

Wargaming is not a new concept, but the level of complexity involved in simulating extended mission based operations and supporting logistics is relatively new and dependent on significant processing power and time necessary to calculate results. BATTLESPACE simplifies the wargaming concept by using system dynamics methodologies to make assumptions that standardize the operational approach and focus on logistics management. This model is applicable to any company, agency, or group that must maintain long range logistics for extended periods to achieve operational goals looking to experiment with policy and initiative impacts:

- Provides a platform to generate an OPTEMPO that drives demand for logistics simulated to test strategic decision making crucial to operational success
- Allows logisticians to stress test issues that affect the distribution of resources
- Provides insight into how operational policies affect logistics and how logistical policies impact operational capability
- Provides quantifiable insight into the worth of initiatives chosen to increase supply, decrease demand, and make more efficient use of resources

The BATTLESPACE model is custom built to focus on logistical planning, development, and implementation and examine stressed operational scenarios. The sophisticated methodology of the model generates an OPTEMPO of multiple missions using a force structure of multiple asset types with different capabilities. It takes in detailed data about the operational area and statistics of the force assets and any underlying assumptions about conflict behavior including attrition, reinforcements, etc. The model is not meant to predict logistics in the real world environment, but to act as a platform to learn about the behavior of logistics and test the impacts of adopting initiatives or establishing policies to aid in decision making. The model is still in continuous development, constantly adding features as it is further refined with improvements:

- Expand capability to include naval, mechanized, infantry, missile and special Ops based missions to utilize additional force structure assets and develop a more complex operational picture and by extension, logistics capabilities.
- Include touch points for commercial influence on logistical planning including contracted transportation,
- Develop a methodology that allows the individual bases to cooperate, share assets, and realign resources within the local network

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