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**NATIONAL DEFENSE UNIVERSITY**

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THE SYSTEMS ENGINEERING DESIGN PROCESS FOR STRATEGY

by

**Jeff D. Baker**

*U.S. Navy*

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**THE SYSTEMS ENGINEERING DESIGN PROCESS FOR STRATEGY**

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**Jeff D. Baker**

*U.S. Navy*

**A paper submitted to the Faculty of the Joint Advanced Warfighting School in partial satisfaction of the requirements of a Master of Science Degree in Joint Campaign Planning and Strategy. The contents of this paper reflect my own personal views and are not necessarily endorsed by the Joint Forces Staff College or the Department of Defense.**

**This paper is entirely my own work except as documented in footnotes. (or appropriate statement per the Academic Integrity Policy)**

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**15 May 2020**

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## ABSTRACT

The systems engineering design process (SEDP), when integrated with joint doctrine, provides an enhanced design methodology using a systems analysis approach that supports a more effective and coherent strategic design via an improved problem definition process that, in turn, leads to the development of clear and attainable objectives and end states. JP-5.0 captures why defining the problem is necessary and what needs to be acted upon to reconcile the differences between existing and desired conditions. However, it does not include a methodical process of doing so. This thesis shows how the SEDP provides a process to fill this void. The doctrinal design methodology is enhanced by the systems analysis approach resulting in a thoroughly analyzed problem definition and assists the strategist in developing and guiding the implementation of a strategic approach, as well as clearly articulating the desired objectives and end states. Additionally, the modeling and simulation of chosen strategic alternatives provides the strategist with detailed insight and information on strategic alternatives that is not available using the current doctrinal approach.

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I would like to personally thank Dr. Gene Paulo, my mentor and professor from the Naval Postgraduate School who taught me to think as a systems engineer through any problem. Most importantly, I want to express my gratitude and sincere appreciation to Dr. Keith Dickson. As my thesis advisor and mentor here at JAWS, his dedication and work on my behalf inspired me to take my thinking and understanding of the Systems Engineering Design Process and integrate it into joint doctrine. As a future strategist, I'm better prepared to think through the problems of today's strategic environment because of his leadership and guidance.

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# Systems Engineering Design Process

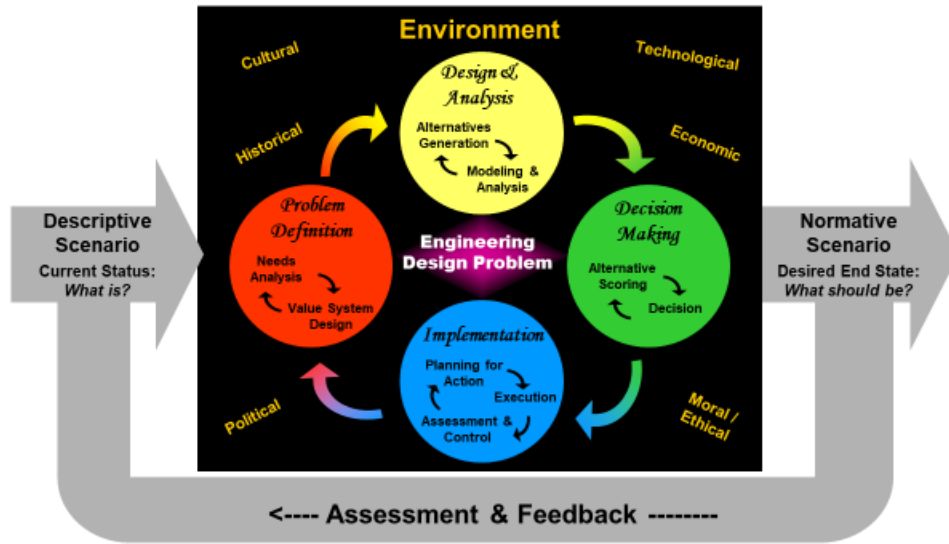


Figure 1

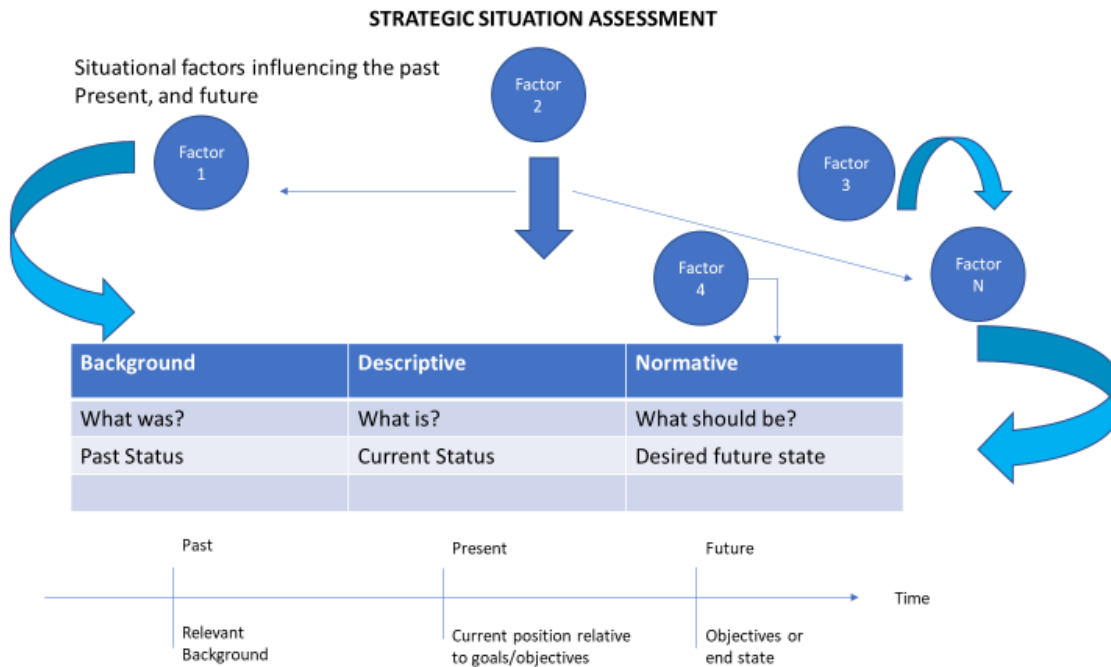


Figure 3

IDENTIFICATION AND DEFINITION OF A STAKEHOLDER

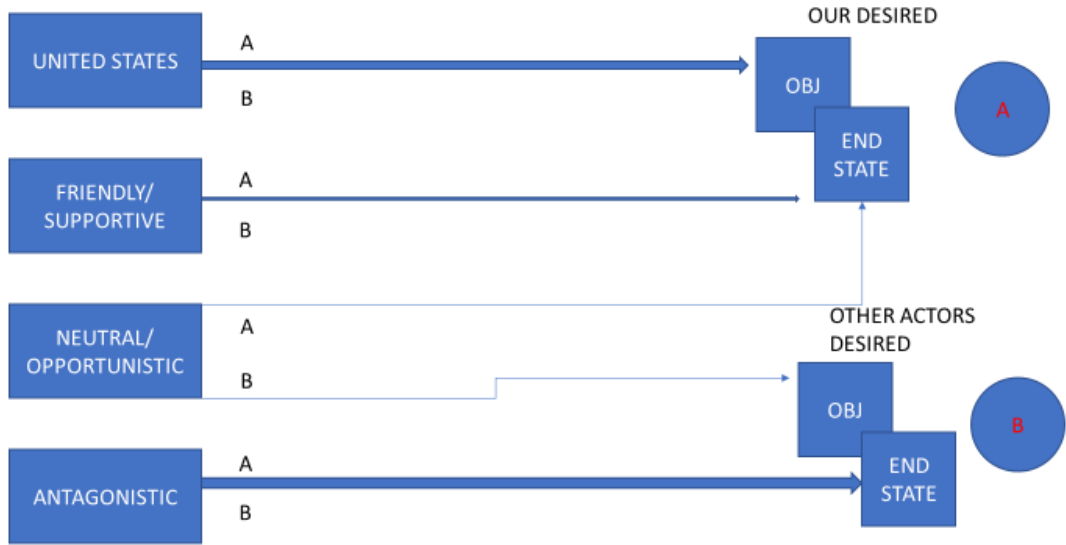


Figure 4

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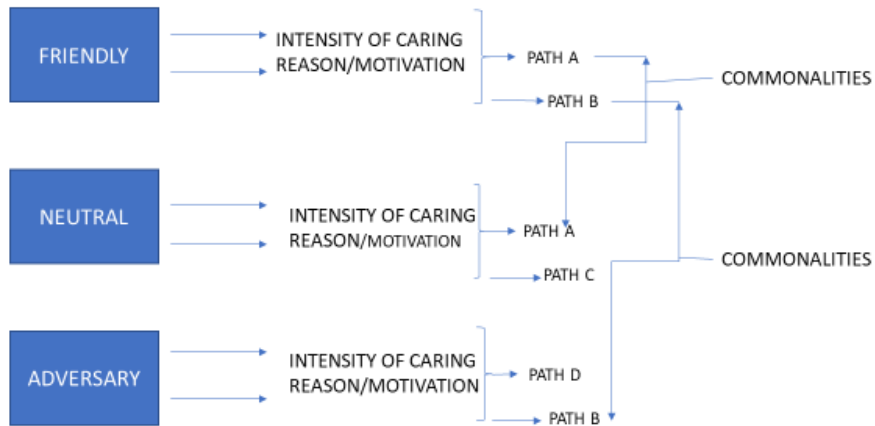


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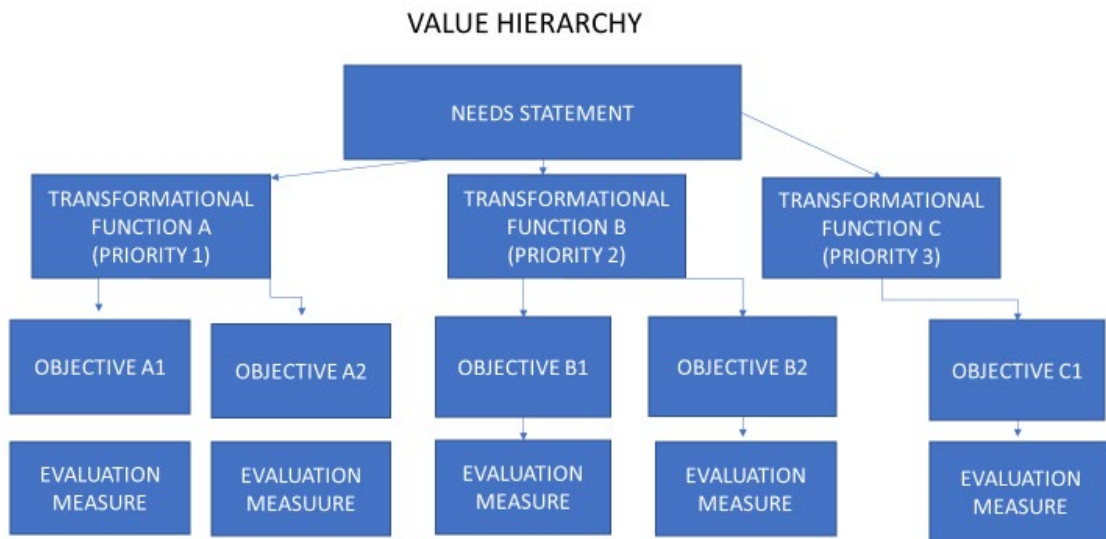


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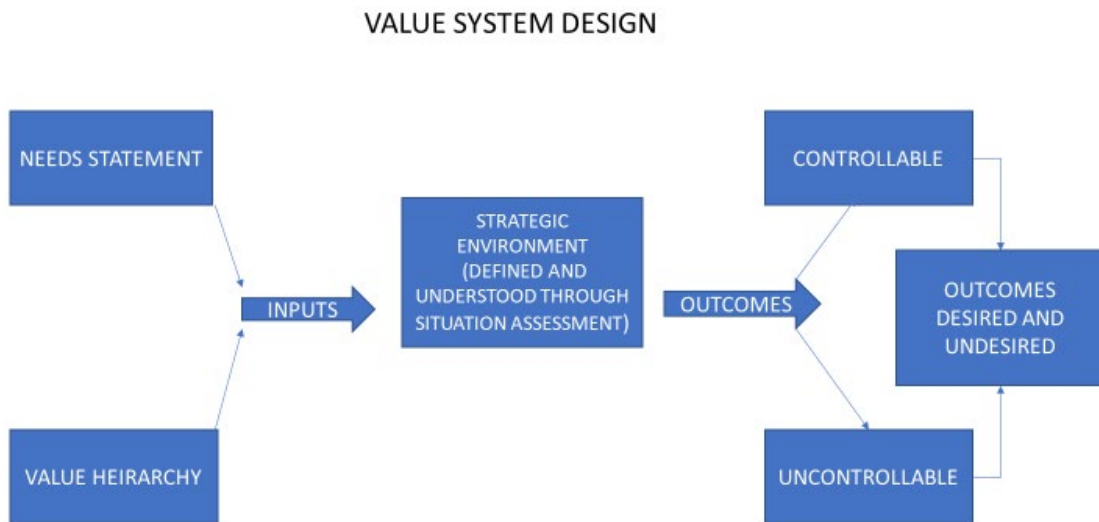


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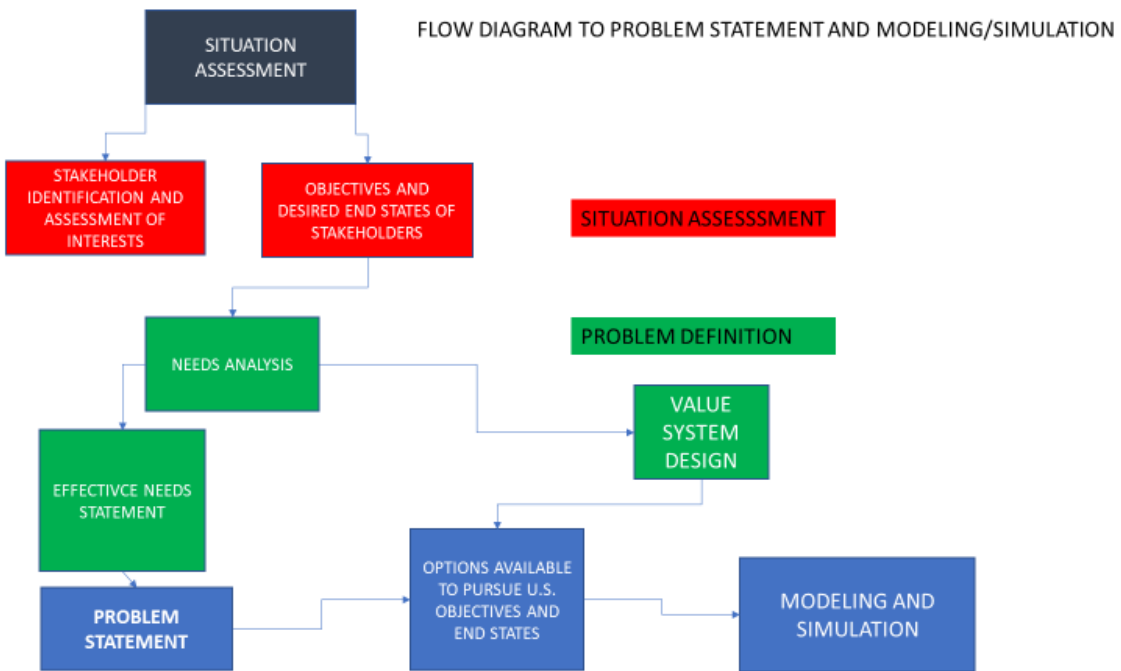


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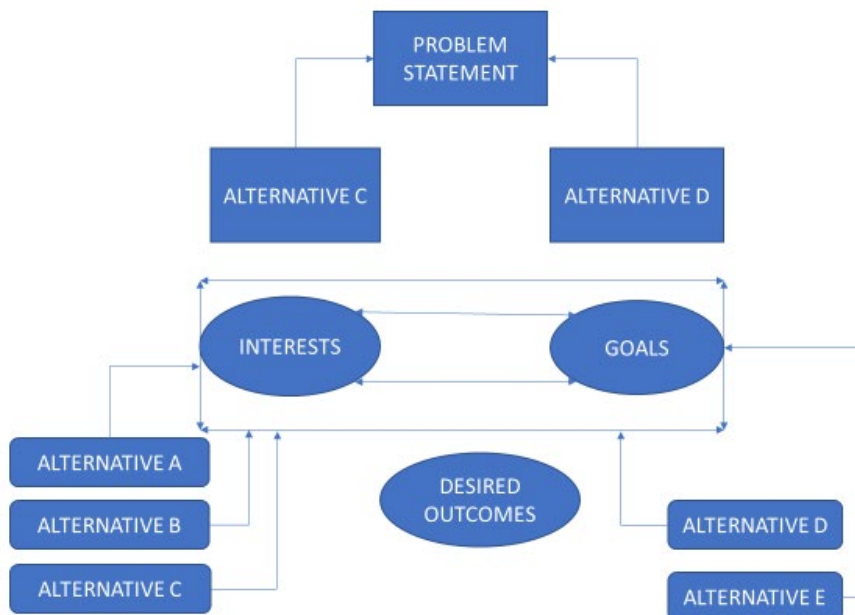


Figure 9

## INTRODUCTION

*A strategy is future-oriented and problem defining and avoiding as opposed to problem-solving. It does this through a specific appraisal of the strategic environment to determine and select key strategic factors that must be addressed in order to advance state interests successfully. From the synthesis and evaluation of these factors, strategy produces a rational statement of ends, ways, and means, that create effects leading to the desired future. Harry Yarger.<sup>1</sup>*

Joint Publication 5-0, *Joint Planning*, (JP-5.0) defines strategy as a broad statement of the Combatant Commander's long-term vision guided by and prepared within the context of the Secretary of Defense's priorities, it is developed within projected resources, and links national strategic guidance to joint planning.<sup>2</sup> The strategy describes the factors and trends in the operational environment that are key to achieving the defined objectives of the Combatant Commander. The Combatant Commander operationalizes this strategy by organizing and aligning operations, activities, and investments with resources to achieve the objectives that support the desired end state.<sup>3</sup> As Harry Yarger points out, strategy's purpose is problem defining. One of the significant weaknesses of U.S. doctrine related to strategy formulation is the process of problem definition. Without proper problem definition, Combatant Commands will pursue strategies and develop campaigns that will falter or fail.

The systems engineering design process (SEDP), as a cognitive approach, when integrated with joint doctrine for design and operational art, provides an enhanced design methodology and systems analysis approach that supports a more effective and coherent strategic design via an improved problem definition process and the development of clear and attainable

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<sup>1</sup> Yarger, Harry R. *Strategy and the National Security Professional: Strategic Thinking and Strategy Formulation in the 21<sup>st</sup> Century*. (British Library, 2008) 10.

<sup>2</sup> U.S. Joint Chiefs of Staff. *Joint Planning*, Joint Publication 5-0 (Washington DC: Joint Chiefs of Staff, June 16 2017), III-2

<sup>3</sup> Ibid. III-2.

theater objectives. JP-5.0 captures why defining the problem is necessary and what needs to be acted upon to reconcile the differences between existing and desired conditions. However, it does not include a methodical process of doing so. The SEDP provides a process to fill this void in design. The doctrinal design methodology together with the systems analysis approach will provide process for problem definition that will assist in developing and guiding the implementation of a strategic approach, as well as defining desired objectives and end states. The *problem definition phase* and the *modeling and simulation* components of the SEDP can be directly linked to the operational approach of JP-5.0, to allow for a better understanding of the strategic environment and support clearer strategic thinking.

The SEDP methodology will guide strategists by defining the problem to reveal opportunities. Various alternative approaches can be modeled and analyzed to develop an optimal operational approach. The results will support focused and structured diplomatic dialogues with multiple regional partners as part of an iterative and continuous process of assessment, adaptation, and response. This methodology offers the advantage of recognizing and appreciating factors of strategic culture that shape problem definition.

The SEDP begins with a preliminary step called the strategic *situation assessment*. The results of the situation assessment provide a *descriptive scenario*, which is a narrative that outlines and employs an analysis of the existing conditions that define the strategic environment. The *normative scenario* is a narrative that describes the strategic environment in an ideal state. The differences in the narratives between the descriptive scenario and the normative scenario will provide the basis for the first phase of the SEDP leading to defining the problem.

The SEDP follows a four-phase process that uses the expertise and experience of the strategist to present an organized approach to addressing complex strategic problems. The

phases are *Problem Definition, Design and Analysis, Decision Making, and Implementation*.

While the process in its entirety could be used for the development of a strategy, the SEDP elements of *Problem Definition* and the focus on *modeling and simulation*, are easily integrated and linked to the JP-5.0 development of an operational approach, allowing the commander to continue the Joint Planning Process (JPP), and translating broad strategic and operational concepts into specific missions and tasks to produce an executable strategy.<sup>4</sup>

Phase one of the SEDP is *Problem Definition*. The essential element in any strategic design or decision process is to identify and understand the problem. Failure to identify and fully understand the actual problem leads to an ineffective strategic approach and a campaign that cannot be executed to meet the desired end state. Clearly defining the problem and, most importantly, understanding the associated complexities will ensure that the strategist has a clear understanding of what needs to be addressed. This is accomplished through two steps: a *needs analysis* and a *value system design*.

The needs analysis includes inputs from a strategic situation assessment which allows the strategist to examine how and why a proposed strategic approach fits within the strategic interests of the U.S. This includes information produced in the stakeholder analysis that identifies the relevant individuals, entities, or actors linked to the problem, and to identify and clearly understand their interests, goals, and desired outcomes. A needs analysis identifies and deconstructs the critical functions of the strategy and organizes them in such a way as to understand the essential requirements as they pertain to the desired end state. The output of the needs analysis is a needs statement as it pertains to the strategic environment.

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<sup>4</sup> U.S. Joint Chiefs of Staff *Joint Planning*, Joint Publication 5-0 (Washington DC: Joint Chiefs of Staff, June 16 2017), IV-1.

The value system design step develops a value hierarchy that is used to evaluate, measure, and subsequently model potential alternatives that reflect the interests, goals, and desired end state of the stakeholders. Critical functions derived from the revised problem statement are deconstructed into objectives and end states. From these objectives, evaluation measures or metrics are determined to measure how well a proposed alternative meets the objective.

Phase two of the SEDP is *Design and Analysis*. This phase links with the operational design of JP-5.0. Operational design, as defined in Joint Publication 3.0 (JP-3.0), is the conception and construction of the framework that underpins a campaign and its subsequent execution. It supports operational art with a methodology designed to enhance understanding of the situation and the problem.<sup>5</sup> JP-3.0 states that operational design is a collaboration of the JPC to identify and solve complex, ill-defined problems.<sup>6</sup> In phase two, alternative approaches to the problem are modeled. Alternatives generation is the process of ideation to develop concepts and ideas to address the defined problem. As there is no single solution to complex problems, various alternatives are developed and modeled based on resources, risk, and desired outcomes.

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<sup>5</sup> U.S. Joint Chiefs of Staff *Joint Operations*, Joint Publication 3-0 (Washington DC: Joint Chiefs of Staff, January 17 2017), II-4.

<sup>6</sup> *Ibid.* II-5.

# Systems Engineering Design Process

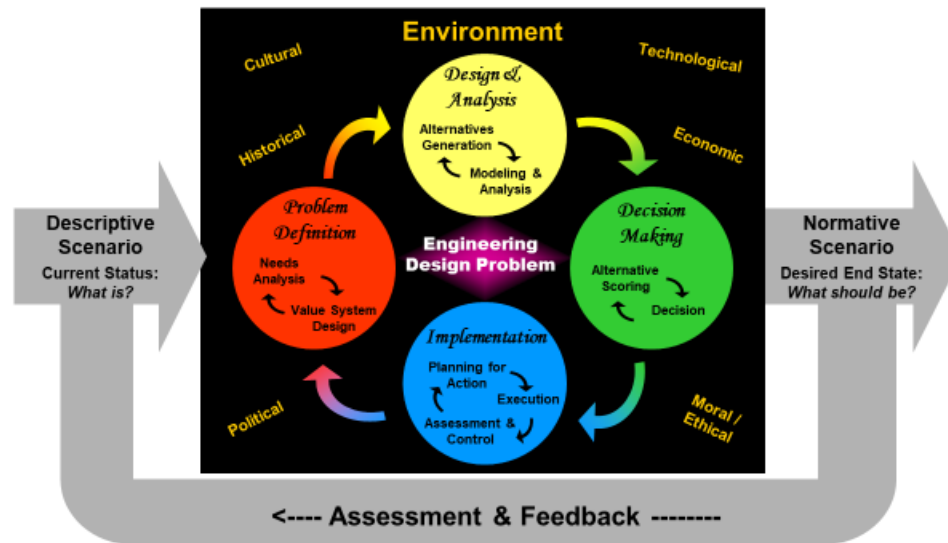


FIGURE 1.

Figure 1 provides a snapshot of the SEDP. As an iterative and adaptable process, it can be linked to the JP-5.0 design process to assess potential strategic approaches and campaigns better. This methodology will define the strategic problem to be addressed, and then utilize polity modeling of strategic alternatives as an aid to better inform the Combatant Commander's decision-making. The strategist can work through *the problem definition* methodology of the SEDP, maintaining the thread of thought regarding the study of the issue being addressed in the situation assessment as essential to defining the problem. If the problem is explained as a discrepancy between the current and desired end state, the strategist attempts to explain the causal explanation for this. Does the removal of one causal factor create the desired end state, or does it create another related or unique problem? The SEDP addresses problem definition through iteration and analysis to mitigate causing a separate problem by the strategic approach to another.

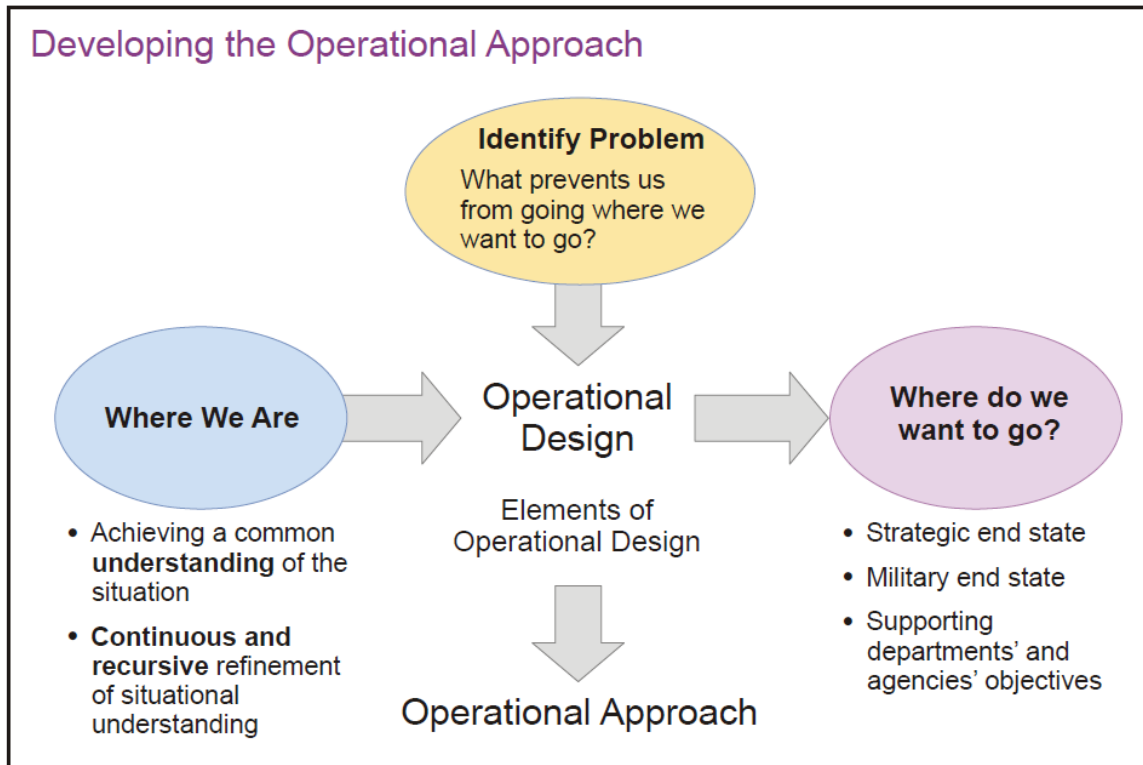


FIGURE 2.

By utilizing the problem definition and modeling analysis methodology of the SEDP, the strategist can better develop an operational approach that considers various elements of national power that lead to the strategic end state desired. Figure 2 illustrates the current framework for developing an operational approach in JP-5.0. The inadequacy of JP-5.0 is multi-layered. Identifying the problem is not defining the problem. This asks the strategist the wrong question. JP-3.0 states that operational design supports operational art with a methodology that enhances the strategic understanding of the situation and the problem. However, JP-5.0 lacks the referenced methodology and thus invalidates the definition of operational design. The strategic situation assessment of the SEDP methodically answers the “where we are”, and “where we want to go” questions of the figure through the development of the descriptive and normative

scenarios. Additionally, through the stakeholder analysis, the SEDP answers what the strategic end state, military end state, and supporting agency objectives are. JP-5.0 addresses these questions in an overly simplistic outline and is inadequate to produce an achievable desired end state.

Ultimately, the SEDP methodology provides for a more detailed and methodical operational approach. Most significantly, as identification of the problem is shown as the essential component of operational design, the SEDP provides a process for problem definition that provides a more comprehensive operational design, and thus a better focused operational approach that meets the objectives and desired end state of the U.S.

## CHAPTER 1. SITUATION ASSESSMENT

According to JP-5.0, the purpose of defining the problem is to transform existing conditions into the desired end state and determining what needs to be acted on to reconcile the differences between the existing and desired conditions.<sup>7</sup> The JFC and staff must identify and articulate:

1. *Tensions* between current conditions and desired conditions at the end state.
2. *Elements* within the OE which must change or remain the same to attain desired end states.
3. *Opportunities and threats* that either can be exploited or will impede the JFC from attaining the desired end state.
4. *Operational limitations*.<sup>8</sup>

These key words fail to help the strategist define the problem and are asking the wrong questions to begin with. They are vague in nature and lead to the development of lists for the strategist to think through without an analytical process. JP-5.0 highlights that the strategist must achieve a common understanding of the situation and continuous and recursive refinement of the situational understanding. However, JP-5.0 lacks guidance or understanding of what these terms mean. The doctrine fails to define or explain what goes into an understanding of the situation. JP-5.0 simply states that the strategist must understand the current strategic environment and assess what the desired end state should be, yet there is no method or process for doing this. According to doctrine, defining where we want to go requires the strategist to understand the strategic and national end states and objectives, theater objectives, military end states and objectives, and the supporting departments' and agency objectives.<sup>9</sup> However, JP-5.0 again fails

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<sup>7</sup> U.S. Joint Chiefs of Staff *Joint Planning*, Joint Publication 5-0 (Washington DC: Joint Chiefs of Staff, June 16 2017), IV-14.

<sup>8</sup> Ibid. IV-14

<sup>9</sup> Ibid. IV-2.

to outline a process or method to make this assessment. The situation assessment preliminary to the SEDP requires the strategist to analyze the past, current, and desired future state of the strategic environment to meet doctrinal intent.

*As nineteenth-century Prussian philosopher of war Carl von Clausewitz, the study of war and warfare “is meant to educate the mind of the future commander, or, more accurately, to guide him in his self-education, not to accompany him to the battlefield; just as a wise teacher guides and stimulates a young man’s intellectual development, but is careful not to lead him by the hand for the rest of his life.” Clausewitz continued, emphasizing that leaders should use their knowledge of military history “to analyze the constituent elements of war, to distinguish precisely what at first sight seems fused, to explain in full the properties of the means employed and to show their probable effects, to define clearly the nature of the ends in view, and to illuminate all phases of warfare in a thorough critical inquiry.”<sup>10</sup>*

In this quote, Clausewitz captures the essence of what the SEDP does for the modern strategist. The situational assessment accomplishes what Clausewitz understood as an essential skill of a commander, to distinguish precisely and understand the major situational and strategic factors that have influenced the environment in the past as well as the present. This is the goal of the assessment and its value to defining the problem.

The strategist also conducts a futures analysis to attempt to capture exactly what the strategy is designed to influence and to describe what this environment will look like. The analysis should identify the key variables and dynamics of the strategic environment that will shape, and ultimately, drive the strategy. This approach shows an appreciation for what forces will work in favor of the strategy as well as those that will work against the strategy. Finding the balance between these forces is the key output of this step.

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<sup>10</sup> McMaster, H.R. LTGEN. *On The Study of War and Warfare*. (Modern War Institute. Feb. 2017) 2.

JP-5.0 defines Operational Design as a methodology to aid commanders in organizing and understanding the Operational Environment.<sup>11</sup> Doctrine provides a general methodology for operational design and includes the following essential elements:

1. Understanding the strategic environment. (policies, diplomacy, and politics)
2. Understand the operational environment.
3. Define the problem.

However, JP-5.0 lacks sufficient guidance and a methodology for the essential elements of understanding of the strategic environment, understanding the operational environment, and defining the problem. Lacking a methodology, the strategist cannot formulate and develop a strategic approach to meet the desired end states of the U.S.

Harry Yarger states that the strategic environment should be considered from the perspective of systems within systems interacting in both linear and nonlinear ways. The strategist must understand the systems, but the proper focus on the strategy is on the dimensions of interaction.<sup>12</sup> Additionally, Colin Gray suggests that there are seventeen or more dimensions to the strategic environment: *people, society, culture, politics, ethics, economics and logistics, organization, administration, information and intelligence, strategic theory and doctrine, technology, operations, command, geography, friction/chance/uncertainty, adversary, and time.*<sup>13</sup>

JP-5.0, Harry Yarger, and Colin Gray all address the importance of understanding the strategic environment to the modern strategist, but each approach is incomplete. They all describe an approach to understanding but lack a clear process or results. The SEDP provides

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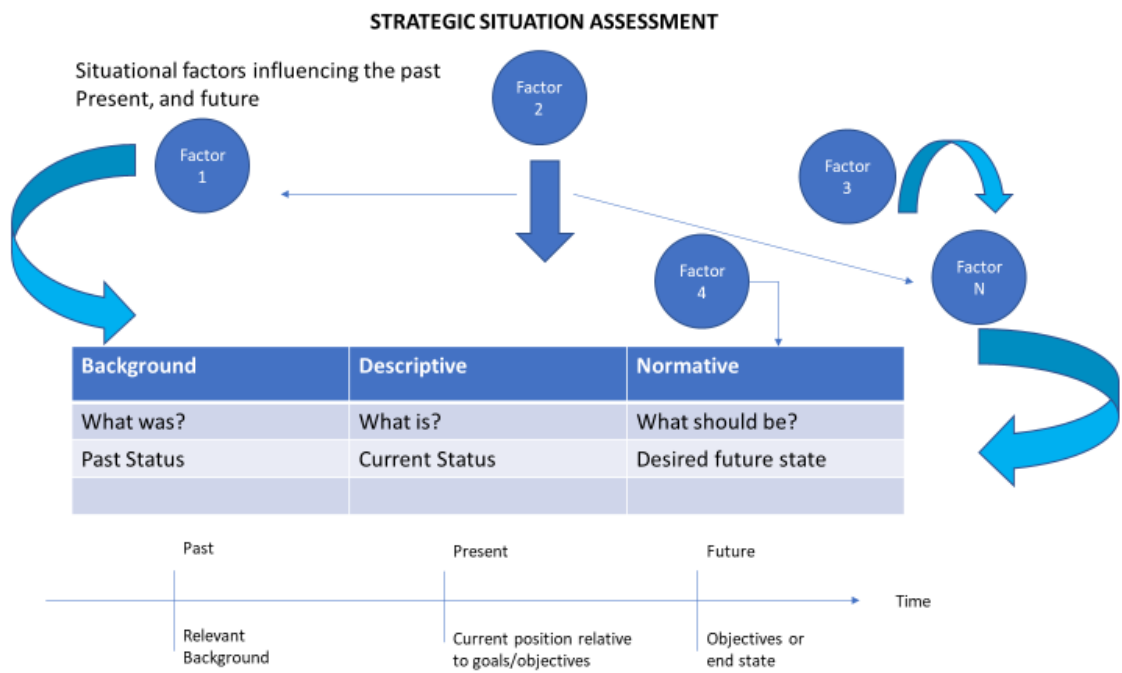
<sup>11</sup> *Joint Planning*, Joint Publication 5-0 (Washington DC: Joint Chiefs of Staff, June 16 2017), IV-6.

<sup>12</sup> Yarger, Harry R. *Strategic Theory For the 21<sup>st</sup> Century: The Little Book on Big Strategy*. (Strategic Studies Institute, Feb. 2006) 34

<sup>13</sup> Gray, Colin S. *Modern Strategy*, (Oxford: Oxford University Press, 1999) 23-43

both a methodical process and a result. The situation assessment of the SEDP studies the strategic environment in ways that JP-5.0, Yarger, and Gray fail to address. This assessment is essential to the strategic understanding of what the desired end state should be. As a means to meet the JP-5.0 approach to understanding the environment, Yarger’s system of systems perspective, and Gray’s extensive list of dimensions, the SEDP provides the process and results to begin a sophisticated strategic design. The strategic situation assessment of the SEDP provides a model as a necessary initiation into the process.

Figure 3 provides an analysis of various scenarios of the assessment.



**FIGURE 3.**

1. Factor 1: Factors that had influence but no longer apply. Why? Factors that describe the state of affairs in the past.
2. Factor 2: Factors that have had a long-term influence. Why? Description of the state of affairs in the present.
3. Factor 3: Factors that have emerged to affect the present condition. Why?

4. Factors that should emerge to achieve desired objectives and end state. Why? Description of outcomes that define a future state of affairs.

Understanding the questions of why for each factor is essential to the assessment. By answering why, the strategist has determined the reason for failure of previous strategic approaches, an understanding of the enduring factors that have remained influential over time, the reasoning for factors that have influence in the current environment, and what factors need to be addressed to produce a strategic approach that leads to the desired end state for the U.S.

The situation assessment now can be further refined by addressing the following questions to arrive at a descriptive scenario:

1. What are the objectives and end states desired?
2. How do a comparison of the past and current state of affairs relate to objectives and end state desired?
3. What relevant factors must exist for the desired end state?

The *descriptive scenario* will explain how the current environment came to be, what the current environment is, and identifies how the current environment relates to the problems or issues that limit achieving the desired end state. The *normative scenario* describes what the future and ideal end state or objectives for the U.S. need to be so that the strategic environment meets the interests of the U.S. The appraisal of all factors allows the strategist to understand what is important to consider as a strategic approach is developed.

Figure 4 illustrates and describes how the strategist identifies stakeholders and measures their level of influence related to the desired end state. Identified in the descriptive scenario, the stakeholder analysis recognizes the entities relevant to the environment and works to clearly understand their interests, goals, and desired outcomes. This approach seeks explicitly to identify

potential partners, allies, and supporters who can be integrated into a strategy of collective effort to achieve a shared outcome.

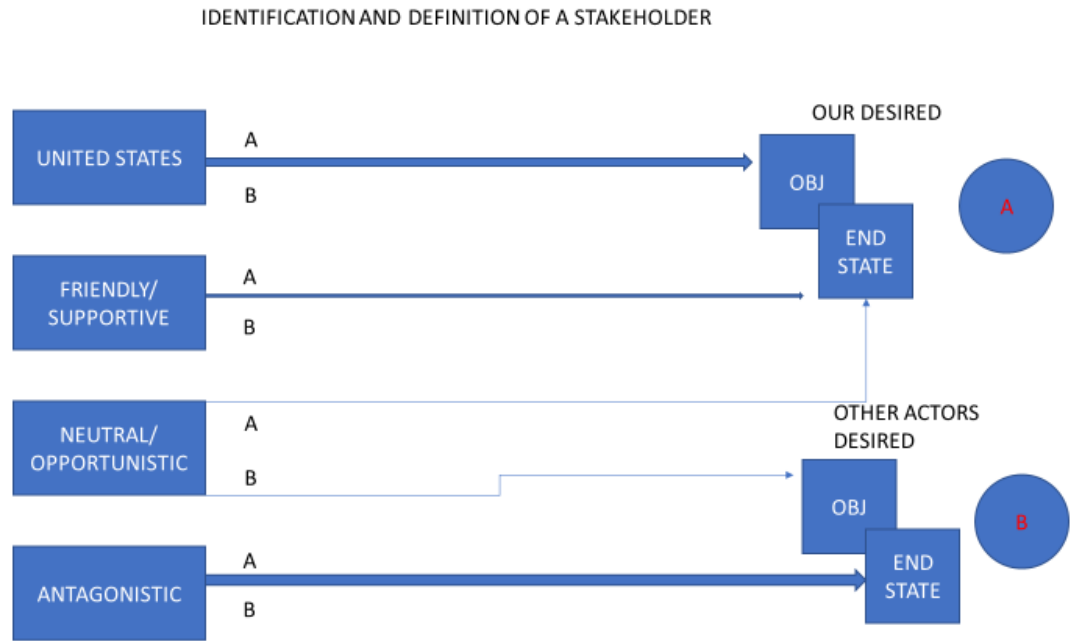


FIGURE 4

**A:** A stakeholder has or influences critical sources that directly influence policy and decision-making related to strategic issues.

**B:** The dimension of time as perceived by each stakeholder, internal or external constituencies within the environment, and the level of interest of stakeholders for current issues within the theater.

Stakeholder analysis further studies the individuals, entities, or relevant actors, defined in terms of friendly, neutral, and adversarial, and works to understand their interests, goals, and desired outcomes. The stakeholders identified should be further examined to include clients, sponsors, and decision-makers. The neutral and adversarial actors have objectives and end states that likely differ from the U.S. and friendly actors

and must be accounted for to assess both their interests and level of influence over the strategic environment.

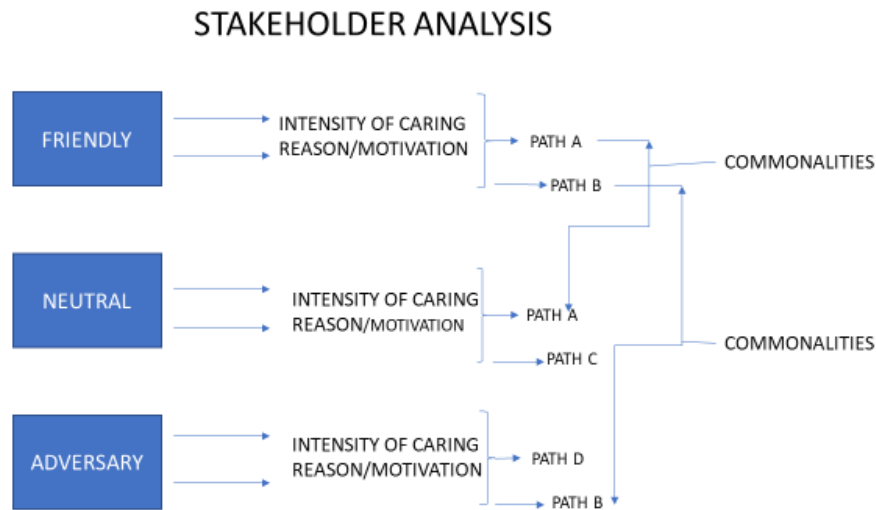


FIGURE 5

Figure 5 provides a representative outline of how to approach the stakeholder analysis, allowing the strategist to look for common themes and connections using the following questions to support the analysis:

Questions for Analysis:

- A. Who cares about the environment? Why?
- B. Who wants what? Why?
- C. What are the specific U.S. interests, goals, outcomes as identified in the descriptive scenario?
- D. Who are the potential partners? Who is a potential spoiler? Why?
- E. Define the interests, goals, outcomes of each individual, organization, actor(s), and entities involved.
- F. What are the paths available to the stakeholders to achieve their interests?
  - a. What paths converge?

- b. What paths separate?
- G. If a stakeholder pursues its interest, what is the most likely outcome? Is this outcome favorable to U.S. interests? If so, then to what degree? If unfavorable, then to what degree?
- H. Futures analysis is asking the questions: If no strategic influence occurs, what is the most likely outcome? Is this outcome favorable to U.S. interests? If so, then to what degree? If unfavorable, then to what degree?

The results of the stakeholder analysis effort is a normative scenario outlining the underlying needs, objectives, and desired end states of the actors who will either influence or be influenced by the strategy. The descriptive and normative scenarios serve to reflect the reality of the strategic environment in its current state and that in an ideal state as accurately and objectively as possible. By identifying the critical sources to strategic issues that are directly related to the relevant stakeholders, the normative scenario reveals both limitations and opportunities for achieving the desired end state.

The situation assessment provides the strategist an understanding of how a strategy will fit within the policy and strategic interests of the U.S. The situation assessment is an examination of the transformation process the strategy intends to follow to achieve desired objectives and end states. Structural or static elements, as well as dynamic elements within the strategic environment, that interact as the strategy operates are identified and can be understood in terms of their relation to objectives that will support the accomplishment of desired end states. The *situation assessment* process is the precursor to *the problem definition phase* of the SEDP and the operational approach of JP-5.0.

## CHAPTER 2. PROBLEM DEFINITION-COMPARISON AND ANALYSIS

*“Obtaining a satisfactory definition of the problem is a task as big as, if not bigger, than solving the problem. Time spent in defining the problem properly and then writing a complete problem statement invariably pays off in effective problem-solving. The worse case is to arrive at a problem statement only to realize that the solution you have obtained is not for the true problem”. George Dieter<sup>14</sup>*

JP-5.0 states that defining the problem is essential to addressing the problem. It involves understanding and isolating the root causes of the issue at hand and thus defining the essence of a complex, ill-defined problem.<sup>15</sup> According to doctrine, defining the problem begins with a review of the tendencies and potentials of the relevant actors and identifying the relationships and interactions among their respective desired conditions and objectives.<sup>16</sup> JP-5.0 further states that a concise problem statement is used to clearly define the problem or problem set to be solved. It considers how tension and competition affect the operational environment by identifying how to transform the current conditions to the desired end state before adversaries begin to transform current conditions to their desired end state.<sup>17</sup> What JP-5.0 does not state is that problem definition lies in the relationship between partners, interests, goals, outcomes, and the “spoilers’ interests, goals, and outcomes and fails to address with specificity how to define the problem and develop a concise problem statement.

JP-5.0 offers a description of a process but fails to address a comprehensive understanding of what a complex, ill-defined problem is, and further fails to address a viable or adequate methodology for clearly defining the problem, and further fails to outline what that process is.

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<sup>14</sup> Dieter, G., *Engineering Design*, 3rd Ed., (McGraw-Hill Book Co., 2000) 10.

<sup>15</sup> U.S. Joint Chiefs of Staff. *Joint Planning*, Joint Publication 5-0 (Washington DC: Joint Chiefs of Staff, June 16 2017), IV-14.

<sup>16</sup> *Ibid.* IV-14.

<sup>17</sup> *Ibid.* IV-15.

Horst W. J. Rittel and Melvin Webber address problem definition as a problem in and of itself. To know what distinguishes an observed condition and the desired condition is only the beginning. The real challenge is finding where, in the complex causal networks of a system, the trouble lies.<sup>18</sup> To assist in identifying the factors that impinge on creating the desired conditions in a system, Rittel and Webber refer to a “wicked problem”, what JP-5.0 describes as a complex, ill-defined problem, and offer a series of characteristics that strategists should be mindful of as the problem is defined.<sup>19</sup>

1. *Solutions to wicked problems are not true-or-false, but good-or-bad.* The judgments of potential solutions are likely to differ widely to accord with a specific group or personal interests, their determined values, and ideological predilections.<sup>20</sup>
2. *There is no immediate and no ultimate test of a solution to a wicked problem, and every solution is a one-shot operation.* Any solution, after being implemented, will generate waves of consequences over an extended time. The consequences may yield undesirable repercussions that outweigh the intended advantages.<sup>21</sup>
3. *Wicked problems do not have an enumerable set of potential solutions.* Whenever actions are effectively irreversible, and whenever the half-lives of the consequences are long, every option counts. Every attempt to reverse a decision or to correct for the undesired consequences poses another set of wicked problems subject to the same dilemma.<sup>22</sup>

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<sup>18</sup> Rittel, Horst W.J. and Webber M.M. *Dilemmas in a General Theory of Planning*, Policy Sciences Vol. 4, (1973) 159.

<sup>19</sup> Ibid. 160

<sup>20</sup> Ibid. 162.

<sup>21</sup> Ibid. 163.

<sup>22</sup> Ibid. 164.

4. *Every wicked problem is essentially unique.* While a host of potential solutions will arise, many more will not be produced. It is then a matter of judgment whether one should try to enlarge the available set or not and then to decide which should be pursued and implemented.<sup>23</sup>
5. *Every wicked problem can be considered to be a symptom of another problem.* Despite similarities between a current problem and a previous one, there is always a distinguishing property of overriding importance, and there is an art of not knowing too early in which type of solution to apply.<sup>24</sup>

Understanding the Rittel and Webber definitions of a wicked problem are necessary for the strategist to define the problem to be addressed. The strategist must ask and understand that if available outcomes are either good or bad, what is the best approach given the known limitations and opportunities. Given that any solution is subject to innumerable responses, both positive and negative, what approach should be taken? If an approach to one wicked problem can produce another or multiple other problems, what is the most careful response the U.S. should take to not make the situation worse. If wicked problems are often interrelated, requiring a broad approach to identifying relationships and interactions, how are the necessary relationships and interactions determined? These are the questions the strategist must be mindful of when developing the definition of the problem. The situation assessment and stakeholder analysis has provided a descriptive and normative scenario in support of JP-5.0, phase one of the SEDP will define the problem to further support doctrine as the strategist develops the operational approach.

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<sup>23</sup>Rittel, Horst W.J. and Webber M.M. *Dilemmas in a General Theory of Planning*, Policy Sciences Vol. 4, (1973) 164.

<sup>24</sup> Ibid. 165.

## CHAPTER 3. PROBLEM DEFINITION PART I: NEEDS ANALYSIS

### NEEDS ANALYSIS OVERVIEW

The strategist has developed a comprehensive understanding of the nature of the environment, conducted a stakeholder analysis, and developed objectives and end states through the situation assessment. Armed with this information, the strategist produces an effective needs statement for U.S. and friendly stakeholders and develops alternative options available for the U.S. and strategic partners to pursue the desired objectives and end states. A thorough needs analysis will also identify the transformational aspects required to meet the objectives and end states as they relate to the diplomatic, informational, military, and economic instruments of national power.

Defining what is critical to the problem is the essential step in any design process. Thus, problem definition is the cornerstone on which the entire subsequent design or decision process is built. According to JP-5.0, critical to defining the problem is determining what needs to be acted on to reconcile the differences between the existing and desired conditions and identifies the areas of tension that merit further consideration as areas of possible intervention.<sup>25</sup> The needs analysis process of the SEDP guides the strategist to determine how the strategic ends or objective are to be accomplished. Failure to articulate this need adequately or an improper emphasis on the wrong conditions leads to decisions that result in a strategic approach to a problem other than the one that requires a solution.<sup>26</sup>

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<sup>25</sup> U.S. Joint Chiefs of Staff. *Joint Planning*, Joint Publication 5-0 (Washington DC: Joint Chiefs of Staff, June 16 2017), IV-14.

<sup>26</sup> Armstrong, L.E. and Sage, A.P. *An Introduction to Systems Engineering*. (John Wiley and Sons, New York, 2000) 120-121.

In 2019, General Joseph L. Votel, commander of U.S. Central Command, provided the following statement on the posture of his command. He stated:

*since 9/11, confronting terrorism and defeating violent extremist groups has been our primary objective . . . . The United States seeks a Middle East that is not a safe haven or breeding ground for jihadist terrorists, not dominated by any power hostile to the United States, and that contributes to a stable global energy market. . . . We will retain the necessary American military presence in the region to protect the United States and our allies from terrorist attacks and preserve a favorable regional balance of power.*

General Votel's statement is useful as a starting point for a needs analysis. Although intended as a complete and definitive statement of interests, objectives, and end states, it must be examined and critiqued to be useful in the needs analysis process. The needs analysis is designed to validate and test the objectives and end states that General Votel describes. An initial analysis will conclude that it is beyond the means and resources of USCENTCOM to shape or influence regional conditions to achieve the end state. Other questions arise: How is a jihadist terrorist different from a VEO? Are countries like Lebanon, UAE, Egypt, and Jordan considered safe havens or breeding grounds for terrorists? By deconstructing this statement, the strategist can address the various questions, get additional stakeholder feedback, and examine various aspects to arrive at a needs statement that represents what effective need the strategy is meant to satisfy.

The strategist can view the USCENCOM Commander's statement as a *primitive need statement*. It is primitive in that these stated objectives (jihadist terrorists, VEOs) offer a starting point that suggests a widespread problem recognized by various stakeholders.<sup>27</sup> The goal of a *needs analysis* is to determine the effective need, which is generally broader, and must outline the real underlying needs.<sup>28</sup> An effective need statement represents a realistic presentation of

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<sup>27</sup> Asimov, Morris. *Introduction to Design*. (Prentice-Hall, Englewood Cliffs, NJ, 1962) 8-10.

<sup>28</sup> Gibson, J.E. *How to Do Systems Analysis*, (University of Virginia: Charlottesville, Virginia, 1991) 57-58.

objectives and end states for the U.S. and other stakeholders who support the U.S. strategic end states. The strategist will gather information and interact with relevant stakeholders to determine the effective need in the most objective and realistic way possible. Based on the needs analysis, the strategist can thoroughly investigate what the actual objectives and end states should be.

The output is a thorough needs statement that will be a translation of the primitive need statement into a concise statement of the strategic objectives that meet and support the desired end states. These objectives can be directly translated into measurable criteria during the Value System Design step of problem definition.

## CHAPTER 3. – PROBLEM DEFINITION PART II: VALUE SYSTEM DESIGN

### Value System Design

Value System Design is derived from the needs analysis and is a reflection of the needs and objectives of the critical stakeholders and is a representation of the evaluation measures for the strategy based on the needs statement.<sup>29</sup> The purpose of this step is to develop a value hierarchy used to evaluate potential alternatives and to provide a comprehensive understanding of the relationship between needs and their value to the stakeholder through an analytical process of combining the previous works of the strategist.

Using the analytical works completed throughout the needs analysis, a value hierarchy derives metrics that are measurable, quantifiable, and directly related to the strategic objectives and strategic ends. This framework is used during modeling and simulation to provide empirical data and aid in decision making on potential operations, activities, and resources that are pertinent to executing the strategy.

Figure 6 represents a Value Hierarchy structure. The value hierarchy represents how strongly needs are assessed, which needs are most valuable, which are less valuable and prioritizes them in the needs statement. The strategist determines through this process what needs can be achieved within the environment and which are limited or unable to be achieved. At the top of the hierarchy is the needs statement derived and articulated during the needs analysis. This concise statement of the strategic objectives supports the desired end states and highlights

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<sup>29</sup> Armstrong, L.E. and Sage, A.P. *An Introduction to Systems Engineering*. (John Wiley and Sons, New York, 2000) 104.

the transformational functions of the strategy, which supports the prioritization of the objectives determined during the situation assessment. This allows the strategist to determine evaluation measures that will be used to assess how well the strategy supports attainment of the objectives. Thus, the value hierarchy allows the strategist to ensure that all objectives have been considered, prioritized, and can be operationalized appropriately.

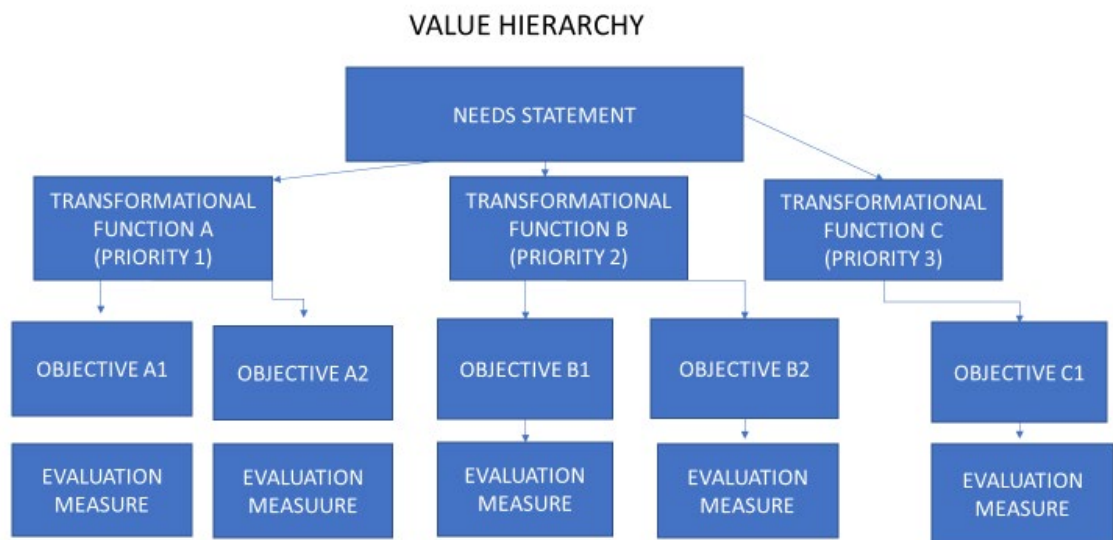


FIGURE 6

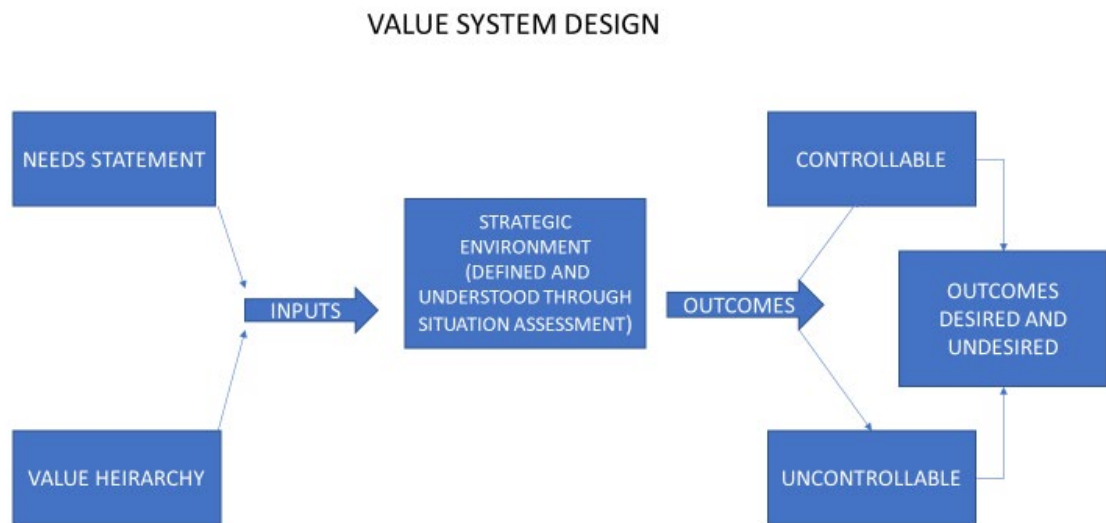


FIGURE 7

Figure 7 shows a model where both the needs statement and the value hierarchy developed are associated with the strategic environment that was assessed in the initial strategic situation assessment. This provides a better understanding of the relationship between needs and their value to the stakeholder. The strategist lists the intended outcomes, which are considered the objectives of the strategy, and the end states, understood as what is meant to be accomplished, or what should be provided in response to needs. The goal is to maximize these desired outputs: to come as closely as possible to meet the objectives and achieve the end state. The strategist considers the relationship between desired and undesired outcomes in the strategic environment to determine which desired outcomes are to be maximized and which undesired outcomes are to be minimized. This becomes the foundation of the problem statement, which defines what is to be accomplished in the face of specific obstacles in the environment and undesired outcomes an adversary stakeholder seeks to accomplish. Based on this determination

it may be necessary to restructure the value hierarchy within the needs statement. If adequately anticipated, undesired outcomes and their overall effects on strategic performance can be minimized. Additionally, the strategist must consider these strategic approaches and alternatives for feasibility, suitability, and acceptability.<sup>30</sup> The desired and undesired outcomes are assessed in terms of controllable and uncontrollable inputs, based on the assessment of the strategic environment. Controllable inputs may be physical, psychological, informational, or economic. Uncontrollable inputs are those environmental characteristics or intangibles that constitute existing conditions influencing the performance of the strategy.

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<sup>30</sup> Armstrong, L.E. and Sage, A.P. *An Introduction to Systems Engineering*. (John Wiley and Sons, New York, 2000) 167.

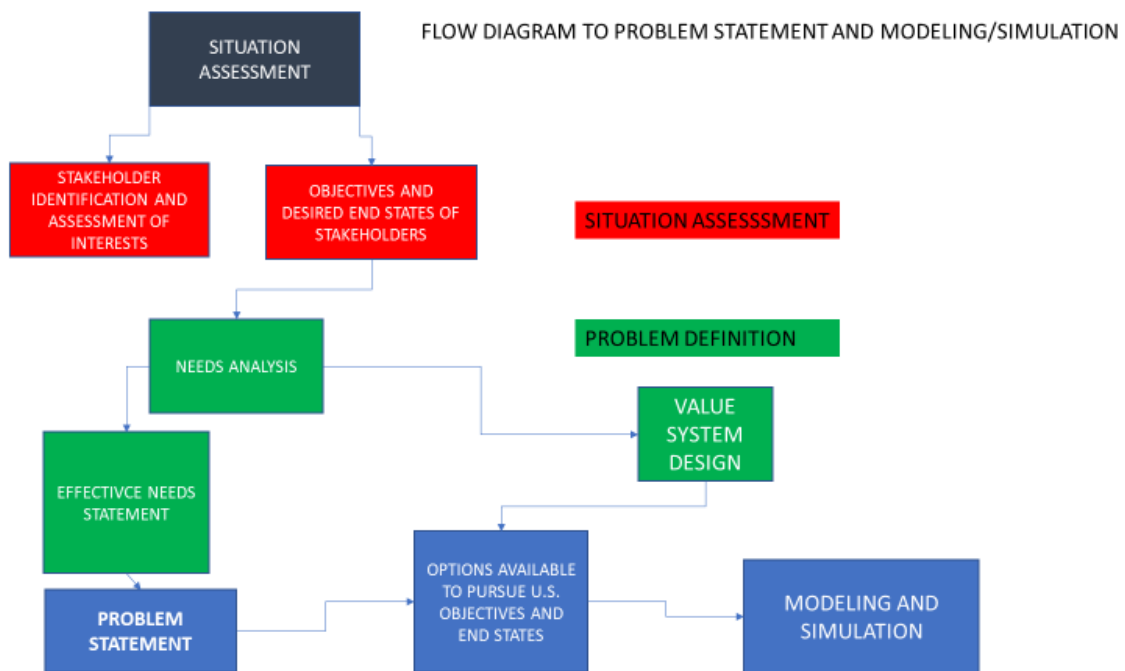


FIGURE 8.

### Summary of Problem Definition

Figure 8 illustrates the flow diagram for the strategist to work towards the problem statement. The stakeholder analysis function of the situation assessment identified and analyzed the individuals, entities, and relevant actors to clearly understand their interests, goals, and desired outcomes. The situation assessment also produced the desired objectives and end states of these stakeholders. The needs analysis identified and deconstructed the critical transformational functions of the strategy and organized them to understand the aspects of the instruments of national power as they influence the strategic approach.

The objectives and end states determined as a component of the situation assessment are primary inputs to the needs analysis. The needs analysis identifies the transformational factors required to meet the objectives and end states of the strategy. This effort reconciles the effective

needs statement and the transformational aspects, leading to the problem statement. In the SEDP application and process, the problem statement makes clear what objectives are to be achieved, what difficulties and challenges must be overcome, what instruments of national power are available, what limitations will reduce the effectiveness of the strategy, and finally, what criterion will be used to determine the effectiveness of potential solutions.

By considering what the strategy must do, rather than how the strategy will function, the strategist does not delve into solutions or visualize the strategy in terms of possible approaches. Strategic thinking in terms of the purpose of the strategy is the heart of the SEDP approach, and should open the strategist to new insights not previously considered. The SEDP supports the development of realistic objectives and achievable end states through an analytical process that results in a highly refined definition of the problem that reflects the relationship between needs, priorities, limitations, and opportunities, as derived from an objective assessment of the strategic environment. The problem statement is the foundation for the operational design and the operational approach. Harry Yarger stated that strategy at any level is not problem-solving in a classic sense. It does not seek to solve a specific problem as much as to anticipate a future and shape an environment in which fewer problems arise and those that do can be resolved in favorable terms.<sup>31</sup> Yarger, Gray, and JP-5.0 discuss the importance of defining the problem, the SEDP provides a systematic and analytical approach to doing so to arrive at a problem statement that reflects the environment as it is.

#### **CHP 4 - OPERATIONAL ANALYSIS: MODELING AND SIMULATION**

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<sup>31</sup> Yarger, Harry R. *Strategic Theory for the 21<sup>st</sup> Century* (Strategic Studies Institute. February 2006) 45.

Operations Analysis (OA) is asserted to be the application of scientific methods to the resolution of operational problems.<sup>32</sup> The OA methodology, based on the problem definition statement and the analytical work developed during the VSD step, can be used to model and analyze alternatives to the strategy as a further refinement of the operational approach as described in JP-5.0.

The strategist takes the identified transformational functions the strategy is to perform and develops detailed alternatives that can be modeled and analyzed based on parameters and variables that predict performance in terms of the evaluation measures identified in the value hierarchy.<sup>33</sup> The strategist uses modeling as a means of predicting or estimating the performance of the alternatives for the evaluation measures selected. The models are used to predict and estimate performance alternatives in meeting the objectives determined in the value hierarchy. Unlike current strategic assessments, this method is less resource-intensive and faster than a direct study of the dynamics of a strategy after implementation. The models produce raw data that can be formulated, interpreted, and ideally, will accurately reflect the effectiveness of a strategic alternative. Effectiveness represents an analytical assessment based on the results the model produces.<sup>34</sup> The alternatives can be outlined in a matrix format for the strategist to make recommendations.

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<sup>32</sup> Wagner, Daniel H, Mylander, W. Charles, Sanders, Thomas J. *Naval Operations Analysis*. (Naval Institute Press, Annapolis Maryland, 1999) 8.

<sup>33</sup> Armstrong, J.E. and Sage, A.P. *An Introduction to Systems Engineering*. (John Wiley and Sons: New York, 1999) 112.

<sup>34</sup> Armstrong, J.E. and Sage, A.P. *An Introduction to Systems Engineering*. (John Wiley and Sons: New York, 1999) 180.

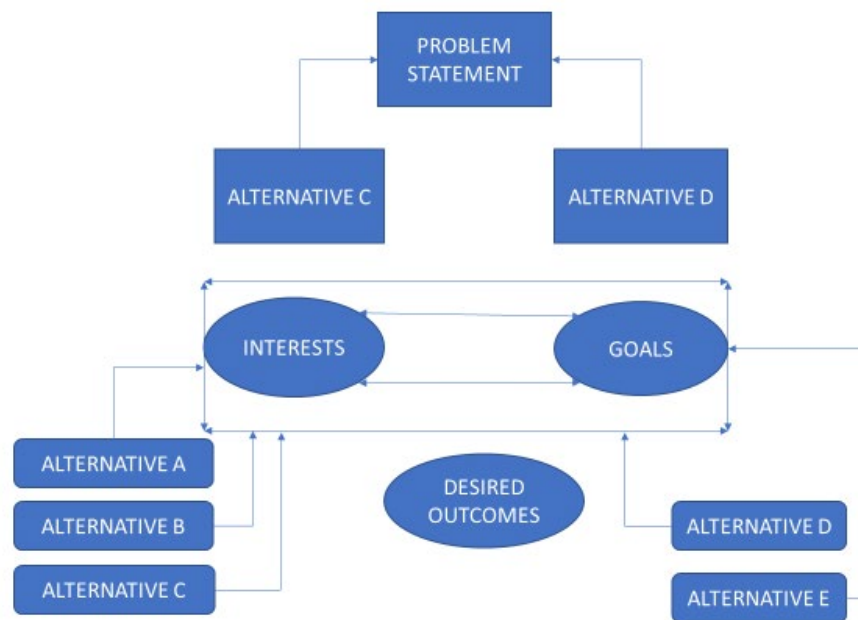


Figure 9

As an example, figure 9 illustrates option C and D as representing the the two most objectively assessed outcomes based on assessment of goals and interests related to the problem statement. The problem statement presents what needs to change within the strategic environment so that national interests are met and end states are achieved. The two alternatives selected for modeling and simulation indicate that given the value hierarchy developed, the best outcome for achieving strategic end states will be aternative C; conversely, if the risks identified predominate, or some of the limitations within the problem statement are not overcome, then alternative D, a less than optimal achievement of strategic end states is the outcome. These two options are selected for modeling and simulation with continuous modifications and revisions to provide a balanced assessment that can be used to adjust the strategy as it is implemented, and much like the operational design of JP-5.0, reveal decision points, options, and alternatives. This allows for a much more rational and flexible strategic approach.

The operational analysis figure is a combination of alternatives associated with the problem statement. The alternatives are defined in terms of possible variations of desired strategic outcomes based on the strategist's assessment of potential risks and opportunities. The best alternatives are applied against the problem statement to determine which offer the most to conclusively meet the objectives and end states identified. Alternatives are individually filtered through the interests and goals of the stakeholders as a determination of how well each alternative supports these interests and goals.

As the SEDP defines the problem, the alternatives selected for the operational approach are modeled to determine the extent they meet the desired end state or objectives. Traditional thinking on defining and addressing these types of problems has led to strategic approaches that have generated consequences over an extended timeframe. While it is not possible to design an unlimited number of feasible alternatives to all problem sets, through operational design and the operational approach, multiple alternatives can be studied, analyzed, and modeled to provide the decision-maker a list of potential solutions to the problem that can be molded into the end state desired.

A simple definition of a model is that it is a set of assumptions that describe how something works. More formally, a model is an abstract generalization or representation of a system.<sup>35</sup> This definition applies to the strategic environment. Models selected to analyze various strategic alternatives represent the strategic environment as it pertains to the problem the strategist is addressing to achieve objectives and a strategic end state. The goal of the model is to approximate the real world and represent real-world decision-making problems. The use of

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<sup>35</sup> Armstrong, J.E. and Sage, A.P. An Introduction to Systems Engineering. (John Wiley and Sons: New York, 1999) 181.

computational, agent-based modeling, simulation, and analysis models by think-tanks and social scientists in the academic world provides a more comprehensive understanding of the strategic and operational environments than the cursory process outlined in JP-5.0. Computational modeling allows for the translation of a theory in a mathematical model to a computational form, thus making possible an operation in virtual media. Virtual experiments allow the strategist to analyze vast amounts of data and work through complexity in ways not possible even a decade ago. The modeling technologies of social science domains are rapidly expanding with the development of artificial intelligence (AI), artificial society modeling (AMS), artificial polity modeling (APM), multi-agent distributed systems (MAS), agent-based systems (ABS), and complex adaptive systems.<sup>36</sup> Computer simulation is proving to be a vital addition to traditional approaches, thinking, and understanding of social phenomena and in fully understanding the dynamics of individual and collective actions of actors as it relates to instability around the world. These simulation tools are crucial to the development and evaluation of policies that affect the way we want to shape our strategies now and in the future.

Polity modeling presents significant value to today's strategist. These models are beneficial to the understanding of the relationships between polity instability and political change phenomena. They emphasize phenomena of polity instability as generated by political issues like the political exclusion of ethnic groups, political ideology-rooted social conflict and the emergence of revolutions in dictatorial regimes, state failure, and territorial disintegration, and

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<sup>36</sup> Voinea, Camelia F. *Political Attitudes, Computational, and Simulation Modelling*. (John Wiley & Sons, Ltd. United Kingdom. 2016) Xxvii, xxxiii.

the emergence of political insurgency as generated by government incapacity to issue public policies for the management of social and political grievances.<sup>37</sup>

The development of polity models is expanding to the extent that multiple models can be run for the same area of study to check against each other and to provide a redundancy throughout an analysis. Within the framework of this thesis, models were chosen for research as examples that could be used to build a more comprehensive strategy for Combatant Commanders. Advanced models may be run within the computing capabilities of a DoD entity or academic institution and are thus applicable to support SEDP (see Appendix A).

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<sup>37</sup>Voinea, Camelia F. *Political Attitudes, Computational, and Simulation Modelling*. (John Wiley & Sons, Ltd. United Kingdom. 2016) 247.

## CONCLUSION

The systems engineering design process (SEDP), when integrated with joint doctrine, provides an enhanced design methodology using a systems analysis approach that supports a more effective and coherent strategic design via clearly defined and attainable objectives and end states with an improved problem definition process. JP-5.0 captures why defining the problem is necessary and what needs to be acted upon to reconcile the differences between existing and desired conditions. However, it does not include a methodical process of doing so. This thesis shows how the SEDP provides a process to fill this void. The doctrinal design methodology is enhanced by the systems analysis approach resulting in a thoroughly analyzed problem definition and assists the strategist in developing and guiding the implementation of a strategic approach, as well as clearly articulating the desired objectives and end states. Additionally, the modeling and simulation of chosen strategic alternatives provides the strategist with detailed insight and information on strategic alternatives that is not available using the current doctrinal approach.

The strategic situation assessment of the SEDP provides a model that considered factors of influence in the past and the present and determines what factors should emerge to achieve the desired strategic objectives and end states. This assessment produces a *descriptive scenario* to explain how the current environment came to be, what the current environment is, and identifies how the current environment relates to the problems or issues that limit achieving the desired end state. Lastly in the assessment, a *normative scenario* is produced to describe what the future and ideal end state or objectives for the U.S. need to be so that the strategic environment supports the strategic end states desired.

The situation assessment further identifies the stakeholders and measures their level of influence related to the desired end state. Identified in the descriptive scenario, the stakeholder

analysis recognizes the entities relevant to the environment and works to clearly understand interests, goals, and desired outcomes. This approach seeks explicitly to identify potential partners, allies, and supporters who can be integrated into a strategy of collective effort to achieve a shared outcome.

Having developed a comprehensive understanding of the nature of the environment, conducted a stakeholder analysis, and determined objectives and end states, the strategist produces an effective needs statement for friendly stakeholders and develops alternative options available to pursue the desired objectives and end states. The needs analysis also identifies the transformational aspects required to meet the objectives and end states as they relate to the diplomatic, informational, military, and economic instruments of national power. The value system design is derived from the needs analysis and reflects the needs and objectives of the critical stakeholders. It is a representation of the evaluation measures for the strategy. This step develops a value hierarchy used to evaluate potential alternatives and to provide a comprehensive understanding of the relationship between needs and their value to the stakeholder through an analytical process of combining the previous works of the strategist.

Through the SEDP situations assessment, stakeholder analysis, value system design, and needs analysis, the problem statement produced not only reflects the intent of JP-5.0, but details and reconciles the strategic and operational environments at a level of understanding beyond what joint doctrine necessitates. The problem statement produced by the SEDP makes clear what objectives are to be achieved, what difficulties and challenges must be overcome, what instruments of national power are available, what limitations will reduce the effectiveness of the strategy, and finally, what criterion will be used to determine the effectiveness of potential solutions.

Lastly, the strategist uses modeling and simulation as a means of predicting or estimating the performance of the alternatives. Using the analytical works of the needs analysis, a value hierarchy derives measurable and quantifiable metrics directly related to the strategic objectives and strategic ends. The product is a framework for modeling and simulation, providing empirical data to aid in decision making on potential operations, activities, and resources that are pertinent to executing the strategy. The models are used to predict and estimate performance alternatives in meeting the objectives determined. The goal of the model is to approximate the real world and represent real-world decision-making problems. Various alternative approaches are modeled and analyzed to develop an optimal operational approach. The results will support focused and structured diplomatic dialogues with multiple regional partners as part of an iterative and continuous process of assessment, adaptation, and response. Additionally, this methodology offers the advantage of recognizing and appreciating factors of strategic culture that shape problem definition.

By utilizing the problem definition and modeling analysis methodology of the SEDP, the strategist can better develop an operational approach that considers various elements of national power that lead to the strategic end state desired. Ultimately, the SEDP methodology provides for a more detailed and methodical strategic design and implementation. This design methodology and systems analysis approach, integrated with JP-5.0 to address complex strategic problems, and subsequently manage the complexity of a strategic approach as an adaptive and iterative process in a dynamic environment. Finally, the SEDP provides a means to successfully deal with a wide variety of strategic challenges.

In a strategic environment more complex than any time in history; superpower dominance, authoritarian regimes, VEO's, insurgencies, and ethnic conflict are primary factors

to global instability. Support of common ideals against threats to the sovereignty and independence of the U.S. and our allies and partners around the world, the strategic design of the SEDP is now more urgent than ever. The SEDP defines the problem precisely and provides strategists with the means to assess needs, interests, goals, and objectives, thoroughly and objectively. Modeling and simulation accurately tests the strategic outcomes developed through the SEDP and provides an evaluation of the effectiveness of a strategy before it is implemented, providing the strategist unprecedented information to ensure that a realistic statement of objectives and ends states have the greatest chance for success.

## Appendix A: THE MODELS

The *Ethnic and Nationalist Insurgency Model*, GeoSim, and GeoContest, developed by Lars-Erik Cederman, Luc Girardin, and the Swiss Federal Institute of Technology, were studied. These computational and simulation agent-based models analyze the polity instability generated by the emergence of ethnic and nationalist insurgency.<sup>38</sup> GROWLab combines GeoSim and GeoContest into the newest model that simulates ethnic and nationalist insurgencies but also expands to validate the social processes of civil unrest, civil war, and regional war.

Assuming the problem statement addresses ethnic conflict, the GeoSim model may aid the strategist in determining what groups are expected to come to power, when, to what level, and where that power resides geographically. If an alternative is troop presence, diplomatic effort, or some other element of national power, the model can factor these variables by making assumptions about their impact to the political organizations within the model, thus gaining an understanding of various outcomes based on the action taken by the U.S. or our partners in the region.

GeoSim modeling approaches polity as a two-level hierarchy with the primary criteria of differentiation between groups being ethnicity. Polity's geographical position, terrain, borders, and neighboring states are addressed as dynamic variables and factors of the model.<sup>39</sup> The state is defined as a territorial agent interacting with other individual and group agents competing for power through multiple interactions. The complexity of an agent-based system with numerous interactions that change the balance of power with multiple local and global equilibria as

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<sup>38</sup> Voinea, Camelia F. *Political Attitudes, Computational, and Simulation Modelling*. (John Wiley & Sons, Ltd. United Kingdom. 2016) 247.

<sup>39</sup> *Ibid.* 253.

variables and constructed with a high sensitivity to the relationship between the leading state agents and all other agents or groups competing for power.<sup>40</sup> The model is run with multiple iterative changes to the variables until one state agent takes enough other state agents as subordinates to achieve an equilibrium of power. Once the balance is lost, the contest for power begins again. The framework uses four basic building blocks to model complex artificial worlds:<sup>41</sup>

- **political organizations:** a state system in which states are hierarchical organizations that interact and can fight wars and are willing to do so.
- **Terrain:** interaction proceeds in a realistic space with geographic obstacles, such as mountains, water barriers, deserts, and other types of rough terrain.
- **Cultural map:** identity formation based on a multi-dimensional substrate of cultural traits.
- **National identities:** nationalist behavior requires identities, which are constituted as combinations of specific cultural traits.

In this model, predatory states with various degrees of power attack one another when they perceive some likely advantage. States forge offensive and defensive alliances and, based on war outcomes, divide territorial and power. Ultimately the model shows a tendency for the simulation to produce universal empires, in which one state eventually achieves domination. By studying the various interactions between neighboring states, this model can be utilized by the strategist for various strategic approaches.

GeoContest is an expanded version of the Geosim model. It allows for a greater variety of conquest strategies to be inputted into the model to more closely study the impact of state and non-state actor actions and their effects in a multipolar setting. Most significantly, the multipolar setting allows factors of external influence of varying magnitude. This influence can be various

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<sup>40</sup> Voinea, Camelia F. Political Attitudes, *Computational, and Simulation Modelling*. (John Wiley & Sons, Ltd. United Kingdom. 2016) 254.

<sup>41</sup> Ibid. 255.

combinations within DIME and therefore allows the strategist to understand what factors lead to the desired outcome.

In this model, the state agent is a unitary system with a unique center of power located and defined in a capital city such as Bagdad or Tehran with multiple provincial agents that are subordinate to the state agent.<sup>42</sup> This model uses a centralized structure that allows a national states hierarchy and a state-province hierarchy approach. This model structure allows for the study of increasingly emphasized nationalist tendencies of the national-states trying to balance the power of the central state with the same variable of potential conflict in which the subordinated state or province rebels against the center state as an insurgency.

With the current understanding that rebellions and insurgencies are characteristic of weak states throughout the middle east and that fragile states which cannot exercise control over their territory, conflict is generated. This model also emphasizes the role of a territorial control mechanism that leads to conflict between the top and lower levels of the state hierarchy.<sup>43</sup> This model has consistently demonstrated that similar results are obtained whether the mechanism of the divide is ethnicity or nationalism. Nationalist Insurgency Model (NIM) simulations show that a hierarchically structured state is conflict-prone if it fails to unify common societal goals based on a shared cultural or national identity. In a state organized as a center-periphery hierarchy with a multi-ethnic distribution of access to power, the mechanism of ethnicity and nationalism will function by providing support to the ethnic nationalist coalitions of the provinces against the center of power.<sup>44</sup> The NIM models the configurations of ethnic political

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<sup>42</sup> Voinea, Camelia F. *Political Attitudes, Computational, and Simulation Modelling*. (John Wiley & Sons, Ltd. United Kingdom. 2016) 255.

<sup>43</sup> *Ibid.* 255.

<sup>44</sup> *Ibid.* 255.

groups and their relationships with civil violence whether they be uprisings or civil war, by forming a hypothesis that synthesizes the conceptual framework:

- **State Ownership.** Ethnicity and nationalism acquire political significance when directly related to state and power and the assumption that civil conflict arises from competition for state power and resources.
- **Political Exclusion of Ethnic Groups.** When ethnic minorities are excluded from state power, they become prone to conflict and civil violence, which may lead to state failure. (ex-Yugoslavia)
- **Mobilization.** A state which fails to mobilize all ethnic groups on a shared identity fails at preventing or avoiding civil conflict. Polity resilience to stress and civil conflict requires collective identity, actions, and shared motivations. Polity stability thus depends on the balance of power between the structural groups involved in power competition, and thus mobilization provides a balance such that polity avoids instability.

This model is valid for the study of ethnic nationalist insurgencies throughout the USCENTCOM AOR and how the U.S. may shape or influence the outcome to our favor. The NIM model provides for nationalist insurgency outcomes by using three key features. First, the terrain is modeled as a dynamic factor controlling the relationship between the center of power and the periphery. Second, a multi-dimensional map is used to support the idea that cultural groups are distributed such that they are identified by national identities and based on the clustering of individuals as ethnic-nationalist groups. This allows a political approach to the identification and the dynamics of groups with a shared ethnic nationalism within a cultural space on the map. Third, an index of ethno-nationalist exclusiveness is used, which associates ethnic configurations with political violence.<sup>45</sup> This index was constructed, so that simulation runs are based on actual empirical data collected based on the degree of exclusion of ethnic groups from power among every state in the world.

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<sup>45</sup> Voinea, Camelia F. Political Attitudes, *Computational, and Simulation Modelling*. (John Wiley & Sons, Ltd. United Kingdom. 2016) 257.

GROWLab represents one of the more advanced geopolitical simulation models that includes modules for modeling, simulation, analysis, and validations of complex social processes with a focus on civil unrest, civil war, and regional war and geographic conflict research.<sup>46</sup> The outcome of GROWLab is the development of agent-based simulations at the highest levels of complexity and realism. It is successful due to its abstraction and inherent flexibility. Four core components have been implemented to support:<sup>47</sup>

- The seeding of the model with empirical facts (including geo-referenced data) to calibrate the environments and mechanism to the appropriate level of realism;
- The effective modeling of complex network and hierarchical relationships between model actors and the efficient scheduling of their interactions;
- The execution of a large number of simulation runs on a grid made of many independent computers to test the sensitivity of the models;
- The statistical and visual analysis of the state of the system, as well as the unfolding of the processes over time.

GROWLab simulations utilize an abstract polity, making use of the polity concepts and specifying the hierarchical structure, the functions of each entity in the model (agents, territory), their relationships, and interactions across a time spectrum.<sup>48</sup> Sunni and Shia violence towards each other in Bagdad from 2003-2019, for example. The simulation is run by employing empirical data from the ESEG index, EPR, and GIS data. The Expert Survey of Ethnic Groups index associates real-world ethnic configurations as related to political violence. Global Information System data specifies geographic areas to be studied. The Ethnic Power Relations (EPR) Dataset Family provides comprehensive coverage of ethnicity around the world, both in time and space. EPR data includes all politically relevant ethnic groups and their level of access to state power for all countries of the world. It incorporates geospatial information about each

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<sup>46</sup>Voinea, Camelia F. *Political Attitudes, Computational, and Simulation Modelling*. (John Wiley & Sons, Ltd. United Kingdom. 2016) 257.

<sup>47</sup> Ibid. 257.

<sup>48</sup> Ibid 258.

ethnic group and linkages between conflict and ethnicity. Transnational ethnic groups that live in more than one state are combined as well as the ethnic composition of refugees. Linguistic, religious, and racial aspects that characterize and internally divide the politically relevant ethnic groups are specified.<sup>49</sup> External influences of DIME from the U.S. or strategic partners are factored as variables based on real-world empirical data. Simulations generate additional data through various runs and iterations of the model that are stored and processed in subsequent model runs. The relevance in this model is that all data inputs are accurate and produced according to history or the latest real-world information available.

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<sup>49</sup> Ethzurich, International Conflict Research\_Center for Comparative and international Studies. <https://icr.ethz.ch/data/>. (Accessed 1 Nov 2019 – 5 May 2020)

## APPENDIX B. THE BAGHDAD MODEL

*Violence and Ethnic Segregation: A Computational Model Applied to Baghdad: Nils B. Weidmann, University of Konstanz and Idean Salehyan, University of North Texas.*

**Summary:** The U.S. implementation of the 2007 military surge in Iraq coincided with a significant reduction in ethnic violence. One explanation is that the troop increase in and around Baghdad increased counter-insurgent capacity, the second explanation is that ethnic unmixing, and the establishment of homogenous enclaves automatically reduced violence by reduced contact. GROWLab modeled the surge with all relevant data available to show that patterns of violence and segregation are consistent with ethnically motivated violence and subsequent migration. At a minimum, the model informs a strategist about the effectiveness of counterinsurgency operations. The model implemented a policing mechanism and demonstrated that even small levels of policing can mitigate ethnic violence, but that the timing is the most crucial element. The bottom line of the modeling effort indicated that early response to ethnic violence is highly effective but quickly loses impact if these efforts are delayed.<sup>50</sup>

**Background:** The 2007 "surge" significantly increased the number of troops in Iraq intending to reduce the level of ethnic violence and insurgency. The U.S. aligned with certain militias, changed tactics, emphasized institution building, and increased the training of Iraqi security forces. By 2008-09, there was a significant decline in violence, but the cause of this remains in debate. The patterns of ethnic violence and residential segregation lead the strategist and policymaker to the following questions: What explains the spike in ethnic violence followed by

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<sup>50</sup>Nils B. Weidmann & Idean Salehyan. *Violence and Ethnic Segregation: A Computational Model Applied to Baghdad* (International Studies Quarterly, 57. 2013) 52.

a significant decline? How are these events related to inter-ethnic violence and forced migration? What measures are then needed to prevent ethnic violence and forced migration? A thorough understanding of this Iraqi case study by the strategist, highlighting the effectiveness of various interventions, can guide future thinking.<sup>51</sup>

The model used various hypothetical scenarios informed by current theories of ethnic violence. Combinations of parameters are randomly selected to produce insurgent violence as well as ethnic settlement decisions. Geo-referenced data on ethnic settlement patterns and data on violent attacks in Baghdad informed the model. This data was analyzed against empirical data collected on Baghdad from 2003-2007 to validate the accuracy of the model.<sup>52</sup>

Sunni and Shia agents were used as a populace within a GIS determined community. Small numbers of each group would attack members of the other. Additionally, a policing mechanism was put in place to punish insurgent behavior, which included both U.S. and Iraqi security forces. The policing function was able to remove insurgent actors at various levels, and the ability to detect insurgents was also varied and adjusted to multiple time phases. The goal was to bring out information about the efficiency of the surge and the increased ability of Iraq to limit violence when policed early or late in various levels of violent ethnic acts.<sup>53</sup>

The simulation suggests three main findings. First, violence will significantly increase ethnic segregation as people search for safety. Second, ethnic segregation limits violence as the ability to carry out these acts naturally diminishes, and thus violence will decrease even absent counterinsurgency operations. Third, even small increases in state policing can significantly

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<sup>51</sup>Nils B. Weidmann & Idean Salehyan. *Violence and Ethnic Segregation: A Computational Model Applied to Baghdad* (International Studies Quarterly, 57. 2013) 52.

<sup>52</sup> Ibid. 53.

<sup>53</sup> Ibid. 53.

reduce the level of violence but is far more effective if done in the early stages of ethnic segregation and insurgency.<sup>54</sup>

**Theories of Interethnic Peace and Conflict:** In the majority of multi-ethnic societies, ethnic violence is not prevalent. However, multiple studies have shown that once state capacity is diminished and extremists begin attacking a member of the out-group, the rise in violence escalates. As the ethnic divide widens, even moderates will seek safety by aligning with other co-ethnics.<sup>55</sup> This phenomenon was evident in Baghdad following the 2003 U.S. led invasion. When the Iraqi government was disbanded of power, Sunni and Shia extremist began to compete for strength, and moderates within both ethnic groups were forced to align. Previously mixed ethnic communities began to segregate with a corresponding decline in violence. This theory was modeled, and the results unquestionably, ethnic segregation reduces ethnic violence in the short term. To prevent this and maintain stability, the government must have control and the ability to detect and defeat insurgents as well as the ability to provide civilians protection.

While it is argued that the troop surge in Iraq reduced ethnic violence and degraded the insurgency, the model shows that this may have been simply a corollary effect and not the solution as General Odierno and Senator John McCain attested too. The surge was determined to be time-late to have had the impact advertised.

While the model cannot prove, or disprove, whether it was the surge or the significant increase in ethnic segregation that reduced the levels of violence, it does show the correlation between violence, segregation, and the strength of the government as primary factors in the stability of a

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<sup>54</sup> Nils B. Weidmann & Idean Salehyan. Violence and Ethnic Segregation: *A Computational Model Applied to Baghdad* (International Studies Quarterly, 57. 2013) 53.

<sup>55</sup> Ibid. 54.

country or region. The outputs of the model and the historically based empirical data are aligned.

**The Model:** The model was assembled using the actual neighborhood of Baghdad. The Sunni and Shia populace was represented as either a civilian or an insurgent. The dynamics of the model operated such that insurgents from one group would attempt to attack civilians within the other group. The success of an attack was dependent on the local ethnic make-up of the location in which it was conducted. A successful attack generated a factor of fear in the targeted population, which led to civilian migration to safer places in the city. This dynamic, in turn, altered the ethnic configuration, which either increased or constrained the susceptibility for violence.<sup>56</sup>

The model used the following inputs and variables for analysis:<sup>57</sup>

1. Model Space and Agent Population: City of Baghdad, Sunni, Shia, (insurgents and civilians)
2. Violence: An act of violence by one group or the other.
3. Probability of Attack: a computed probability to determine if an attack was successful.
4. Migration: Based on measured “fear” factor and Bernoulli probability that civilians will migrate after an attack.
5. Probability of Migration: a logarithmic probability that a civilian will migrate based on the success of an attack.

Empirical Data to make a comparison with the model were as follows:<sup>58</sup>

1. Unit of Observation: 85 Baghdad neighborhoods geo-referenced by the UN Humanitarian Information Center.
2. Violence: Incidents of sectarian violence obtained from the SIGACTS database.
3. Ethnicity: Obtained from M. Iady at the Gulf 2000 project at Columbia University.
4. Period of Observation: February 2006 through June 2007.

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<sup>56</sup> Nils B. Weidmann & Idean Salehyan. Violence and Ethnic Segregation: *A Computational Model Applied to Baghdad* (International Studies Quarterly, 57. 2013) 56.

<sup>57</sup> Ibid. 56-57

<sup>58</sup> Ibid. 57

The mathematical conduct of the model is not relevant to this thesis. Still, for context, the model was run with thousands of iterations that used the empirical data to generate 20,000 randomly drawn parameters. These parameters changed in value for each run to validate the accuracy of the model.

**Violence and Segregation over Time:** The model showed that there is a reciprocal relationship between violence and settlement patterns. Violence induces migration, but ethnic homogeneity then reduces violence. However, the model also showed that as mixed ethnic neighborhood moves towards homogeneity, attacks against minorities increased. Concurrently, the outflow of minority members reduces the number of potential targets, thus removing the risk of violence in homogenous neighborhoods.<sup>59</sup>

This study concluded that violent attacks are consistent with an ethnic-cleansing mechanism. Attacks are more likely to occur in areas where there are small but significant minorities. Second, violence increases the level of ethnic segregation over time.<sup>60</sup> The search for civilians to find safety is all that is required for mass migration, and that ethnic segregation alone can reduce the levels of violence within a polity.

**Policing to Reduce Ethnic Violence:** The model further indicates that policy cannot be discounted as a function of reduced violence.<sup>61</sup> The model inserted policing at various times

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<sup>59</sup> Nils B. Weidmann & Idean Salehyan. Violence and Ethnic Segregation: *A Computational Model Applied to Baghdad* (International Studies Quarterly, 57. 2013) 60.

<sup>60</sup> Ibid. 60.

<sup>61</sup> Ibid. 60.

throughout the period of observation and vary the level of success as measured by reduced violence and reduced segregation. Success is defined by the probability that an insurgent is removed from the space through the capture or killing after having carried out an attack. The model did not account for the capture or killing of an insurgent that had not attacked. The only method for this model to identify an insurgent is through a deliberate attack. The empirical data suggests that the actual number of insurgents captured or killed exceeded what the model showed. To compensate, the model used a higher probability of attack than the empirical data showed. In either case, the reduction in violence and segregation over the period of observation was consistent.

The policing mechanism inserted led to the following analysis. The later the policing starts, the smaller the reduction in violence and segregation. The importance of timing is the most crucial variable identified. The model ran through 100 time-steps, hypothesized to be approximately two years, showing that the policing effort would have to be tripled to achieve the same reduction in violence.<sup>62</sup> The effect on segregation indicates a similar result.

**Conclusion:** The GROWLab agent-based model examined the relationship between violence and ethnic segregation over time, as well as how policing efforts on the part of the U.S. and Iraqi forces could affect the increase or decrease of each dynamic. It's feasible for the strategist to conclude that there is a reciprocal relationship between ethnic separation and violence and th<sup>63</sup>the timeliness of policing action must be executed at the earliest onset of ethnic violence to have any measurable effect. In this example, both the empirical data and output of the model

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<sup>62</sup> Nils B. Weidmann & Idean Salehyan. Violence and Ethnic Segregation: *A Computational Model Applied to Baghdad* (International Studies Quarterly, 57. 2013) 62.

<sup>63</sup> Ibid. 62.

demonstrate that when the ethnic violence in Iraq began a sharp decline, ethnic segregation was nearly complete by the time of the surge.

The model informs current thinking about the effectiveness of counterinsurgency operations. Even small increases in policing effectiveness can dramatically mitigate the level of violence, but only if policing is implemented very early in the escalation of violence. Delayed implementation of a robust counterinsurgency may help reduce violence to a smaller degree, not can not be nearly as effective as demonstrated by both the historical data and the output of the model.<sup>64</sup> This finding alone has significant implications for both policymakers and the strategist alike in future ethnic conflict. Additionally, policymakers and strategists should be aware that the data suggests any military occupation must be done with a devotion of overwhelming resources to contain an insurgency.<sup>65</sup>

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<sup>64</sup> Nils B. Weidmann & Idean Salehyan. *Violence and Ethnic Segregation: A Computational Model Applied to Baghdad* (International Studies Quarterly, 57. 2013) 62.

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