Vying for Survival: Bolstering a Proxy Actor's Military Capability

Blaine Jones[a*], JD Caddell[a,b]

[a]*The United States Military Academy, West Point, New York 10997, United States of America*
[b]*Stevens Institute of Technology, Hoboken, New Jersey 07030, United States of America*

Abstract

Understanding how policy interventions affect the composite capability of a proxy actor is critical for policymakers who desire to increase the capability of actors engaged in proxy wars. Leveraging manpower modeling, this study shows how this approach can be used to connect the experience level of an army to personnel capability. Additionally, utilizing organizational equipment lifespan and maintenance models, this research investigates the effects of increasing maintenance rates and its effects on equipment capability in a military. By leveraging a systems dynamics model, this study constructs a simulation tool that allows policymakers to analyze the effects of their decisions on an actor's overall composite capability as a combination of equipment and personnel capability.

Keywords: manpower modeling, system dynamics, proxy war

1. Introduction

Following the fall of the USSR, Ukraine's border with Russia was contentious. The border tension escalated in 2014 when Russia annexed the Island of Crimea. Ultimately, the heightened tension between Russia and Ukraine boiled over in 2022, when Russia invaded Ukraine from three different axes. In the wake of the Russian advance, the United States, the United Kingdom, Germany, and various other Western and NATO countries flooded Ukraine with various military assistance. Some of these countries provided training, intelligence, and equipment or a combination of all three. All the military assistance was provided to increase the capability of the Armed Forces of Ukraine Military assistance allowed Western and NATO countries to promote Ukrainian in large-scale combat without needing to personally intervene. But the second and third-order effects of degrading an adversary while attempting to increase the capability of the Ukrainian military have made Ukraine exclusively reliant on continued Western military assistance to continue functioning.

An aspect of promoting the military capability of a country is forecasting its military capability as a function of its equipment and personnel. Military modeling often portrays military personnel life cycles as individuals advance in the organization, the composition of differing types of equipment in the organization, the military maintenance life cycles, and how they can be combined and adjusted in simulation to test how the resulting capability of the military changes. Simulating the capability of a military workforce has been extremely useful in determining potential pitfalls in workforce attrition, effects of policy interventions, and long-range workforce sustainment. A series of simulation models proposed by Mooz (1969) leveraged simulation modeling for the United States Air Force's long-range budget planning and manpower sustainment. This model was comprised of different types of aircraft, the number of pilots, their time in service, and their progression through training. Another simulation method constructed using the simulation software SLAM (Simulation Language for Alternative Modeling) by McGinnis (1994) has been used to map policy effects on officer career paths and the subsequent result on the personnel capabilities of the United States Army. The simulation method outlined by McGinnis (1994) identified the shortfalls in policy before they significantly affected personnel capability. Simultaneously, simulating the cycles of maintenance for systems of deteriorating components has shown promise to enable policies to be generated that can reduce the frequency of maintenance and the consequences for overall equipment capability. Mathematical models proposed by J. Enrenyi et al. (2001) leverage mathematical relationships to present conditions-based maintenance measures to increase maintenance and optimize the amount of equipment in the system. J. Enrenyi et al. (2001) utilize critical electrical infrastructure deterioration and mathematical modeling techniques to show how different types of maintenance can reduce the frequency of service interruptions increasing the capability of the equipment. Studies such as these provide valuable insight into aspects of a military but fail to outline how policies meant to bolster proxy military capability, a combination of equipment and personnel, could be modeled.

This paper provides a systems dynamics approach to investigating future policy implications on the growth or decay of a proxy force's military capability. It achieves this objective through the systems dynamics modeling of the Armed Forces of Ukraine's composite capability through the combination of both equipment and troop capability. This model introduces the variables that are associated with growing and supporting a proxy force and what is necessary to continue the growth of the proxy force's composite military capability. The simulation and its outputs show the effects of supporting a proxy military actor and the policies that can be made to make the actor more capable.

*Corresponding author email: blaine.jones@westpoint.edu

2. Introduction of Methods to Measure Military Capability

The military capability of a proxy force can be framed from the perspective of Koivisto, Ritala, and Vilkko's (2022). Military capability is an instrument of foreign policy, in which all the components of a state's functional capability contribute to a state's overall defense. The relationship between people, their equipment, and subsequent feedback generates the overall functional capability of a military, and this can be used to define the capability of the system of material and personnel.

2.1 Introduction of Systems Dynamics to Measure Military Capability

Systems Dynamics is a modeling and simulation tool that outlines the mathematical relationships between different variables and their change inside a system. It can be utilized to explain and understand relationships that are often complex and nonlinear. Created in the 1950s by Jay Forrester, Systems Dynamics can be used to explain how the internal feedback structure of a system generates dynamic complexity and how this complexity relates to the internal behavior of the system's pieces (Sterman, 2000). Because of Systems Dynamics' usefulness in studying differing dynamical behaviors, the models can represent policy analysis and how social systems respond to different policy interventions (Casey & Töyli, 2012). Military Capability traditionally, has been considered through the lens of defense capability and force structure analysis (McLucas & Elsawah, 2020). McLucas & Elsawah (2020) assembled military capability as a combination of personnel, equipment, and organization; that is used to generate a force structure to inform policymakers on a country's level of preparedness.

Systems Dynamics Modeling efforts to understand a military's personnel capability traditionally revolve around individual workforce management and recruitment sustainability. Workforce management inside of the military is dynamic, due to each individual entering, leaving, and advancing inside of the military. McLucas & Elsawah (2020) represent the dynamics of personnel as they enter, are trained, leave, or are promoted. Individual progression in the military is usually extremely rigid and hierarchical, with there being requirements (certain levels of experience, time in service, or other professional requirements) to promote. Systems Dynamics simulations analyzing individual military advancement have been modeled using aging chains that evaluate promotion requirements with individual military progression (Armenia et al., 2012; Wang, 2020). Armenia et al. (2020) utilize this approach to represent the promotion of senior officers in the Italian Air Force, mapping senior officers using three relational flows: officer recruitment, officer promotion, and officer dismissal. Officer recruitment increases the total population of officers in the system, officer promotion transitions the officer from one rank to the next, and officer dismissal is where the officer ultimately leaves the system by retirement or by being relieved. For Armenia et al. (2020) the use of aging chains for the analysis of the personnel in the system allowed gaps to be exposed between the desired number of officers and the current number of officers leaving the military. Allowing Armenia et al. (2020) to generate different policy analyses that could address the gaps in managing the senior ranks in the Italian Air Force.

Because militaries rely on personnel recruited from the population to sustain their operations, if the size of the population cannot contribute to the military, military capability will suffer. The sustainability of the Croatian Military Forces Systems Dynamics model used by (Tustanovski et al., 2015) represents the topic of recruit sustainability to address the relationship between Croatia's total population and the size of its military. The most significant finding from Tustanovski et al. (2015) was that a reduction in the population of young individuals in Croatia resulted in a proportional decrease in the size of the military. Because military capability is directly affected by the number of individuals entering the military, if the population of a country shrinks, it makes it extremely difficult to sustain heavy losses, replace these losses, or further expand the size of the military necessary to deter an adversary.

While personnel are a critical aspect of military capability, to fully encapsulate military capability one must also consider the equipment that they will be fielding. Military equipment models often focus on life cycle sustainability and maintenance cycles. Varelis et al. (2002) life cycle maintenance model is a useful way to outline the evolution of maintenance on the number of platforms available and how it affects an increase or decrease in maintenance for a fleet of aircraft. Because engines are mechanical systems, they necessitate maintenance to continue functioning. For Varelis et al. (2002) the quantity of working engines available was the direct result of the interaction between the components of repair rate, failure (breakdown) rate, and engine destruction. The most significant insight from Varelis et al. (2002) model was that the amount of maintenance necessary to sustain the amount of working aircraft engines significantly increased with heavy usage. This enabled policies to be enacted to increase the number of available aircraft engines—which increased the total life span of the engines—while increasing the overall performance factor of the engines.

McLucas (2001) developed a model to inform military decision-making by combining both personnel and equipment. McLucas's (2001) model defined readiness as a combination of the effectiveness of military forces and their preparedness to respond to military threats. McLucas's (2001) model generated this combination by running simulations changing the internal components of personnel, training, and equipment. Where McLucas concluded that as training rates increased personnel and equipment casualties would occur, altering the inner dynamics of the affected military. To compensate for the increased attrition, militaries had to implement policies to increase the amount of equipment and personnel in their militaries to maintain the military capability to respond to threats at the strategic level.

This paper builds upon the Systems Dynamics military workforce management and recruitment sustainability models built by McLucas & Elsawah (2020), Armenia et al. (2020), Tustanovski et al. (2015), and the equipment maintenance life cycle model by Varelis et al. (2002) to build a model to simulate policy interventions on a proxy actor's composite military capability. It will seek to bridge the gap between previously outlined methods, representing military capability as a combination of the two distinct systems not previously addressed in military modeling.

2.2 Introduction of the Casual Loop Relational Diagrams

High-level causal loop diagrams are useful to establish an understanding of how all the pieces in the model fit together. The composite capability of the Ukrainian Armed Forces is a function of their Troop and Equipment capabilities. As shown in Figure 1, as *Equipment* and *Troop Capability* increase the *Composite Capability* also increases due to the positive relationship that troops and equipment give to the capability of a fighting force.

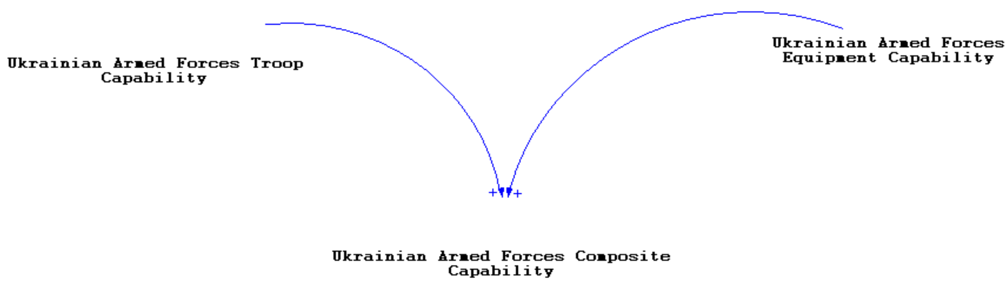

Figure 1. Composite Capability as a Combination of Troop and Equipment Capability.

Figure 2 builds off Figure 1 by introducing a causal relationship that expands on Troop Capability inputs for Ukraine. Figure 2 outlines how the fraction of the population serving in the military changes in response to the number of soldiers and the population of a country. While a country's military is fighting a war, the troops in the military are going to need to be replaced to maintain a *Fraction of the Country in the Military*. While fighting a war, the *Soldier Replacement Cycle (B1)* can be used to outline how *Soldier Recruitment* increases the *Total Number of Troops* in response to exogenous *Soldier Attrition* and *Desired Number of Troops*. In large-scale combat conditions, the *Desired Number of Troops* might be situationally adjusted to increase the *Total Number of Troops* in the military. If the *Desired Number of Troops* significantly outnumbers the *Total Number of Troops* in the military; this creates a *Delta Troops* difference between the *Total Number of Troops* and the *Desired Number of Troops*. When this Delta Troops variable is large enough it is going to spur an increased *Soldier Recruitment* rate to replace those lost by *Soldier Attrition*. The *Delta Troops* variable continues to grow while the *Total Number of Troops* decreases until the *Total Number of Troops* matches the *Desired Number of Troops*. The growth in the *Total Number of Soldiers* ultimately balances the number of soldiers in the *Soldier Replacement Cycle (B1)*, by replacing those lost to attrition while matching the goal established by the *Desired Number of Troops.*

Simultaneously, the *Fraction of the Country in the Military* is also dependent on how the *Desired Fraction of the Population in the Military* and *Population Growth* change the *Unrecruited Population* size available for recruitment in the *Population in the Military (R1)* cycle. Usually, a country's military is comprised of a certain percentage of the country's population. However, the *Desired Fraction of the Country in the Military* might be changed to accommodate for a change in the country's threat perception or if it is actively fighting a war. To simulate the Russo-Ukrainian War, a value of 0.09% of the population is going to be used for the *Desired Fraction of the Country in the Military*. This value is based on World War Two statistics of the percentage of the United States population that was in the military during the height of World War Two (Pew Research Center, 2011). When the *Desired Fraction of the Country in the Military* is increased, a difference exists between the *Desired Fraction of the Country* and the Current *Fraction of the Country in the Military*, creating a desire to leave the country to avoid military service. The increase in the *Population Fleeing Military Service* will lead to fewer available recruits, which shrinks the population. However, individual losses can be offset by *Population Growth*, which increases the number of the unrecruited population. The increase in the size of the unrecruited population ultimately reinforces the Population in the Military's (R1) *Fraction of the Country in the Military* because the fraction of the population in the military ultimately decreases with an increase from the Soldier Replacement (B1) *Total Number of Troops*.

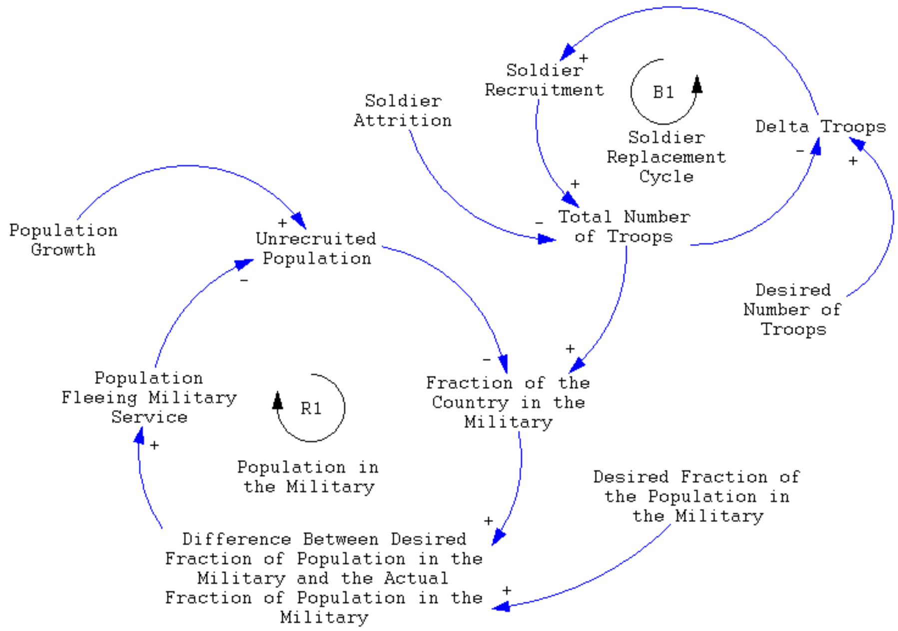

Figure 2. The Relationship Between Society and the Military.

While Figure 2 focuses exclusively on the personnel component of *Composite Capability*, Figure 3 is focused on how the equipment that these personnel are going to be using is introduced and retained inside the organization. One of the mechanisms of controlling the working equipment is to replace the equipment with equipment from storage by loop *(B3) Replacement* When there is not enough *Working Equipment* this increases the different between the current and *Desired Working Equipment* which leads to more *Equipment being Pulled out of Storage;* and a subsequent increase in the amount of working equipment. This loop will continue until the current equipment matches the desired Working equipment or there is not any equipment left in storage.

The other way that armies control their stock of equipment is through maintenance exhibited in loop (R2) Maintenance. When *Working Equipment* breaks down it becomes *Broken Equipment*. To return broken equipment to Working Equipment, the broken equipment will need to be repaired. Whenever *Working Equipment* increases, we expect to have an increase in the amount of *Broken Equipment*. This leads to an increase in the amount of broken equipment that can be repaired. The increase in the amount of broken equipment being repaired eventually leads to an increase in the amount of working equipment, thus completing the reinforcing loop.

While replacement and maintenance occur within an army's control, external donations and the attrition of our combat fleet are two variables that are external to these processes. Equipment Attrition is going to decrease the overall amount of *Working Equipment*, while *External Equipment Financing / Donation* will increase the amount of *Working Equipment* in the system.

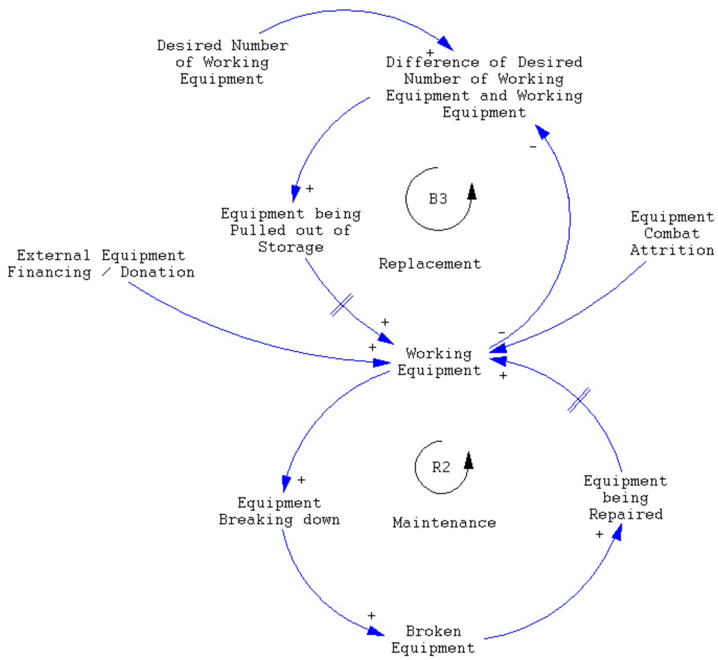

Figure 3. The Relationship of Working Equipment and its Replacement and Maintenance.

3 Stock and Flow Diagrams

3.1a Personnel Aging Chain Introduction

Modeling the military as an organization in large-scale combat conditions requires stratification to accurately account for distinct types of soldiers and their effectiveness. The aging chain structures proposed by McLucas (2020), Wang (2020) & Armenia et al. (2012) took a different approach that modeled individual progression through a rigid and hierarchical promotion structure. To model the conditions of the Russo-Ukraine War more accurately, a similar approach was taken, but we simplified the workforce management structures outlined by McLucas (2020), Wang (2020) & Armenia et al. (2012), to represent Ukrainian soldiers' advancement solely based on levels of experience. For accuracy, inside of the model, the individuals were organized and sorted by either not having any training and being unexperienced, being fully trained and assimilated but not combat experienced and therefore a novice, or fully trained and combat experienced and therefore experienced. Finally, regarding attrition, different categories were used to stratify the Ukrainian troops, where we adjusted Ukrainian attrition rates to encapsulate casualty rates as a function of the number of wounded or killed in action based on distinct levels of experience.

3.1b Presentation of the Systems Dynamics Aging Chain for Personnel

Aging chains are used to model the progress of troops based on the experience level in the Ukrainian Military. The *Delta Ukrainian Troops* is the difference between the desired number of troops and the actual *Total Number of Ukrainian Troops*, when this difference increases it will trigger an increased recruitment of troops into the Ukrainian Military. The *Recruitment Rate* pulls from the *Unrecruited Ukrainian Population* and transitions them to the population of *Unexperienced Troops*, which is simply troops without training. The troops will continue to first receive training and move into the Novice category, where novice troops will eventually become combat-experienced following a similar trajectory outlined in (Wang, 2020; Armenia et al. 2012). While individual troops will leave the system through attrition, the number of troops in each category *(Unexperienced Troops, Novice Troops, and Experienced Troops)* can be tailored by correctly adjusting variables in the model that impact attrition rates (*Unrecruited Population Flee Rate, Unexperienced Troops Nominal Attrition Rate, Rate, Novice Troops Nominal Attrition Rate, and Experienced Troops Nominal Attrition Rate*).

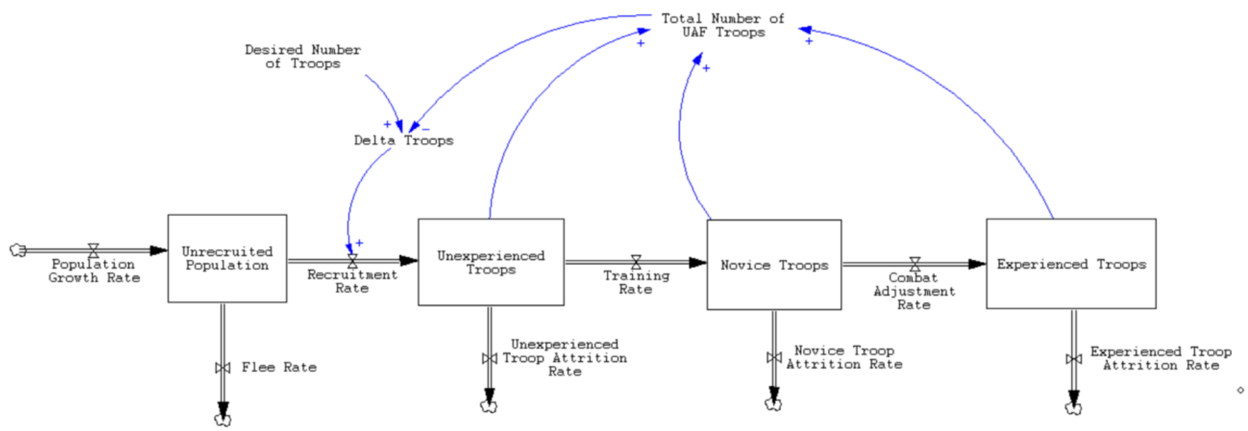

Figure 4. The Composition of the Armed Force of Ukraine

Troop Capability represents the fighting ability of the personnel within the Army as depicted in Equation 1. When the number of troops available equals the desired number of Troops and these troops have all assimilated and gained experience, this figure grows to 1. Differences in the total of number of troops or the average level of experience reduces the term. In this way, the equation captures how the changes in troop end strength as well as their level of competence affects the expected effectiveness on the battlefield.

$$\text{Troop Capability} = \left(\frac{Total\ Number\ of\ UAF\ Troops}{Desired\ Number\ of\ Troops}\right) * Troop\ Experience \tag{1}$$

Because of how Novice Troops are less experienced than Experienced troops Equation 4 can define Troop Experience:

$$Troop\ Experience = \frac{0.5 * Novice\ Troops + Experienced\ Troops}{Total\ Number\ of\ UAF\ Troops} \tag{2}$$

3.2a Equipment Systems Dynamics Model Introduction

Because modeling military capability necessitates modeling the personnel and the necessary equipment needed to operate. A model is needed that organizes and assesses the composition of equipment and its functioning status in the military. Similar work done by Varelis et al. (2002) outlines equipment in an organization as a combination of equipment repair rate, failure rate, number of engines available, and the total number of engines destroyed.

Tailoring the previous work done by McLucas (2001) to more accurately assess the composite capability of the Russo-Ukraine War required two distinct changes to the structure of the equipment model. First, the equipment had to be broken up into two distinct structures for the differing ages of the equipment while accounting for how the equipment is brought into both structures. Because most of the Ukrainian equipment before the war consisted of Soviet Era equipment, Figure 5 depicts the composition of Soviet Era equipment as it moves through breaking, being repaired, and being attritted. Similarly, since most of the equipment that has been given to Ukraine has been modern equipment Figure 6 starts at zero platforms and grows as more countries provide Western equipment to Ukraine over time. Second, how the equipment is introduced into the system also had to be accounted for. Since Ukraine possessed stockpiles of Soviet Era equipment before the beginning of the war, they were able to internally acquire Soviet Era equipment from the internal stock of *Stored Equipment*, additionally, externally Soviet Equipment was donated by some countries and is represented by the *Donation Rate Variable*. The acquisition of modern equipment differs in the model and is not considered to be internally acquired but instead is financed or donated from other countries.

3.2b Presentation of the Systems Dynamics Models for Equipment

Simpler models are utilized to represent the equipment and its state in the overall model. When equipment is used breaks down it moves to the population of *Broken Equipment* the number of *Broken and Working Equipment* for both models in Figure 5 and Figure 6 are predetermined. The equipment that is destroyed, captured, or rendered unserviceable is presented in the *Battle Loss Rate* and can be adjusted based on data to functionally represent the number of platforms that exit the system and are no longer able to be used. The Working Equipment will enter the system in Figure 5 through the *Pull Rate* or the *Donation Rate*, whereas the *Modern Working Equipment* will enter the system through the *Acquisition Rate*. The total number of Repairable equipment that can be repaired can be correctly tailored by adjusting the variables in the model that impact Broken and Working Equipment (*Repair Rate and Breakdown Rate*).

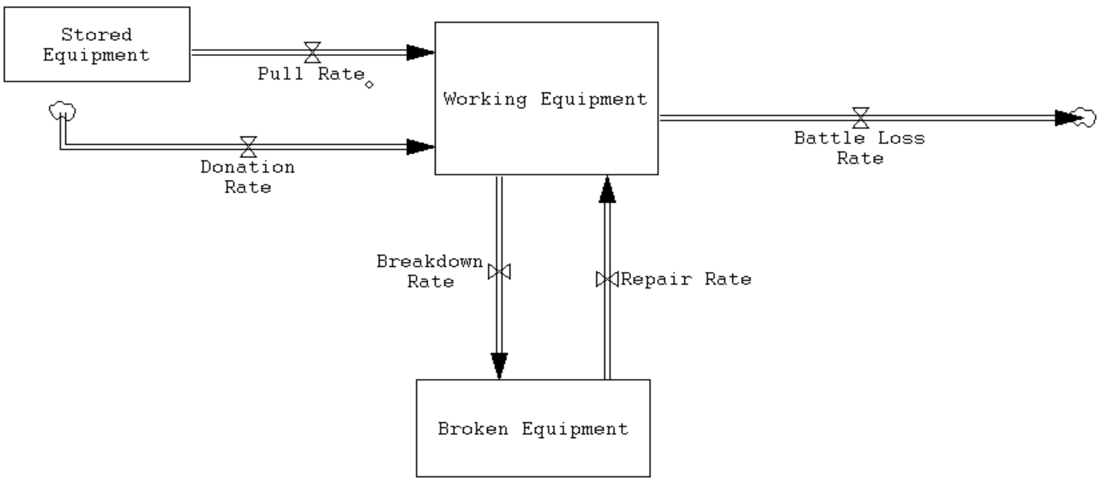

Figure 5. Systems Dynamics Model for Ukrainian Pre-War Equipment

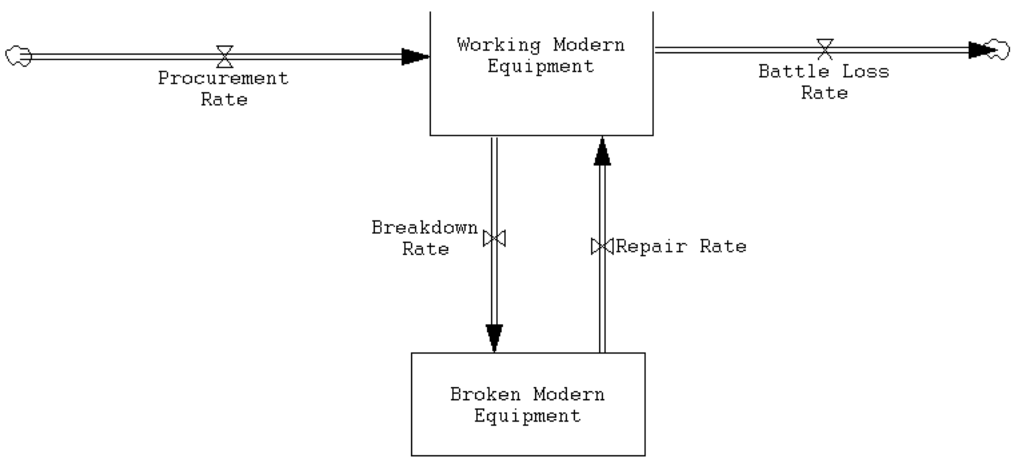

Figure 6. Systems Dynamics Models for Ukrainian Modern Equipment

From the Systems Dynamics Model of Equipment, the Equipment Capability will be generated using the equation presented below.

$$Min(1, \frac{(0.75)*(Working\ Equipment)+Working\ Modern\ Equipment}{Desired\ Equipment\ Level}) \quad (3)$$

Since composite capability is a combination of Equipment and Troop Capability the overall composite capability will be found using the equation below. Where the Composite Capability is the average of Equipment and UAF Troop Capability. When the UAF Troop Capability and Equipment Capability are maximized to one the average will be one, whereas if either decrease the Composite Capability will decrease.

$$\frac{Equipment\ Capability + UAF\ Troop\ Capability}{2} \tag{4}$$

4. Definition of Policy Levers

Increasing the capability of the Ukrainian Armed Forces is a difficult problem, originating from fighting conditions that rapidly degrade the available number of personnel and equipment. The first policy intervention to increase Ukraine's composite capability will be increasing the rate of modern equipment repair. This policy intervention is intended to give Ukraine an increased equipment repair rate, which will allow for more of its equipment to be repaired after it has broken. Traditionally, NATO countries have promoted increased repair rates of their equipment to negate unnecessary and expensive equipment replacements, additionally by increasing the maintenance rates of their equipment, NATO countries can field larger quantities of armaments in the field by having the capacity to repair more equipment than those that are lost to combat conditions or breakdowns.

The second policy intervention is increasing the external financing rate of modern equipment into the Armed Forces of Ukraine. This policy intervention will lead to an increase in the number of equipment platforms flowing into Ukraine. When dealing with a proxy actor, by increasing the rate of external financing, NATO can increase the composite capability of Ukraine without necessarily becoming too involved in the conflict. Increasing the rate of modern platforms flowing into Ukraine; allows Ukraine the ability to sustain a level of composite capability when dealing with equipment losses that result from equipment breaking down or being lost in combat.

The third policy intervention is increasing Ukraine's desired number of troops. Increasing the desired number of troops is going to promote an increased recruitment rate of soldiers into Ukraine. This intervention is designed as a means for Ukraine to increase the personnel capability of its army. It is intended to increase the total number of experienced and novice troops inside Ukraine's military, by scaling the army to offset initial personnel losses. Historically, militaries around the world have utilized this goal-based intervention based on the severity of threat perception and intensity of involvement in war, first, to scale their armies by increasing the number of soldiers in their army, and second, to maintain the capability of their army when dealing with extreme losses or high rates of soldier turnover.

Finally, the last policy option is decreasing the assimilation time of Ukrainian troops by decreasing the training time as they transition from unexperienced to novice troops. Unexperienced troops demand a certain amount of time to become fully trained and assimilated, by decreasing the amount of time it takes for soldiers to assimilate into the military, troops will be able to move from unexperienced to fully trained in a faster amount of time. Decreasing the assimilation time should allow Ukraine to have more fully trained soldiers available to take part in operations.

Table 1. Policy Interventions and their Levels

Simulation Number	Modern Equipment Repair Rate (Percentage of Platforms/Month)	External Financing (Platforms)	Assimilation Rate (Months)	Desired Number of Troops (Million Individuals)
1	15%	840	5	1
2	60%	840	5	1
3	15%	1340	5	1
4	15%	840	3	1
5	15%	840	5	2
6	60%	1340	5	1
7	60%	840	3	1
8	60%	840	5	2
9	15%	1340	3	1
10	15%	1340	5	2
11	15%	840	3	2
12	60%	1340	3	1
13	60%	1340	5	2
14	60%	840	3	2
15	15%	1340	3	2
16	60%	1340	3	2

5. Simulation Results

Leveraging the total cost of an alternative with the resulting composite capacity at a common time (time step 100), we can compare the results of the varying policies. In general, the more money spent on an intervention the larger capability being generated. By plotting each simulations values we can generate a tradespace for consideration. Figure 7 depicts the tradespace, with pareto optimal alternatives labeled and in blue. These points represent a tradeoff between increasing costs and increased capability. By selecting alternatives along the pareto frontier, policy makers are ensured to choose the most cost-effective composite capability. There are no alternatives that will generate the same or more capability for less cost.

Increasing the repair rate from 15% to 60% is the most inexpensive way to increase the capability of the armed forces (Simulation 7 and Simulation 14). But, without an increase in the amount of modern equipment coming into Ukraine from outside, Ukraine repairing the equipment it already possesses will not be able to overcome equipment that leaves the system through the *Figure 6 Battle Loss Rate*. Another more expensive option is increasing the external financing of equipment (Simulation 9 and Simulation 15) but over time the equipment capability rate is going to decrease as the repair rate is not able to overcome the breakdown rate of the equipment in the *Maintenance Cycle*. The most expensive option that can increase Ukraine's capability the most is simultaneously increasing the repair rate from 15% to 60% of platforms while also increasing the external financing of equipment to Ukraine (Simulation 12 and Simulation 16). This increases the rate of equipment that is available to be used in combat while also increasing the rate at the equipment that breaks down can be repaired.

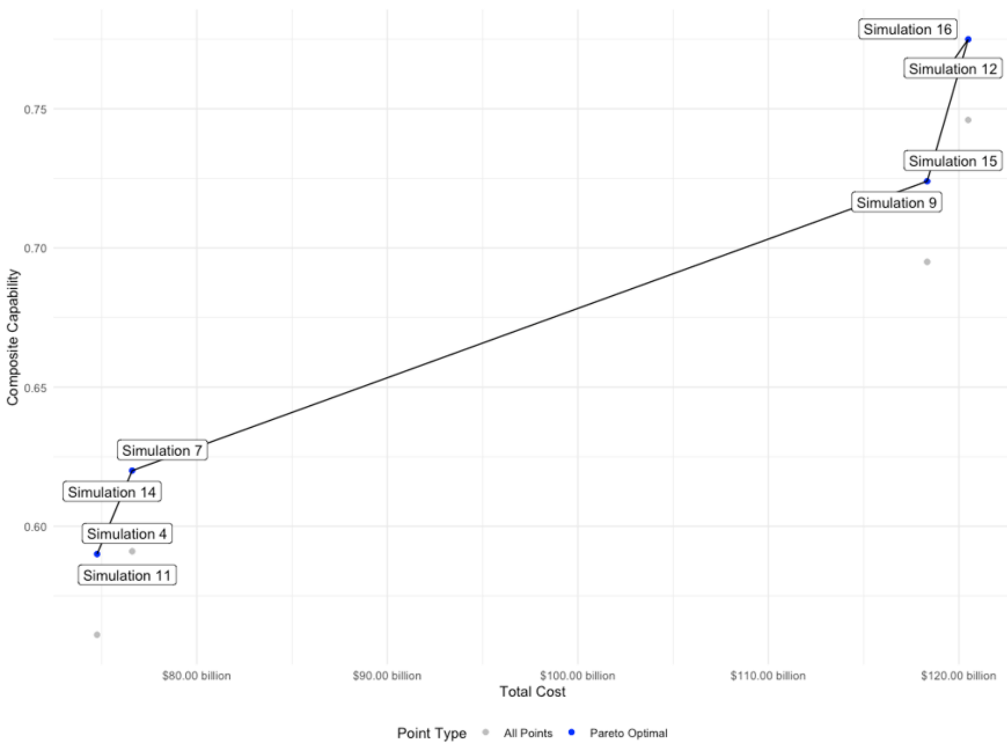

Figure 7. Pareto Frontier for 16 Policy Interventions

While the Pareto Frontier displayed in *Figure 7* the cost associated with equipment, Ukraine can conduct other internal policy interventions to increase and complement overall composite capability. All the optimal simulations outlined in *Figure 7* have a decreased Ukrainian troop assimilation rate, which allows the overall composite capability to be sustained over time by the increase in the number of trained troops that can be used for combat operations. In addition to the decreased troop assimilation rate, when Ukraine increases the desired number of troops it can lead to a substantial increase in composite capability. Simulation fourteen shows the behavior when an increased number of troops is desired but no change in the amount of equipment leads to a decreased composite capability because there is not enough equipment to supply the increase in the number of soldiers in the army. Simulation fifteen and Simulation sixteen show how an increase in internal policy decisions can complement external policy interventions, by increasing the desired number of troops and external financing rate, there is an increase in both the troop and equipment capability that leads to the greatest increase in the composite capability of Ukraine.

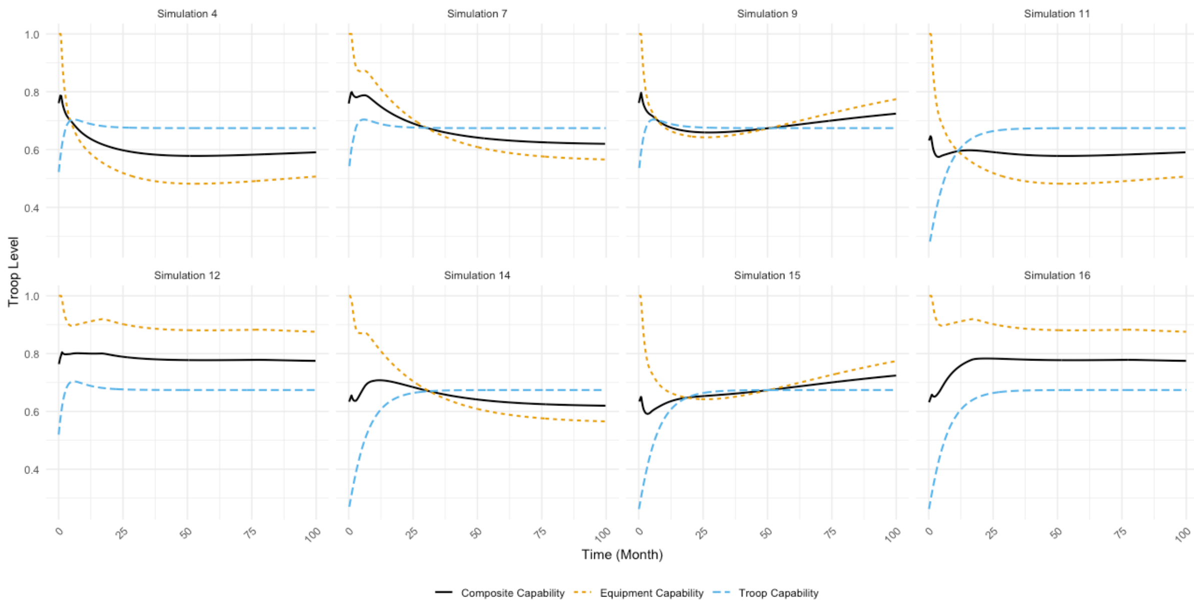

Figure 8. Composite Capability of Pareto Optimal Alternatives.

6. Limitations of the Model

It is important to note that when modeling active war conditions, it is impossible to incorporate all variables that could change capability into the model. Additionally, another issue with modeling a current conflict is the reliability, credibility, and source of all the initial data points that were used to feed the model and get the initial results. Because the Russo-Ukraine War is currently ongoing the amount of verifiable data is low and the data that is reported is either under or over-reported in the interests of the national security of both Russia and Ukraine.

While military assistance has the potential to extremely boost the capability of actors, there exists the perspective that the military is more used to utilizing their old equipment and that it could have the same or even more capability when compared to the modern equipment that the country is given. The model assumes that the old equipment the country utilizes is automatically less capable, but the possibility is that it might be overall more dependable and capable than modern platforms. The difference could occur due to the sheer differences in the number of platforms from an array of different countries that make it harder to adopt. The model could easily be expanded if most of the old equipment is performing better than the modern equipment given to the proxy actor.

Another critical issue that can negatively impact the results is if the modern equipment does not work. In the model, it is assumed that all the modern equipment that makes it into Ukraine is working. If the modern equipment is not in working condition it will mean that the composite capability will be over-reported. The model does have specific components that acknowledge returning equipment to working condition in the *Maintenance Repair Rate,* but this only acknowledges reactive maintenance efforts after the equipment has already been used. If circumstances change and Ukraine starts expecting a large amount of modern equipment to not be in working condition when it is delivered the model could potentially be extended to account for the implications and investigate how this impacts composite capability.

The equipment that is provided is focused on ground fighting platforms. The model fails to account for how naval or Air Force platforms impact composite capability. Since these weapons systems are expensive strategic weapon systems, the model would need to be expanded to incorporate them and further investigate their impacts on composite capability. Finally, the composite capability fails to fully account for how the enemy will change the capability of Ukraine leaving work to be done to further incorporate these changes into the overall Composite Capability.

7. Conclusion

This study presents how different policy interventions effect the composite capability of a proxy actor. The model enables leaders and policy makers to test and analyze the cost effectiveness of different policy initiatives and their effects on equipment, personnel, and composite capability. Our analysis of the model has revealed that to maximize the capability of a proxy actor in large scale combat conditions is going to require a substantial increase in external financing alongside increasing the amount of fully trained troops in a proxy actors army.

While the model does not capture all aspects of large-scale combat effects on a proxy actor, it provides a foundation for the future research into capability modeling of a proxy actor in large scale combat conditions. Additionally, the model can be adapted in the future to better account for the opponent engaged in the conflict. This study emphasizes the critical role of external financing in increasing the composite capability of a proxy actor and the associated cost over time. By understanding the dynamics of cost, equipment capability, troop capability, and composite capability; leaders can understand how best support actors engaged in similar conditions.

8. Acknowledgements

All the Systems Dynamics modeling was conducted in Vensim, and data analysis was conducted in R-Studio.

9. Disclaimer

The views expressed herein are those of the authors and do not reflect the position of the United States Military Academy at West Point, Stevens Institute of Technology, the Department of the Army, or the Department of Defense.

Works Cited

Armenia, S., Centra, A., Cesarotti, V., De Angelis, A., & Restrosi, C. (2012). Military Workforce Dynamics and Planning in the Italian Air Force. *Proceedings of the 30th International Conference of the Systems Dynamics Society*, *1*.

Chinchilla, A. & Matisek, J. (2023). Ukraine's Hidden Advantage. *Foreign Affairs*. https://www.foreignaffairs.com/ukraine/russia-war-ukraines-hidden-advantage

Casey, T. R., & Töyli, J. (2012). Mobile voice diffusion and service competition: A system dynamic analysis of regulatory policy. *Telecommunications Policy*, *36*(3), 162–174. https://doi.org/10.1016/j.telpol.2011.07.002

Endrenyi, J., Aboresheid, S., Allan, R. N., Anders, G. J., Asgarpoor, S., Billinton, R., ... & Singh, C. (2001). The present status of maintenance strategies and the impact of maintenance on reliability. *IEEE Transactions on power systems*, *16*(4), 638-646.

Koivisto, J., Ritala, R. & Vikko, M. (2022). Conceptual Model for Capability Planning in a Military Context – A Systems Thinking Approach. *Systems Engineering Journal*. 457-474. https://doi.org/10.1002/sys.21624

McGinnis, M. L., Kays, J. L., & Slaten, P. (1994). Computer Simulation of U.S. Army Officer Professional Development. *Proceedings of Winter Simulation Conference*, 813–820. https://doi.org/10.1109/WSC.1994.717438

McLucas, A. (2001). An Investigation into the Integration of Qualitative and Quantitative Techniques for Addressing Systemic Complexity in the Context of Organizational Strategic Decision Making. *UNSW Sydney. http://hdl.handle.net/1959.4/38744*

McLucas, A. & Elsawah, S. (2020). Systems Dynamics Modeling to Inform Defense Strategic Decision Making. *Springer*. https://doi.org/10.1007/978-1-4939-8790-0_657

Sterman, J. (2000). *Business Dynamics: Systems Thinking and Modeling for a Complex World.* McGraw Hill Education.

Varelis, A. & Stamboulis, Y. (2002). A Life Cycle Systems Dynamics Model of Aircraft-Engine Maintenance. https://www.semanticscholar.org/paper/A-life-cycle-system-dynamics-model-of-maintenance-Varelis-Stamboulis/e9ec13d75f49820434c20487584e7c288eb0b799

Wang, J. (2020). Path and Policy Analysis: A Sustainability Study of Military Workforce Supply Chains. *The Journal of Defense Modeling and Simulation.* 387-397. https://doi.org/10.1177/1548512919865381

W. E., M. (1969). *Pilot Training Study*. The RAND Corporation. https://apps.dtic.mil/sti/citations/AD0686725