Optimizing Smaller Western Countries' Resource Allocation in Remote Warfare via System Dynamics Modeling

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ABSTRACT

Remote warfare consists of specific components interacting to maximize operational effectiveness. Many smaller Western countries opt for this model to counter threats from a distance, reduce risk, and curb financial costs. However, due to their strategic culture and limited resources, these countries cannot fully employ the model, which reduces their operational effectiveness. To determine how small Western countries can maximize their use of resources, in this paper, system dynamics modeling, and simulation is used to analyze the impact some remote warfare components have in a counterinsurgency. Remote warfare occurs in substate conflicts where Western countries support local partners acting as counterinsurgents. The end state of counterinsurgency military operations is to defeat the insurgents militarily. Consequently, the study uses the insurgents' size as the key variable measuring the operational effectiveness of two types of support: training support and intelligence support to a local partner. Equations quantitatively and qualitatively model insurgents with an information advantage competing against counterinsurgents with a size advantage. Data from the Islamic State insurgency case is used to validate the model's fit over a simulated 36-month run and draw conclusions. The study finds that intelligence support is highly operationally effective, while training support by itself is not.

1.0 BACKGROUND AND METHODOLOGY

In the final years of the George W. Bush administration, a new form of "remote warfare" was pursued by the United States that involved many of the characteristics of light-footprint operations. Mainly characterized by the use of drones in the early stages, remote warfare aims to counter threats at a distance. Moreover, the notion of remoteness denotes that militaries do not have to operate on the contact line anymore [1, p. 17]. Remote warfare instead focuses on "'shaping' the international security environment through technology, flexible operations, and military-to-military partnerships [2, p. 364]." As a result, kinetic operations are carried out without exposing Western military personnel to the risks normally associated with armed conflict in a warzone [3, p. 1].

The spectrum of remote warfare is broad. Abigail Watson and Alasdair McKay state that this model involves the following measures:

- Supporting local security forces, either official state forces, militias or paramilitaries; for example, through the provision of training, equipment or both
- Special operations forces, either training or sometimes even working alongside local and national forces

- Private military and security contractors undertaking a variety of roles
- Air strikes and air support, including unmanned aerial vehicles (UAVs) or "armed drones" and manned aircraft
- Sharing intelligence with state and non-state partners involved involved in frontline combat [1, p. 1].

Since the early 2000s, remote warfare has become a central instrument in the U.S. counterterrorism toolbox [4, p. 1]. Following this pattern, many other Western nations have adopted the model [1, p. 1]. Smaller Western countries' policy makers engage their military in remote warfare, hoping to decrease the risk to the force, counter threats at a distance, and limit budgetary costs. Problems arise, however, for smaller Western nations when they cannot access the full spectrum of remote warfare features. Due to a lack of resources, such as drones, geospatial intelligence (GEOINT), or human intelligence (HUMINT), these nations cannot or do not deploy even the minimum number of remote warfare features when not operating under a coalition umbrella. Executing remote warfare while lacking adequate resources increases the force's exposure to risk, jeopardizes mission success, or both. These deviations from the original remote warfare model therefore often lead to added force-protection measures and increased footprints that can adversely impact building a relationship with the population and a partnership with local forces during low-intensity conflicts [5]. Moreover, without the right deployed capabilities, smaller countries' SOF may have very limited freedom of action (FoA) and consequently may not be able to measure their remote warfare operational effectiveness. Without such measures, SOF may not receive the necessary support and funding at the strategic and political levels. This problem mainly manifests organizationally due to the hierarchical governmental and military planning and decision-making process.

Therefore, this paper seeks to answer the question, "What form of support is primarily responsible for making the remote warfare system effective?" by analyzing the impact of remote warfare components on operational MoEs. The study employed system dynamics modeling and simulation to analyze the effectiveness of two types of remote warfare support to a local partner during a counterinsurgency: training support and intelligence support. Operational research and literature on the importance of information in insurgencies enabled the development of equations that quantitatively and qualitatively model the system's structure and behavior. Using insurgent force size and information availability as major variables, the model simulated multiple ways in which these characteristics of remote warfare impact the dynamics of a substate conflict. After confirming the validity of the model's framework, real-world data was employed to initiate modeling simulations that cover a time horizon long enough to enable system feedback to impact behavioral outcomes [6, p. 125]. Data from the Islamic State insurgency case was used to validate the model's fit over a simulated 36-month run and draw conclusions.

This research found that small Western nations should more carefully consider the proportion of different forms of remote support they provide to the local partner in a conflict. Growing the partner's force size through training is ineffective if remote intelligence support is not provided. By contrast, intelligence support to a partner nation's force routinely enhances its ability to find and fix the insurgent force, reducing the latter's size and effectiveness.

2.0 SYSTEMS DYNAMICS MODELING AND ANALYSIS

Remote warfare, by definition, supports a local partner. That partner is often an actor engaged in an internal conflict in which two opponents confront each other for control of the political space [7]. In such conflicts, local forces, also called counterinsurgents (or COIN), fight against a guerilla force called insurgents [7]. When a third-party state provides military support to a local partner's counterinsurgency, that state also becomes part of the COIN force. System dynamics modeling and simulation was used in this research to analyze the impact remote warfare components have in counterinsurgency. Using force size and information availability as main variables, the model simulates ways in which the characteristics of remote warfare may impact the dynamics of a substate conflict.

• To combat insurgencies effectively, it is crucial to have a clear understanding of the characteristics and capabilities of the opposing forces. Typically, insurgents have an information advantage, which means that they are better able to gather and disseminate information about their opponent's activities and objectives. However, they often have a disadvantage in terms of the size and strength of their forces compared to counterinsurgents. On the other hand, counterinsurgents typically have a force advantage, meaning that they have greater numbers and resources at their disposal. Nevertheless, they often struggle with an information disadvantage, which means that they may have limited knowledge about the insurgents' activities and objectives. Balancing these advantages and disadvantages is essential to achieving success in COIN operations [8]–[10]. The end state of counterinsurgency military operations is to defeat the insurgents militarily. While COIN Size and Find and Fix Capability are relevant variables to measure the probability of success, the ultimate variable that indicates whether such operations are effective is the size of the insurgent force. In short, the more the insurgents' force size decreases, the more effective the operation is.

2.1 User Interface

• As a notional decision support tool, the Insurgent Competition Size and Information System model features an interactive User Interface (Figure 1), in which certain model variables may be changed by the user to evaluate the impact on the system's behavioral outcomes over the run of the model. A switch turns on or off the Training Inflow in the COIN Size element. On the right side of the figure, under the Intelligence Support to COIN label, each INT has a slider in the interface, varying the value between 0.01 and 0.1. The assumption, based on typical intelligence yields, is that each INT can provide at least 1% accurate information and cannot provide more than 10%. While the input values may not precisely reflect the accuracy of the intelligence used in every period of counterinsurgencies, they serve as best estimates to simulate the average accuracy values of the INTs over the whole simulation period. The input values of the different INTs may also be lowered on the interface (Figure 1) to simulate periods with less actionable intelligence. A slider is also provided so that the user can change the extent of the Insurgents' Information Advantage.

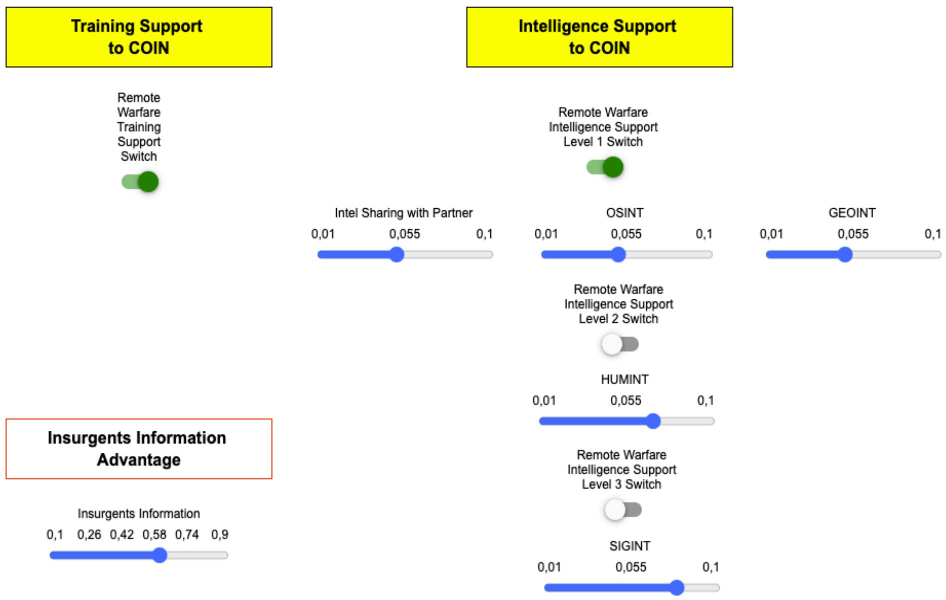

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Figure 1:User Interface of Remote Warfare Model.

2.2 Remote Warfare Stock and Flow Model

Using the settings from the user interface, the model determines the impact of COIN Size and COIN available information on Insurgents' Size. In particular, to analyze the operational effectiveness of remote warfare in insurgent competitions, the model analyzes the impacts of Training Support and Intelligence Support to COIN forces and insurgent forces, respectively. To do that, the initial model run illustrates the dynamics between opponents' size and available information, without external (other state) support. Then, the different supports are added, and the results are compared. The results demonstrate the degree of impact for each type of support, but most importantly, which type is the most operationally effective.

The model of the endogenous Size and Information system presented in this study was created using Stella Architect, Version 2.1.2 [11]. Figure 2 shows the complete model. Equations define the inflows and outflows connected to three key stocks: Insurgent Size, COIN Size, and COIN Find and FIX Capability. Equations also define endogenous variables, some supported by literature and previous research on force versus information advantage in insurgent-counterinsurgent conflicts.[7]–[10]

Data taken from the IS insurgency case was used to validate the model's fit over a simulated 36-month run. Numerical values reflect the Islamic State in Iraq (2016) case when inserted. Cited data from this case appears throughout the analysis of the system dynamics.

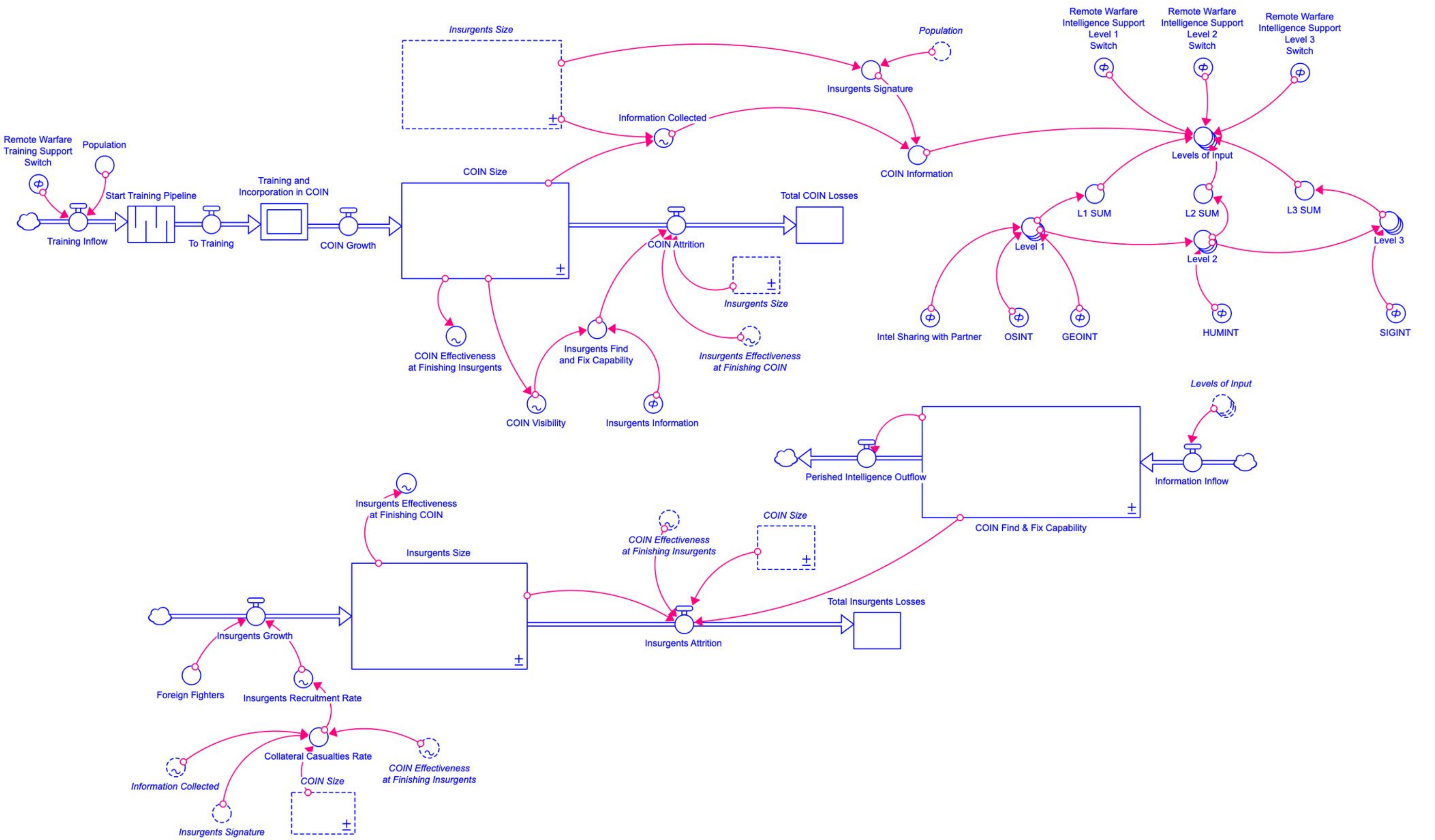


Figure 2: Complete Remote Warfare Stock and Flow Model

2.2.1 Stocks, Inflows, and Outflows

The COIN Size stock and Insurgents' Size stock in Figures 3 and 4 express the sizes of the counterinsurgency force and insurgent force, respectively. A Population converter provides the size of the general population that contributes to the Insurgent Signature, discussed in 2.2.2.

The COIN Size stock in Figure 3 has a COIN Growth inflow and a COIN Attrition outflow, where COIN Attrition is defined by the following equation, adapted from Kress and Szechtman [10];

COIN Size = COIN Growth – Insurgent Effectiveness at Finishing COIN x Insurgent Size x Insurgents Find and Fix Capability (1)

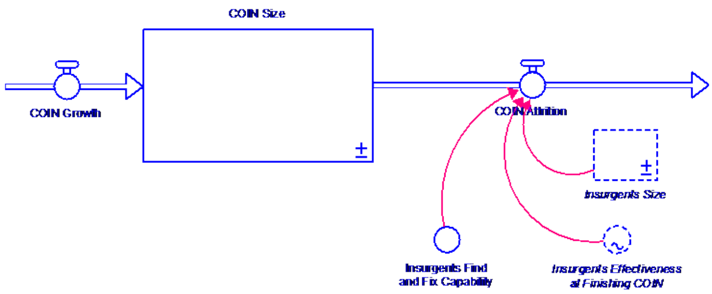


Figure 3: COIN Size Stock

Following the same logic, the Insurgents' Size stock in Figure 4 has an Insurgents' Growth inflow and an Insurgents' Attrition outflow, where the following equation defines Insurgents' Attrition:

Insurgents Attrition = COIN Effectiveness at Finishing Insurgents x COIN Size x COIN Find and Fix Capability (2)

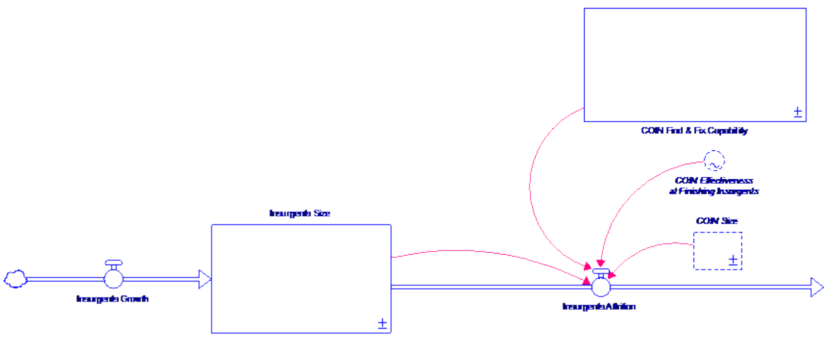


Figure 4: Insurgents' Size Stock

The IS data for these portions of the model consists of the following:

- COIN Size: The initial value of 206,000 corresponds to the Iraqi Security Forces (ISF), a term used to describe law enforcement (Ministry of Interior, or MoI) and military forces of the Republic of Iraq. The estimated ISF size in 2016 was 61,000 military and 145,000 paramilitaries (MoI), resulting in 206,000 ISF [12, p. 11]. These numbers were unchanged in 2017 and 2018.

- Insurgents' Size: By using population control ratios, Daveed Gartenstein-Ross has estimated the number of fighters within the IS to have been approximately 100,000. This is the value of the Insurgents' Size used to initialize the stock [13].
- Population Size: The Iraqi population in 2016 was estimated to be 36,610,600 [12, p. 23].
- ISF Attrition: In 2016, the attrition value for the Iraqi Security Forces (ISF), represented by COIN in the model, reached 6,100 deaths over the year [14].
- IS Attrition: In August 2016, the United States declared that 45,000 IS fighters had been killed in the previous two years [15]. So, 11,250 IS fighters were removed in six months. This would mean an attrition of 22,500 per year.

Assumptions:

- Although COIN Size and Insurgents' Size may vary over time, we assume that the size of the general population remains constant throughout the model's run.
- There are no reinforcements to the COIN force before remote warfare training support is provided. So, without the Training Support Switch turned on, COIN Growth = 0.
- There is no sectarian or coercive violence; the insurgents target the COIN force only, not the population.

2.2.1.1 COIN Growth

COIN Growth is interrelated with training and is discussed in detail in 2.2.10, Training Support.

2.2.1.2 Insurgents' Growth

The Insurgents' Growth (Figure 5) is defined by adding the Insurgents' Recruitment Rate defined in equation (1) and Foreign Fighters defined in (2):

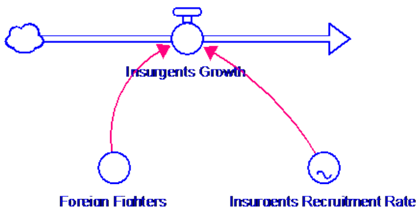


Figure 5: Insurgents Growth Inflow

<u>Insurgents' Recruitment Rate and Collateral Casualties</u>

Insurgents normally do not target the general population since elements within local communities provide them an information advantage and consequently superior situational awareness on the ground. Insurgent attacks that produce collateral damage to the population were therefore not modeled. On the other hand, without accurate information for targeting insurgents, the COIN force may cause collateral damage to the civilian population. Figure 6 shows all the variables influencing the Collateral Casualties Rate and the latter's relationship with Insurgents Recruitment Rate.

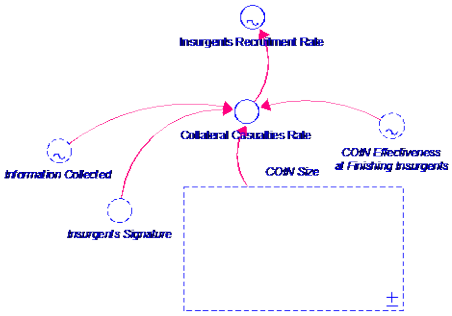


Figure 6: Insurgents' Recruitment Rate and Collateral Casualties Rate

Collateral damage subsequently boosts insurgent recruitment: during insurgents-counterinsurgents conflict, population sentiment is driven by security [10, p. 579], [16], [17]. People will side with the group they think would protect them best. Therefore, the Insurgents' Recruitment Rate is a function of the collateral casualty rate [10]:

Insurgents Recruitment Rate = f (Collateral Casualties Rate) (3)

From Equation (2), the Insurgents' Attrition equation, it follows that:

Collateral Casualties Rate = COIN Effectiveness at Finishing Insurgents x COIN Size x (1- Information Collected) x (1- Insurgents Size / Population) (4)

Alternatively, it can be expressed as:

Collateral Casualties Rate = COIN Effectiveness at Finishing Insurgents x COIN Size x Fraction of Incorrect Information x Non-Insurgents in the Population (5)

The Collateral Casualty Rate, even when it is minimized, has its place in the modelling due to its strong relationship with the recruitment of new insurgents. The model shows an increase in the Recruitment Rate, a function of the Collateral Casualty Rate, on a logarithmic curve (Figure 7). However, to what degree it influences the Recruitment Rate has not been empirically demonstrated.

Figure 7: Insurgents Recruitment Rate Graphical Input

The logarithmic function simulates a decreasing physically eligible population over time. The population eligible to join insurgents is limited in each district or village. As the male population that survives COIN attacks and is of fighting age (approx. 15 to 55 years old) joins the insurgents, the recruitment rate in that area reaches its carrying capacity.

The value on the x-axis corresponds to the monthly (annual value divided by 12) Collateral Casualties Rate attributed to the ISF in 2014 when they were executing operations without kinetic air support (or with very little kinetic air support at the end of 2014) from the coalition [18].

The y-axis limits are set with the same values to simulate a sharp increase in recruitment at the beginning and slow growth at the end of the simulation run. That input assumes that there is, on average, one insurgent recruited per collateral casualty. The rationale behind these numbers is that each casualty might have one willing and eligible family member who joins the insurgents.

Assumptions: In this case, the Recruitment Rate is only a function of the Collateral Casualty Rate. An insurgent recruitment rate would typically be a function of multiple factors such as the number of civilians in the occupied territory and the percentage of eligible males of fighting age, the media campaign's impact on their recruitment, and a variety of intangibles. The considerable differences in IS fighters' numbers given in various sources also explain why no reliable recruitment rate was found [13].

Foreign Fighters

IS managed to attract over 40,000 foreign fighters from 130 countries before and after the caliphate declaration in 2014 [19]. No research established a precise timeline for the flow of foreign fighters (FF). Most researchers estimate this inflow at 40,000 FF between 2012 and 2016 [20]. In the model, the inflow is estimated at 10,000 FF per year. The yearly and monthly inflow can vary. Without reliable annual and monthly numbers, the model uses a monthly inflow that corresponds to a lognormal distribution with a mean of 850 and a standard deviation of 200.

2.2.2 COIN Visibility and Insurgent Signature

As COIN Size increases, its Visibility increases. Increasing its visibility or posture means patrolling more often, patrolling with larger numbers of troops, or both. This requires increasing the size of COIN encampments or building new ones, consequently adding to the density of the COIN presence or the footprint.

The model uses an exponential (increasing) function because this rapid military footprint growth and change in visibility is a large disadvantage, making the COIN force increasingly visible to insurgents. The model assumes that the COIN Visibility Converter follows an exponential curve with COIN Size varying between 150,000 and 300,000 (maximum limits of attrition and growth over the simulation's 36-month run time) on the x-axis and a COIN Visibility going between 0.1 and 0.3 on the y-axis (Figure 8). The values of the converter can be adapted to handicap even more COIN Forces when they grow in size because it further grows the insurgents' information advantage.

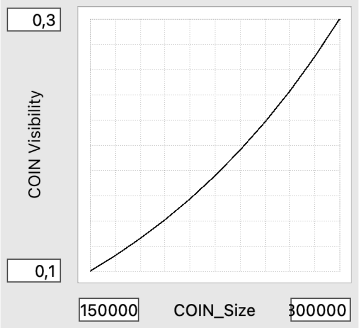


Figure 8: COIN Visibility Graphical Input

Unlike COIN Forces which most often must take force protection measures and separate themselves from the population, insurgents live and recruit amongst the population. In the absence of reliable intelligence, one way to estimate the signature of an insurgency is by calculating the ratio of the size of the insurgent group to the size of the population (Figure 9). This ratio can be interpreted as the probability that a randomly selected individual in the area is an insurgent [10]. It is important to note that this approach may not accurately capture the full complexity of the situation, particularly if the insurgency is well-hidden or has a significant support network within the population [8], [10].

Signature of the Insurgents = Insurgents Size / Population **(6)**

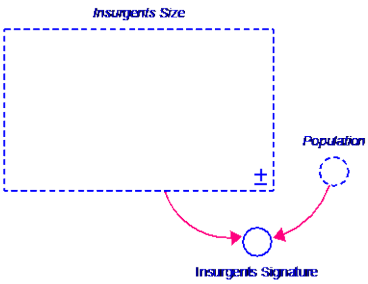


Figure 9: Insurgents Signature Converter

2.2.3 Insurgents' Information

There is no Information flow (per se) attributed to the insurgents because they operate and live among the population. All other things being equal, it is assumed that the insurgents, compared to the counterinsurgents, have more and better information [21, p. 157]. At the extreme, some literature assumes that insurgents have perfect information (100% accurate) [8], [9]. The stock and flow model initially sets the Insurgents' Information at 0.6 (60% accurate information), but a slider in the interface allows the user to set the variable value between 0.1 (10%) and 0.9 (90%). The insurgents' roots within the population are the rationale behind these numbers. Growing, living, and recruiting among the population provides them with more than 50% accurate information.

One reason not to accept that the insurgents have perfect information (100%) is their characteristics. It is natural to assume that insurgents have more information than their opponents, but counterinsurgents still apply operational security (OPSEC) measures. In these conflicts, some insurgents and counterinsurgents may live in the same villages, and the OPSEC might be very low, but it would be unreasonable to believe that there is no OPSEC at all. Another reason the notion of bounded rationality. Despite their best intentions and efforts, insurgents, like everyone else, are constrained by delayed, incomplete, and imperfect information, so their actions may be perceived as less than entirely rational [22, p. 19], [23, p. 8].

2.2.4 Information Collected

In COIN operations, the information level might fluctuate. If the number of insurgents becomes very small, the information level may become less significant, as there is less insurgent activity to monitor and analyze [8]. Additionally, the information level may be deficient during the early stages of an insurgency when little is known about the group, or later when the insurgency has been weakened and fragmented into smaller cells. The information level may also decline if the COIN force loses its information sources, making it more difficult to gather and analyze data on the insurgents' activities [10], [24]. This proportional relationship is consistent with previous operations research formulating the Information Collected as a function of COIN and the Insurgents' Size (Figure 10) [10].

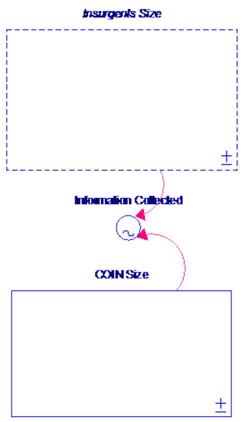


Figure 10: Information Collected Converter

Information Collected as a function of COIN and the Insurgents' Size is also represented as follows:

$$\textbf{Information Collected} = \textbf{Information (COIN Size, Insurgents Size)} \quad (7)$$

The greater the COIN Size, the greater the number of information collectors and the greater the number of people needed to analyze and process this information. The greater the Insurgents' Size, the greater their signature among the population, and the greater the likelihood of collecting information on Insurgents.

Figure 11 shows that Information Collected follows an exponential curve with COIN Size x Insurgents Size on the x-axis and Information Collected on the y-axis. The x-axis is divided by 10,000,000,000 to maintain an acceptable scale. The y-axis varies between 0.1 and 0.4 because collecting no information is not credible and achieving more than 40% accuracy of the information collected would come unrealistically close to the accuracy of Insurgents' Information. That would not align with the premise regarding the Insurgents' Information advantage, on which this model is based [8]. Since the insurgents' roots within the population explain why they have more than 50% accurate information, the COIN Force, which is not rooted in the local people, may not reach 50% of accurate information. The characteristics of both opponents give them different access levels to accurate information.

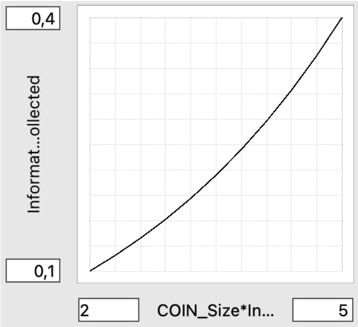


Figure 11: Information Collected – Graphical Function

2.2.5 COIN Information

COIN Information expresses the level of information available to COIN forces. It may be defined as the fraction of the information reports that accurately identify insurgents' positions. (1- Information Collected) x Signature of the Insurgents is a fraction of reports that are incorrect because the intelligence on which they are based is inaccurate. Therefore, because the COIN force has no way to verify which reports are accurate and which are not, it attacks every target with equal ferocity[10].

COIN Information = (Information Collected + (1 - Information Collected) x Signature of the Insurgents) (8)

Assuming that the COIN force can process all the information it receives, it follows that the more Information Collected, the more COIN Information is available (Figure 12).

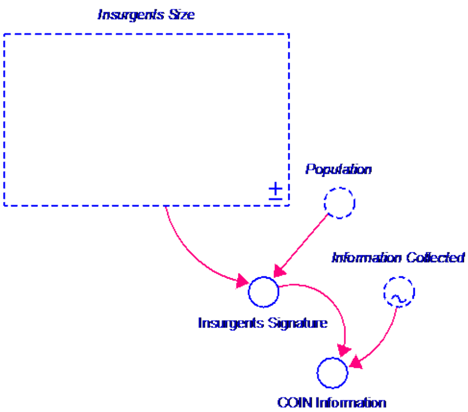


Figure 12: COIN Information Converter

2.2.6 Intelligence Support

The four different levels of intelligence (INTs) converters at the bottom of Figure 13 represent the intelligence collection disciplines employed in modern conflicts [25]. Intel Sharing with Partner(s) is one of the remote warfare characteristics and the sine qua non condition for any form of intelligence support. It also adds a synergistic effect with other INTs because sharing goes both ways, allowing the COIN Information (a function of the opponents' sizes) to add to the Intelligence Support

Levels.

In the model, there are three levels of support possible. They are grouped by ease of sharing. Sharing open-source intelligence (OSINT) products, unmanned aerial vehicle (UAV) images, and geospatial intelligence (GEOINT) with a partner is often seen as the minimum and easiest remote intelligence support to provide. Therefore, they are modelled as Level 1 support. Human intelligence (HUMINT) involves more risks for the agents and the sources, so it requires more risk acceptance from the supporting nation. Therefore, HUMINT is added to Level 1 inputs to constitute Level 2 support. Finally, signal intelligence (SIGINT) is expensive and often requires a higher security classification. Therefore, SIGINT is added to the sources in Level 2, to constitute Level 3 support.

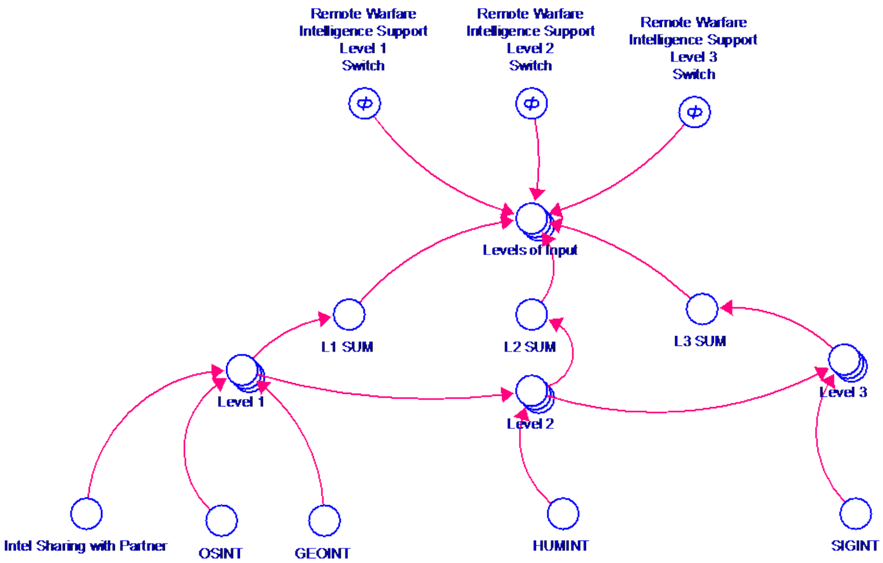


Figure 13: Levels of Intelligence Support Converters

2.2.7 COIN Find and Fix Capability Stock, Inflow, and Outflow

The Information Inflow depends on the Level of Input that is turned on. If no Remote Warfare Intelligence Support is activated, the only information flowing into the COIN Find and Fix Capability Stock comes from the COIN Information Converter (Figure 14). The three other Levels of Input are the Remote Warfare Intelligence Support Levels 1, 2, and 3.

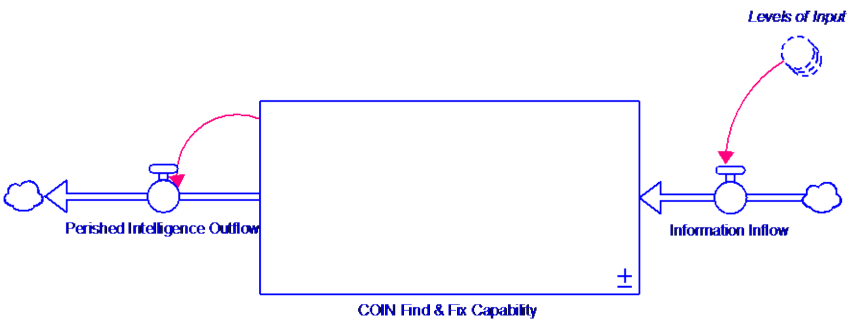


Figure 14: COIN Find and Fix Capability Stock

In this context, the Find and Fix Capability stock is simply the Information Inflow less the Perished

Intelligence Outflow. Actionable Intelligence is useful and delivered on time. The stock accumulates all the Information Inflow, and while some information is still valuable, perishable information is not. Therefore, Perished Intelligence Outflow is eliminated each prior month. It purges the stock in order to maintain the most recent COIN Find and Fix Capability value. So, the stock reflects the monthly value of actionable intelligence. The values of this stock range between 0, meaning that there is no Find and Fix Capability within the COIN Force, and 1, meaning that they have a perfect capability, leaving no room for mistakes.

2.2.8 Insurgents' Find and Fix Capability

The Insurgents' Find and Fix Capability Converter (Figure 15) is a function of two variables. It adds COIN Visibility to Insurgents' Information.

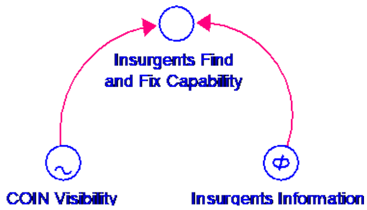


Figure 15: Insurgents' Find and Fix Capability Converter

2.2.9 Effectiveness at Finishing

Most insurgent-counterinsurgent competitions last years and even decades, and some never end [26]. Insurgents' Effectiveness at Finishing COIN and COIN Effectiveness at Finishing Insurgents are attrition coefficients that can be understood as each opponent's effectiveness at reducing the other's size (i.e., eliminating opposing troops). These coefficients express the premises of the model regarding any size advantage or disadvantage. The greater the size of a force, the greater its impact on its opposing force attrition during confrontations. So, each coefficient modifies the attrition of the opponent, e.g., COIN Coefficient of Effectiveness at Finishing Insurgents modifies Insurgents' Attrition. This coefficient is associated with the firepower and mobility of each actor (i.e., each opposing force), not directly with its available information.

Both coefficients of effectiveness at finishing the other actor $\in (0 \;\; 1)$ vary between 0.001 and 0.01. During the run-time of the simulation, these values serve to diminish the opponents' force size by 0.1 % to 1% each time step. Insurgents' Effectiveness at Finishing COIN and COIN Effectiveness at Finishing Insurgents are modeled as a linear function linked to each Force's size. The greater the size, the greater the Finishing Capability. However, the two actors do not have the same value scale on the y-axis. Since sizes are the only dependent variables, one force would not have the same effectiveness with 100,000 people as the other with 200,000 (Table 1). This reflects the COIN Size (Force) advantage.

Table 1: Relative Values of Effectiveness a Finishing – Function of Actors' Sizes

Opposing Forces' Size	100,000	200,000	300,000
Effectiveness at Finishing $\in (0 \;\; 1)$	0.001	0.005	0.01

Assumptions:

- The coefficients of Effectiveness at Finishing (Figure 16 and Figure 17) are a function of the actors' respective force Sizes. Many other variables, however, might influence this coefficient. Air strikes and advising and assisting local troops are good examples of variables that might influence those coefficients. This model does not take these additional variables into account.

- It is assumed in the model that the individual skill level of the fighters and their collective tactics, techniques, and procedures, as well as their equipment, materiel, and capabilities, follow the same proportional increase as their size.

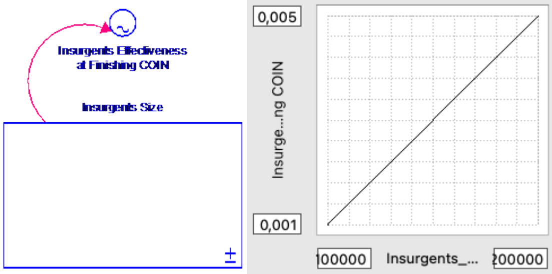


Figure 16: Insurgents' Effectiveness at Finishing COIN Converter and Graphical Input

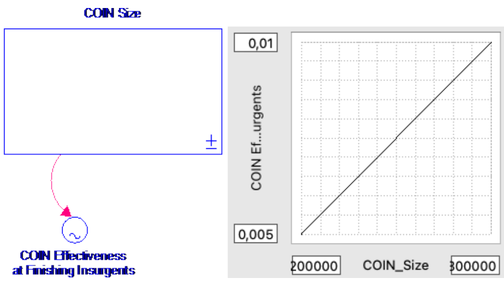


Figure 17: COIN Effectiveness at Finishing Insurgents Converter and Graphical Input

2.2.10 Training Support

The purpose of Training Support is primarily to increase the size of COIN Forces (COIN Size). The Training Inflow corresponds to a percentage of the male, fighting-age population (15–55 years old) [27]. Based on the success level of the training pipeline, which includes a high percentage of dropouts during training, the assumption is that approximately 45,000 people (0.12% of the 2016 population) present themselves to begin training. This represents a monthly inflow of 3,750 potential COIN fighters.

Future soldiers enter the Start Training Pipeline queue stock and flow into the Training and Incorporation in COIN oven stock (Figure 18). The oven simulates a three-month training pipeline with a "cook time" of three months and a capacity of 9,625 persons. This reflects actual data from the Iraq counter-insurgency: the growth of the ISF was attributed to an estimated 38,500 ISF trained by the coalition in 2016 [28]. The training given by the coalition, depending on the assigned force (Regular Brigade, Counter Terrorism Service, or Police), lasted, on average, three months. This means 9,625 ISF came out of the training pipeline every three months.

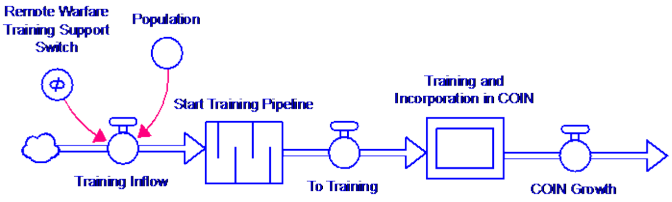


Figure 18: Training Support Inflow, Queue, and Oven

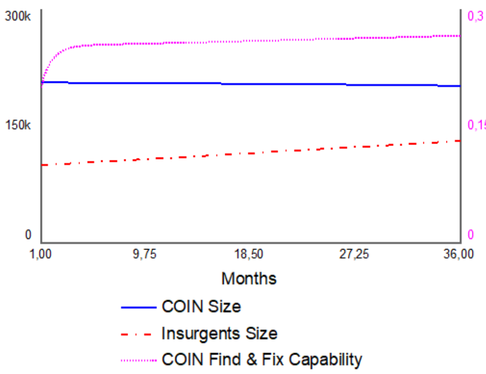
2.3 Data Analysis

The process of evaluating data and modeling results occurs through four scenarios. Scenario 1 does not involve any type of remote warfare support, with the COIN force fighting insurgents in a substate conflict. Scenario 2 involves Training Support, meaning that a third party's SOF is participating in training activities with a local partner security force, consequently growing the COIN Size. Scenario 3 involves a third party's three alternative Levels of Intelligence Support, as described in 2.2.6. Scenario 4 includes Training Support and Intelligence Support, with different variations in levels of support.

The goal of the four scenario sections is to compare the behavioral outcomes of the simulation runs. The scenario outcomes are measured in terms of Insurgents Size, COIN Size, and COIN Find and Fix Capability Each figure is presented in three parts. The first part graphically depicts the outcomes of the three measured variables. The second part is a table of the first 12 months – out of 36 – generated by the model. This table shows how the values change during the start of the model's run. Finally, a blue row displays the final – 36th month of simulation run – numerical output for each studied variable (i.e., Insurgents Size, COIN Size, COIN Find and Fix Capability; in that order), demonstrating the impacts of the support types over the extended period.

2.3.1 Scenario 1: No Support

As shown in Figure 19, there is a slow increase in COIN Find and Fix Capability, reaching 0.257 after 12 months. However, this increase is insufficient to cause an outflow of insurgents and consequently decrease the Insurgents' Size. As visible in the 36-month graph and the 12-month table, the Insurgents' Size increases, while the COIN Size decreases.

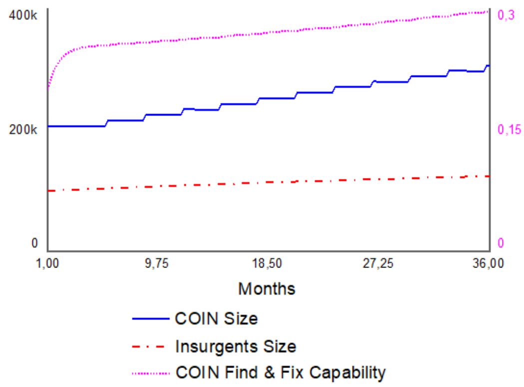


	Insurgents Size	COIN Size	COIN Find & Fix Capability
1	100k	206k	0,2
2	101k	206k	0,237
3	102k	206k	0,248
4	103k	206k	0,252
5	103k	206k	0,254
6	104k	206k	0,255
7	105k	206k	0,255
8	106k	205k	0,255
9	107k	205k	0,256
10	108k	205k	0,256
11	108k	205k	0,256
12	109k	205k	0,257
Final	125k	202k	0,263

Figure 19: Scenario 1 – No Support – Results

2.3.2 Scenario 2: Training Support

The effect of the Training Support provided is visible in the increase in COIN Size (Figure 20). The increase in COIN Find and Fix Capability is similar to that for Scenario 2. The COIN Size increase does not affect the Insurgents' Size during the first 12 months. Its impact on the Insurgents' Size is negligible and visible in the final month, going from 125,000 without support (Scenario 1) to 117,000 with support (Scenario 2).

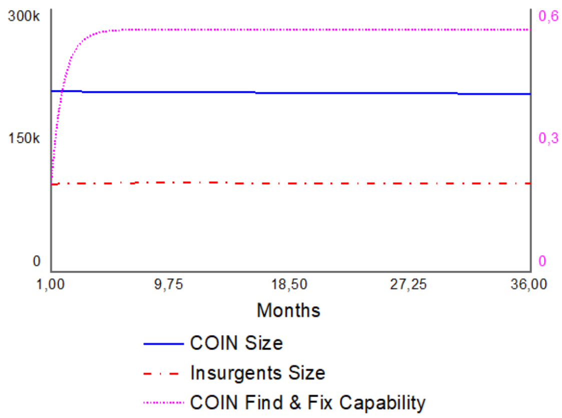


	Insurgents Size	COIN Size	COIN Find & Fix Capability
1	100k	206k	0,2
2	101k	206k	0,237
3	102k	206k	0,248
4	103k	206k	0,252
5	104k	206k	0,254
6	104k	215k	0,255
7	105k	215k	0,257
8	106k	215k	0,257
9	106k	225k	0,258
10	107k	224k	0,26
11	108k	224k	0,261
12	109k	234k	0,262
Final	117k	306k	0,29

Figure 20: Scenario 2 – Training Support – Results

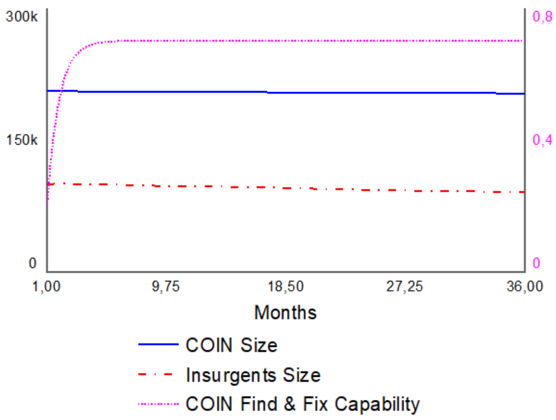
2.3.3 Scenario 3: Intelligence Support

The purpose of Intelligence Support is precisely to increase COIN Find & Fix Capability. So, as the levels of Intelligence Support increase, the COIN Find and Fix Capability increases (Figures 21 through 23). With the User Interface settings depicted in Figure 1, and compared to Scenario 1 and 2, the COIN Find & Fix Capability values double and even triple at Level 3. The Insurgents' Size does not increase after 36 months with Level 1 Support and decreases to 78,600 with Level 3 Support. The COIN Size slightly decreases from 206,000 to 203,000 or 204,000 over the course of the simulations.



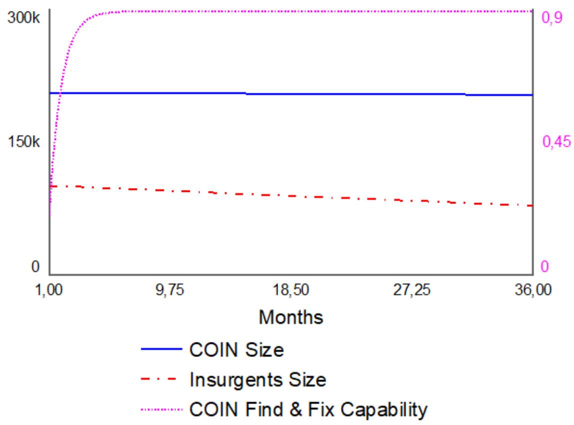
	Insurgents Size	COIN Size	COIN Find & Fix Capability
1	100k	206k	0,2
2	101k	206k	0,442
3	101k	206k	0,518
4	101k	206k	0,542
5	101k	206k	0,55
6	101k	206k	0,553
7	101k	206k	0,553
8	102k	205k	0,554
9	102k	205k	0,554
10	102k	205k	0,554
11	101k	205k	0,554
12	101k	205k	0,554
Final	100k	203k	0,553

Figure 21: Scenario 3 – Intelligence Support Level 1 – Results



	Insurgents Size	COIN Size	COIN Find & Fix Capability
1	100k	206k	0,2
2	100k	206k	0,544
3	100k	206k	0,653
4	99,7k	206k	0,687
5	99,6k	206k	0,698
6	99,3k	206k	0,701
7	98,8k	206k	0,702
8	98,4k	205k	0,702
9	98k	205k	0,702
10	97,7k	205k	0,702
11	97,5k	205k	0,702
12	97,5k	205k	0,702
Final	90,5k	204k	0,702

Figure 22: Scenario 3 – Intelligence Support Level 2 – Results

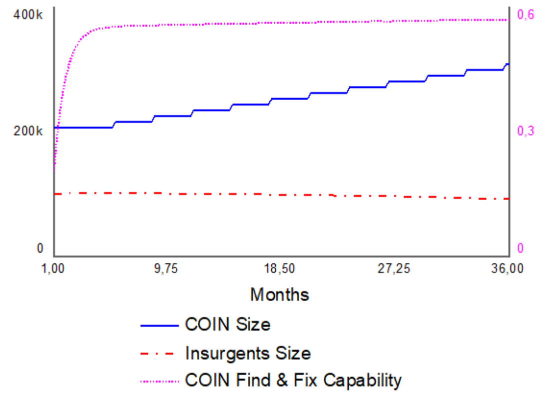


	Insurgents Size	COIN Size	COIN Find & Fix Capability
1	100k	206k	0,2
2	100k	206k	0,675
3	100k	206k	0,825
4	99,3k	206k	0,872
5	98,5k	206k	0,887
6	97,9k	206k	0,891
7	97,4k	206k	0,892
8	96,6k	205k	0,893
9	95,9k	205k	0,893
10	95,1k	205k	0,893
11	94,4k	205k	0,893
12	94k	205k	0,893
Final	78,6k	204k	0,893

Figure 23: Scenario 3 – Intelligence Support Level 3 – Results

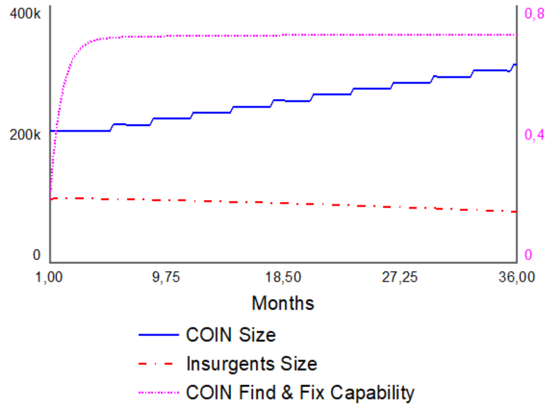
2.3.4 Scenario 4: Training Support and Intelligence Support

The effect of Training and Intelligence Support is visible on the graphs for each of the three levels of Intelligence Support (Figures 24 through 26). Scenario 2 succeeded in decreasing Insurgents' Size from 125k to 117k insurgents. The COIN Find and Fix Capability seems vital in decreasing Insurgents' Size. Scenario 2 showed that Training Support alone does not improve COIN Find & Fix Capability much over No Support. Scenario 4 also shows that Training Support does not improve COIN Find & Fix Capability much when added to Intelligence Support. The initial COIN Size does not change through any Levels of Intelligence Support. By reducing Insurgents' Size, the Insurgents' Effectiveness at Finishing COIN decreases, and the insurgents slowly lose their ability to effect COIN Attrition and consequently COIN Size.



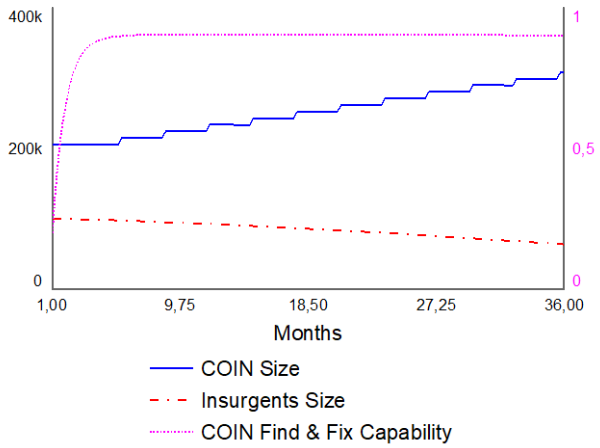
	Insurgents Size	COIN Size	COIN Find & Fix Capability
1	100k	206k	0,2
2	101k	206k	0,442
3	101k	206k	0,518
4	101k	206k	0,542
5	101k	206k	0,55
6	101k	215k	0,553
7	101k	215k	0,555
8	101k	215k	0,555
9	101k	225k	0,556
10	100k	225k	0,557
11	100k	224k	0,557
12	100k	234k	0,558
Final	90,9k	308k	0,569

Figure 24: Scenario 4 – Training and Intelligence Support Level 1 – Results



	Insurgents Size	COIN Size	COIN Find & Fix Capability
1	100k	206k	0,2
2	100k	206k	0,544
3	100k	206k	0,653
4	100k	206k	0,687
5	100k	206k	0,698
6	99,6k	215k	0,702
7	99,2k	215k	0,704
8	98,9k	215k	0,704
9	98,4k	225k	0,705
10	97,8k	225k	0,706
11	97,4k	224k	0,706
12	96,9k	234k	0,706
Final	80,2k	309k	0,711

Figure 25: Scenario 4 – Training and Intelligence Support Level 2 – Results



	Insurgents Size	COIN Size	COIN Find & Fix Capability
1	100k	206k	0,2
2	100k	206k	0,681
3	99,8k	206k	0,833
4	99,3k	206k	0,881
5	98,6k	206k	0,896
6	97,8k	215k	0,901
7	97,1k	215k	0,903
8	96,2k	215k	0,903
9	95,5k	225k	0,904
10	94,5k	225k	0,904
11	93,8k	225k	0,904
12	93k	234k	0,904
Final	64,2k	309k	0,901

Figure 26: Scenario 4 – Training and Intelligence Support Level 3 – Results

3.0 FINDINGS

The remote warfare model shows the high effectiveness of intelligence support and the relative lack of effectiveness of training support when the latter is mainly focused on increasing the COIN size.

3.1 Information as a function of Force Size and multi-source Intelligence gathering

Many insurgent competition models measure the trade-off between information and force according to various levels of conflict or stages of insurgency [8], [10], [21, p. 147]. One of the central assumptions of such models is that the level of information is a function of the COIN Size and the Insurgents' Size. In the remote warfare stock and flow model in this study, Training Support increases the COIN Size, while Intelligence Support dramatically increases the information component (COIN Find and Fix Capability). This is accomplished by providing a synergistic effect of multiple intelligence activities including sharing intelligence with the partner, OSINT, GEOINT (manned and unmanned aircraft included), HUMINT, and SIGINT. So, in the remote warfare model, information remains a function of COIN Size and Insurgents' Size, but it is more a function of the added synergy of multi-int provided by the Remote Warfare Intelligence Support.

3.2 Growth in COIN Size, Limited Impact of Training Support on Insurgent Size

The analysis reveals that without external intervention in the insurgent conflict, the Insurgents' Information advantage counterbalances their Size disadvantage. So, Insurgents' Size continues to grow.

The analysis regarding the impact of Training Support shows that a growing COIN Size has little to no impact on Insurgents' Size if the Insurgents are relatively invisible to COIN forces.

3.3 Impact of Remote Warfare on Insurgents' Size

Scenarios 3 and 4 demonstrate that Intelligence Support is the only type of support, to a lesser or a greater degree depending on the Level, able to decrease the Insurgents' Size. The main difference between the scenarios with, and those without, Intelligence Support is the capacity of the COIN force to "see" the Insurgents.

The analyses for the three Levels of Intelligence Support show the relationship between an increasing Find and Fix Capability and the decreasing Insurgents' Size. The more the COIN force can Find and Fix the Insurgents, the more the Insurgents' Size decreases.

3.4 Kinetic air support and the attrition gap

The actual IS data for the Insurgents' Attrition amounts to 22,500 fighters annually [15]. Figure 26 shows 64,200 insurgents after three years of fighting. So, with Training Support and Intelligence Support Level 3, the model reaches an attrition average of 12,000 insurgents a year (100,000 - 64,000 = 36,000 after three years). This leaves a gap of 10,000 insurgents per year. As previously mentioned, kinetic air support is not included in the model, although it played a crucial role in defeating IS [29]. A RAND Corporation research report observes, "Over five months of operations, coalition aircrafts employed 2,025 weapons, 1,700 of which were precision-guided munitions, and air-dropped supplies and weapons to Kurdish partners on the ground [18]." These numbers give a general idea of the intensity of the kinetic air support. The model runs with COIN Effectiveness and Insurgents Effectiveness having the same scale on the y-axis. Adding kinetic air support would change their relative effectiveness, and there would undoubtedly be multiple effects from this addition/adaptation. First, the scale on the y-axis of COIN Effectiveness would then have to be adapted to reflect this. Also, it would significantly enhance the COIN Effectiveness Coefficient, thereby impacting the Insurgents' Attrition rate. Second, it would also increase the insurgents' Recruitment Rate because the

Collateral Casualty Rate would increase, as demonstrated by the 1,300 civilian deaths attributed to the U.S.-led coalition in 2016 [18].

4.0 CONCLUSIONS

Full-scale support is the most effective form of remote warfare: training support, in combination with kinetic air support and Level 3 intelligence support. This broad spectrum of support is operationally effective as evidenced by its contribution to the U.S.-led coalition militarily defeating the IS insurgency in a three-year period. Full-scale support is most effective due to the range and synergy of capabilities deployed that allow not only for a high level of intelligence, knowledge, and understanding of the OE but also a high level of protection provided by dedicated air support. Unfortunately, such comprehensive support is not achievable for countries with limited resources and risk appetites when they do not operate under a coalition umbrella. Therefore, they should prioritize intelligence support.

However, intelligence support, cannot completely defeat an insurgency on its own [10]. A complete counterinsurgent win also involves gaining control of the political environment and addressing the underlying social and political issues that gave birth to the insurgency in the first place [30].

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