AN EXAMINATION OF THE APPLICABILITY OF COMPLEX SYSTEMS THEORY TO POLICY MAKING

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> Every quantitative measurement we have shows we're winning the war [1]
>
> When the Nixon Administration took over in 1969 all the data on North Vietnam and on the United States was fed into a Pentagon computer – population, gross national product, manufacturing capability, number of tanks, ships, and aircraft, size of the armed forces, and the like
> The computer was then asked, "When will we win?"
> It took only a moment to give the answer "You won in 1964!"[2]
>
> In a linear world, the underdog never wins [3]

Linearity is the unitary view, the root metaphor, of Western thinking It is ubiquitous in our visualization of the way the world works "Humans have a terrific need for stability and one of the ways we serve this need is through the search for paradigms We consider reality tamed if we find a classification, a description for it "[4] We have created stability and understanding through the metaphor of the world as a giant, clockwork machine governed by linear relationships National leaders and diplomats often react to problems, crises, and negotiations with a linear mindset This linear view usually manifests itself in the unstated assumptions underlying courses of action chosen by policy makers – courses of action which often assume there is a direct link between means and ends, that carefully calculated and precisely applied actions will lead to equally precise political outcomes, or that what worked before will work again Even though policy makers recognize the inherent complexities of their craft, they often fall back upon a linear mindset – because they have not been given an alternative This paper will examine the possibility of creating such an alternative mindset – an analytical framework based on an understanding of nonlinearity and complex systems theory

Recognizing the "generic" complexity of a problem (i e solution will be difficult because there are many factors to consider) is not the same as understanding the difference between linearity and nonlinearity, nor is it the same as understanding complex systems

theory To categorize a system or a relationship as linear is to imply two conditions The first is that changes in system input result in proportional changes in system output The second is that of additivity – simply put, the whole equals the sum of its parts These two conditions mean that understanding linear systems is relatively easy. Knowledge of inputs leads to knowledge of outputs Problems are solved by breaking them into individual parts and analyzing the parts In order to understand and, more importantly, control a linear system, we keep breaking it down until we find parts that are basic enough to understand and control – at which point we can understand and the control the reassembled intermediate parts, and then the whole [5]

Regardless of the appeal of the linear metaphor, the "real world" exhibits significant nonlinearities – instances where things do not operate in a clockwork manner, systems that are open to outside influences, that are unstable, inefficient, unpredictable, and not controllable, systems in which it is impossible to understand the rules of operation or behavior, in which small changes in input may result in large changes in output, in which no amount of knowledge of initial or current states will allow calculation of subsequent or final states

The emergence of new, nonlinear fields of study – chaos, nonlinear dynamics, complexity, complex adaptive systems, cellular automata, artificial life, etc , has made explicit the pervasiveness of the linear metaphor and the fundamental inadequacy of such a linear view of the world That fundamental inadequacy means the root metaphor must change The new root metaphor must rest on a foundation of nonlinearity The nonlinear field of study most applicable in the context of this paper is complex systems theory

At the core of complex systems theory are complex adaptive systems Systems, in general, often display nonlinear characteristics, therefore, the results of actions often cannot be

predicted and outcomes are sometimes less or more than the sum of inputs Small inputs may have great effect, but, similar to the economic law of diminishing returns, more may not result in even greater effects Conversely, input may have little effect until some "critical mass" is reached Also, an input may have no effect unless some other input or condition is present Finally, "in a system, the chains of consequences extend over time and many areas the effects of action are always multiple 'we can never do merely one thing' "[6] In complex adaptive systems, the agents forming the system have the capacity to cope collectively with new challenges [7]

The nature of systems, then, leads to four key premises of complex systems theory The first is self-organization and emergent properties The agents of complex adaptive systems will form and re-form patterns of connections and behavior which are self-organized, i e not imposed from outside the system As this happens, new properties or attributes emerge [8] The second premise is the existence of adaptation and co-evolution Complex adaptive systems maintain essential elements of structure by maintaining a balance between external demands and internal needs At the same time, they change in response to their environment, just as the environment changes in response to the system The third key premise rests on the power of small events "Small, seemingly minor events can give rise to large outcomes, systems are sensitive at any moment in time to the conditions prevailing at that moment and can thus initiate processes of change that are substantial and dramatic "[9] The final premise is that of sensitivity to initial conditions – which means "even the slightest changes in initial conditions can lead to very different outcomes "[10] This does not mean those different outcomes are always bad [11]

The characteristics of complexity and complex adaptive systems are prevalent throughout the full range of human activities – including the relationships between nation-states Any application of nonlinearity to the policy making process must, therefore, be based on the following basic lessons of complex systems theory First, there appear to be many more nonlinear than linear systems (whether naturally occurring or human-created), and nonlinearity leads to complexity Second, the relationships or connections between parts of systems are just as important as the parts themselves There is, in fact, no meaning without the connections The connections determine the context, and context defines the system Third, there is no "solution " Complexity is about process and evolution, not problems and end-states Fourth, adaptability is the essence of a complex system It has the ability to sense and learn from its environment Reactions to problems are time-sensitive because the system continually evolves – a given reaction will not recur even if the problem is the same And fifth, low-level interactions result in high-level emergent behaviors [12]

In the human world where complex adaptive systems interact with each other, the nature of complex systems insures that there are things which are unknown and unknowable The difference between linear and nonlinear thinkers is how they cope with those unknowns The linear policy maker attempts to reduce the complexity by simplifying and assuming, and by looking at parts of the whole The linear chain of reasoning is based on what is known The nonlinear policy maker, on the other hand, understands that the complexity is inherent in the system and cannot be reduced The nonlinearist who appreciates the unknowables may arrive at the exact same decision as the linear thinker, but will be far better equipped to cope with the inevitable unforeseen consequences of the decision

In order to examine the utility of a nonlinear mindset and complex systems framework, the lessons of complex systems theory will be used in a comparative case study We will briefly examine the decision making in the Cuban missile crisis, and the decision by the US to apply "graduated pressure" during the Vietnam War This discussion will be quite limited – conducted solely for the purpose of illustrating the concepts involved These two cases are interesting because many of the same decision makers were involved in both, and they made explicit comparisons between the two

> We had seen the gradual application of force applied in the Cuban Missile Crisis and had seen a very successful result We believed that, if this same gradual and restrained application of force were applied in South Vietnam, that one could expect the same result [13]

The seeming triumph of US objectives ("eyeball to eyeball and the other guy blinked") during the Cuban Missile Crisis led to the mythology of a carefully managed outcome The outcome of the missile crisis, representing as it did a step back from the nuclear brink, seemed to herald the return of diplomacy to the forefront of international relations The primacy of rationality, crisis management, and the regulated application of force were the lessons taken – especially by policy makers in the United States The combination of diplomacy plus the credible threat of force led to specific political ends by means of limited coercion – or so the myth goes This myth of ever-increasing pressure on the Soviets conveyed in a vocabulary of signals, messages, pauses, and squeezes was transferred whole cloth to Vietnam, where it failed miserably [14]

The mythology of the missile crisis was not only an artifact of the heady relief at its outcome and the subsequent adulation accorded the participants, it was also an artifact of the linear mindset of those participants The chief linearist among them was Secretary of Defense Robert McNamara McNamara and his "Whiz Kids" from Ford Motor Company had come to

Washington and turned the Defense Department on its head with the application of quantitative analysis and decision making throughout the Pentagon This quantitative approach extended to the policy arena and the use of military force When confronted with the crisis in Cuba, McNamara rejected the air strikes and invasion recommended by the military chiefs and supported the President's delicate gamble of converting a blockade (an act of war) into a "quarantine" (something less than war) He viewed the quarantine as a communication from Kennedy to Khrushchev, not a military operation The message communicated by the gradual application of pressure was that of US resolve and the need for changed behavior on the part of the adversary [15]

An analysis of the missile crisis using a framework of complexity theory reveals a completely different picture The mythology of calm, rational evaluation of various alternatives is belied by the record of long, inconclusive meetings conducted by increasingly fatigued men under great stress The US decision makers were indeed sending signals and messages, but had no way of knowing how they were truly interpreted by the Soviets [16] Observing Soviet actions and reactions had to serve as a poor substitute for definitive knowledge

There were a number of other areas where US decision makers were similarly handicapped by lack of information or understanding Throughout the crisis there was the difficulty of assessing Soviet motives. Kennedy and his advisors assumed aggressive intentions on their part and did not consider the possibility that the Soviets might view their actions as defensive in nature, or as a response to an aggressive posture on the part of the US (e g putting intermediate range nuclear missiles in Turkey) US leaders also assumed that leaders in the Kremlin had complete control over every action of their subordinates during the

time of the crisis In reality, they did not For example, the offer of withdrawal of the missiles in exchange for a promise of no invasion conveyed by Washington KGB head Aleksandr Fomin through an ABC reporter was at his own initiative, although it paralleled Kremlin thinking More seriously, the order that led to the shooting down of a U-2 over Cuba was given by the local air defense commander without authorization from his superiors on the island or in the Soviet Union US leaders were also basing their decisions on incorrect intelligence estimates Analysts estimated there were 8-10,000 Soviet troops on the island when in fact, there were approximately 42-44,000 They were also unaware of the existence of Soviet nuclear warheads for tactical missiles when there were nine of them deployed to Cuba and when local commanders had authorization to use them on their own initiative in the event of a US invasion of the island [17]

The US leadership also suffered from a lack of total knowledge of and control over US actions during the crisis On 22 October, the Commander in Chief of Strategic Air Command, General Thomas Powers, forwarded the order to increase the defense posture of his forces in the clear – thus "signaling" the Soviets on his own initiative There was also a test launch of a US ICBM from a location near that of nuclear-armed ICBMs which were on high alert as a result of the crisis The launch took place without the knowledge of national leaders Finally, previously initiated covert actions against Cuba continued despite orders from both McNamara and Robert Kennedy that they be discontinued after the crisis broke [18]

A nonlinear analysis of the missile crisis would have highlighted these factors and perhaps led to far different conclusions regarding the lessons to be learned Instead, the linear mode of thinking prevailed McNamara acknowledged his reliance on the Cuban crisis as a model for his thinking regarding military action in Vietnam He viewed graduated pressure as

a sensible course of action between the extremes of confrontation with the Soviets and the Chinese leading to potential nuclear war and the failure of containment exemplified by withdrawal [19]

In a memo to the President in March 1964, the linear nature of McNamara's thinking is readily apparent In describing the US objective as establishing an independent, non-Communist South Vietnam, he uses perhaps the most linear metaphor of the Southeast Asia conflict – the famous "domino theory " He wrote that failure to keep South Vietnam free of Communism would result in the probable fall of Laos and Cambodia, the ascendance of Communist influence in Burma, the likely fall of Indonesia and Malaysia, grave pressure on Thailand, the Philippines becoming "shaky," and threats to India, Australia, New Zealand, Taiwan, Korea, and Japan [20] McNamara also noted that early in his tenure as Secretary of Defense, the falling dominoes became more plausible with the strengthening of the links between the USSR and Cuba, and with the consistent provocative behavior of the Soviets with respect to Berlin In his mind, these actions indicated continued aggressive intent on their part [21]

The progressive application of ever-increasing military force against North Vietnam recommended by McNamara and a number of other advisors gave President Johnson the illusion of control over the situation In reality, it devolved into a surreal exercise existing in a nebulous realm between academic management theory and game strategy [22] Even the men "on the ground" in Vietnam were stymied by the failure of the enemy to understand that they were being beaten

> The ability of the Viet-Cong continuously to rebuild their units and to make good their losses is one of the mysteries of this guerilla war we still find no plausible explanation of the continued strength of the Viet-Cong if our data on losses are even approximately correct Not only

> do the Viet-Cong units have the recuperative powers of the phoenix, but they have an amazing ability to maintain morale Only in rare cases have we found evidence of bad morale [23]

Yet, graduated pressure as conceived by the victors of Cuba was never intended to defeat the enemy Rather, their intent was to engender confidence and cohesion in the South, to apply a modest effort that would demonstrate their resolve and the implicit costs and risks to the North, and to "level the playing field" so that an acceptable negotiated settlement could be reached [24]

Much later in life, McNamara unwittingly identified the inherent weakness of the linear mindset when he confessed that

> We failed to recognize that in international affairs, , there may be problems for which there are no immediate solutions For one whose life has been dedicated to the belief and practice of problem solving, this is particularly hard to admit But, at times, we may have to live with an imperfect, untidy world [25]

Our understanding of that imperfect, untidy world is a bit clearer when we apply a complex systems analysis to these two cases In Cuba, the two primary "systems" involved, the US and USSR, were clearly both complex and adaptive, and thus nonlinear That nonlinearity is evident when one examines the unknowns and "unknowables " The US could not know the exact motivations of the Soviets and thus was handicapped in devising a response to their actions Soviet leaders, in turn, could not have known what the US reaction would be as they set out to install missiles in Cuba Neither side could know what action or counter-action might trigger a military confrontation between the superpowers or what might result in nuclear exchange The danger of nuclear war and the unknowns surrounding it, in fact, were key contributors to the ultimate diplomatic solution of the confrontation

There are other lessons from complex systems theory which shed light on the Cuba case A focus on the connections within and between systems might have diluted the post-crisis emphasis on the supposed connection between graduated pressure and reversal of the Soviet decision It might have highlighted, instead, the connection between the removal of the missiles and the US guarantee of no invasion of Cuba and removal of Jupiter missiles from Turkey and Italy [26]

Complex systems theory also highlights the errors made by US policy makers in using the Cuban model in forming policy for Vietnam The actions of complex adaptive systems are never wholly transferable from one system to another nor from one time to another because of the qualities of self-organization and emergence, the processes of adaptation and co-evolution, and the sensitivity to initial conditions of subsequent actions US policy makers obviously knew the North Vietnamese were not the "same" as the Soviets, yet they assumed graduated pressure would bring about the same result in Vietnam as it had in Cuba

Ambassador Maxwell Taylor's report (quoted above) clearly shows the qualities of self-organization and emergence exhibited by the Viet Cong Yet, in applying graduated pressure to the North Vietnamese, US policy makers had no understanding of if or how that pressure would influence the behavior of the Viet Cong in the South An understanding of the nonlinearity exhibited in the inability of US leaders to totally control their own forces during the Cuban crisis might have led to better understanding of the inability of the North to totally control Viet Cong actions Finally, an understanding of complex systems might have led decision makers to question the fundamental linear metaphor at the foundation of US involvement in Southeast Asia – the falling dominoes

* * * * *

What lessons can we draw from this initial attempt to apply complex systems theory to an analysis of diplomacy and policy making? First, it is extremely difficult to transfer what are essentially scientific and mathematical concepts to the study of the social sciences Second, despite the difficulty of doing so, it is a worthwhile endeavor because it can shed light on factors often overlooked with a linear frame of reference Therefore, adding nonlinearity and complex systems theory to the education of policy makers and their advisors would prove equally worthwhile.

It is also important to recognize that understanding nonlinearity and complexity does not mean an end to systematic thinking or logical analysis It does mean recognizing that the logic is probably not analogous to a straight line The linear metaphor stands in opposition to the "rules of nature " The natural world is a nonlinear world in which complex adaptive systems are the primary actors Changing our basis of understanding and analysis is not a trivial nor a short-term process, the linear metaphor has been 250 years in the making We must, however, take the first steps now, by recognizing the pervasively linear foundation of our thinking, the weakness of the linear metaphor when confronted with the realities of how the world works, and the alternative foundation being exposed for us through progress in the nonlinear sciences

Notes

[1] Robert McNamara, press conference, Fall 1962 (?), quoted in Lloyd C Gardner, *Pay Any Price Lyndon Johnson and the Wars for Vietnam* (Chicago Ivan R Dee, 1995), p 62

[2] Harry G Summers, Jr , *On Strategy A Critical Analysis of the Vietnam War* (Novato CA Presidio Press, 1984), p 18

[3] Paraphrased from Alan D Beyerchen, "Clausewitz, Nonlinearity, and the Importance of Imagery," in *Complexity, Global Politics, and National Security*, ed David S Alberts and Thomas J Czerwinski (Washington DC National Defense University, 1997), p 167

[4] Steven R Mann, "The Reaction to Chaos," in *Complexity, Global Politics, and National Security*, ed David S Alberts and Thomas J Czerwinski (Washington DC National Defense University, 1997), p 138

[5] Alan Beyerchen, "Clausewitz, Nonlinearity, and the Unpredictability of War," *International Security*, Vol 17, No 3 (Winter 1992/93), p 62, John F Schmitt, "Chaos, Complexity, & War What the New Nonlinear Dynamical Sciences May Tell Us About Armed Conflict," (draft) (Quantico VA Concepts and Doctrine Division, Marine Corps Combat Development Command, 4 September 1995), pp 13-14

[6] Robert Jervis, "From Complex Systems The Role of Interactions," in *Coping With the Bounds Speculations on Nonlinearity in Military Affairs*, ed Thomas J Czerwinski (Washington DC National Defense University, 1998), pp 260, 264, 261

[7] James N Rosenau, "Many Damn Things Simultaneously Complexity Theory and World Affairs," in *Complexity, Global Politics, and National Security*, ed David S Alberts and Thomas J Czerwinski (Washington DC National Defense University, 1997), p 83

[8] Perhaps the single best example of self-organization and emergence is the building of the human brain and the emergence of intelligence There is no property of any single element of the brain which accounts for human intelligence, yet when all the individual components are connected, intelligence exists Additionally, as an individual grows and matures, the brain stores information and experience in new and ever-changing patterns (i e self-organization) such that the nature of the intelligence exhibited changes over time

[9] Rosenau, p 86

[10] Ibid , p 87

[11] Ibid , pp 83, 84-5, 86

[12] Andrew Ilachinski, "Land Warfare and Complexity, Part II An Assessment of the Applicability of Nonlinear Dynamic and Complex Systems Theory to the Study of Land Warfare, (U)" (Alexandria VA Center for Naval Analysis, July 1996), pp 139-40

[13] Cyrus Vance, quoted in H R McMaster, *Dereliction of Duty* (New York Harper Collins Publishers, 1997), p 62

[14] James A Nathan, "The Heyday of the New Strategy The Cuban Missile Crisis and the Confirmation of Coercive Diplomacy," in *The Cuban Missile Crisis Revisited*, ed James A Nathan (New York St Martin's Press, 1992), pp 1-2, 25-6

[15] McMaster, pp 30, 62

[16] Nathan, pp 20-1, 25-6

[17] Lawrence Chang, "The View from Washington and the View from Nowhere Cuban Missile Crisis Historiography and the Epistemology of Decision Making," in *The Cuban Missile Crisis Revisited*, ed James A Nathan (New York St Martin's Press, 1992), pp 137-9, 143-6, 149

[18] Ibid , pp 146-9

[19] McMaster, pp 73, 75

[20] "SecDef Memo for the President," 16 March 1964 in *The Pentagon Papers*, Vol III, by Senator Mike Gravel, chairman (Boston Beacon Press, 1971), pp 499-500

[21] Robert S McNamara, *In Retrospect The Tragedy and Lessons of Vietnam* (New York Random House, 1995), p 32

[22] Anthony Short, *The Origins of the Vietnam War* (New York Longman, Inc , 1989), p 307

[23] Maxwell Taylor, "The Current Situation in South Vietnam, November 1964," NSF files, Johnson Library, quoted in Short, p 305

[24] *Pentagon Papers*, p 269

[25] McNamara, p 323

[26] Nathan, pp 20-2

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