SYSTEMS SOLUTIONS TO CHALLENGES OF THE 18TH AND 21ST CENTURIES

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Systems Solutions to Challenges of the 18th and 21st Centuries

- Purpose of Presentation
  - The Science of Laws team has a challenge to interest the larger INCOSE audience in the broader application of systems thinking to the science of law and governance (i.e., human systems)
    - In particular, many engineers view SE application through a lens of complex technology applications, big data, artificial intelligence, and software systems
    - They don't see a relationship for the human systems of law and governance to systems thinking and systems engineering as they practice it

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Systems Solutions to Challenges of the 18th and 21st Centuries

- Topics
  - Defining systems and systems thinking
    - A history of ‘systems’ thinkers
    - The American experience
    - Governance as a system
  - Application of systems thinking to human systems and governance
    - The INCOSE SE Vision 2025 and the need for a systems view of human systems
    - Challenges to systems thinking as applied to human systems
    - The science of chaos and complexity
    - The challenge of quantification, precision, and predictability

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Introduction

- There seems to be little interest in and discussion of a true scientific and systems thinking approach to human systems
  - Human systems include social structures, governance, ethics, economics, and management of complex technology
  - Factors such as agency, preference, consensus, and ethics have confounded application of the traditional quantitative approaches of the scientific method of the physical sciences to human systems
  - Social sciences tend to accept current standards as a statistical norm rather than basing theories on fundamental axioms
  - Recent applications of INCOSE SE Vision 2025 to national and global technology challenges rely more on project management approaches rather than systems thinking

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DEFINING SYSTEMS AND SYSTEMS THINKING

"In effect, the art of systems thinking lies in seeing through the detail complexity to the underlying structures generating change."

Peter Senge, *The Fifth Discipline*, 1990, p.124

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What Is a System?

- Characteristics of a system
  - Context (Boundaries/Environment)
  - Structure/Hierarchy (Interaction/Control)
  - Relationships (Communication/Interdependency)
  - Inputs/Outputs (Process)
  - Transition (Openness/Emergence)

Both physical and human systems have these common characteristics

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What Is Systems Thinking?

- Systems thinking encompasses a vision to model real-world behaviors and instantiate them into workable systems

- "Systems thinking" is not new to the 20th century
  - Modern practitioners have only coined the term
  - Formally viewing the world as a system was a development of the scientific revolution

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Historical Focus of Systems Thinking

- **16th - 17th Centuries**
  - *Scientific Revolution*
    - Nature and physical systems
      - Mechanics
      - Astronomy
      - Biology
- **18th - 19th Centuries**
  - *The Enlightenment*
    - Human systems
      - Natural vs. positive law
      - Rights and liberties
      - Constitutionalism and the rule of law
      - Utilitarianism
- **20th - Early 21st Centuries**
  - *The Digital Revolution*
    - Technology and information systems
      - Complexity
      - Systems of systems
      - Hardware/software systems
      - Big data
      - Artificial Intelligence
      - Machine learning

While the Enlightenment was a natural extension of the Scientific Revolution, subsequent study of human systems as an axiom-based science has not been satisfied through the social sciences

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The Scientific Revolution – The Physical World as a System

- Isaac Newton's Principia (1687) included his book *The System of the World*
  - Newton's rules of reasoning (axioms):
    - **Rule 1 [Simplicity]**: We are to admit no more causes of natural things than such as are both true and sufficient to explain their appearances
    - **Rule 2 [Intelligibility]**: Therefore to the same natural effects we must, as far as possible, assign the same causes
    - **Rule 3 [Universality]**: The qualities of bodies, which admit neither intensification nor remission of degrees, and which are found to belong to all bodies within the reach of our experiments, are to be esteemed the universal qualities of all bodies whatsoever
    - **Rule 4 [Induction]**: In experimental philosophy we are to look upon propositions inferred by general induction from phenomena as accurately or very nearly true, not withstanding any contrary hypothesis that may be imagined, till such time as other phenomena occur, by which they may either be made more accurate, or liable to exceptions

https://en.wikipedia.org/wiki/Philosophi%C3%A6_Naturalis_Principia_Mathematica#Preliminary_version

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The Enlightenment and Human Systems

- Thinkers of the Enlightenment period sought to extend Newton's systems view to human systems of governance and policy
  - Works of Hobbes, Montesquieu, Locke, Smith, et. al. analyzed classical civic theory as applied to their day
    - Structures: monarchy, oligarchy, democracy, republic
    - Policies: citizenship, governance, law of nations, economics
  - Bentham's and Mill's utilitarianism
    - Bentham: *"The said truth is that it is the greatest happiness of the greatest number that is the measure of right and wrong"*
    - Utilitarianism seeks an optimized solution amongst imperfect real-world alternatives – the greatest good for the greatest number

The Enlightenment was a major influence on the American Founding

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The Enlightenment and the American Founding

- From a human systems thinking perspective the American Founding might be viewed as a high point of the Enlightenment experience
  - The United States Declaration of Independence and Constitution are products of systems thinking
  - They resulted in the instantiation of a government based in rational and ethical principles to reassess and replace traditional inherited precedence
    - Literacy and political debate were extensive in the colonies
    - The checks and balances of federalism were established to address the historical failures of monarchy (the one), oligarchy (the few), and democracy (the many)
    - Non-enumerated powers and intentional ambiguity in the Constitution's structure and language provide openness and emergence for the challenges of future generations

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Documenting the American Experience

- Declaration of Independence (a vision statement)
  - Axioms based in self-evident truths and natural law theory
    1. Equality under law
    2. Unalienable rights – life, liberty, pursuit of happiness
    3. Consent of the governed through just powers of government
    4. Right to alter or abolish unjust government
- United States Constitution (a compact or operational concept)
  - Application of Lockean principles as federalism
    1. Separation of powers
    2. Enumerated and limited powers
    3. Consent of the governed
    4. Bill of rights

"We have it in our power to begin the world over again."
Thomas Paine, *Common Sense,* 1776

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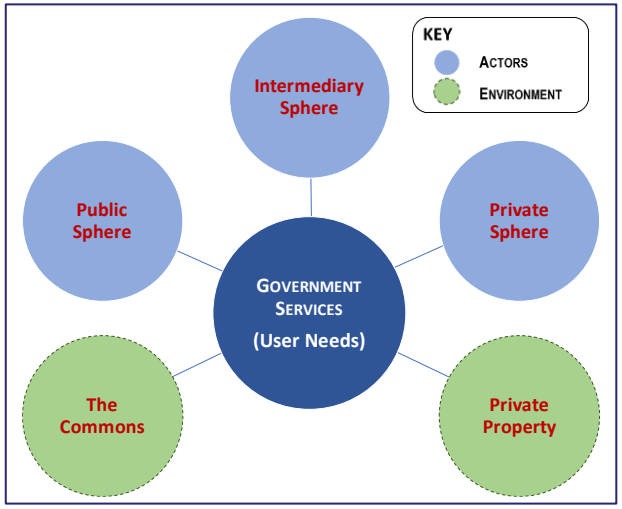
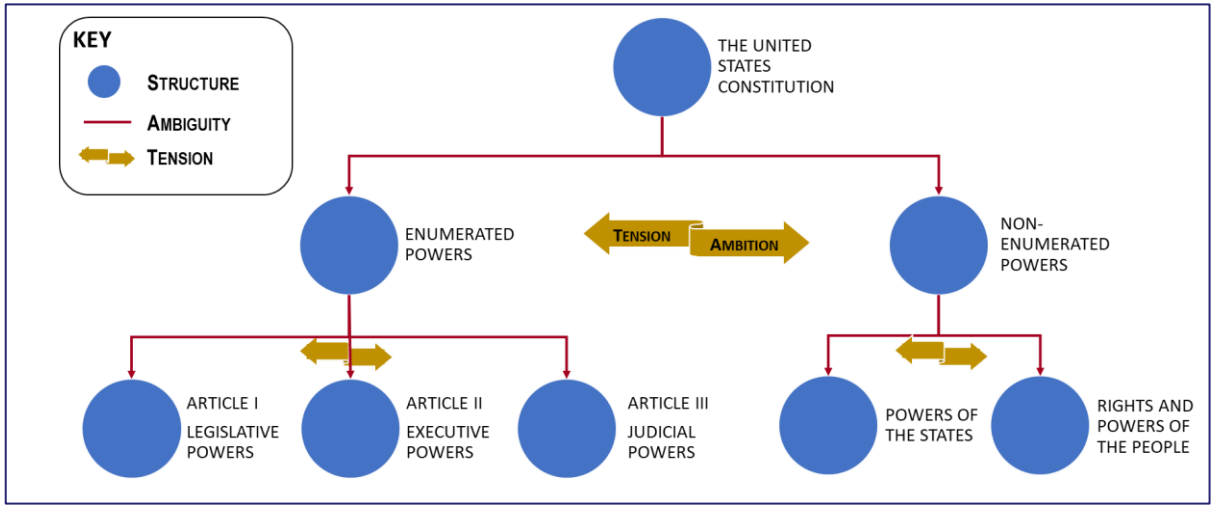
Governance as a System

Context/Boundary



- Environment
- Actors
- Relationships

The Constitution's Federalist Structure



- Structure/Hierarchy
- Interactions/Control
- Ambiguities/Openness

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APPLICATION OF SYSTEMS THINKING TO HUMAN SYSTEMS AND GOVERNANCE

The Future – INCOSE SE Vision 2025

National and global challenges will require systems thinking through an enterprise/policy landscape view to address the interdependencies between technology solutions and human systems

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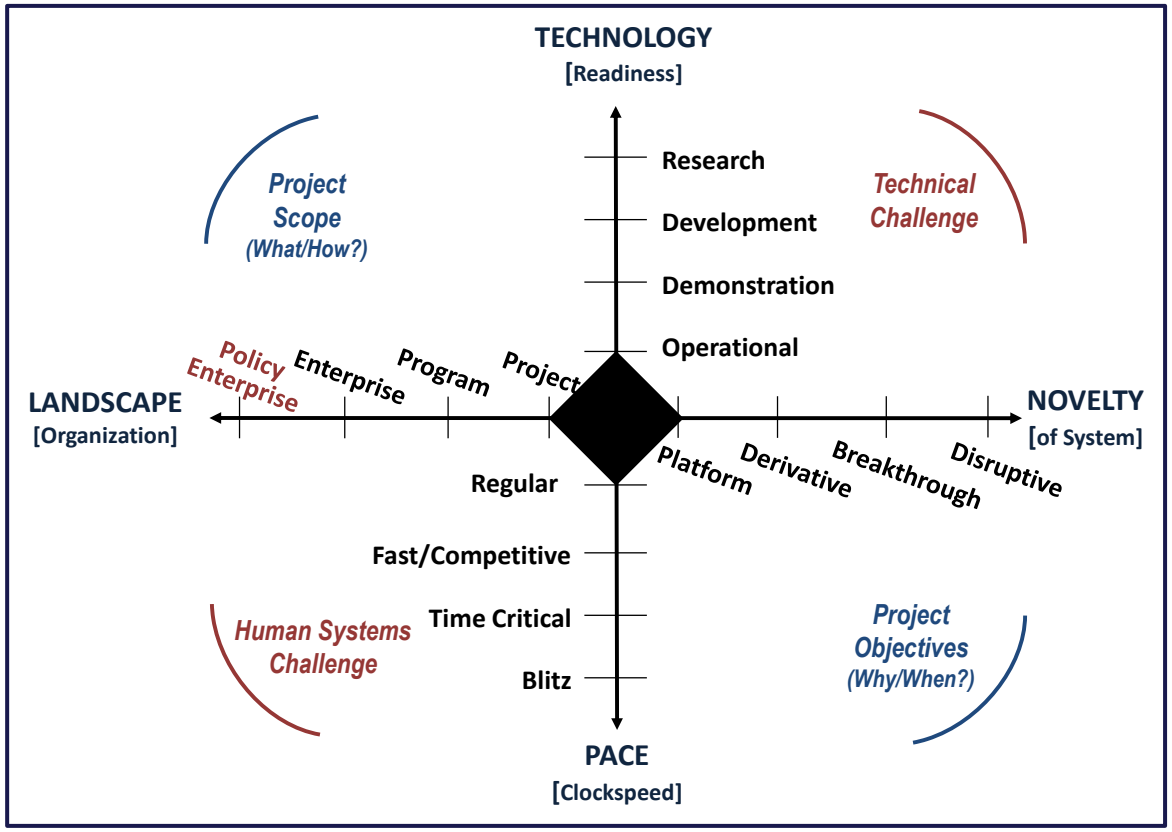
Systems Thinking and INCOSE SE Vision 2025

- Solutions must be viewed as human systems harnessing technology
  - The true challenge is at the policy/enterprise level, not the technology level
  - **Factors Influencing System Complexity**
    - Technology
    - Landscape
    - Pace
    - Novelty



Adapted from Shenhar, Aaron; *Reinventing Project Management*; Harvard Business School Press, 2007, pp.46-49

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Law and Governance Today – Complexity vs. Complication

- Complication occurs in the absence of systems thinking to address complex problem situations
  - A systems approach is required to transition from historical complication to true systems solutions
- Complications related to the lack of a science of law
  - Technology
    - Complication – Lack of scientific approach (low-TRL lawmaking)
  - Landscape/Policy
    - Complication – No quality processes to assess interdependencies to existing body of law, nor for validation after promulgation of laws
  - Pace
    - Complication – Excessive law-making as the norm of current elected officials
    - Complication – Clockspeed mismatch between stakeholders
  - Novelty
    - None – Lack of interest for improvement in state of the lawmaking art

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Challenges to Systems Thinking Applied to Human Systems

- Unresolved challenges of human systems as a science
  - Flawed 'scientism'* of the French Revolution and Marxism
  - Generally unsuccessful attempts at quantification
    - Complex equities of utilitarianism viewed through greatest good for the greatest number
    - Impact of 'scientism'* on quantification of the social sciences
- Misapplications of 19th and 20th centuries
  - Silos of 'expertise' lead to crowding out of distributed/tacit knowledge and generally recognized past wisdom
  - Statistical methodologies based in measurement of "what-is" rather than "what-ought-to-be"
    - Unwarranted privileging of current norms as accepted goodness – *rather than iterative advancement to an asymptotic ideal*

***** ***"A mechanical and uncritical application of habits of thought to fields different from those in which they have been formed"***

Friedrich Hayek, *"Scientism and the Study of Society,"* Economica, vol. IX, no. 35, August 1942

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Chaos and Complexity Theory

- The author believes the path to reignite interest in a scientific approach to human systems lies in the new science of chaos and complexity
  - The axioms of chaos and complexity theory can be applied to bound rational and durable systems of human behavior (such as law and governance) and to identify the excesses that lead to societal failure
  - My 2019 mini-conference presentation addressed an application of synthetic annealing to the problem of excessive growth of the administrative state

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Chaos and Complexity Theory – Axioms

- Complexity/chaos theory offers three fundamental axioms that are relevant to the study of human systems
  i. For certain behaviors, sensitivity to initial conditions limits the precision of predictability over time
  ii. Factors such as diversity, connection, interdependency, and adaptation tend to optimize outcomes within a mean range (a consequence of the central limit theorem)
  iii. Large divergence from mean behaviors can lead to system instability and cascading systemic failure

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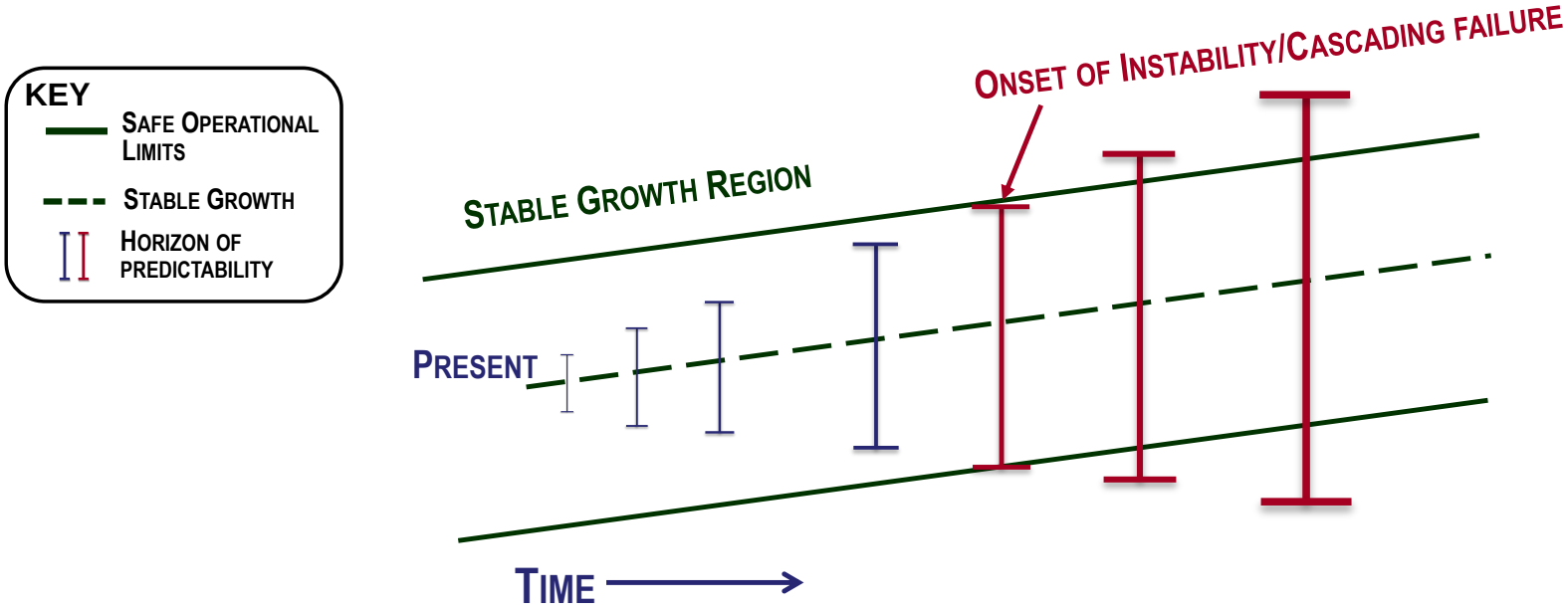
Quantification and Precision – The Horizon of Predictability

- Predictions of future behavior based on initial conditions lose precision without continual updates of valid current information
  - The horizon of predictability is a measure of expected future precision estimated from the current knowledge of initial conditions
  - A Kalman filter provides a control theory example for predicting behaviors affected by multiple variables



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Factors Underlying Systems Predictability

- Scott Page identifies four qualifiers for complexity in systems
  - Diversity, connection, interdependence, and adaptation
    - *"Complex systems are collections of diverse, connected, interdependent entities, whose behaviors are determined by rules, which may adapt, but need not"* [1]
- The interesting "In-Between"
  - Miller and Page identify an area of interest between the extremes where stable and predictable behaviors are observed [2]
  - Extreme deviations of these qualifying factors from a normal range have been observed to lead to unpredictability and cascading failure in ecosystems and other physical systems

[1] Page, Scott E. (2011); *Diversity and Complexity*; Princeton University Press, Princeton, 2011
[2] Miller, John H. and Page, Scott E.; *Complex Adaptive Systems, An Introduction to Computational Models of Social Life*; Princeton University Press, Princeton, 2007, pp.227-8

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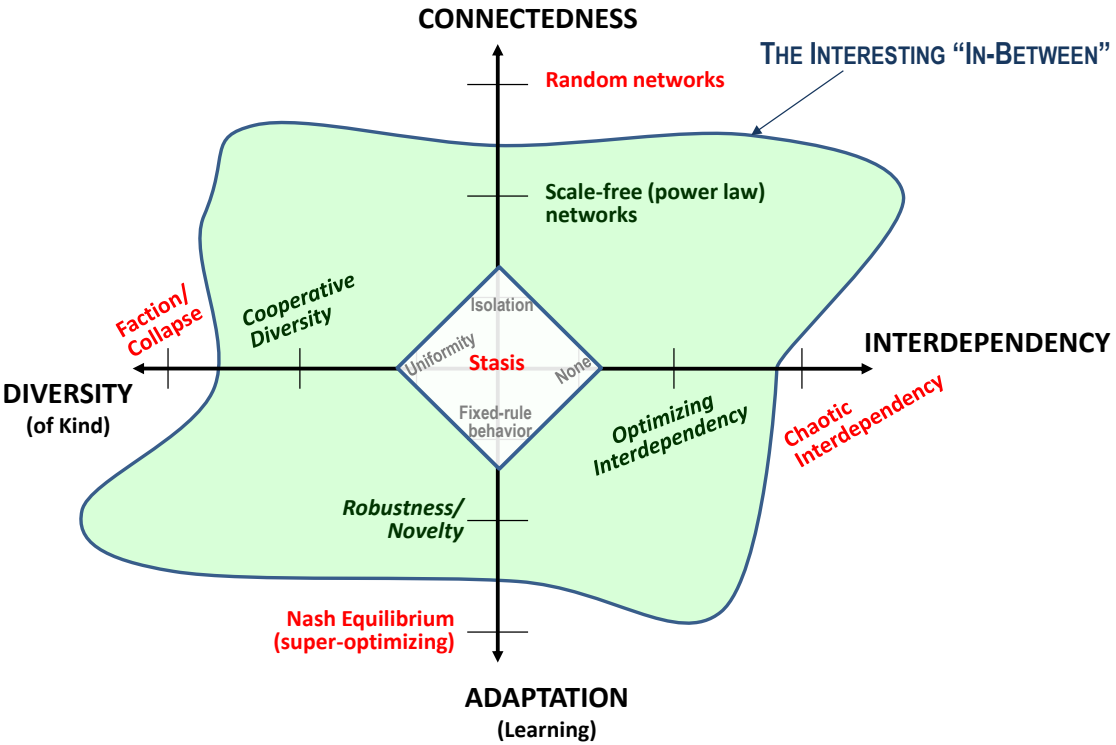
The interesting "In-Between"

- Extreme deviations of qualifying factors (such as diversity, connection, interdependence, and adaptation) from a normal range can lead to unpredictability and cascading failure in both physical and human systems
  - This must be a key consideration for systems thinkers addressing predictability and stability of human systems



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Summary

- Systems thinking encompasses a vision to model real-world behaviors and instantiate them into workable systems
  - Systems thinking is applicable to both physical and human systems
  - Systems thinking is not new to the 20th century (modern practitioners have only coined the term)
  - Formally viewing the world as a system was a development of the Scientific Revolution
  - INCOSE SE Vision 2025 solutions must be viewed as human systems harnessing technology (a policy/enterprise level challenge)
  - The axioms of chaos and complexity theory can be applied to bound rational and durable systems of human behavior (e.g., law and governance) and to identify the excesses that lead to societal failure
  - The interesting “In-Between” defines a balance between qualifiers such as diversity, connection, interdependency, and adaptation in analyzing the predictability and stability of both physical and human systems

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Systems Solutions to Challenges of the 18th and 21st Centuries

CV

Mr. Michael Martin, PE, PMP, is nearing the end of his career as a technical project manager, systems engineer, and adjunct instructor. His personal investigations into the fields of science, history, and philosophy, facilitated by a long commute and an iPod, have led him to the study of chaos and complexity theory as the gateway to a new understanding of the possibilities and limitations driving human systems. His 2019 mini-conference presentation addressed an application of synthetic annealing to the problem of excessive growth of the administrative state. He plans to continue to highlight application of the tools of systems thinking and the sciences to public policy and governance in future publications.

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ABSTRACT

Peter Senge summarizes systems thinking succinctly as *"seeing through the detail complexity to the underlying structures generating change."* While many likely view systems thinking as a late 20th century concept developed to address the complexity in applications of modern technology, this presentation will highlight the systems thinking underlying the 18th century American founding documents. Understanding the world as a system was the basis for Isaac Newton's *Principia Mathematica* published in the late 17th century, and a goal of the subsequent Enlightenment thinkers was to define a scientific approach to translate Newton's system-of-the-world vision to human activities. Following the initial successes of the American founding, that goal has largely faltered in a wake of misapplication and unrealistic quantification. The author believes the path to reignite that pursuit lies in the axioms of chaos and complexity theory to bound rational and durable systems of law and governance, and to identify the excesses that lead to societal failure.

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