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RESEARCH INITIATIVE TO UNDERSTAND & MODEL STATE STABILITY: EXPLOITING SYSTEM DYNAMICS

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Abstract

In its Preface, *The 9/11 Commission Report* states: "*We learned that the institutions charted with protecting …national security did not understand how grave this threat can be, and did not adjust their policies, plans, and practices to deter or defeat it*" (2004: xvi). Given current realities and uncertainties "better preparedness" can be achieved by identifying, controlling and managing the elusive linkages and situational factors that impact state stability and fuel state decay and destruction – and hence create new threats to the nation's security.

We propose to focus on the use of system dynamics modeling techniques to help understand, measure and model the complex dynamics shaping state stability, initially for two regions. We will specifically consider the impacts of unanticipated disruptions, such as a tsunami and its aftermath, on the dynamics of the two regions. For each region, we will deliver a detailed country model, including 3-5 futures predictions in the 6-12 month range along with an analysis of conditions and casual links between predicted futures plus corresponding mitigated options.

1. Introduction

In its Preface, *The 9/11 Commission Report* states: "*We learned that the institutions charted with protecting …national security did not understand how grave this threat can be, and did not adjust their policies, plans, and practices to deter or defeat it*" [1: xvi]. Given current realities and uncertainties "better preparedness" can be achieved by identifying, controlling and managing the elusive linkages and situational factors that fuel hostilities. This proposal demonstrates new opportunities and capabilities provided by anticipatory technologies that help us to better understand, measure and model the complex dynamics shaping propensities for state instability, and generating some predictions pertaining to alternative outcomes. The instability propensities may well be more 'severe' cases given the magnitude of dislocations created by the recent large-scale environmental catastrophe.

We propose to accomplish these objectives by drawing upon the power of system to capture the diversity, intensity, and dynamics of state stability. System Dynamics [13] is a computer-based approach for modeling and simulating complex physical and social systems and experimenting with the models to design policies for management and change. Feedback loops are the building blocks of these models and their interactions can represent and explain system behavior. Our strategy is to develop a suite of system dynamics models of the stability of two states and provide 3-5 futures based on a 6-12 month horizon.

2. DYNAMICS OF STATE STABILITY

2.1 States and Societies under Stress

The instability of states is not an isolated event. Every action engenders a reaction. Context matters and matters a lot. Surprises are more of a rule than an exception. Often instability is a function of internal institutional and leadership weaknesses, domestic contenders for power, insurgencies, and the like, as well as external factors, such as people, armies, or other threats perceived or actual that are 'crossing borders'. When the fundamentals of life supporting property are threatened, eroded, or damaged entirely, then the entire fabric of the social order is damaged, and the reconstruction challenges in themselves may create new and unprecedented pressures on institutions of governance that, under even the most 'normal' of circumstances, are marginal at best.

At this point in time, we are caught in a paradoxical situation. On one hand, our analytical and computational tools have never been as powerful as they are today, and their future promise is virtually unlimited. On the other hand, the complexities of reality require commensurate specialization and concentration of knowledge and skills, which generate information, insights, data, and 'predictions' far more extensive than we have the ability to integrate, synthesize, and prioritize when confronted with unexpected changes in the global landscape or with new configurations of state-threatening conditions.

2.2 The 3-D's Dilemma

Against this background, we highlight three fundamental features of current and complex realities, namely the distributed nature of data, the diversity of stress, and the density of instability-factors – jointly labeled the 3-D's. It presents some broad directives for the pursuit of a coherent web-based, information-robust knowledge strategy for understanding and anticipating state instability. Each of the individual D's is significant in its own right, but together they signal the generic nature of the embedded challenges, and the irrefutable relevance, if not centrality, to the overall calculus of state stability in general and with specific applications and reference to the two designated regions.

Distributed Nature of Data. Addressing problems central to complex domains as the stability of states requires tools that easily combine observations from *disparate sources, compiled initially for different purposes, using different methods, and subject to different interpretations.* Moreover, the degree of damage created by the tsunamis – devastating large areas – is difficult to gauge with any degree of precision due to the diversity of sources and varying reliability of information.

Diversity of Stress. Diversity in the global landscape – and all that this entails – is one of the most important legacies of the 20^{th} century. In many ways, the powerful new parameters for global politics are reflected in critical new challenges to ways of understanding societies under stress and the conditions under which they would become unstable. And, if we also consider the threats to security created by 'nature,' they may span from relatively minor pressures on the social order and on government performance all the way of massive large scale disasters that undermine the very survival of the institutions of law and order – as we are currently witnessing in many countries.

The unit of the 'state' is no longer the only source of, or agent for, instability and/or conflict. A range of non-state actors and/or 'free agent' pressures creates new instability and uncertainty, the nature of which may not be fully understood. Too much is changing, too quickly; creating too many challenges for effective information access and knowledge provision. While every threat to the sanctity of the state is unique in its own right, diverse threats and counter threats all share common features characterized by dynamics of actions and reaction and escalating hostilities, rendering actions and interactions increasingly vulnerable to the proverbial 'tipping point' – into state instability.

Density of Stability Factors. In many regions of the world, the increased mutually reinforcing, interlocking, and dynamic interactions among systems of threat to the survival of the state create multipliers effects of their own. This means that a disturbance in one source of threat could result in 'spillover' effects in others. Such conditions, generally known as loosely or tightly coupled system (as the case may be) invariably call for 'advanced concepts'. In East Asia today, it is difficult to believe that the impacts of the devastation created in minutes can remain insulated from the long-standing effects of prevailing social and political cleavages – despite all evidence of collaboration among warring parties in the immediate aftermath of catastrophe,

2.3 Essential Information Needs

These broad contours of the 3D's point to some information needs that must be met (i.e. data problems) and some conceptual challenges that must be resolved in order to make any progress at all. At a minimum these include:

(1) Capturing the ***'meaning(s)'*** of stability in different contexts, diverse time frames, and various levels of social aggregation. (Note the view that "one man's terrorist is another's 'freedom fighter'").

(2) Understanding and tracking the ***dimensionality*** of state stability, in terms of *who* does *what*, *when* and *how* - and with what potential *impacts* - in order to formulate viable dynamic perspectives.

(3) Improving the ***contextual basis*** for drawing inferences from different databases about propensities for state instability from *diverse sources,* natural as well as man-made.

(4) Using the above probes to frame 'rules of thumb' to help *anticipate* (or assess) potential severity of ***alternative forms*** of social threats that can lead to state instability under various conditions.

(5) Developing ***differentiation criteria*** or metrics to provide more nuanced inferences in a timely way (for example, understanding and differentiating the damage potential of various sources of instability—i.e. internal, external, and those undermining life-supporting properties.

(6) Representing dynamics of potential unstable states – before they are actually unstable —and capturing the changing ***role of critical drivers toward instability***, as well as their manifestations and measures in order to better understand and model the mitigating factors

Clearly, some order in the domain and dimensionality of state stability must be achieved so as to help model the process towards instability and its outcomes linkages from the root causes or critical drivers into the *emergent process*es that must be controlled if the outcomes of the processes are to be managed. We believe that problems of this sort are fundamentally complex and can be best addressed if a research strategy is designed applying system dynamics principles of modeling and simulation to the domain of 'state stability', focusing on the linkages among (i) internal sources, (ii) external threats that may reinforce instability possibilities, and (iii) underlying viability of life-supporting properties whose very erosion might propel toward instability.

2.4 Information Needs

There is a considerable amount of publicly available information on all key aspects for the regions to be studied. Some of the economic data has been 'homogenized' to some extent by international institutions (such as the World Bank) but there is no guarantee that this homogenization in itself has rendered robust data. For this reason, we need to focus explicitly on the range of variability across diverse sources other than the most commonly used ones. Greater challenges are posed by conflict-related information where discrepancies across data sources are considerable and adjustments may be needed.

To expedite the development of state stability futures we propose to draw upon the existing technologies embedded in the analytical and computational capabilities of the *Global System for Sustainable Development* (GSSD) and of the *COntext INterchange* Project (COIN) [5,14,15,17], where helpful to meet the goals of this effort. GSSD is an Internet-based 'platform' for exploring forms of information generation, provision, and integration and contributes to analysis of problems reflected in multiple domains, regions, languages, and epistemologies. This platform has been applied to international development problems. To our knowledge, *GSSD* remains the only existing multilingual (non-Western), hierarchical, tested knowledge platform for distributed information worldwide, operating in the public domain. We propose to explore the special application of this system to the complex domain of conflict analysis (in, for example, the deployment of a 'Global System for Conflict Analysis'), as a critical capability for analysis of propensities for instability and insecurity in specific settings.

Advances in computing and networking technologies now allow extensive volumes of data to be gathered, organized, and shared on an unprecedented scale and scope. Unfortunately, these newfound capabilities by themselves are only marginally useful if the information cannot be easily extracted and gathered from disparate sources, if the information is represented with different interpretations, and if it must satisfy differing user needs [6, 17, 18]. The data requirements (e.g., scope, timing) and the sources of the data (e.g., government, industry, global organizations) are extremely diverse. For system dynamics modeling, however, some important pragmatic information-strategies can be undertaken based on capabilities already in place, especially regarding propensities toward state instability, of forecasting alternative outcomes, or of making predictions about the future

3. SYSTEM DYNAMICS MODELING (SDM)

3.1 Value of System Dynamics

System dynamics modeling (SDM) has been used as a modeling and simulation method for more than 30 years. System dynamics focuses on understanding and representing the dynamics of a system, including interactions among actors, actions, structures and processes in complex situations, with a special focus on feedback dynamics and delays to highlight the unanticipated consequences. System Dynamics modeling is designed to eliminate the limitations of linear logic. It is based on understanding system structure, identifying core variables, specifying interconnections among positive and negative feedback loops, and tracking intended as well as unintended consequences of action. Based on iterative process of difference equations, this approach requires an a priori identification of system boundary, clarification of core elements and 'causal linkages', and exploratory propositions about the sources and consequences of alternative system behaviors.

SDM is a valuable resource for understanding possible and often unexpected and undesirable outcomes, creating 'insurance' against unintended consequences, and enabling a better fit between conflict conditions and strategic operations. SDM has been applied to numerous domains, for example, crisis and threat in the world oil market, stability and instability in developing countries, conflict among competing countries, dynamics of arms races, etc. SDM enables analysts to uncover 'hidden' dynamics in conflict situation, and helps anticipate new modes of threat and violence.

3.2 SDM of State Stability

Over the years, a large number of individual factors have been studied as impacts on the stability of states, and most of them are anchored in internal causes of conflict and the extent to which they are influenced by external factors and international sources of threat. But how do these individual factors interact with each other? SDM is well suited for analysis of complex systems and evolving or emergent dynamics under great uncertainty. The literature on system dynamics models of state instability explores new terrain in both modeling and analysis. It has been used for better understanding of interconnections among causes and consequence of threats to domestic stability, and has successfully captured the linkages between domestic and international factors [10, 4, 16, 21, 22] and generated robust representation and modeling of conflict by differentiating between internal sources and external influences, and articulating the linkages between and among them. The initial representation of a system dynamics model (highlighting the core logic of stresses on stability and security – and factors shaping propensities toward state instability) is through the causal loop diagram (a step prior to computational rendering).

Most SDM models of conflict draw upon the theory of lateral pressure in international relations [11, 12]. The theory argues that internal sources of state instability can be characterized as (i) internal (ii) external and/or (iii) fundamentally threatening life supporting properties (like famine, desertification, earthquakes, etc.) and then posits that actual instability is a function of the loss of resilience in institutional performance whereby the loads on the overall system are greater than the system's overall performance capabilities rooted in its 'master variables', namely: population features (P), level of technology (T) and resource access and availability

(R) – with the implication that different 'base lines' of P, T, R generate different propensities for state performance and resilience under conditions of stress.

Clearly, each of these variables (P, R, T) and their constituent elements, are influenced by public policy, by social norms, and by investment strategies – all related to human-decisions in one way or another. By contrast, the tsunami-devastations in East Asia show massive destructions of each of these variables by forces of nature, devoid of human interventions. While we do not intend to model 'nature', we do intend to address the potentials or propensities of system-responses to nature's devastations.

The following figures, based on [22], illustrate the progression of SDM logic and modeling. This model is designed to explore the connections between internal and external sources of threat to the sanctity of the state, which we refer to here in the generic term of 'conflict' – with the full understanding these figures are for illustrative purposes only. They are intended to show the logic of progression in the problem definition and modeling process – to be applied to the domain of state instability – but to not represent the specific model that we propose to focus on. More specifically, we intend to model state stability with use of a SDM model that relates the conditions *within* a country to *external* impacts and, by extension, the feedback dynamics between internal and international factors as these affect system decay.

A highly simplified view of the overall logic is in Figure 1, which shows the entire system and defines the components or 'sectors' of the model that must be rendered more explicit in order to formulate the key equations. It is the most skeletal form of the functional relations (note, at this stage, the absence of positive or negative in the directionality of the arrows). Figure 1 is clearly too general to be used operationally. The point however is that even at this most abstract level, an SDM model is rendered in terms of critical feedback dynamics. For example, we can see in Figure 1 that "resources" (and other factors) influences "military force." In turn, the amount of "military force" (and other factors) influences the amount of "violent conflict." The amount of "violent conflict" influences the amount of "resources" – leading us around the circle back to "resources". This type of feedback loop is fundamental to System Dynamics and, when all the factors are considered simultaneously, easily exceed the cognitive skills of most "mere mortals." That is why the computer-based SDM modeling and simulation are so important.

For the two regions to be studied, we fully expect the internal pressures to be as important, if not more so, than the international ones. For modeling purposes, however, it is important to model and track these as distinct processes, and then explore their interconnections and potential multiplier effects.

The logic for the use of these figures as illustrative devises is as follows: here we assume that state instability is a function of conflict. Under conditions of stress, tension, and conflict, we can expect states to become unstable. Therefore, for illustrative purposes in these simple examples, we use 'conflict' as a proxy for state instability.

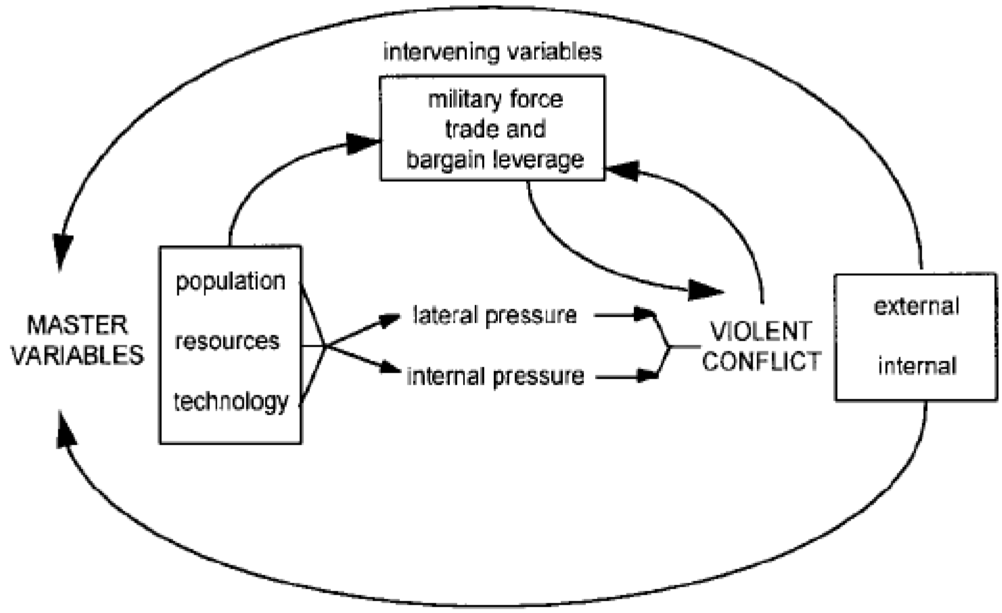

Figure 1. Overview of State Stability Model. [22]

More specification of the logic is required in order to formulate the key equations. Figures 2 and 3 proceed then to unbundle the dynamics into more detailed key feedback relationships.

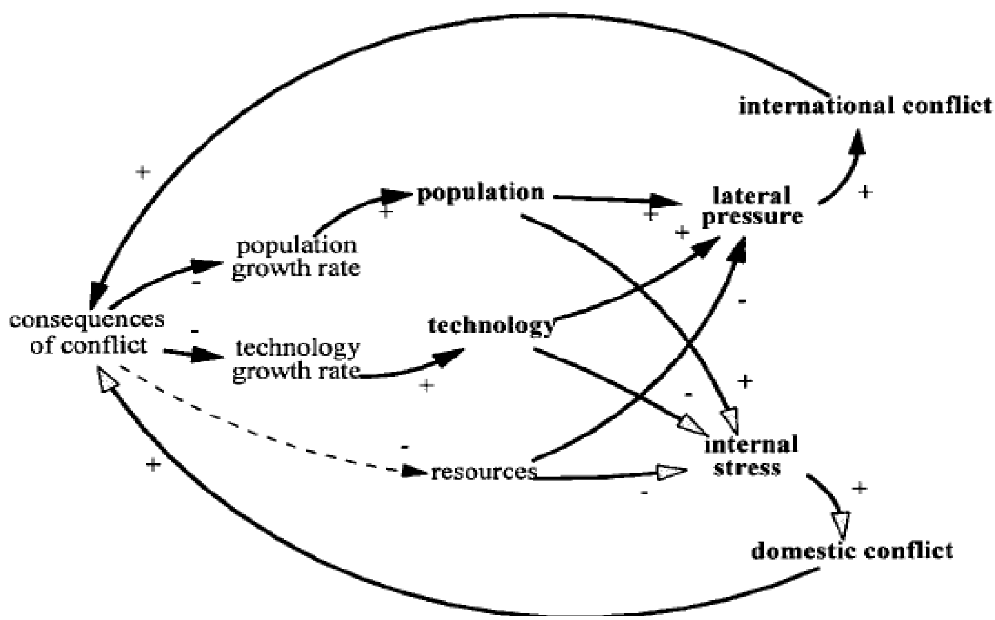

Figure 2. Six core loops for impacts of master variables [22]

In Figure 2 the connections among the core drivers (or master variables) namely population, resources, and technology represent the hypothesis that when increases in population and in technology (or overall capability) are accompanied by declining resources, then the greater the resource needs, the more will be the level of internal stress. Sustained internal stress leads to domestic conflict, and the greater the conflict the more severe will be the impacts on the country's core capabilities (the master variables).

The plus and minus signs in Figure 2 represent the nature of the expected causal relationship. A plus (+) indicates that we expect an increase to occur, whereas a minus (-) indicates that we expect a decrease to occur. For example, we expect that an increase in "population" will likely lead to an increase in "internal pressure." There is nothing predetermined about (+) or (-), it simply is a way of rendering the feedback dynamics explicit and to connect to the rest of the model.

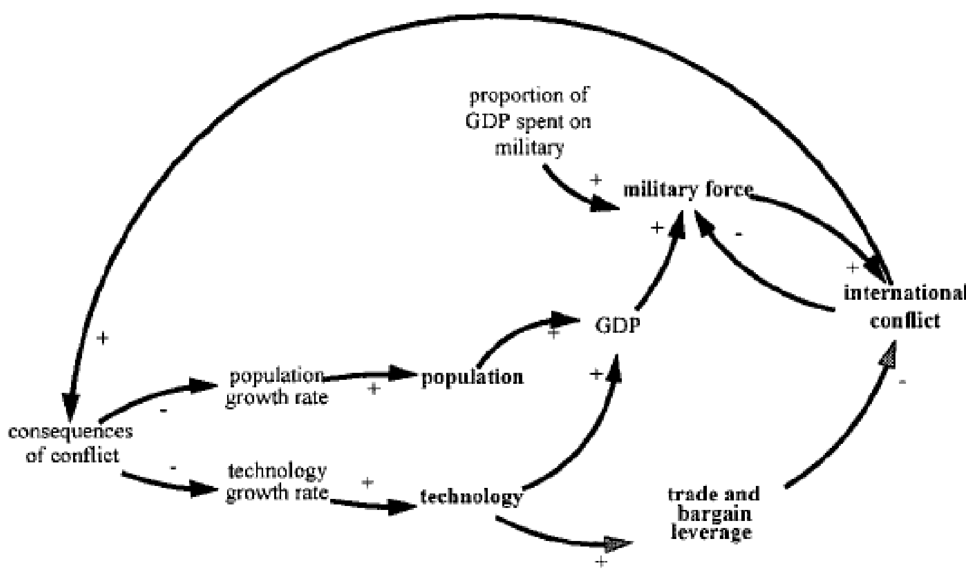

Figure 3. Military force loop and trade and bargain leverage loop as mitigating factors impacting state stability [22]

Some of the more detailed connectivity logic is shown in Figure 3, indicating how the impacts of conflict – mediated through the master variables as intervening processes – influence the country's overall economic performance, indicated by its GNP, will be affected accordingly. The greater the domestic stress, the more will be the detrimental effects on economic performance. When this happens, then there is an increase in the propensity to use military force and to engage in external conflict and when this happens, we expect the propensities for state instability to increase.

Figure 3 also includes an alternative to the military option, namely trade and bargaining. These are essentially two different 'pathways.' The propensity for system management and/or the de-escalation of stress increases with less reliance on the military and greater use of trade and bargaining options. The eventual outcomes, then, are shaped by the relative strength of the alternative pathways.

It is important to stress again that in this model the feedback dynamics is from the external to the internal environments. The nature of the feedback dynamics is a specific (and practical) mechanism through which to explore all the processes impacting the stability of the state.

3.3 The Problem of Data Deficits in SDM

Comparing leading modeling technologies in the social sciences along specific criteria, Axelrod [3] ranks SDM high on flexibility, transparency, and range of application domains; and low on construction time, user prerequisites, and learning time. This ranking however, does not take into account construction or expansion of the database or meeting key information needs. In this connection, a chronic limitation of SDM applications, so far, has been its relatively limited empirical bases, i.e. it does not take into account the construction of expansion of the data base or of meeting key information needs that must be addressed prior to actual modeling. Therefore, capturing the full value of understanding and representation of the stability of states requires the prior resolution of select information needs (as noted in Section 2.3 above).

4. OVERVIEW OF RESEARCH STRATEGY

4.1 Leveraging the Power of SDM's

In the domain of state-stability analysis, there are some particular 'leverage tasks', essential for enhancing the power of SDM's. These include reducing barriers to information access and use when the *properties of the problem* themselves are changing as a function of *unfolding* conflicts and contentions, and when the *demands* for information change in the course of the contentions. Several specific challenges are anticipated in the course of this research:

(1) **Disconnects in Definitions of 'State Stability'** – e.g. the decay of the state problem. Of the leading 10 data sets on international conflict and violence over time, no two data sets are synchronized or reconciled for either the core definition of the 'activity' or its implications for the stability of the state.

(2) **Shifts in Spatial Configuration** – e.g. the territorial boundaries problem. As any student of international relations knows, when states become unstable, often new ones are created, but seldom are the boundaries the same and often it is not clear if we are talking of nation-building or decaying states.

(3) **Distortions due to Data Temporality** – e.g. economic and political 'currency' problems. Achieving integration of diverse data sets on attributes and activities of states over time requires the ability to reconcile different coding schemes representing states as well as the ability to track and integrate the impacts of changes in territorial and jurisdictional boundaries. When the state of interest is made of several distinct internal-jurisdictions, with different ethnic groups etc. than the data temporality issues become important.

5. SPECIFIC GOALS OF RESEARCH PROJECT

To deploy the power of the system dynamics modeling (SDM) to address the question of state stability, we plan to accomplish the following goals:

(1) Identify the referent situations and factors relevant to conflict and state instability for the defined regions.

(2) Create a catalog of selected past cases and identify all conflict-related or overlapping special reconfigurations over the past 20 years.

(3) Develop the broad system dynamics causal logic connecting determinants and consequences through an intervening 'process' and use this initial logic to identify the most dominant feedback loops (and differentiate between the positive and the negative loops).

(4) Compare the system structure and dynamics (in terms of key variables, functional relationships etc.) to the topic and/or domain specific ontology in our GSSD system in order to provide some initial verification of the logic coherence and completeness of the system dynamics model.

(5) Identify the key sources of data needed to parameterize the system dynamics model. Determine the degree of congruence among alternative sources for representing basic state stability-related information.

(6) Construct the initial detailed system dynamics model (SDM) to model the "state stability" prospects for the two region cases.

(7) Run various test cases of the systems dynamics country models with various sets of assumptions regarding the key parameters and alternative intervening actions.

(8) Undertake sensitivity analyses of the two country models and map-out the results in terms of the relative 'robustness' of the predicted processes over time.

(9) Refine the SDM model based upon feedback and analyze.

(10) Determine how the system dynamics model can best be used to mitigate future state instabilities by identifying low probability (and usually unexpected events – such as 9/11) that have a high risk and high impact – a form of "insurance" policy.

(11) Prepare reports describing the model and the insights and "lessons learned" from experiments performed using the model.

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