THE SCIENCE OF LAWS JOURNAL

- Excellence in Governance through Science -

VOLUME 4, ISSUE 1

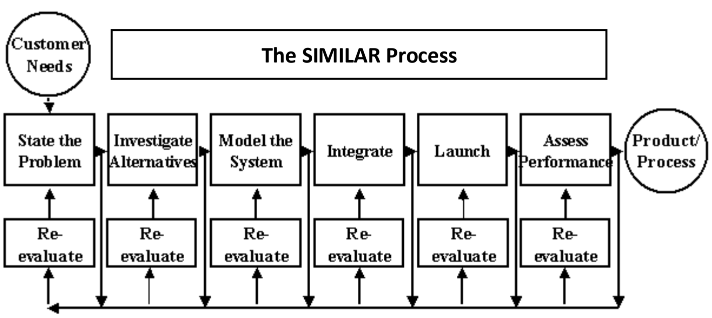
"**Essentially, all models are wrong, but some are useful.**"
–George Box

THE SCIENCE OF LAWS JOURNAL

Excellence in Governance through Science

SHOULD LAWMAKING USE A "SIMILAR" PROCESS?

I recently came across a process model titled with the acronym SIMILAR. It was created as a systems engineering process model but, as is the case with many systems engineering tools, it can be readily applied to a wide variety of scenarios. The seven steps of this process are: **S**tate the problem, **I**nvestigate alternatives, **M**odel the system, **I**ntegrate, **L**aunch, **A**ssess performance, and **R**e-evaluate.



The SIMILAR Process (Bahill and Gissing, 1998)

While one size rarely fits all, this model appears to have a wide variety of applications, including that of lawmaking. Interestingly, many of the concepts inherent in this model are addressed in this issue of the *Science of Laws Journal* in which our authors lay out their thoughts, experiences, and research related to developing, modeling, and assessing laws both prior to and after the law's enactment.

I hope you enjoy this latest issue of the *Journal*. Further, I hope you get the chance to join us at the 5th Annual Science of Laws Conference currently being planned for December 1, 2018 in San Diego, California. In the meantime, please send me your thoughts on the *Journal*, the application of the SIMILAR process, and/or ways in which we can continue to advance the science of laws.

–John Wood, Editor
John.Wood@ScienceOfLaws.org

JOURNAL INFORMATION

VOLUME 4, ISSUE 1

September 17, 2018

PROCEEDING

Application of Systems Engineering to the Affordable Care Act and Other Lawmaking Practices

Thy Guintivano*

ABSTRACT

Enacting laws in the 21st century is no longer constrained to humans. The digital age has ushered in many new technologies such as machine learning and artificial intelligence systems to perform tasks that support legislative-driven compliance and governance activities on behalf of organizations and private businesses. Designing quality systems to address these new laws requires humans and machines to effectively translate legislation into accurate instructions for execution.

This paper uses the Affordable Care Act as an example of how systems engineers can design and test legislative-driven governance systems.

This paper also explains:

1) the challenges associated with ensuring systems meet legislative mandates;
2) how to leverage Model Based Systems Engineering;
3) and a framework for validating systems in the context of Law

Keywords: Affordable Care Act, Artificial Intelligence, Design, Compliance, Governance, Framework, Lawmaking Processes, Legislation, Machine Learning, Model Based Systems Engineering, Systems Engineering, Test, Verification, Validation

INTRODUCTION AND BACKGROUND

In today's Digital Age, machines support humans with all aspects of daily living and work activities. These systems, which include technologies like artificial intelligence, machine learning, and software applications, are being utilized to enable people, businesses, and other organizations to meet their goals, objectives, and legislative-driven compliance and governance activities.

A challenge with current, traditional lawmaking practices is the legislation rarely if at all considers how to design quality systems that will support legislative-driven compliance and governance activities. Take a recent example of this, H.R. 3031: TSP Modernization Act of 2017, which is a bill enacted on November 17th, 2017, that is intended to modernize a retirement savings and investment plan for Federal employees and members of the uniformed services [1]. The bill states high level capabilities that are expected with this modernization effort, but there is no timeline for implementing the changes, nor does it provide use cases describing how users can interact with the system to perform these functions.

Designing and testing quality systems to address the TSP Modernization Act of 2017 can be challenging, but it is not nearly as complex as the Patient Protection and Affordable Care Act, often referred to as the Affordable Care Act (ACA) [2]. This United States federal statute was enacted by Congress and signed into law by President Barack Obama on March 23, 2010. The provisions represent the U.S. healthcare system's most significant regulatory overhaul and expansion of coverage since the passage of Medicare and Medicaid in 1965 and it mainly expanded access to health insurance and changed the way federal government pays doctors. These provisions required small businesses with more than 50 full time employees, large employers, and health insurance providers to collect health insurance coverage information from individuals and employers so that it could be processed using new Internal Revenue Service (IRS) tax forms. The conformance and governance of these new provisions required changes impacting many systems for different organizations and businesses alike.

This paper addresses some of the challenges associated with designing and testing systems responsible for enacting the ACA from an IRS perspective, provides examples for leveraging Model Based Systems Engineering, and establishes a framework for validating systems in the context of law.

The Science of Laws Journal, Vol. 4, No.1, (2018): 2-6.

*Author to whom all correspondence should be addressed (e-mail: thy.guintivano@gmail.com).

THE CHALLENGES

In this section, the challenges of implementing a complex legislative direction such as the Affordable Care Act, are described in detail. The next section, Leveraging Model Based Systems Engineering, will describe an approach to address these challenges.

Understanding and Decomposing the Legislation

The ACA is a total of 906 pages, divided into 10 Titles, or Chapters, each containing corresponding Subtitles and Sections that describe various provisions, entities that are impacted, reporting requirements, responsibilities and new processes that will be introduced to citizens, businesses, and Government organizations like the Internal Revenue Service (IRS). Although it was signed into law in March 2010, the IRS, health insurance providers, and other organizations needed several years to get prepared to enforce the law. The first challenge is understanding what the legislation means, who it applies to/affects/impacts, what it means to adhere to the legislation, and what it means to not be compliant.

Management and Governance

Management is defined as the activities of or pertaining to the management of tasks in an organization. It includes the person(s) or group that has the daily responsibilities of managing and overseeing a project from start to finish. This includes project managers and program managers.

Governance is defined as the structure and relationships which determine organizational direction and performance. The governing body, such as a Board of Directors, provides the necessary strategic oversight and decision making that include the organization's purpose, values, and structure. It helps ensure the right stakeholders are identified for the project, with a clear understanding of responsibilities, and a common understanding of the operational mechanisms needed to document, track, and update progress and/or deliverables.

If law enforcing organizations, state and federal legislative, judicial, and executive branches were removed from government, consider if it would be as effective and coordinated with introducing new laws and enforcing compliance for the state and the nation. The same concept, in theory, applies to organizations attempting to enact laws and/or implement new programs or procedural changes without management and governance. The complementary management and governance practices in organizations are necessary to ensure desired outcomes of stakeholders. IT Programs that are driven by Legislative direction require clear guidance and coordination among departments to execute design, development, testing, deployment, and operational maintenance activities.

Silo Mentality

Many organizations experience challenges when attempting to execute a new program or initiative and the struggle to fulfill business objectives can create schedule delays and frustration among the employees. Barriers preventing colleagues to move forward in the same strategic, operational, and tactical direction may be attributed to different causes, but for this paper, the challenges experienced by these organizations will be referred to as "silo mentality." Silo mentality is defined as the mind set of employees in different departments making a conscious decision not to share information with others in the same organization [3]. As described in Forbes' article, "Why Silos Kill the Ability to Communicate a Unified Vision," the silo mentality reduces efficiencies in the overall operation, reduces trust and morale, and ultimately contributes to the demise of a productive company culture. Addressing these challenges is crucial to ensuring the success of an organization's mission and the enactment of new Legislation.

Release Planning

It is probably the program manager's worst nightmare: schedule slippage. Organizations need IT release plans to coordinate activities between various project teams and to minimize the impacts to Production systems to support go-live deployments. Having a schedule enables project teams to plan and deliver deliverables without impacting the customer and the organization needs to provide a systematic way to release new features or fixed services. With Legislative-driven programs, release planning is a major challenge because some laws require organizations to comply by a specific date, and there is no room to adjust schedules if any upstream activities are delayed.

Test Planning

Testing, which refers to Validation and Verification activities, is usually an afterthought with many projects. Verification is defined as the activities that verify requirements are met as defined in the requirements specification. The verification of systems requires traceability of requirements and testing of services, capabilities, and functionalities, that may not be explicitly identified in requirements. Validation is defined as the activities to validate that the system functions under highly controlled conditions. These include possible failure modes, design problems and operational effectiveness and suitability.

Testing activities are at the end of the Systems Engineering V model, and only some project teams execute test planning activities at the beginning of a project. Testing is necessary to state confidently to stakeholders, decision makers and users "the system meets your needs and is operationally effective." A comprehensive Test Strategy and Program is needed for the Program Manager to confidently state operational effectiveness for a program as complex and challenging as the Affordable Care Act, or other Legislative-driven initiatives.

LEVERAGING MODEL BASED SYSTEMS ENGINEERING

In this section, Model Based Systems Engineering and other insights are applied to solve for the challenges described in the previous section.

Model Based Systems Engineering is defined by INCOSE as "the formalized application of modeling to support system requirements, design, analysis, verification, and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases." [4] It includes behavioral analysis, system architecture, requirement traceability, performance analysis and simulation test.

As described by INCOSE, model-based engineering moves the record of authority from documents to digital models including Electrical Computer Aided Design (E-CAD), Systems Modeling Language (SysML) and Unified Modeling Language (UML) managed in a data rich environment. This enables engineering teams to understand design change impacts more readily, communicate design intent and analyze a system design before it is built. MBSE also provides mechanisms for driving more systems engineering depth without increasing costs and allows Systems Engineers to focus on value added tasks. As an example, modeling test scenarios enables requirements analysis activities to be verified upstream in the Systems Engineering Vee model and provides teams with the capability to detect defects early.

Understanding and Decomposing the Legislation

The first challenge of designing systems that are Legislative-driven is to understand what the legislation means, who it applies to/affects/impacts, what it means to adhere to the legislation, and what it means to not be compliant. During this time, it may be beneficial to begin drafting context diagrams, operational view diagrams (OV-1), user scenarios, and high level use cases that describe how a user would interact with the system.

Using the Systems Engineering "V" model as a reference for mapping activities that are performed, this activity can be compared to Concept Exploration and Concept of Operations (Figure 1).

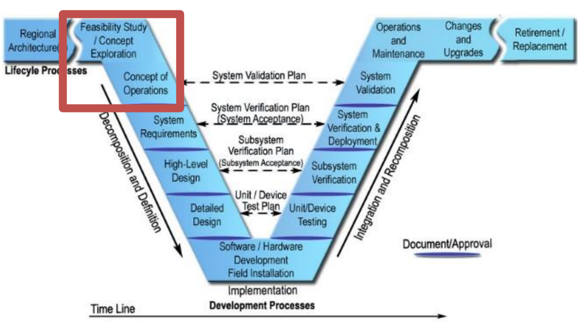


Figure 1: Systems Engineering "V" Model

Concept Exploration and Concept of Operations: This activity helps systems engineers and other key stakeholders understand the Legislation, its key impacts to responsible entities, and consequences for not complying with the Law.

In addition to understanding the Legislation, Model Based Systems Engineering artifacts can also be developed at this time to supplement one's understanding of the Law, enhance communication across departments/teams, and be leveraged for the Solution Architecture.

MBSE Example Output:

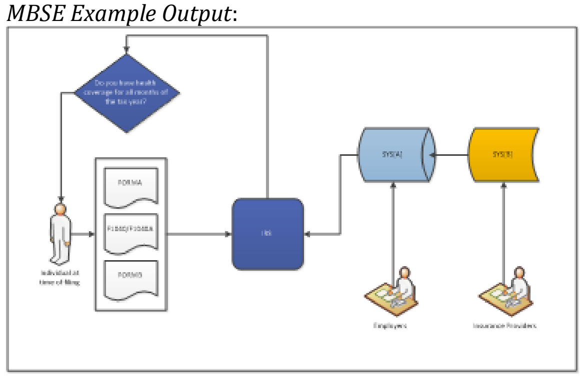


Figure 2: Use Case Diagram

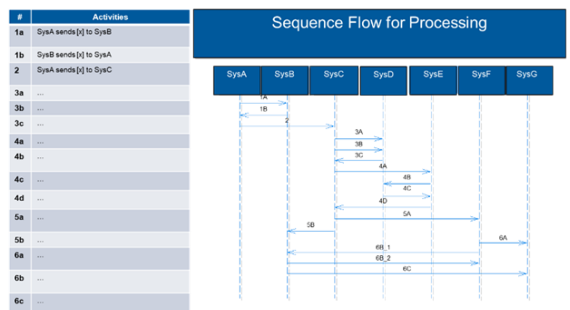


Figure 3: Sequence Flow for Processing

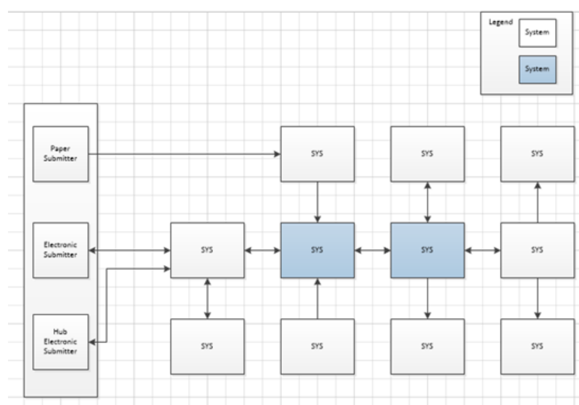


Figure 4: Processing Systems Model View

Silo Mentality

Information sharing between departments is needed for the organization to successfully meet its objectives and implement the legislative-driven changes to systems. This activity can be facilitated by the Systems Engineer throughout the project and during well-planned meetings with stakeholders. These meetings can be used to understand and collect requirements, verify requirements, draft systems architecture diagrams, and engage other teams from different departments.

Systems engineering artifacts can be created and reviewed with stakeholders so that everyone has a common understanding and visualization of the system architecture, systems inventory, interfaces, and tax processing system dependencies. This will improve communication between stakeholders and ensure that accurate information is being presented all times.

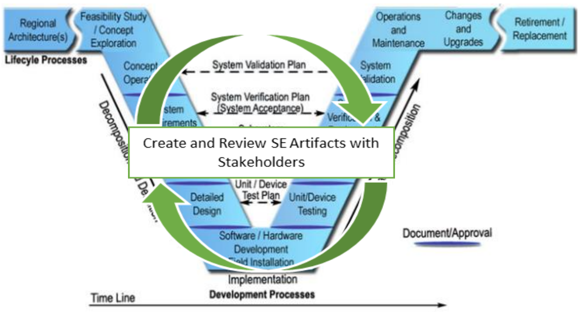


Figure 5: Create and Review SE Artifacts with Stakeholders

Examples of MBSE artifacts:

- **Solution Architecture:** depicts the systems and changes by Release
- **Systems Architecture:** depicts the components of the system and individual data elements that get processed by the component
- **Requirements Traceability Matrix or a product management tool:** traces Provisions to Program Requirements to Test Scenarios to Test Cases

Management and Governance

The Control Objectives for Information and Related Technologies (COBIT) is a framework created by the international professional association Information Systems Audit and Control Association, ISACA, for information technology (IT) management governance [5]. It provides an implementable set of controls over IT.

In some organizations, Management and Governance is an afterthought until deliverables and timelines slip, and team members are uncertain about who is responsible/accountable and what the process is for escalating issues. A Management and Governance structure should be in place for effective collaboration, execution, and monitoring activities to effectively occur. Meetings and workshops should be scheduled with key stakeholders and team members regularly to share information, collaborate on a plan, and execute against these timelines.

Refer to the next figure for a visual representation of the relationship between the two.

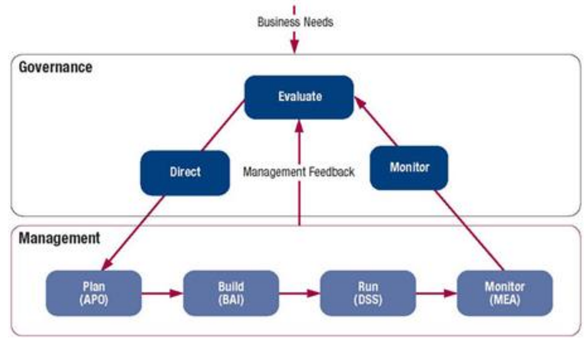


Figure 6: CBIT Management and Governance Model

In addition to M&G, a Change Control Board (CCB) or Change Advisory Board (CAB) should be established with representatives from impacted systems/departments represented so that decisions to make changes to the systems, architecture, and/or program/projects can be monitored, tracked, and reviewed accordingly. This will also mitigate silos between departments and provide key stakeholders with opportunities to engage in governance activities.

Release Planning

As previously mentioned with Legislative-driven programs, release planning is a major challenge because some laws require organizations to comply by a specific date, and there is no room to adjust schedules if any upstream activities are delayed. To mitigate the risks of schedule slippage, create a Release Strategy and Release Plan for the overarching Program as well as the individual Projects. Program and Project Managers should be familiar with when their deployment windows are, when they should expect to deploy their changes to the architecture, how long the system is expected to be down, and dependencies between all project teams and their deliverables.

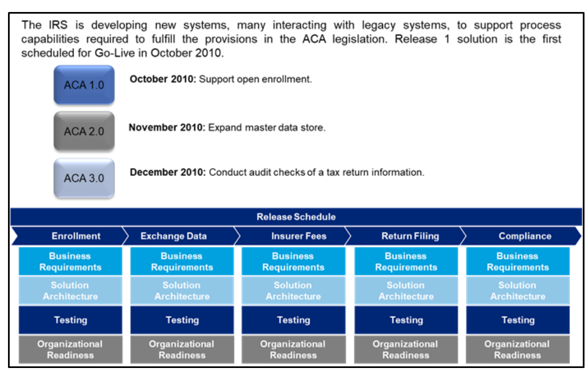


Figure 7: Example Release Schedule

Release Summary
• Performing Cost and Impact Analysis. • Proposed new dates: All artifacts and documentation due on 1/1/2010. • Continue to update the design and incorporate updates in the next iteration of the Program. • Need plan for implementing interim and long-term solutions. • Meeting held with CIOs to resolve outstanding issues – decided to conduct weekly recurring meetings. • The current plan is to remove the interface (ICDX), but it is still pending approval of a CR. • Proof of Concept work for SYS integration with SYS2 systems ongoing, with target completion date 1/31/2010.

Key Issues	Key Risks	Upcoming Activities/Key Dates	
• N/A	• The solution is under discussion. • There is currently no project for the long-term SYS5 solution. • Need to figure out how to implement the Data Strategy. • Solution Architecture for returns. • Consensus needed for Requirements Traceability and Change Control.	• Sprint 1 Complete • Baseline Release Schedule	1/1/2010 1/1/2010

Decisions	Owner	Date
• N/A	N/A	N/A

Figure 8: Example Release Summary

Test Planning

Testing is usually an afterthought with many projects and the breadth of testing on a major program like the ACA is broad. It is encouraged for stakeholders, systems engineers, and managers to invite testers to requirement meetings early in the program and to encourage participation with Solution Architecture discussions. Testers may provide a different perspective to the program and account for edge cases, or rare scenarios, not typically considered with use cases, that impact requirements, design and testing activities.

A test strategy and test plan should also be created to define prerequisite testing activities and planning and preparation activities. The next figure provides an example of these activities.

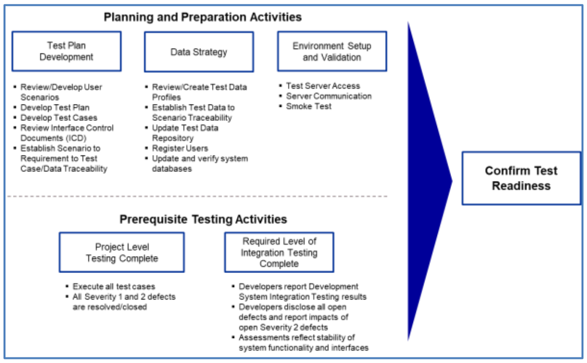


Figure 9: Example Detailed Test Planning and Preparation Activities

FRAMEWORK FOR VALIDATING SYSTEMS IN THE CONTEXT OF LAW

Enacting new laws from a systems perspective is a complex and challenging effort that requires accurate Legislative translations between humans and humans to machines. It is imperative that test activities are baked into the beginning and throughout a program's systems engineering life cycle to ensure that the right system is designed and built to meet operational needs.

To aid current and future digital implementations of legislative-driven compliance and governance activities, a Framework for Validating Systems in the Context of Law is depicted below.

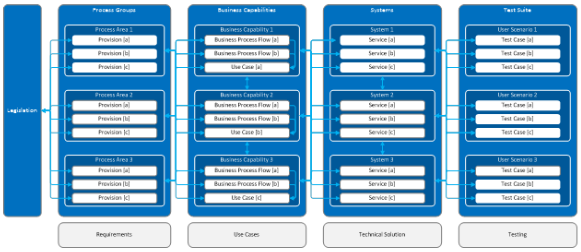


Figure 10: Create and Review SE Artifacts with Stakeholders

REFERENCES

[1] https://www.govtrack.us/congress/bills/115/hr3031
[2] http://housedocs.house.gov/energycommerce/ppacacon.pdf
[3] https://www.forbes.com/sites/brentgleeson/2017/06/20/why-silos-kill-the-ability-to-communicate-a-unified-vision-and-5-ways-to-eliminate-them/#586714b329a4
[4] http://www.incose.org/docs/default-source/delaware-valley/mbse-overview-incose-30-july-2015.pdf
[5] http://www.isaca.org/cobit/pages/default.aspx

Thy Guintivano is a Systems Engineer and Project Manager who helps organizations achieve their objectives through the realization of systems development and integration activities. She received her Master of Science in Systems Engineering from the Johns Hopkins University and Master of Science in Administration from Central Michigan University. She holds the Project Management Professional (PMP) and Information Technology Infrastructure Library (ITIL v3) certifications.

As a Systems Engineer, she has worked for Booz Allen Hamilton, Deloitte, and Intuit. She leads business case analysis, requirements engineering, user interface design, test planning, and governance activities.

Her past clients include:

- a Fortune 500 Energy and Utilities company
- the Internal Revenue Service
- the Department of Defense
- Executives of major organizations

PROCEEDING

System Dynamics Behaviors for Modeling Lawmaking Processes

Raymond Madachy
Department of Systems Engineering, Naval Postgraduate School

ABSTRACT

Modeling and simulation can help improve lawmaking processes. System dynamics is a simulation methodology for modeling continuous systems that provides a rich and integrative framework for investigating lawmaking process phenomena and inter-relationships from a holistic perspective. There are recurring structures with associated time-based behaviors for modeling process patterns that frequently occur in many aspects of society including lawmaking.

This paper continues previous work on defining system dynamics model structures interpreted for lawmaking processes to elaborate their behavior patterns. It first reviews basic system dynamics elements and their applied instances in lawmaking. It then introduces related tools for causal loop diagrams and system archetypes for better insight into the behaviors.

Causal loop diagrams show high level cause and effect relationships and information feedback in systems. They can be very effective in explaining how dynamic behavior patterns are generated from system structures and how they can be affected.

System archetypes interpret generic structures to draw lessons about their characteristic modes of behavior. They explain and make visible the recurring stories that happen. They can be used to understand existing lawmaking systems for problem solutions or assess future anticipated challenges.

A demonstrative system dynamics model is provided that illustrates a system archetype commonly observed in lawmaking. Other prevalent examples of the system archetypes in lawmaking are identified as starting points for further work. The sets of structures and behaviors (with dynamic lessons learned) are provided as modeling templates to incorporate, adapt and apply to address the multitude of lawmaking challenges.

Keywords: Lawmaking Processes, System Dynamics, Modeling and Simulation

INTRODUCTION AND BACKGROUND

Modeling and simulation can be used to improve the efficiency of lawmaking processes, and the effectiveness of laws created. They have been successfully applied across disparate fields to gain better process understanding, and lawmaking is a fruitful area for investigation.

This work applies simulation concepts to create model structures with associated behaviors that can be used to 1) evaluate the lawmaking process, i.e. the steps taken to create laws including their order, and 2) assess laws before implementation on how well they will meet their goals and compare options. The latter consideration includes all intended and unintended consequences of law implementation.

Previous effort focused on defining system dynamics model structures, interpreting them for lawmaking processes, and trial modeling (Madachy, 2016). Increasingly detailed structures for model elements, generic flow processes, infrastructures and flow chains were described and examples shown.

This is a natural continuation that elaborates behaviors associated with the generic structures and identifies lawmaking examples. The structures and their behaviors are process patterns that frequently occur. The recurring structures are model "building blocks" that can be reused. They provide a framework for understanding, modifying and creating system dynamics models (Madachy, 2016).

This paper also describes related systems thinking tools that can help grasp the complexities of laws and to address the stubborn, recurring problems that confront us in a society governed by laws. It introduces causal loop diagramming, highlights important structure-behavior pairs found in systems, and overviews system archetypes.

Lawmaking examples are identified and beginning illustrative models are provided. The reader should consult (Madachy, 2016) for more detailed background on the modeling components this paper derives from.

Overview of System Dynamics Structures

System dynamics models are formulated using continuous quantities interconnected in loops of information feedback and circular causality. The quantities

The Science of Laws Journal, Vol. 4, No.1, (2018): 7-17.

*Author to whom all correspondence should be addressed (e-mail: rjmadach@nps.edu).

are expressed as levels (also stocks or accumulations), rates (also called flows) and information links representing the feedback loops (Forrester, 1968).

Below is an overview of terminology related to system dynamics model structures that have associated behaviors:

- *Elements* are the smallest individual pieces in a system dynamics model: levels, rates, sources/sinks, auxiliaries and information connections. See Figure 1 for their visualizations.
- *Generic flow processes* are small microstructures and their variations comprised of a few elements and are sometimes called *modeling molecules*. They are the building blocks, or substructures from which larger structures are created and usually contain approximately 2-5 elements.
- *Infrastructures* refer to larger structures that are composed of several microstructures, typically producing more complex behaviors.
- *Flow chains* are infrastructures consisting of a sequence of levels and rates (stocks and flows) that often form a backbone of a model portion. They house the process entities that flow and accumulate over time and have information connections to other model components through the rates.

The reader is encouraged to read supplemental traditional references on the smaller general structures for system dynamics (Forrester, 1968), (Hines, 2000), (Madachy, 2008), (Sterman, 2000).

Overview of Model Elements for Lawmaking

The basic structural elements of system dynamics models are levels, flows, sources/sinks, auxiliaries and connectors or feedback loops. Figure 1 serves as a legend showing the standard notation of these elements in a rate and level system with an auxiliary variable connected to the rate via an information link. Next the standard elements are briefly reviewed with example instantiations for lawmaking processes.

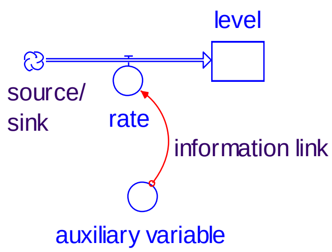


Figure 1. Model Notation of a Rate and Level System

Levels are the state variables representing system accumulations. Their counts can be measured in a real system at a snapshot of time (e.g. the number of current laws on the books). Typical state variables are laws or rights, violations, lawsuits, or the numbers of people involved in legal systems. These major level types are detailed further per the following:

- Laws or Rights – These may include laws (e.g. statutes, ordinances, regulations, common laws); copyrights or intellectual property rights for any jurisdiction, etc. Laws can be represented at any stage in the lawmaking process from proposed bills to amended or repealed laws, and for any level of jurisdiction. Rights levels can be in different process stages from initial filing to infringement (see example flow chains in the Lawmaking Process Chain Infrastructures section).
- Violations – Law violations cover crimes or infractions at any jurisdiction level (international, national, local) including copyright or intellectual property right infringements. These may lead to criminal cases potentially resulting in jail and/or fines levied, or civil lawsuits potentially resulting in damages to pay.
- People – People levels represent pools of individuals performing legal-related functions including their sub-divisions such as law creation by elected or appointed officials, legislative staff support, legal enforcement, and judicial personnel; people affected by laws such as overall population levels, victims, incarcerated prisoners, family dependents of incarcerated people, and others.

Level examples may also include quantities such as effort and cost expenditures, fines levied or paid, case schedule dates, personnel attributes such as motivation, staff exhaustion or burnout levels, law amendments and law drafting errors.

There could be many application-specific level types based on the purpose and context of modeled laws. For example, modeling the dynamics of illicit drug laws may entail drug demand levels, the number of cartels, or agricultural resource levels of cartels as demonstrated in (Olaya & Angel, 2014).

When the intent of a regulatory law is to prevent bodily injury or harm, then evaluating its effectiveness may necessitate modeling injuries, deaths, hospital stays, health costs incurred, etc.

Sources and sinks represent levels or accumulations outside the boundary of the modeled system. Sources are infinite supplies of entities and sinks are repositories for entities leaving the model boundary. Typical examples for lawmaking sources could be needs for new regulations originating in society or business at-large, or the generation of court filings to be handled. Sinks could represent final judgments of cases leaving court dockets or legal personnel attrition repositories for retirees.

Rates in the lawmaking process are necessarily tied to the levels. Levels don't change without flow rates associated with them. Some examples include law-writing rates, law change rates, case turnover rates, infraction rates, personnel hiring and retiring rates.

Auxiliaries often represent "score-keeping" variables. Example for tracking purposes include the percent of infractions per population level, percent of injuries or deaths per population, case progress measures, percent of cases in legal states, other ratios or percentages used as independent variables in dynamic relationships.

CAUSAL LOOP DIAGRAMS

Causal loop diagrams are simple diagrams that help portray cause and effect relationships and information feedback in a system. A loop is a closed chain of cause and effect. They can be very effective in explaining how dynamic behavior patterns are generated and remedied. They are a step up in abstraction from rate and level models and thus easier to understand for most people.

Causal loops are best suited for top-level views and communication to explain cause and effect. They obscure the more precise rate and level structures using the elements in Figure 1. The connections do not distinguish between information links and flow rates.

Table 1 shows the components of causal loop diagrams. They show variables connected by causal links with connection polarities, delays and feedback loops.

Time delays are ubiquitous in processes and are an important structural component of feedback systems shown on causal loop diagrams. Examples include delays associated with any complex activity performed by resource-limited teams, hiring or infrastructure delays, problem resolutions, legal process changes, etc. A new law does not result in its immediate implementation.

A positive causal link means the two nodes change in the same direction and a negative causal link means they change in opposite directions. Positive and negative feedback loops describe the circles of cause and effect. A closed cycle is defined as a reinforcing or balancing feedback loop.

Table 1. Causal Loop Diagram Elements

Symbol	Description
⟶	causal link
+	positive causal link
-	negative causal link
||	time delay
R	reinforcing loop
B	balancing loop

Positive and negative loops can be identified by tracing the direction of change around each loop in the diagram. If after cycling around the loop, the direction of change of the starting point variable is in the same direction as its initial change it is a positive (reinforcing) feedback loop per Figure 2 showing population growth.

A consideration for some lawmaking contexts is the existence of population growth, which is a positive feedback loop shown in Figure 2. The births (growing action) increases the population (+), which in turn positively affects more births (+). It produces an escalating process, or a snowballing effect. The reinforcing loop is sometimes denoted with a running snowball.

The population growth feedback loop in Figure 2 can be modeled with systems dynamics using a single rate and level. The population becomes a level fed by a flow for the birth rate with an associate growth factor.

In a negative (balancing) loop, the direction of change is opposite to its initial direction. A gap between desired and actual conditions causes a correction action, which positively affects the actual condition that reduces the gap. It tends to bring a system into balance, and the loop is sometimes portrayed with a balance scale.

An example negative feedback loop demonstrates a goal of lawmaking to decrease crime per Figure 3. The implicit gap being narrowed is the existence of a particular crime trend vs. the ideal zero crime. An increasing crime rate leads to creation of laws to stem it (+). Legislation attempts to narrow that gap through effective laws that decrease the crime rate (-) .

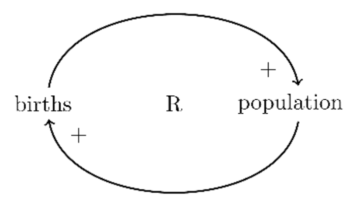


Figure 2. Example Causal Loop Diagram of Positive Feedback for Population Growth

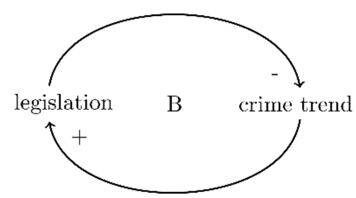


Figure 3. Example Causal Loop Diagram of Negative Feedback for Crime Legislation

Example Regulatory Causal Loop Diagram

A recent example of an extensive modeling effort to assess regulation options by the U.S. Environmental Protection Agency uses causal loop diagrams for stakeholder negotiation and communication. A high level view of the underlying system dynamics model is shown in the causal loop diagram in Figure 4 for evaluating a light rail project in North Carolina (Kolling et. al, 2016). General behaviors can be discerned by following the marked connections.

The diagram shows different model sectors clearly displaying all the aspects considered, constituencies covered, and feedback polarities between the model components. For more precise details, there is an underlying rate and level model corresponding to the causal loop components.

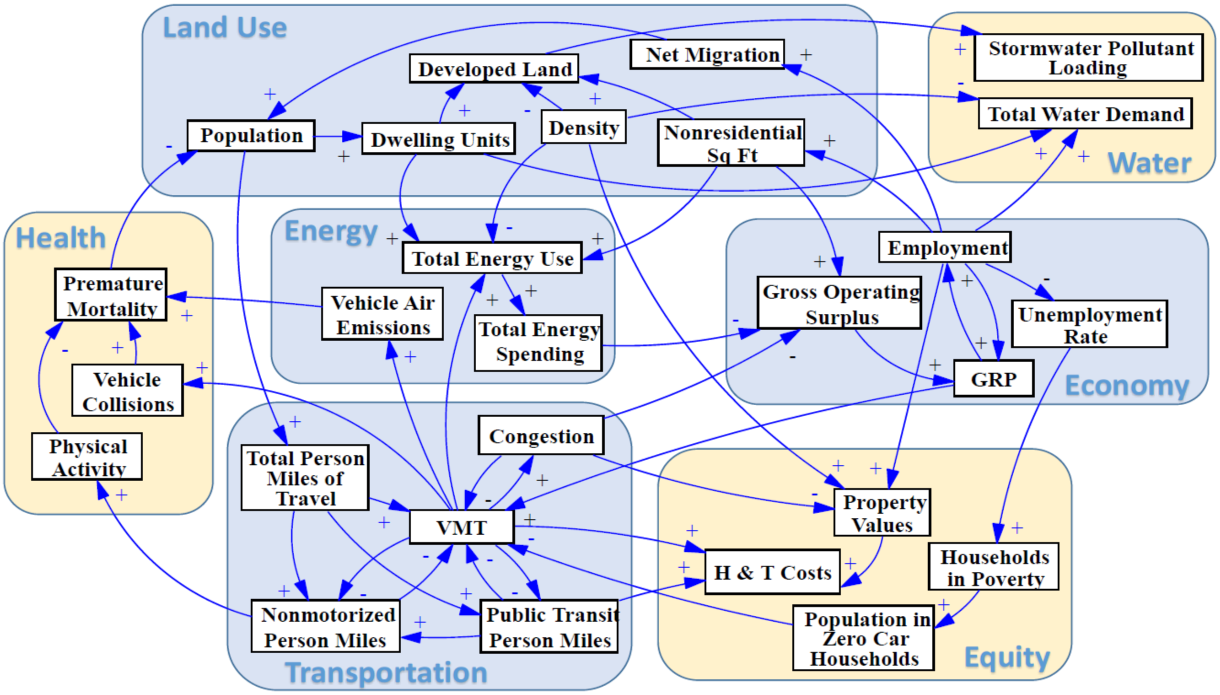


Figure 4. Example Causal Loop Diagram to Assess Environmental Regulation

Causal loop diagrams are used to illustrate the structure-behavior pairs and system archetypes in the next sections. The archetypes are composed of interacting negative and positive feedback loops.

STRUCTURE – BEHAVIOR PAIRS

Exponential Growth/Decay

Exponential growth and decay are the result of a reinforcing process shown in Figure 5. Growth structures are based on the generic compounding flow process. Positive feedback is reinforcing feedback that tends to amplify movement in a given direction. Positive feedback often produces a growth or decline process viewed in Figure 6, such as population growth.

Growth structures are based on the generic compounding flow process. Decay structures are similar but a draining flow process whereby the outflow rate decreases with the level. Lawmaking examples include escalation in number of laws, legal paperwork levels, and escalation of new crime markets (until balancing limits are reached). See (Madachy, 2016) for simple models of exponential growth in lawmaking.

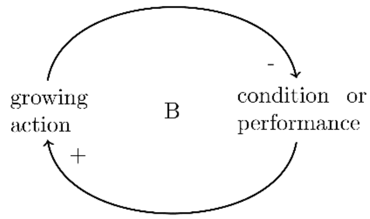


Figure 5. Exponential Growth Causal Loop Diagram

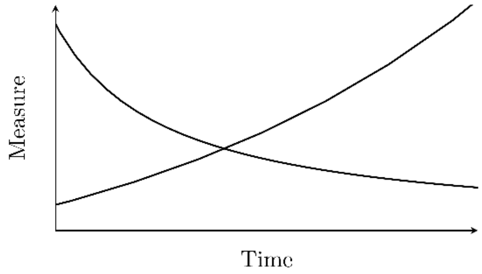


Figure 6. Exponential Growth and Decay Behaviors

Goal Seeking Behavior

Goal Seeking Behavior is characterized by a simple balancing process seeking to close the gap between a goal and actual conditions. See Figure 7 for the goal seeking causal loop diagram. The behavior of closing the gap is illustrated in Figure 8.

Balancing feedback (also called negative feedback) occurs when a system is trying to attain a goal, such as a minimum threshold of injuries via regulation or an enforcement hiring goal.

Example lawmaking goals may include desired revenue from taxes or other means, reduced crime levels, minimizing deaths and accidents via regulation (driving, drug laws), public construction, welfare or health care coverage, preservation of natural resources, legal-related resource needs, bill output. See (Madachy, 2016) for some models of goal seeking behavior in lawmaking.

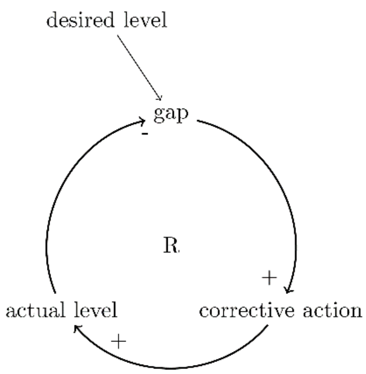


Figure 7. Goal Seeking Behavior Causal Loop Diagram

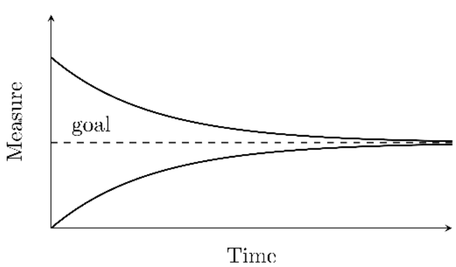


Figure 8. Goal Seeking Behavior with Balancing Feedback

Oscillation

Oscillation is caused by a balancing process with large time delays, creating under and over adjustments around the goal as shown in Figure 9. More than one level must be in system to cause oscillation.

Often there is a target goal that the system is trying to reach, and the system is unstable as it tries to attain the goal. This behavior is shown in Figure 10.

Lawmaking examples are oscillating crime rates, levels of law enforcement (event-driven over adjustments, panic reactions), and short term transient fixes. See (Madachy, 2016) for simple models of oscillation in lawmaking.

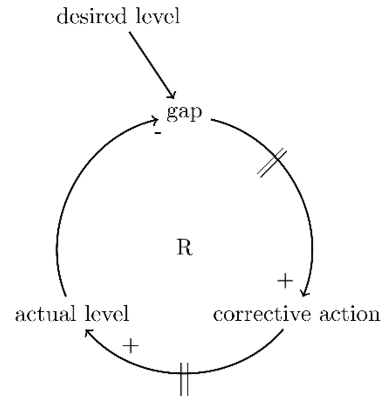


Figure 9. Oscillation Causal Loop Diagram

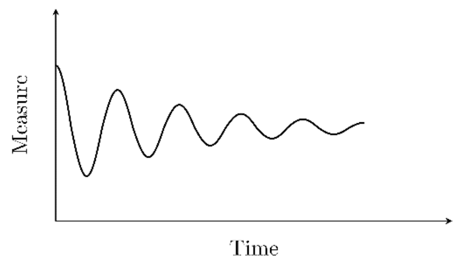


Figure 10. Oscillation Behavior

S-Shaped Growth

S-shaped growth is the result of a reinforcing process that becomes stalled by a balancing process. See Figure 11 for these interacting feedback loops. An S-shaped growth structure contains at least one level, provisions for a dynamic trend that rises and another that falls. There are various representations because S-curves may result from several types of process structures representing the rise and fall trends.

Lawmaking examples include cumulative progress/cost to establish new laws, knowledge diffusion of regulations or enforcement, law adoption, or population coverage over time. Deterrence against penalty levels exhibits the diminishing returns in S-curves. Figure 12 shows example S-shaped behavior over time. See (Madachy, 2016) for some models of S-shaped growth in lawmaking.

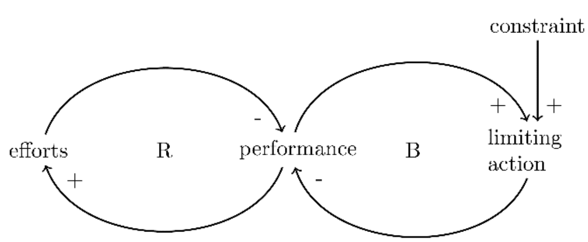


Figure 11. S-Shaped Growth Causal Loop Diagram

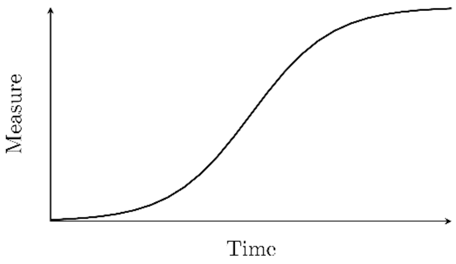


Figure 12. S-Shaped Growth Behavior

SYSTEM ARCHETYPES

This section presents system *archetypes* from a lawmaking modeling perspective. They present lessons learned from dynamic systems with specific structures that produces characteristic modes of behavior. The structures and their resultant dynamic behaviors are also called patterns. Whereas molecules and larger structures are the model building blocks, archetypes interpret the generic structures and draw dynamic lessons from them. Senge discusses organizational archetypes based on simple causal loop diagrams in *The Fifth Discipline* (Senge, 1990).

System archetypes are effective tools to gain insight about patterns of behavior that emerge from the underlying system structures. They can be used diagnostically to reveal insights into the existing systems, or prospectively to anticipate potential problems and/or problem symptoms.

The systems archetypes explain and make visible the recurring "stories" that happen in many areas of society. The archetypes let us step back and see how many organizations and governments experience similar systemic challenges. Systems archetypes help us deepen our understanding of these challenges and design effective action plans for addressing them.

Some of the more prevalent archetypes operative in a lawmaking context will be elaborated with examples in the following sections. One recurring type of phenomena is time delay effects. Delays in systems cause people to perceive a response to an action incorrectly. This causes an under or overestimation of the needed action and results in oscillation, instability or even breakdown.

Fixes That Fail

In a *Fixes That Fail* situation, efforts to bring something into balance create consequences that reinforce the need to take more action. A "quick-fix" solution can have unintended consequences that worsen the original problem. The short-term fix creates side effects for the long-term, and often results in more fixes needed. The feedback loops involved are illustrated in Figure 13. The associated general behavior over time trends are shown in Figure 14.

A problem symptom exists that is desired to resolve. A solution is quickly implemented, which alleviates the symptom. However, the solution produces unintended consequences that, after a delay, cause the original problem symptom to return to its previous level or even get worse clearly shown on Figure 14. This development leads us to apply the same (or similar) fix again. This reinforcing cycle of fixes is the essence of *Fixes That Fail*.

Lawmaking examples include:

- Government increasing the cigarette tax to raise more taxes causes smuggling of cigarettes, thus reducing the number of taxed cigarettes sold.
- Drug war enforcement raises price of illicit drugs, thus profiting and further empowering the cartels.
- Endangered species act causes landowners to kill such animals on property in order to sell to developers.
- The "Three strikes and you're out" California law gave incentive to evade a 3rd arrest, leading to more violent crime on police.

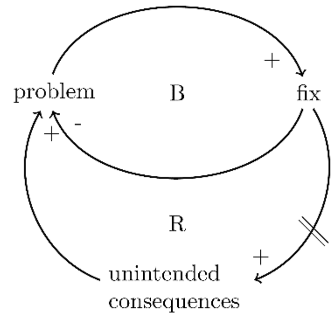


Figure 13. Fixes that Fail Causal Loop Diagram

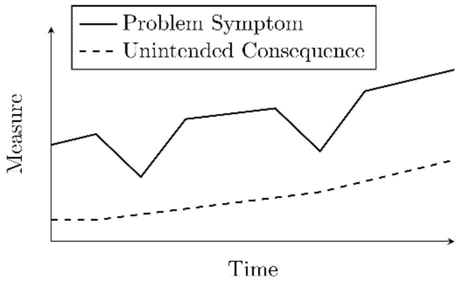


Figure 14. Fixes that Fail Behavior

Example: Lawmaking Fixes that Fail Model

A demonstrative system dynamics model was developed. The causal loop diagram for the dynamic behavior is in Figure 15. The elaborated rate and level model is shown in Figure 16, with output behavior in Figure 17. It models the typical situation in which government spending programs exceed its revenues. Elected lawmakers are faced with spending programs that exceed national or state revenues. They cover the shortfall by borrowing money to finance roads, defense, medical assistance, welfare, and other programs and services.

The following year, these expenditures include continuation and maintenance of existing projects, new promises to constituents, and payments on the earlier debt. Faced with the painful and unpopular choices of cutting programs or raising taxes, they take the easy way out and borrow again. Government gets saddled with increasing debt, and interest payments on that debt. Short term improvement gets overwhelmed by long term new debt costs.

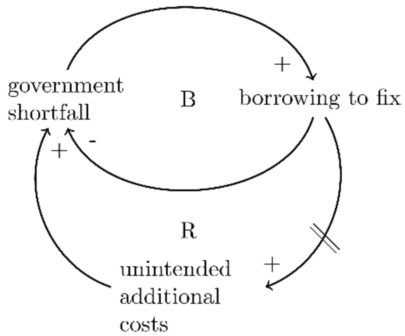


Figure 15. Government Spending Causal Loop Diagram

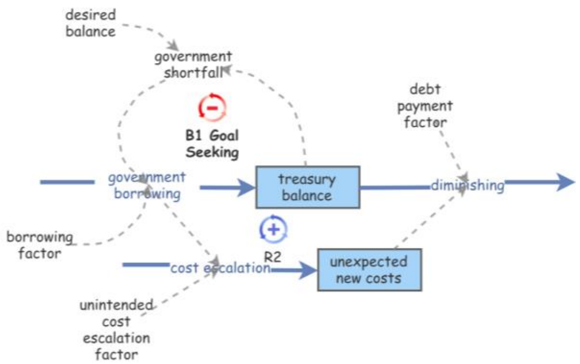


Figure 16. Government Spending Demonstration Model

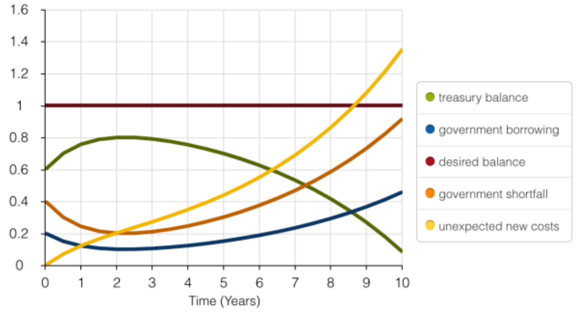


Figure 17. Government Spending Model Results

The underlying relationships can be viewed in the model at: https://insightmaker.com/insight/93082/Lawmaking-Fixes-that-Fail. It can also be executed in a browser or cloned for further development.

Shifting the Burden

In the *Shifting the Burden* archetype, two balancing loops compete for control in "solving" a problem symptom, while a reinforcing side-effect of one solution makes the problem worse. The feedback loops are illustrated in Figure 18. The associated general behavior over time trends are shown in Figure 19.

When a symptomatic solution is implemented, the symptom is reduced which lessens the pressure for implementing a more fundamental solution. Over time, the symptom resurfaces, and another round of symptomatic solutions is implemented. This side effect exacerbates the problem by further diverting attention away from more fundamental solutions.

For example, government programs dictated by law often increase the recipient's dependency on the government. Welfare programs do this when they do not attempt to simultaneously address low unemployment or low wages. Drug rehabilitation programs that do not address the root causes of addiction lead to the patients returning. All of these shift the burden back to the intervener, the government.

Other lawmaking examples include:

- Inadequate regulations and drug company behavior shifting the high cost of drugs to consumers.
- Bank failures addressed symptomatically by creating FDIC and FSLIC, not a fundamental solution of prudent banking practices. Responsibility for protecting deposits shifted to government.

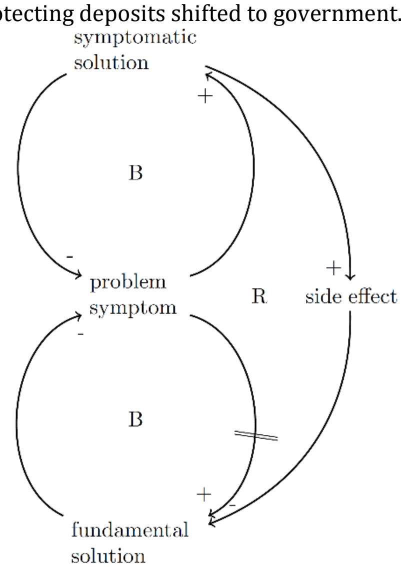


Figure 18. Shifting the Burden Causal Loop Diagram

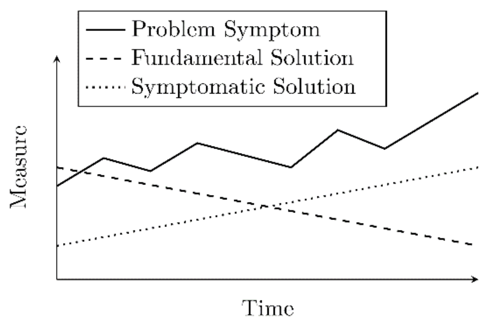


Figure 19. Shifting the Burden Behavior

Limits to Growth

In a *Limits to Growth* scenario, a reinforcing loop creates pressure in the system that is relieved by one or more balancing loops that slow growth. The reinforcing process of growth or expansion will encounter a balancing process as the limit of the system is approached. The reason is that the system has hit some limit such as capacity constraints, resource limits, etc. that is inhibiting further growth. These feedback loops are illustrated in Figure 20. The associated general behavior over time trends are shown in Figure 21.

Lawmaking examples include:

- Municipal building codes allowing rampant development until no space is left.
- Governments allowing depletion of natural resources eventually stymying industrial growth.

Growing actions initially lead to success, which encourages even more of those efforts. Over time, however, the success itself causes the system to encounter limits, which slows down improvements in results.

The archetype has a structure characterized by a reinforcing process (which serves as the initial growth engine) and a balancing process which contains the limits that eventually cause growth to level off per Figure 20.

As efforts increase, so does performance, which encourages even more efforts, as loop R in Figure 20. But the performance (or growth) is linked to a limiting factor that, as performance increases, so do the forces slowing the success. The limiting factor then comes back around to decrease performance (loop B).

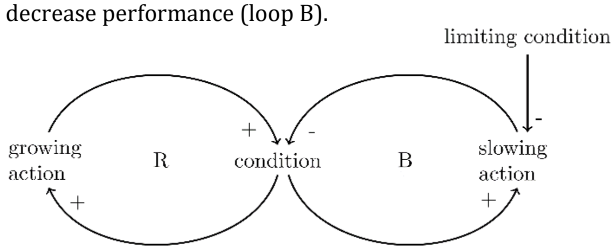


Figure 20. Limits to Growth Causal Loop Diagram

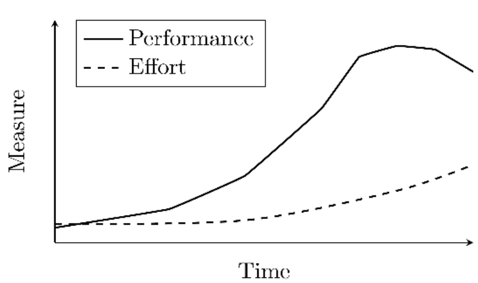


Figure 21. Limits to Growth Behavior

Drifting Goals

In *Drifting Goals*, two balancing loops strive to close the gap between a goal and current reality. When a gap exists, the goal is often lowered to close the gap. Eventually the lowering of the goal leads to deteriorating performance. The feedback loops are illustrated in Figure 22. The associated general behavior over time trends are shown in Figure 23.

Similar to shifting the burden, as current problems need to be handled immediately, the long-term goals continuously decline. Lawmaking examples include:

- Lawmakers allowing public debt increase, sliding limits of environmental pollution.
- Lawmakers adopting watered down provisions in new bills in order to demonstrate some progress.

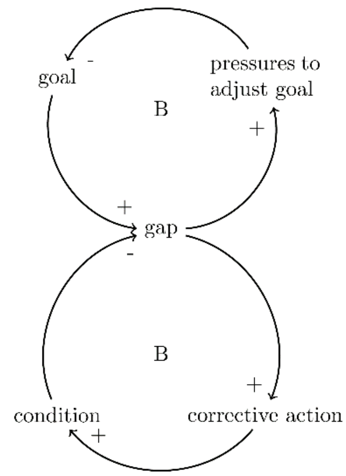


Figure 22. Drifting Goals Causal Loop Diagram

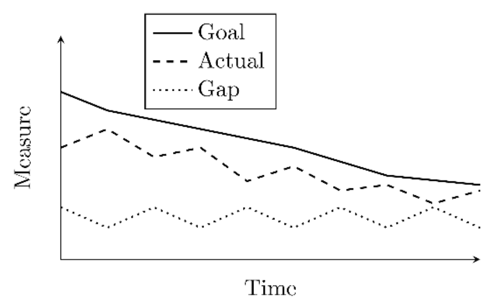


Figure 23. Drifting Goals Behavior

Growth and Underinvestment

The *Growth and Underinvestment* is similar to the *Limits to Growth* structure with an investment-policy balancing loop as a system constraint. When growth approaches a limit, the system compensates by lowering performance standards. This reduces perceived need for capacity investments and leads to lower performance, justifying further underinvestment. The feedback loops are illustrated in Figure 24. The associated general behavior over time trends are shown in Figure 25.

Lawmaking examples include public transportation becoming overcrowded, in need of expansion, but city accepts substandard service and does not invest more.

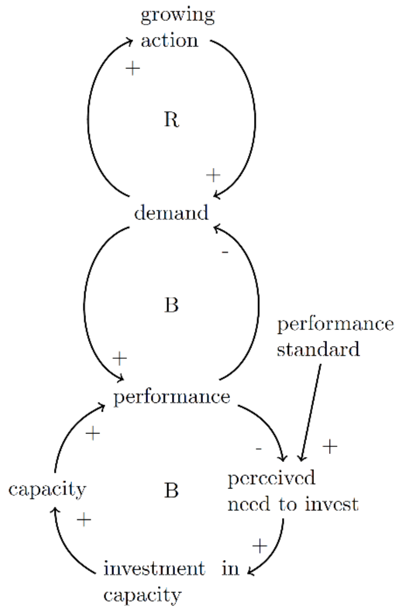


Figure 24. Growth and Underinvestment Causal Loop Diagram

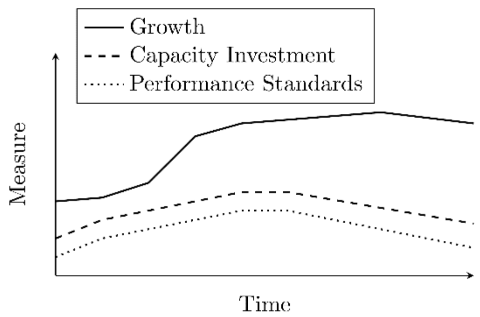


Figure 25. Growth and Underinvestment Behavior

Success to the Successful

The *Success to the Successful* archetype has two reinforcing loops competing for a common, limited resource. In a system with limited resources, one party's initial success justifies devoting more resources to that party, which widens the performance gap between the various parties. The feedback loops are illustrated in Figure 26. The associated general behavior over time trends are shown in Figure 27.

Lawmaking examples include:

- Legislated tax codes: the top 2% continue getting more tax advantages, becoming more influential still.
- International treaty bodies where select countries have more power than others and use it to maintain advantage over other countries.

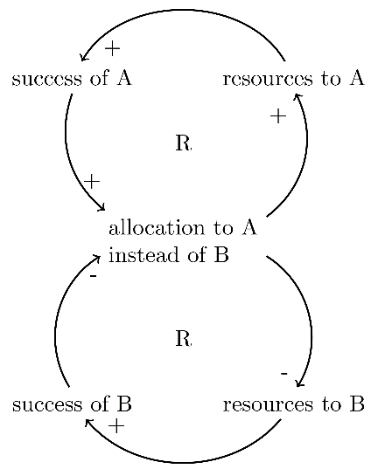


Figure 26. Success to the Successful Causal Loop Diagram

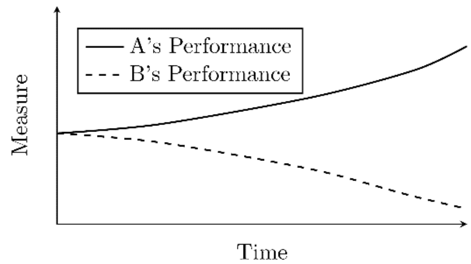


Figure 27. Success to the Successful Behavior

Escalation

In an *Escalation* situation, two or more players manage their own balancing loop in response to the threatening actions of others. The feedback loops are illustrated in Figure 28. The associated general behavior over time trends are shown in Figure 29.

A perception of threat causes one party to take actions that are then perceived as threatening by another party. The parties keep trying to outdo one another in a reinforcing spiral of competition.

Lawmaking examples include:

- Legislation supporting war and arms races.
- Legal suits and countersuits.
- Regional escalation of competing security and criminal forces.

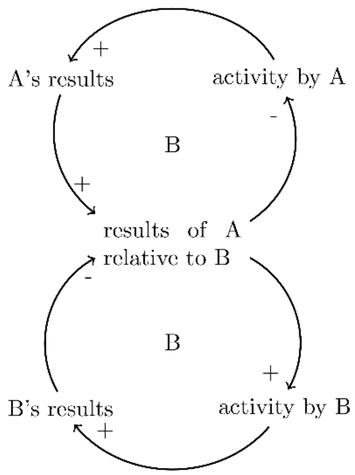


Figure 28. Escalation Causal Loop Diagram

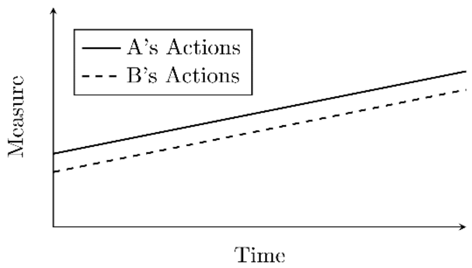


Figure 29. Escalation Behavior

Tragedy of the Commons

In *Tragedy of the Commons* situation, the sum total of two or more reinforcing activities strains a limited resource and creates balancing consequences for all. The feedback loops are illustrated in Figure 30. The associated general behavior over time trends are shown in Figure 31.

If total usage of a common resource grows too great, the commons will become overloaded or depleted, and everyone will experience diminishing benefits.

Lawmaking examples include infrastructure, such as state government building new highways, leading to higher population, more cars using the resources, and then congestion for all.

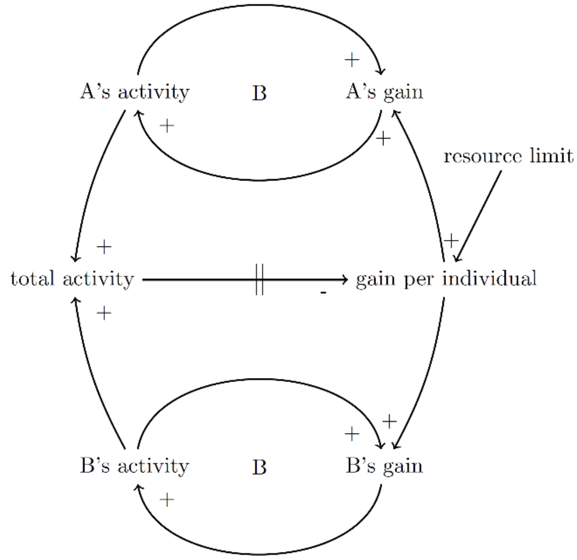


Figure 30. Tragedy of the Commons Causal Loop Diagram

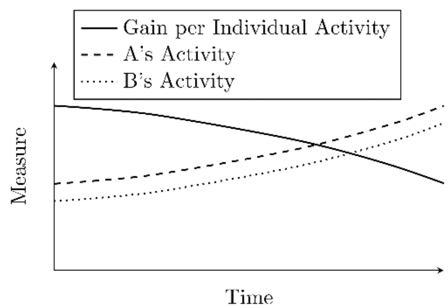


Figure 31. Tragedy of the Commons Behavior

CONCLUSIONS AND FUTURE WORK

This work furthers previous model structures interpreted and tailored for the lawmaking process domain with associated generic behaviors. The model structures and patterns can be used to compose lawmaking applications. Characteristic behavior patterns over time are encapsulated with their causal structures.

The structure – behavior pairs are part of a reusable library of patterns. Modelers can save time by leveraging existing and well-known patterns. The generic structures are starting templates that can be combined in different ways, and with detail added to create larger infrastructures and complex models. The building blocks help lower the barrier of adoption in the community because they can be quickly reused and adapted for numerous applications.

System archetypes are effective tools to gain insight about patterns of behavior that emerge from the underlying system structures. They can be used diagnostically to reveal insights into the existing systems, or prospectively to anticipate potential problems and/or problem symptoms. The provided examples of archetypes in lawmaking are a beginning very small sample. They can be further explored for numerous lawmaking applications in great detail.

This author will continue improving these modeling assets, developing fuller models for specific investigations and seeking empirical data to support the modeling. The generic structures, sample flow chains and models will be provided in the public domain.

Subsequent work will include small scale models demonstrating system archetypes in lawmaking, such as showing how unintended consequences of laws occur. More elaborated, complete model applications will also be provided. Web-based, executable versions will be accessible for public usage of the lawmaking applications.

This work is a beginning as there are numerous law topics to investigate aided by simulation. It is hoped to catalyze interest in the field and provide guidance on one approach for applying science for better lawmaking. Eventually we hope that modeling and simulation of lawmaking will become adopted as an inherent part of the process and standard professional practice.

REFERENCES

Bodner, Douglas A. "Mitigating Counterfeit Part Intrusions with Enterprise Simulation", Procedia Computer Science 61, Elsevier (2015): 233 – 239

Derwisch, Sebastian and Kopainsky, Birgit. "Dynamics of Enforcement and Infringement of Intellectual Property Rights and Implications for Innovation Incentives", Proceedings of the 28th International Conference of the System Dynamics Society (2010)

Forrester, Jay W. Principles of Systems. Cambridge, MA: MIT Press, 1968.

Forrester, J. W., Urban Dynamics, Cambridge MA: Productivity Press, 1969

Ghaffarzadegan, Navi, et al. "How Small System Dynamics Models Can Help the Public Policy Process", System Dynamics Review 27(1): 22-44., System Dynamics Society, 2011.

GovTrack, "Historical Statistics about Legislation in the U.S.Congress", https://www.govtrack.us/congress/bills/statistics

Hines, Jim. Molecules of Structure Version 1.4, LeapTec and Ventana Systems, Inc., 2000.

Kolling, J., L. Cox, N. Flanders, A. Procter, N. Tanners, A. Bassi, and R. Araujo. A System Dynamics Model for Integrated Decision Making: The Durham-Orange Light Rail Project. U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-15/333, 2016.

Levin, G., et al. The Persistent Poppy: A Computer-Aided Search for Heroin Policy. Cambridge MA: Ballinger, 1975.

Madachy, Raymond J. Software Process Dynamics, Hoboken, NJ: Wiley-IEEE Press, 2008.

Madachy, Raymond J. System Dynamic Structures for Modeling Lawmaking Processes, Proceedings of the Third Annual Science of Laws Conference, San Diego, CA, 2016.

Meadows, Donella H., et al. The Limits to Growth, New York: Universe, 1972.

Meadows, Donella H., et al. Limits to Growth-The 30 year Update, White River Junction, VT: Chelsea Green, 2004.

Morecroft, J. D., "System Dynamics and Microworlds for Policymakers", European Journal of Operational Research 35 (3): 301-320, 1988.

Olaya, Camilo and Angel, Vanessa. "The War on Drugs: A Failure in (Operational) Thinking", Proceedings of the 32nd International Conference of the System Dynamics Society (2014)

Richmond, Barry, et al. Ithink User's Guide and Technical Documentation, High Performance Systems Inc., Hanover, NH, 1990.

Schrunk, David G. The End of Chaos: Quality Laws and the Ascendancy of Democracy. Poway, CA: QL Press, 2005.

Senge, Peter. The Fifth Discipline. New York, NY: Doubleday, 1990.

State of California, "OVERVIEW OF LEGISLATIVE PROCESS", http://www.leginfo.ca.gov/bil2lawx.html

Sterman, John D. Business Dynamics: Systems Thinking and Modeling for a Complex World, Boston, MA: Irwin/McGraw-Hill, 2000.

Dr. Raymond Madachy is an Associate Professor in the Systems Engineering Department at the Naval Postgraduate School. His research interests include system and software cost modeling, affordability and tradespace analysis, modeling and simulation of systems and software engineering and lawmaking processes, integrating systems engineering and software engineering disciplines, software litigation and intellectual property rights. Previously he was a Research Assistant Professor in the Industrial and Systems Department at the University of Southern California and a Principal in the USC Center for Systems and Software Engineering. He has over 90 publications including the book *Software Process Dynamics*, is a co-author of *Software Cost Estimation with COCOMO II* and *Software Cost Estimation Metrics Manual for Defense Systems*. He is currently writing *Systems Engineering Principles for Software Engineers*.

PROCEEDING

An Architecture Scaffolding for Analyzing Overlap and Conflict Between Laws

Beryl Bellman*
Professor, California State University, Los Angeles
Ann Reedy
Consultant
Prakash C. Rao
Enterprise Sherpas, LLC

ABSTRACT

Based on years of research and practice in the field of government and defense laws and mandates for enterprise architecture we present a systematic method for analysis of multiple laws to find intersections, overlaps and conflicts using the six interrogatives framed by Zachman. The use of the 6 interrogatives provides a complete decomposition of the architecture elements that are embedded inside the narratives of the laws and provides a method to transform a narrative, human intensive understanding into a structured analysis problem. In this paper, we discuss this approach and apply it to a case study regarding regulations for small, modular nuclear reactors.

INTRODUCTION

In this paper, we propose using techniques from the emerging discipline of Enterprise Architecture to provide a standard format for extracting the contents of laws for analysis. This standard format supports the comparison of laws and the identification of conflicts, overlaps, and potential unintended consequences. The same standard format can be used to document the viewpoints of stakeholders and can be used to support the development of new or revised laws. We propose a repeatable process for law analysis using these borrowed techniques that can form the foundation for architecting the law-making process. We illustrate the techniques and process with examples from a specific situation where the emergence of new technology will require the revision, consolidation, or expansion of existing laws and regulations.

PROBLEM DEFINITION

Laws are comprised of narratives, making them hard to analyze for comparison with other overlapping or complementary laws. In addition, multiple laws may have overlapped scopes and/or overlapped but differently named or described content.

In order to deal with stifling and inconsistent regulation, we need rapid ways to analyze existing laws and a streamlined way to create new lighter, leaner legislation that does not inhibit innovation, does not pose an unusual burden on the regulated entities, fosters creativity and economic growth and shields citizen at large from the impact. Some of the ways that simplifying and streamlining laws can be achieved are:

1. *Refactoring or restructuring existing laws*. In the IT community, software developers have found that by "cleaning up" parts of the code that they maintain when they encounter a problem and are fixing it, can go a long way to restoring the effects of entropy on system behaviors.
2. *Comparing laws and potentially merging laws*. Laws that regulate in similar domains and may have partial or significant overlaps can be merged in order to simplify them. Comparison of laws requires that the elements of the laws are comparable (and are reduced to a common set of comparable data). A risk is that by combining two smaller laws into a larger more complex law, the benefits of consolidation are offset by the increased complexity.
3. *"Getting ahead" of emerging technology innovation*. Start drafting laws that complement existing or extend existing laws instead of waiting to observe some of the darker consequences before moving to pass legislation to curb excesses or inadvertent health and safety side effects of technology adoption.

The problem is: How to achieve these goals using techniques that provide streamlined and systematic methods for decomposing laws, synthesis of requirements for drafting new laws, and methods for analyzing impact of laws on regulated entities in terms of negative burdens?

The Science of Laws Journal, Vol. 4, No.1, (2018): 18-22.

*Author to whom all correspondence should be addressed (e-mail: bbellma@calstatela.edu).

PROBLEM METAPHOR: COMPLEXITY IN SYSTEMS ENGINEERING AND ARCHITECTING

In the Information Technology world, disciplines like Enterprise Architecture and Systems Engineering address a similar problem of ballooning requirements, complex requirements for interfacing, interoperability, diversity in components, and diversity in viewpoints of stakeholders that makes architecting and designing modern systems both complicated and complex (c.f. Rao, Reedy & Bellman, 2011 and Rao, Reedy & Bellman, in press).

An *enterprise* is a collection of resources and performers performing complex activities directed towards a common purpose. An enterprise by definition is complex, risky, involves a lot of moving parts and can range in scale from specific projects to large enterprises such as the Federal Government, or an Agency of the Government or a large commercial enterprise. An enterprise can also cross multiple organizations, such as the Nuclear Reactor Industry.

Enterprise Architecture is the representation of the structural components and behavior of an enterprise, their relationships both within the enterprise and to elements outside the enterprise, and the evolution of structure and behavior over time. Enterprise architecture, more correctly defined as architecture description, is a representation of these elements.

Just as the study and narrative representations of law have been codified and standardized over the years, architecture frameworks, standardized vocabulary and unified methodologies have brought disparate architecture descriptions built for multiple stakeholders with multiple viewpoints into common formats that provide architecture based analysis using aggregation, integration and comparison capabilities across architectures.

The techniques we are interested in borrowing from Enterprise Architecture for law analysis include the following:

- Standard formats for representing data and information
- Visual representations of data and information to aid communication
- The concepts of viewpoints and views to analyze fitness for purpose and impact of change

A STANDARD FORMAT

We can view the various elements of laws using the same metaphor as an architecture description. In its narrative form, a law is a composition of many statements, definitions, constraints and relationships. When a bill is drafted, multiple stakeholder viewpoints and concerns and interests, from both sources internal to the enterprise concerned and from its context, come to bear upon the exact wording and shape that the bill takes.

For representing the content of a law in a standard format, we propose a scaffolding approach that we have described in (Bellman, Reedy & Rao, 2016). This same format can be used for documenting stakeholder viewpoints. The scaffold is a conceptual structure that is based on the six interrogatives used by Aristotle described by John Zachman. The six interrogatives (WHAT, HOW, WHERE, WHO, WHEN and WHY) are mutually exclusive and cover all aspects of a law from a single viewpoint.

WHY - Elements of purpose, rationale and drivers

For lawmakers: what is the intent of the bill? What is the rationale or set of assumptions that make the case for passing the bill? What existing drivers like initiatives, mandates, stated directions or observations are driving the creation of the bill?

- HOW - Elements of constrained activities
  For lawmakers: what types of activities are constrained by the bill?
- WHERE - Elements of constrained locations, equipment and tools –
  For lawmakers: what types of locations, equipment and tools are constrained by the bill?
- WHO - Elements of constrained roles and responsibilities
  For Lawmakers: what are the roles or types of organizational structures that are created by the bill or that are assigned responsibilities by the bill?
- WHEN - Elements of constrained time periods, events and cycles
  For lawmakers: what time periods, latencies and events are specified as controlled and mandated by a bill?
- WHAT - Elements of constrained products, services, materials or information
  For lawmakers: what types of products and services are controlled, or regulated by the bill? What information must be disclosed per the terms of the bill in the form of disclosures and reports?

VISUAL REPRESENTATION

For a visual representation, we can use a "spider" chart illustrated in Figure 1. The spokes of the web represent the six dimensions of the scaffold and a polygon can be overlaid on the diagram to outline the areas of focus the coverage of a bill, law, or viewpoint. For visualizing the comparison of multiple laws, multiple polygons can be overlaid. The overlap of the polygons identifies the dimensions of overlaps and highlights areas of potential conflicts. Figure 1 shows the scope of an existing Law 1, the incremental improvement of a refactored version of Law 1, and the comparison of Law 1 with Law 2.

APPROACH AND EXAMPLE

We outline our approach and where in the process of preparing a bill our proposed techniques are useful by walking through an example situation where emerging technology will call for a detailed review of existing law and extensions to that law or new laws.

Example Situation: Small/Medium (Modular) Reactors

A potential revolutionary new technology called Small/Medium Reactors (SMRs) is emerging as an alternative to conventional sources of energy such as oil and gas. A small reactor is defined by the International Atomic Energy Agency as one whose electricity output is less than 300 MW. The smaller reactors are also termed modular as their components are made separately and brought together at the site to be assembled, integrated and installed before becoming operational. The promise of installing previously fabricated modular reactors in remote locations, at disaster recovery sites to restore temporary power, and at austere environments for fielded warfighters, amongst many others, is driving an increasing set of players such as manufacturers, fabricators, and customers. As this technology evolves, opportunities for using these reactors in normal civilian use, for local or neighborhood power cooperatives, will emerge.

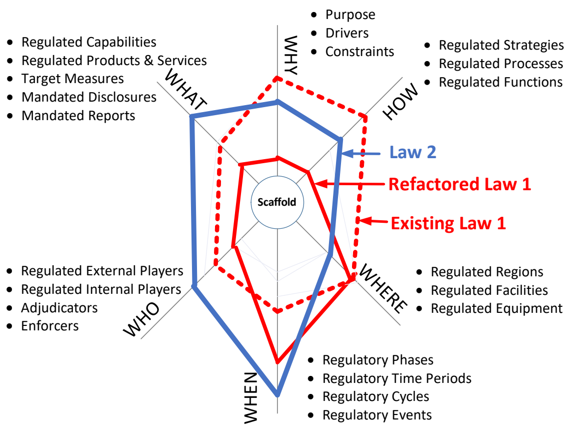


Figure 1: Example Spider Chart Illustrating Visual Comparison of Laws

The first nuclear power generation effort was first established in 1951 in Idaho and since then has grown to power plants producing outputs of over 1,400 MW. As the understanding of the hazards and risks in the design, development and operation of nuclear reactors to the environment, to people and to the communities around the plants has grown, increasing legislation has been brought to bear to regulate various aspects of the nuclear power industry. Today the Nuclear Regulatory Commission, established by Energy Reorganization Act of 1974, regulates the following types of items:

- Nuclear Reactors
- Nuclear Materials
- Regulated Activities
- Radioactive Waste Disposal
- Nuclear Security and Safeguards

After spectacular nuclear accidents at sites like Three Mile Island, Fukushima and Chernobyl, the commissioning of large scale power generation nuclear reactors has faltered. While SMRs have been used in the US Navy for several decades, the evolution of SMR technology is a trend that appears to be countering the decline in conventional nuclear power generation because of the distributed, small footprint and modular conveniences that it brings.

In an accelerating world of SMRs, the questions that arise from a lawmaker's perspective are:

- Is existing legislation sufficient to accommodate SMR technology evolution, growth and proliferation?
- What security and safety risks are posed by SMRs that are not currently addressed by legislation?
- What new players and roles are introduced by SMRs that did not exist under previous nuclear power generation conditions that are covered by existing legislation?
- Does regulating of SMRs require a new set of departments and organizational structures within the NRC or can they be folded in under the existing departmental functions of the NRC?
- Are existing nuclear laws and regulations too complex and confusing and does a new SMR regulatory initiative offer a method to amend or refactor existing laws?

These are complex questions.

Lawmaking has for the most part, lagged behind technology innovation and its effects on society. The International Atomic Energy Agency timeframe for the projected timelines of readiness for deployment of SMRs generally range from the present to 2025-2030. With advertisements for SMRs already appearing, this is a good time for lawmakers to proactively examine the issues and concerns raised by the proliferation of SMRs throughout the US (and throughout the world) as well as their role in nuclear waste and radioactive end products proliferation.

Application of Approach

We describe an approach as a non-exhaustive, but rather an illustrative example. The first step is to identify both the existing and the potential new stakeholders and develop scaffolding representation for each of these stakeholder groups. A partial list of these stakeholder groups includes:

- Power Companies (Public Utilities)
- Small Reactor Manufacturers
- Small Reactor Leasing Companies
- Local Power Cooperatives
- Emergency Responders/Defense Services
- Operators
- Nuclear Fuel Carriers and Storage Operators

Some example comparative scaffolding representations are shown as lists in Tables 1 and 2. (These examples are not meant to be definitive or complete.)

Table 1. Reactor Management Stakeholders' Viewpoints

Traditional Power Company	Cooperative Power Company
WHY: Profit	Why: Lowest Cost Power; Local Control
WHAT: Electrical Power	WHAT: Electrical Power
HOW: Power Generation	HOW: Power Generation
WHO: Public Utility Company/Management	WHO: Small Town/Neighborhood Power Co-op or Contracted Management

WHERE: Fixed, Centralized Facilities (old); Distributed, Potentially Mobile Facilities (new)	WHERE: Local facility, Potentially Relocatable in Response to Growth
WHEN: As soon as technology is ready	WHEN: As soon as technology is ready

Table 2. Reactor Builders' Viewpoints

Traditional Power Companies	**Small Reactor Manufactures**
WHY: Effective Power Generation; Controlled Costs	WHY: Profit
WHAT: Nuclear reactors	WHAT: Small nuclear reactors
HOW: In-house and contracted design and construction (old) and leasing of small nuclear reactors (new)	HOW: In-house design and construction; sales, marketing and leasing
WHO: Public utility company/management	WHO: Manufacturing management
WHERE: Fixed facilities for design and on-site construction (old) and flexible siting for small reactors (new)	WHERE: Fixed utilities
WHEN: As need to meet power generation needs	WHEN: As soon as technology is ready and company can start up

Note that the situation is complicated by the fact that Public Utilities have yet additional sets of regulations that may impact their ability to start up a separate business such as manufacture of SMRs, assuming the management decides this is a good idea.

The stakeholders' viewpoints need to be analyzed to identify new information, new situations that may need regulation, and potential conflicts where decisions will have to be made. Analysis of just the above examples yields the following potential conflicts between traditional, public utility power companies and local power co-ops.

- WHY: Profit vs Non-Profit
  - Will non-profit power generation with (very) local control be allowed?
  - Should there be limits on how large non-profit power generation co-ops should be allowed to grow?
- WHO: Contracted Management vs Local Co-op Board
  - Is there a need for additional regulations for contracted management for co-op local power generation?
- WHERE: Both
  - How should the siting of SMRs in residential areas be regulated?
  - What should the constraints on relocating SMRs be?

Note that some of these issues are national and some can have additional state and local input. Regulations at all levels of government need to be coordinated.

Similarly, there are the following potential conflicts between traditional power companies and the SMR manufacturers.

- HOW: Traditional Power Companies vs SMR Manufacturers
  - Are additional regulations needed for small reactor manufacturers?
  - Are restrictions needed on traditional power companies that want to also manufacturer and sell SMRs? How should this potential conflict in mission (using vs selling) be addressed?
  - Are additional regulations needed for leasing SMRs?

A second step is to investigate relevant existing laws. The laws currently in force for regulating nuclear reactors are the following:

- Atomic Energy Act of 1954 as Amended (Regulates Atomic Energy)
- Energy Reorganization Act of 1974 (Establishes and charters NRC)
- Nuclear Waste Policy Act of 1982 (Regulates types of Nuclear Waste)
- Low Level Radioactive Waste Policy Amendments Acts of 1985 (Radioactive Wastes)
- Uranium Mill Tailings Radiation Control Act of 1978 (Uranium Mill Wastes)
- Nuclear Non-Proliferation Act of 1978 (Control of nuclear materials for security)
- Administrative Procedure Act (Organization Structure, Rulemaking, Adjudication etc.)
- National Environmental Policy Act (Environmental Impact)

By developing individual scaffolding of the coverages and scope of these laws, we can map them into a "canonical format" that allows for aggregation, comparison and matching elements into the scaffolding for the proposed SMR Bill. The spider diagrams can be used to visually represent the scope of each law. In the case of SMRs, the various public utility laws may also need to be investigated.

SUMMARY AND ADDITIONAL RESEARCH

We have seen how a technique from enterprise architecture can be used to provide a standard, normalizing format for dealing with the multi-viewpoint multi-stakeholder issues common in law. This format supports the analysis of existing laws and the issues of new law proposals. The format provides the capability to restructure existing laws and merge or separate laws by detecting overlaps between laws. There is also a technique for visual representation of overlaps and potential conflicts.

However, there are additional enterprise architecture techniques that may also be useful in analysis of laws: rules models and patterns. Unfortunately, there is not enough space in this paper to discuss these approaches. The rules models focus on statements that constrain the enterprise. For laws, these rules would formally describe the constraints on behavior intended by a law. Since there are different types of law, such as chartering laws, procedural laws, and role regulation laws, there may be underlying patterns that can be codified for each type of law in terms of the representation scaffolding. This would provide a common starting point for the structure of new laws in each category. We hope to have time to explore the use of these additional techniques to manage laws in the future.

REFERENCES

Bellman, Reedy and Rao, 2016, "Enterprise Architecture Patterns for Innovation" paper presented at the ISPIM Innovation Conference, Porto, Portugal.

International Atomic Energy Agency, "Small and Medium Sized Reactors (SMRs) Development, Assessment and Deployment." https://www.iaea.org/NuclearPower/SMR/.

Nuclear Regulatory Commission – Website – https://www.nrc.gov.

Rao, Prakash, Reedy, Ann and Bellman, Beryl, 2011 FEAC Certified Enterprise Architecture Study Guide, McGraw Hill, New York.

Rao, Prakash, Reedy, Ann and Bellman, Beryl, forthcoming, Enterprise Architecture Foundations: All-In-One Guide for Practitioners and EA Certifications, McGraw Hill, New York.

Rao, Vivek (forthcoming), 'Numerical Investigations of Thermal-Hydraulic Phenomena in a Pressurized, Light-Water, Small Modular Nuclear Reactor'. Doctoral dissertation at Missouri University of Science and Technology.

Schrunk, David G., 2012, "The Systems Engineering Approach to the Design of Laws", Procedia Computer Science, 8, Challenges in Systems Engineering and Architecting Conference on Systems Engineering Research (CSER), St. Louis, Mo.

Zachman, 2008, A Concise Definition of the Zachman Framework by John Zachman, https://www.zachman.com/about-the-zachman-framework.

Dr. Bellman is co-founder and Academic Director of the FEAC™ Institute and is also a tenured full Professor of Communication Studies at California State University at Los Angeles. He has been involved in teaching, research; publishing, consulting and project management in the fields in Enterprise Architecture for over 45 years and has an excellent reputation in both academe and professional consulting. He held faculty and research positions at the University of California at San Diego, SUNY Stonybrook, CUNY Graduate Center and California Institute of the Arts, and was Research Director of the Western Behavioral Sciences Institute prior to his current university position. In addition to academic positions he has thirty plus years concurrent consulting experience in both government and the private sectors. He holds enterprise architecture certifications in FEAF, DoDAF, Zachman, TOGAF 8 and TOGAF 9.

Dr. Reedy has a PhD in Computer Science with more than 40 years of experience in academia and Federal research and contracting communities. She taught computer science at both the University of Iowa and the University of Nebraska, Lincoln. After working with analyst support systems and software development environments in the Federal contracting community, she focused on Enterprise Architecture. While working for the MITRE Corporation, a Federally Funded Research and Development Center, she was one of the principal developers and editors of the C4ISR Architecture Framework and worked on its evolution into the DoD Architecture Framework (DoDAF).

Now retired from MITRE, she continues to pursue research into new enterprise architecture concepts and approaches.

Prakash Rao has 38 years of experience as a researcher, innovator and entrepreneur involved with startup, management, product innovation and evolution of three different companies; as a teacher and trainer for Enterprise Architecture for the US Air Force for three years and a faculty member at the FEAC Institute for more than 7 years, and an early pioneer, consultant and practitioner of enterprise architecture for more than 20 years.

Prakash is a Certified Enterprise Architect with an MS in Computer Science from the University of Minnesota, Minneapolis and a BSEE from Bangalore University, India. He is a member of several professional societies and participates actively in outreach and advocacy for enterprise architecture amongst startup professionals, as well as seasoned corporate managers and the lay public. Currently he is the Chief Executive Officer of Enterprise Sherpas LLC in Fairfax, Virginia.

PROCEEDING

Legislative Bills: Design Criteria and Assessment

David Schrunk*
The Science of Laws Institute

ABSTRACT

The task of engineers is to solve problems through the creation of new, efficacious implements, devices, and systems. To meet this design challenge, engineers observe problem-solving protocols and apply appropriate design tools. Similarly, the task of lawmakers of government is to solve societal problems by the creation of law-solutions (laws of government). This paper reports on a study that evaluated the extent to which the first steps of the lawmaking process adhere to established, generic quality standards for the creation of new tools. The study focused on senate bills (proposed new laws) that were submitted to the Legislature of the State of California for the 2015-16 legislative session. The study observed that the present lawmaking process does not meet established design standards and thereby places the public at risk from the issuance of poorly designed laws. It is recommended that problem-solving design standards be developed and applied to the creation of laws of government.

INTRODUCTION AND BACKGROUND

Science

Science has of two branches: investigative science and creative science. The purpose of investigative science is to derive new, reliable knowledge of observed phenomena in the physical universe through the use of knowledge, tools of investigation, and the scientific method. The purpose of the creative branch of science, or engineering, is to solve problems by the creation of new tools, or technology [1]. Analogous to investigative science, the engineering design process uses knowledge, innovation, tools of design, and the problem-solving method (PSM) to achieve its purpose. When new tools are created by engineering disciplines, they are accepted only if they are superior in their problem-solving performance as compared to the previous generation of tools; the rule of engineering is that change is always characterized by improvement.

The synergy between the investigative and creative sciences results in the successful and beneficial scenario where, at any given point in time, knowledge is growing, current problems are being solved by ever-improving means, and problems of the next higher order of complexity are in the process of being solved.

The key feature that enables creative science to be successful is the problem-solving method. The PSM consists of several steps, including problem definition and analysis, purpose statement, cost and risk analyses, testing and validation of solution-models, citation of references, and follow up evaluation of outcomes, [1 (Appendix F), 2]. The PSM is the only reliable method by which problems can be solved. There are no problems that it cannot address and it blocks attempts to solve problems that do not exist. If a problem cannot be solved by the problem-solving method, that problem cannot be solved.

The Science of Laws Journal, Vol. 4, No.1, (2018): 23-28.

*Author to whom all correspondence should be addressed (e-mail: david.schrunk@scienceoflaws.org).

Government

The purpose of government, as defined in the Declaration of Independence of the United States of America, is to secure the inalienable rights and liberty of the citizenry of the government [3]. To achieve that purpose under the directives of the Constitution of the United States, federal, state, and regional governments are obligated to solve (solve, mitigate, or prevent), by means of laws and to the extent that is practicable, the problems that degrade or threaten to degrade the rights and liberty of the people. The measurable parameters that define rights and liberty are human rights, living standards, and quality of life standards [1 (Appendix A)]. The government of the State of California is the subject for the discussion of lawmaking in this paper. However, the discussion applies generally to all systems of governance.

Lawmaking

Governments have three functional divisions: Executive, Judicial, and Legislative. The legislative branch of government has the responsibility for establishing and maintaining, by the creation, amendment, and repeal of laws, a body of “necessary and proper” laws that satisfies the purpose of government. Legislatures use the traditional method of lawmaking, the legislative process, to create and amend (redesign) laws. The legislative process is divided into two principal steps: bill drafting and legislative sessions [4, 5, 6, 7]. Bill drafting begins with an idea for a law, which is transcribed into a proposed new law, or “bill.” Virtually anyone, including individuals, legislators, corporations, and professional groups, etc., is entitled to draft (i.e., design) a bill for consideration as a new law of government. After the bill has been written, the designer(s) must find a legislator to sponsor the bill. If a legislator agrees to be a sponsor, the bill is submitted to the Office of Legislative Counsel for review and additional editing-preparation to assure that it has the appropriate format and syntax and does not have constitutional or other legal conflicts [8, 9]. The bill is assigned a designation number and is then submitted, by the sponsor, to the legislature, thus completing the first step of the legislative process.

In the second step of the legislative process the bill is evaluated, by means of debate and deliberation, in legislative sessions and is subjected to possible amendments (design changes). If the bill in its final form is approved (enacted) by the legislature and the chief executive, it becomes a new law and is added to the government's body of enforceable laws (see Figure1).

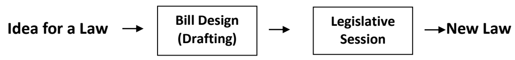


Figure 1. The Legislative Process. The creation of a law involves two principal steps: Bill Drafting and Legislative Sessions.

The task of the legislative branch of government is identical to the task of creative science: to solve problems by the creation of new tools (laws are the tools that governments use to solve societal problems). The creative sciences are noted for their success in the solution of complex problems through the development of new technologies in fields such as aviation, medicine, agriculture, and information technology. However, in contrast with the experience of science, governments have been less than successful in their goal of solving societal problems. Despite the annual production of tens of thousands of laws by the federal and state governments of the United States [10] , for example, and the expenditure of substantial resources under the authority and direction of laws, there has been little proportional improvement, over time, in the abatement of societal problems such as poverty, unemployment, illiteracy, and homelessness [11]. To determine the reason for the discrepancy between the outcomes of creative science and legislatures (consistent success for engineering; limited success for legislatures), the protocol for the creation of laws was evaluated and compared to the problem-solving protocol of creative science. That study and its results are the subject of this report.

METHODS AND MATERIALS

During the 2015-16 session of the California Legislature, 1481 bills were submitted to the Senate for evaluation [12]. These bills were the result of the bill drafting efforts during the first step of lawmaking. For statistical random sampling accuracy, every tenth bill was analyzed (148 of 1481 bills). The purpose of the analysis was to determine the extent to which the law-design process complied with the PSM for the design of proposed new laws. To make that determination, each bill in the study was analyzed for its content of the following problem-solving elements:

- Legislative designation number
- Name of legislative sponsor
- Title
- Definition of the societal problem that the law addresses
- Problem analysis
- Purpose statement (intent) of the law
- Estimated costs of the law
- Estimated risks and side effects of the law
- Sanction (forcing mechanism; command) of the law
- Follow up evaluation and validation
- References
- Name, credentials, and affiliation of law designer

An explanation of these parameters of the Problem-Solving Method, as they apply to the design of proposed new laws in the bill drafting stage of lawmaking for the California State Senate, is as follows:

Legislative Designation Number The designation number of each bill is needed for record keeping.

Sponsor The name of the legislative sponsor (Senator) is important for future reference (e.g., as to the sponsor's justification for the need of the law).

Title The title of the law communicates the general purpose of the law to all of the people who are impacted by the law.

Problem Definition A statement of the definition of the societal problem that needs correction is an absolute requirement for problem solution; it is impossible to solve a problem that has not been defined.

Problem Analysis The size and nature of the defined problem need to be analyzed so that an appropriate law-solution can be formulated.

Purpose Statement A statement of purpose is an essential requirement of problem solution. It informs all parties, including those who promulgate, enforce, comply with, and interpret (i.e., in the court system) the law, of the need and expectations of the law. If the law does not include a purpose statement, the enforcers and end-users of the law must make their own conclusion as to the purpose of the law, which may be different from the original intent of the legislature. Thus, the absence of a purpose statement may produce spurious results; also, it is impossible to evaluate the problem-solving performance of a law that has no stated purpose in terms of a measurable outcome.

Estimated Costs For any productive activity to be acceptable, the benefit of the activity must be greater than the sum of its burdens (costs and other negative factors). That is, the net benefit of the activity, of the benefit minus the burdens, must be greater than zero. For laws of government, the benefit of a law is the degree to which it solves (solves, mitigates, prevents) a societal problem. The burdens of a law consist of direct and indirect costs, unwanted side effects, and other negative factors such as intrusiveness, added paperwork, and time and effort that are diverted, by the law, away from other productive activities.

A government that is obligated to serve the best interests of the citizenry must assure that each law, by itself and in concert with other laws, produces a positive net benefit for the people. It is therefore essential that the costs of each bill be identified and accurately estimated in the design process. If the estimated net benefit of a bill is less than positive, in terms of the public wellbeing, then the legislature should not accept the bill for consideration. The accurate estimations of the costs of a bill during the design process are therefore highly useful because they allow the legislature to limit the focus of its efforts to those bills that are predicted to have a positive net benefit. For this report, the predicted costs of bills were separated into eight separate categories (C1 through C8) as follows:

(Cost Category-C1) Research and Development Costs The cost of research and development (R&D) of a new law. Every substantive development project that has an impact upon the environment and the public wellbeing (e.g., the construction of a nuclear reactor, creation of a new pharmaceutical, modification of food crop DNA, etc.) requires a thorough research and development (R&D) effort. R&D is important not only for the efficient creation of new, more effective tools, but to assure that the operation of new devices will not be harmful to the public. For the responsible design of a new law of government, the R&D effort must include an investigation of the size, nature, and “solvability” of a societal problem, the reason for the failure of existing laws to solve the problem, and the internal and external factors (costs, legal boundaries, side effects, interaction with other laws, etc.) that impact the design of the new law. These factors constitute a model of the new law that can be used to predict its performance. Depending on the size and complexity of the societal problem that is being addressed and the complexity of the law-design, the R&D effort may extend over a period of months or years before the bill is suitable for consideration by the legislature. Thus, every law has a cost for its R&D effort, and that cost must be accounted for in the design effort.

(C2) Legislative Process Costs The pro-rata cost of the legislative branch of government. The purpose of the legislative branch is to create, maintain, and optimize the body of laws so that it satisfies the purpose of government. Since the legislative branch consumes resources for its existence, each new law (or the amendment or repeal of an existing law) consumes a pro-rata share of the cost to maintain the legislative branch of government.

(C3) Promulgation Costs The cost of promulgation. When a new law is enacted or when an existing law is amended or repealed, those changes in the body of laws must be promulgated to all affected parties, such as the executive and judicial branches of government and the end-users of the law.

(C4) Drain from Treasury The drain of funds from the treasury. A direct cost of a law is the mandated disbursement of funds from the treasury for transfer payments and for purchases of goods and services, etc.

(C5) Administration and Enforcement Costs The cost, by the government, to enforce the law. This cost of a law is the expenditure required of the executive branch of government (bureaucracy) to carry out (“faithfully execute”) the dictates, or “letter” of the law.

(C6) Judicial System Costs The cost to interpret and apply the law by the Judicial Branch of government. Every law generates costs, for the government and for the public, to the extent that it involves the interaction of the judicial branch of government (e.g., court actions related to civil and criminal infractions of the law).

(C7) Compliance Costs The cost, by the public, to comply with and pay for the law. The members of the public, as individuals and groups (corporations, associations) are required to pay for mandates of the law such as taxes and fees, and for costs and efforts required to meet safety and health regulations, etc.

(C8) Quality Assurance and Improvement Costs The cost of follow up evaluation and improvement. Every law must undergo a quality assurance (QA) review of its structure and performance to confirm that it is serving a valid public purpose. Similarly, laws should periodically undergo a quality improvement (QI) program to simplify and clarify their language and enhance their performance.

Risks and Side Effects The risk of the law to the public. The operation of any useful device involves an element of risk and the generation of unwanted and potentially harmful side effects. A commonly used requirement for projects that pose a potential risk to the public is an “environmental impact statement,” which assures the public that the project has been studied and found to be within acceptable limits. Laws are useful devices that have an impact, including a possible negative impact, on the wellbeing of the public. Therefore, an important consideration in the design of a new law is an objective assessment and report of the risk, if any, that the law poses to the public.

Sanction of the Law Forcing measure. Every law has a forcing mechanism, or sanction (e.g., fine, tax, subsidy…), that enables the law to accomplish its stated purpose. In this study, only the existing or proposed sanction was recorded; the efficacy of sanctions was not evaluated.

Follow Up Evaluation and Improvement QA and QI. A follow up quality assurance (QA) evaluation of the performance of each law is needed to validate its problem-solving efficacy; it is the final step of problem solution. Unless a law can be demonstrated to provide a net benefit to the public it should be repealed. Laws that are found to be satisfactory through the QA process are then subjected to a program of quality improvement (QI) to simplify and clarify their language and to increase efficacy. QA and QI programs for laws are the mechanisms by which legislatures can maintain a rule of law that optimally satisfies the purpose of government.

References Reference citation. The citation of all data bases, methods, and sources is an absolute requirement for competent law-design processes. The citation of references confirms that the problem analysis and design process used only relevant and reliable knowledge bases and procedures. These sources will also be a useful reference for future law design efforts. If, after enactment and enforcement, a law fails in its purpose or is harmful, a review of the cited references may help to determine the cause of failure, e.g., from the use of inaccurate or incomplete data bases in the design process.

Name, Credentials and Affiliation of Law Designers Transparency and competency. As noted in the introduction, anyone (in the State of California) may come up with an idea for a new law of government and submit that idea to the government. However, the design of the law, to assure its efficacy in terms of the wellbeing of the public, must be performed by competent law-designers. A new law should thus be created by individuals who are qualified to design laws and are contracted to work for the public. The public may be placed at risk if a law is created by someone who is not qualified to design laws or who has a conflict of interest, e.g., someone whose goal is to advance a special interest at the expense of the public. Therefore, every law should have a statement of the identity, credentials, and affiliations of the individuals who designed the law.

RESULTS

144 bills, representing a 10% sampling of the 1481 bills introduced to the California Senate in the 2015-16 session, were evaluated for their content of the elements of the problem-solving method, and the results were tabulated (Table 1). For the data collection of 144 bills, thirteen bills concerned only non-substantive language corrections of existing laws. These bills were credited with having a problem definition (imprecise language) and purpose statement (to improve language). None of these thirteen bills contained a statement of other problem-solving design criteria such as costs, risks, and references.

A breakdown of the cost estimation of bills is presented in Exhibit 3. None of the bills (0%) had cost estimations for research and development (C1), the pro-rata cost of the legislative process (C2), or follow up evaluations (C8). Every bill that comes before the legislature is either an amendment to an existing law or a proposed new law. Every bill that is enacted into law will incur costs for promulgation and enforcement (C3 and C5), and for its potential interaction with the court system (C6). In this study, the percentage of bills that contained estimates of C3, C5, and C6 were 12%, 10%, and 5%, respectively.

The cost that was most frequently cited was the drain from the treasury, or the "general fund," C4 (28% incidence). For this study, the C4 cost was intended to include direct costs to the general fund such as transfer payments and purchases of goods and services; however, other expenses such as promulgation and enforcement costs were often assigned, in the text of bills, to the general fund, and the estimation of C4 costs in this study was, at best, imprecise.

Another cost that was not evaluated but bears mentioning is the opportunity cost of laws. The people within the jurisdiction of a government have limited financial, time, and human resources. Opportunity costs denote the extent to which the design, promulgation, enforcement, compliance, and evaluation of laws consume societal resources that would otherwise be available to the people for alternative activities such as education and research.

Table 1. Summary results of the incidence of essential problem-solving elements in proposed new laws (bills) for the California Senate, 2015-16 Session.

Design Criteria Elements for Bills	Number of Bills with Design Element Citation	Incidence of Design Element in Bills (%)
Bill Designation Number	144	100
Sponsor Name	144	100
Title of Bill	144	100
Definition of Societal Problem	72	50
Analysis of Societal Problem	8	6
Purpose Statement	87	60
Cost Estimations	55	38
Risk Assessment of Bill	0	0
Sanction (Forcing Mechanism)	144	100
Reference Citation	14	10
Follow Up Evaluation	4	1
Law Designer Name, Credentials	0	0

Table 2. Cost Estimations of Bills, 2015-16 California Legislative Session. The true cost of every proposed law was underestimated in the bill-design process.

Cost Estimation of Bills	Number of Bills with Cost Estimate	Incidence of Cost Estimate in Bills (%)
C1 R&D	0	0
C2 Legislative Process	0	0
C3 Promulgation	17	12
C4 Drain from Treasury	41	28
C5 Enforcement	15	10
C6 Court System	7	5
C7 Compliance (by Public)	4	3
C8 Follow Up (QA and QI)	0	0

The substantive findings of the 144 bills in the study include the following:

- All of the bills (100%) in this study contained a designation number, legislative sponsor, title, and sanction.
- None of the bills (0%) satisfied all of the criteria of the problem-solving method.

- 50% of the bills did not include a definition of the problem to be solved.
- Of the bills that addressed a defined problem, 6% (8 of 144) were determined to have adequate documentation of the size and nature of the problem.
- 40% of the bills did not have a statement of purpose.
- 38% of the bills included some estimates of costs but none of the bills (0%) estimated all costs.
- None of the bills (0%) analyzed the risk that the bill, if enacted into law, might pose to the public
- 10% of the bills contained a citation of references in a standard notation form such as that is used in this article.
- 1% of the bills had a provision for follow up evaluation
- None (0%) of the bills stated the name, credentials, and affiliations of the designer of the bill. (Note: The legislative sponsors of bills were named as "authors," and they may have designed or helped to design some of the bills. However, that distinction was not clear and the number of the identified, original law designers could only reliably be stated as zero.)

DISCUSSION

The results of the study demonstrate the deficiency or absence of essential PSM elements in every legislative bill. This outcome is not surprising since, as noted in the Introduction and Background section, bills only need to have a title, designation number, proper format and syntax, and a legislative sponsor to comply with the legislative requirements of bill drafting. Of significance, and for all intents, the legislative process, as currently structured and practiced, cannot be a competent mechanism for the solution of societal problems: it is not based upon reliable knowledge, it does not use tools of design (modeling and simulation), and its endpoint is the enactment of a law, not the solution of a societal problem [5] (see Figure 1).

Thus, traditional lawmaking is only a law-making process, and not a problem-solving process. A logical explanation for the poor performance of laws and the persistence of societal problems is that legislatures currently attempt to solve societal problems with a lawmaking process that does not have problem solution as its objective. Of concern is the ongoing risk to the public, not only from persistent societal problems, but also from the production of laws that have harmful design defects and omissions related to the lack of design standards.

Recommendation

Based on the results of this study, it is recommended that legislatures adopt the quality design standards of the problem-solving method for the creation of proposed new laws of government (bills), and include summary statements of the adherence to these standards, by law designers, in every bill. The following criteria have proven to be successful for the fields of creative science and they should be equally successful for lawmaking [13]:

- Problem definition
- Problem analysis
- Purpose statement of proposed law
- Cost analysis
- Risk analysis
- Performance prediction
- Citation of references
- Follow up evaluation and validation
- Signature of law designer(s)

These design standards will yield several benefits for both legislatures and the public. First, they will assure that the lawmaking process is always directed towards the solution of societal problems. Second, summary statements of the criteria will provide relevant and accurate knowledge of the structure, function, and predicted performance of each proposed bill so that legislators can make informed voting decisions. Third, the requirement for problem analysis will identify the most serious problems that currently face the public so that legislators can address the solution of those problems on a priority basis. Problem analysis will also identify the existing laws that have failed to solve problems. The subsequent repeal of these failed laws will save government resources and reduce the complexity of the body of laws.

Fourth, the testing and refinement of law-models and the evaluation of outcomes will increasingly involve the creative and investigative sciences, leading to more sophisticated design methods, higher quality standards, improved performance of laws, and emergence of the science of laws [14, 15, 16, 17, 18].

Fifth, the citation of references will generate a growing body of reliable knowledge of data bases, sources, and methods that will benefit future lawmaking efforts.

Sixth, the requirement of follow up validation studies of the performance of each law will lead to the development of quality assurance and quality improvement (QA and QI) programs for laws [1, 13]. These programs will lead to the repeal of non-beneficial laws. They will also make continuous improvements in useful laws so that they approach the characteristics of the "ideal law" [19]. Finally, statements of the fulfillment of standards for each bill, including the identification and credentials of law designer(s), will increase the transparency and accountability of laws and the lawmaking process.

FUTURE RESEARCH

The present study involved the investigation of a sample of bills in one legislative session of one Chamber of the California Legislature. To increase the accuracy of, and further validate, the findings of this report, similar studies should be carried out for other legislative sessions and for other legislative assemblies.

CONCLUSION

A 10% random sample of bills that came before the California Senate during the 2015-16 Legislative Session was examined for the content of problem-solving criteria. These criteria are the basis for the successful design of tools and systems in the fields of creative science (engineering). The results of the analysis demonstrated that all of the sampled bills lacked one or more essential problem-solving elements such as problem definition and analysis, cost and risk evaluation, and follow up validation. To correct the defects and omissions of traditional lawmaking and improve the performance of the rule of law, it is recommended that legislatures adopt the science-based problem-solving method as the basis of the legislative process.

REFERENCES

[1] Schrunk, D., *THE END OF CHAOS: Quality Laws and the Ascendancy of Democracy*. QL Press, Poway, CA, 2005. (Appendix A: Human Rights, Living Standards, and Quality of Life Standards; Appendix F: "The Problem-Solving Method")

[2] Long, D., and Scott, Z., *A Primer for Model-Based Systems Engineering*, 2nd edition. Vitech Corporation, Blacksburg, Virginia, 2011.

[3] Jefferson, T., "The Declaration of Independence*." Great Books of the Western World*, vol. 43, Encyclopaedia Britannica., Inc. Chicago, Illinois. 1952.

[4] Overview of the Legislative Process of the State of California: http://www.leginfo.ca.gov/guide.html

[5] Davies, J., *Legislative Law and Process in a Nutshell*. 2nd ed. St. Paul, MN: West Publishing, 1986.

[6] Kernochan, J., *The Legislative Process*. Mineola, NY: The Foundation Press, Inc., 1981.

[7] Filson, L., *The Legislative Drafter's Desk Reference*. Congressional Quarterly, Inc., Washington, D.C. 1992.

[8] Office of the Legislative Counsel. U.S. House of Representatives. *Style Manual: Drafting Suggestions for the Trained Drafter*. Washington, DC: U.S. Government Printing Office, 1989.

[9] California Office of Legislative Counsel: http://legislativecounsel.ca.gov/home

[10] California Enacted Bill Information: http://www.leginfo.ca.gov/pdf/BillsEnactedReport.pdf

[11] Woolsey, R., "Poverty in California: Recently Released Census Data." September 13, 2016. http://www.lao.ca.gov/LAOEconTax/Article/Detail/206.

[12] California Legislative Bill Information: http://www.legislature.ca.gov/the_state_legislature/bill_information/bill_information.html .

[13] Schrunk, D., "The Quality Approach to the Science of Laws." Presented at 16th Annual International Deming Research Seminar, New York, February, 2010.

[14] Schrunk, D., "The Science and Engineering of Laws." *Proceedings of the Seventh International Conference on Space 2000*, American Society of Civil Engineers, Reston, VA, 2000.

[15] Schrunk, D., "The Systems Engineering Approach to the Design of Laws." *Proceedings of the Conference on Systems Engineering Research (CSER)*, St. Louis, MO, 2012.

[16] Madachy, R., "System Dynamics Structures for Modeling Lawmaking Processes." *The Science of Laws Journal*, Vol. 3, No.1, (2017): 12-22, 2017.

[17] Gottfried, J., "Applying Risk Management to Lawmaking." *The Science of Laws Journal*, Vol. 3, No.1, (2017): 2-4, 2017.

[18] Science of Laws Web Site: www.scienceoflaws.org.

[19] Schrunk, D., "The Ideal Law of Government." *Proceedings of the Eighth International Conference on Space 2002*, pp. 580-586, American Society of Civil Engineers, Reston, VA, 2002.

David G. Schrunk, MD is an aerospace engineer and medical doctor. He is the founder and president of The Science of Laws Institute of Poway, California, and is the author of the book, *THE END OF CHAOS: Quality Laws and the Ascendancy of Democracy*.

PROCEEDING

Hitchins' Five Layer Model as an Evaluation Framework for Regulations

John M. Green*

ABSTRACT

In theory, the relationship between society and laws is well understood. In practice, the implementation of laws does not necessarily lead to the desired result. There is a need for a systematic method by which to analyze laws, new and old, to ascertain their projected impact. At the macro level, laws provide structure to guide behavior and systems theory is replete with multiple models that can describe various aspects of that behavior. This paper proposes using a 5-layer model of systems engineering developed by Hitchins to examine the impact of laws and regulations on the various socio-economic structures of a society. The specific focus is a simple example of energy policy with an emphasis on developing causal relationships between laws and society using systems theory. The five layers: socio-economic, industry, business-enterprise, project, and product form a nested relationship with product at the center. Causal loop models based upon N2 diagrams show the interactions within and between layers providing insight into a change in policy.

Keywords: N-2 Diagrams, Causal Loop Model

INTRODUCTION

The basic premise of this paper is that laws guide the conduct of a society. Implicit in this premise are two subtle points. First, laws are necessary for an ordered society. Second, laws should not be about control; rather, they should be about solving the problems that arise in society. This requires a methodology by which to correctly identify and analyze said problems.

To examine this premise the paper presents several concepts that when linked together form a framework by which to examine the impact that certain forms of law has on society. The concepts are the notion of society as a system and the representation of this system in a form amenable to analysis. The analysis concepts center around methods by which elements of the human enterprise are related to each other and changes to the status quo can be evaluated. N-2 diagrams and causal loop models are presented as viable analysis methods.

The form of law of interest to this paper is that of regulation. This paper defines regulation as the rules that govern the provision of services to the public (society). Examples are energy, water, and telecommunications among others. Regulation is of interest because it exemplifies Schrunk's model (Figure 1). In theory, regulation is predicated upon a need and results in a predictable outcome. Cause and effect.

However, there is a difference between the necessity of law and necessary laws. As society has become more complex the predictability of the outcome of a law is not certain and it may well be that the law is not needed. Given the mechanism for the development and implementation of regulations there is a potential for abuse; regulations that advance a political agenda. Hence the necessity for an analysis framework that can assess the societal impact of a regulation.

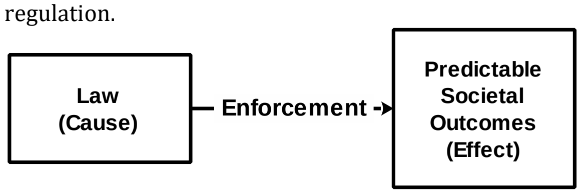


Figure 1. The Premise of Lawmaking (Schrunk, 2005)

SOCIETY AS A SYSTEM

The term system is often used in conjunction with human societies and their cultures. It is a simple word with profound meaning. System refers to an entity composed of interrelated parts. A system is holistic. Thus, a system is the sum of all its parts plus all the relationships between them. Societies vary greatly in the degree to which the functions of the parts are coordinated with one another and with the functioning of the system as a whole.

Concept of an Open System

An open system is a system that has external interactions. Such interactions can take the form of information, energy, or material transfers into or out of the system boundary, In the social sciences, an open system is a process that exchanges material, energy, people, capital and information with its environment.

Macrosystems

Human systems are defined by both conflict and harmony. Although there must be enough cooperation for

The Science of Laws Journal, Vol. 4, No.1, (2018): 29-33.

*Author to whom all correspondence should be addressed (e-mail: jmgreen635@gmail.com).

the system to exist and function, coordination among parts is often poor and components do not always function in ways conducive to the well-being of the system. One way to describe a system that accounts for coordination or lack thereof is the macrosystems model of Bronfenbrenner used in his ecological systems theory of development. (Paquette and Ryan 2001). Bronfenbrenner's focus was on child development but the model (shown in Figure 2) is useful for this paper. It is a hierarchical, multi-layered model wherein the outer layer represents the cultural or societal context in which the individual lives.

There is a temporal element to Bronfenbrenner's that is not shown in Figure 2. Referred to as the chronosystem, it is the transitions or state changes that occur within the model over time. As will be shown, causal loop models capture the temporal element through the flow of change through its loops.

Hitchins' Model

Hitchins (2003) developed a five-layer model (Table 1) of the interrelationships within the discipline of systems engineering. Like the macrosystem model, it is a hierarchical model with a socio-economic layer (the macrosystem) on the outside. The lowest layer, the product, is analogous to the individual.

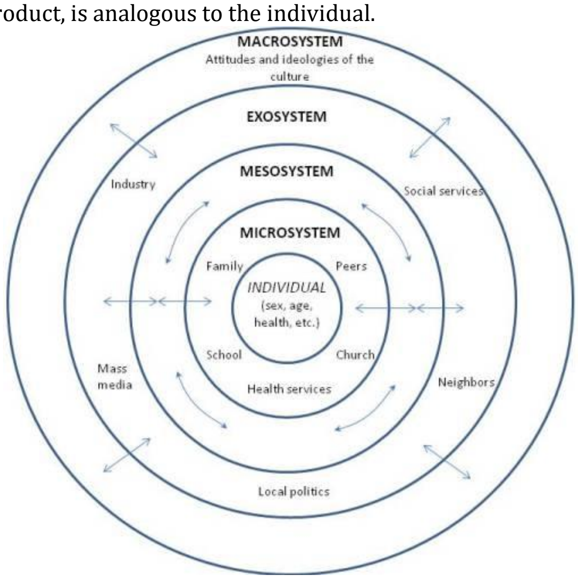


Figure 2.: Bronfenbrenner's Ecological Systems Theory Model (Paquette & Ryan, 2001)

Table 1: The Five Layer System Structure (Hitchins, 2003)

Layer	Generic Title	Sphere
5	Socio-Economic System Engineering	Legal and political influences, government regulation and control
4	Industrial System Engineering	National wealth creation – the nation's engine – industries comprise the socio-economic system
3	Business System Engineering	Industrial wealth creation – many businesses make an industry
2	Project System Engineering	Corporate wealth creation
1	Product/Subsystem Engineering	artifacts

As formulated, the focus of this model is on the role of systems engineering in wealth creation. Hitchins (2003) also notes that socio-economic systems influence culture, social behavior, and, through financial markets, the growth and demise of businesses and industries. Hence, Hitchins' model, while in a different form, appears to be complementary to Bronfenbrenner's model.

Figure 3 is Hitchins' socio-economic model in the form of a N-2 diagram. This diagram shows the functions on the diagonal and all outputs are on the horizontal (left and right). The industries are functions and their outputs are items. The inputs to raw materials are the items in column 1 and the output of raw materials are the items in row 1. Hitchins simplified the diagram for clarity by only showing the major inputs and outputs from each function.

Raw materials industries	• Energy • Metals • Woods • Plastics • Composites	• Dated skills	• Domestic raw materials	• Fertilizers
• Machinery • Knowledge • Power	**Manufacturing industries**	• Dated skills • Power • Machines	• Domestic products/materials	• Farm machinery • Power
• Skilled people • Recyclable raw material	• Skills • Logistics • Machinery	**Service industries**	• Power • Food • Distribution • Transport • Communication	• Power • Fertilizers • Pesticides • Husbandry
• Human resources	• Human resources	• Human resources • Dated skills	**Society**	• Human resources
• Recyclable resources	• Recyclable machinery	• Foodstuffs • Dated skills	• Food	**Farming industries**

Figure 3. Hitchins' Layer 5 Socio-Economic Model (Hitchins, 2003)

Figure 4 is the industrial system model and shown in the form of a casual loop model (cause and effect). It represents a general supply chain model that can be tailored to describe the industries of Figure 3. As previously noted, this model captures Bronfenbrenner's chronosystem concept via the flow rate of change through the loop(s). The models of levels 1-3 are described by Hitchins in the form of flow charts. Note: The lower layers (1-3) are not shown for clarity though they should be included for completeness.

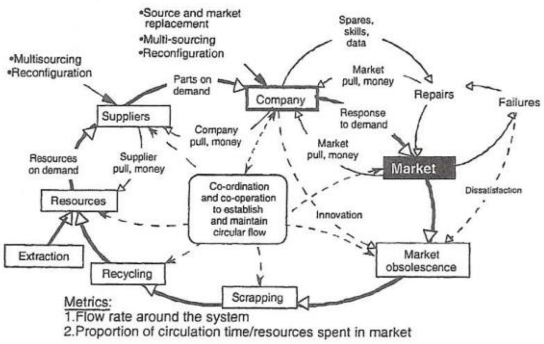


Figure 4. Industry-Level Model (Hitchins, 2003)

A METHODOLOGY TO ASSESS THE IMPACT OF LAWS AND REGULATION

Regulatory laws impact society at all five levels. The socio-economic layer is typically where the regulatory system resides though industries can self-regulate through standards committees. It is the function of the industry to thrive and make profits. It is the function of the regulatory system to tax industries and control their behavior as appropriate. In the context of this paper regulation is a layer 5 function but may captured in layer 4. For example, in Figure 4, a regulation loop could be added to the market element of the loop. It is important to realize the socio-economic system is also a hierarchy with various levels from national to local. In practice, regulation trickles down through all layers. Thus, there is a set of causal loops that describe the impact of a regulation at each level.

The basic methodology is straightforward.

1. Identify the major entities of interest and capture them in a N-2 diagram
2. Identify the relevant inputs and outputs
3. Develop the causal loop models for each entity
4. Create a stock and flow model from the causal loops

Note: Step 4 is required only if a quantitative analysis is desired.

REGULATION OF ENERGY EXAMPLE

Figure 5 is a simplified version of Figure 3 and shows that energy is an output from the raw materials industry and is an input to the other four industries. A refined form of energy is also an output from the manufacturing and service industries.

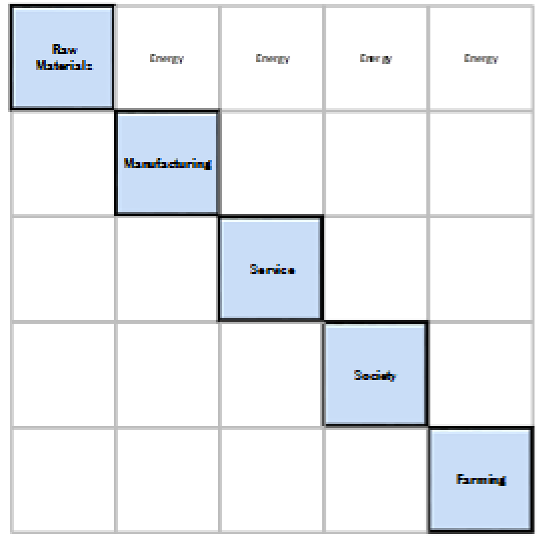


Figure 5. Figure 3 Simplified

There are several ways to assess the impact of regulation on the supply of energy. One is the event-oriented view where the impact of change is regarded as a sequence of events.

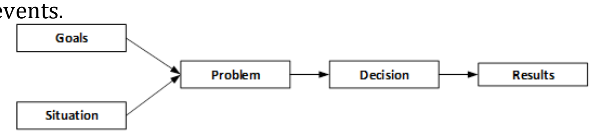


Figure 6. Event-oriented view of the world (After Sterman, 2000)

For example, if the supply of energy is changed, this viewpoint would assess the systemic change in a linear fashion. The results are a reaction to the decision. What is not considered is the environments response to the results where environment encompasses those entities not within the system of interest.

In reality, there is feedback from the environment. Assume that the regulations target emissions from certain types of energy sources with the intent of reducing pollution. The event driven model focuses on the result. Has pollution caused by the energy source been reduced? It can be argued that the event-driven model follows from Schrunk's model of Figure 1. Such an argument is really not supported when the lack of predictability of societal outcomes is considered. Are there negative impacts on society? Looking at Figure 5 provides some insight. Removing an energy source to reduce pollution reduces the net energy available to the other industries. So, while the goal of reducing pollution may have been achieved, the event-driven model does not describe what effects occur within the other industries as a result. One reason is because cause and effect are separated temporally and spatially. Unanticipated effects take place over time and space.

The elemental open systems model follows a sense/decide/act paradigm. It senses the input, decides if the input meets the goals of the system, and acts accordingly. The feedback model of Figure 7 is a simple representation of the paradigm.

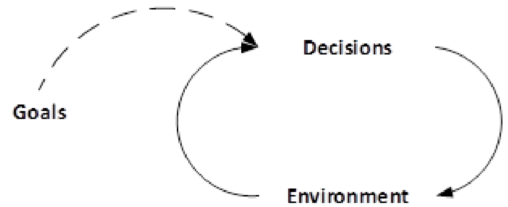


Figure 7. The Feedback View (After Sterman, 2000)

Figure 8 expands on Figure 7. Sterman (2000) notes that that the term "side effects" is a misnomer. There are intended effects and unintended effects. The latter indicates that the initial understanding of the system was incorrect. Within the systems world unintended effects are referred to as negative emergent behavior.

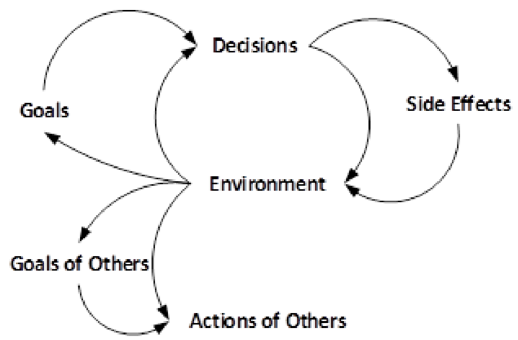


Figure 8. An Expanded View (After Sterman, 2000)

There are two types of feedback loops, positive and negative. Within the example, reduced pollution is positive or self-reinforcing feedback. Increased energy costs are negative or self-correcting. It is possible to misconstrue the solution to a problem. Does the solution deal with the fundamental problem or is it only addressing the symptoms? Correctly identifying the difference between a positive or negative loop is straightforward. A negative loop has an odd number of negative links.

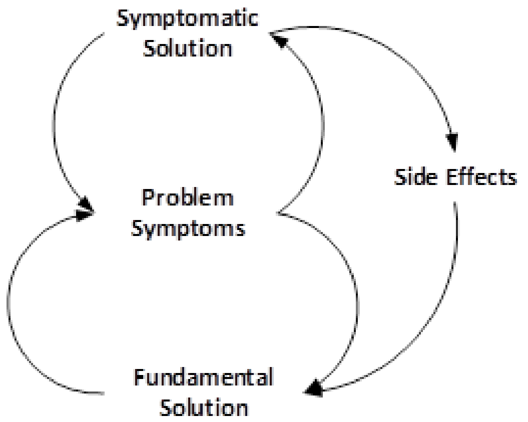


Figure 9. What is the Real Solution? (After Senge, 2006)

Causal loop modeling is qualitative in nature and useful for initial analysis when identifying the problem and explaining the problem to others; however, to develop a qualitative solution, the causal loop may be converted to a stock and flow model. A stock is an accumulation. A bank balance is a stock. A flow is exemplified by deposits or withdrawals from the bank account. Figure 10 shows the basic Symbology. The stock is the square and the flows are the arrows. The star-like symbols are sources and sinks, and the hourglass shapes represents flow rate.

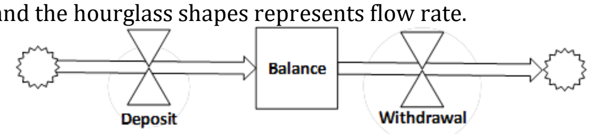


Figure 10. A Stock and Flow Model.

This concept allows complex mathematical models to be built that examine the impact of a regulation or regulations on multiple segments of society. The impact of a change in energy policy can be traced and analyzed across multiple industries.

APPLICATION TO THE SCIENCE OF LAWS

A science is predicated upon a theory. Theory provides the foundation for the practical through its axioms and its models and their ability to predict outcomes. For the Science of Laws to be viable it has to move from the normative form to a descriptive form where results can be assessed empirically. This paper has presented the overview of a modeling approach that contributes to that goal.

SUMMARY

This paper has presented a brief introduction into several systems engineering concepts that can be used to model the impact of regulations and by extension, laws in general. N-2 diagrams are useful diagrams by which to establish basic relationships within a system or system of systems. They can be easily extended to causal loop diagrams which facilitate an initial qualitative analysis of the problem space. While stock and flow models can be developed independently of causal loop models, the two are complementary and, when combined with N-2 diagrams, support the analysis of existing and future regulations.

FUTURE WORK

An essay by Hahn (2005) provided food for thought and direction for additional long-term research. Hahn makes it clear that a good survey of the literature is required. For example, Hahn's focus was on regulation but an essay by Fiskel (2006) on sustainability and resilience indicates the breadth of potential literature sources. Paraphrasing Fiskel, this paper closes with two research questions:

1. What scientific advances are required to better understand the linked behavior of laws and complex socio-economic systems?
2. How can this knowledge be applied to the design and implementation of analytic tools needed to advance the Science of Laws?

REFERENCES

Paquette, Dede & John Ryan. (2001). Bronfenbrenner's Ecological Systems Theory, https://en.wikipedia.org/wiki/Ecological_systems_theory (accessed October 13, 2017).

Fiskel, Joseph, Sustainability and resilience: toward a systems approach, *Sustainability: Science, Practice, & Policy*, Fall 2006, Volume 2, Issue 2. Available at: http://ejournal.nbii.org.

Hahn, Robert W., The Economic Analysis of Regulation: A Response to the Critics. *The University of Chicago Law Review*, Vol. 71, No. 3, pp. 1021-1054, Summer 2004; AEI-Brookings Joint Center Working Paper No. 04-03. Available at SSRN: https://ssrn.com/abstract=821449.

Hitchins, Derek K., *Advanced Systems Thinking, Engineering, and Management*, Artech House, 2003.

Schrunk, David G., *The End of Chaos: Quality Laws and the Ascendancy of Democracy*, Quality of Laws Press, 2005.

Senge, Peter M., *The Fifth Discipline, The Art & Practice of The Learning Organization*, Doubleday, 2006.

Sterman, John D., *Business Dynamics*, McGraw-Hill, 2000.

John M. Green is a Senior Lecturer in the Department of Systems Engineering at the Naval Postgraduate School where his teaching and research is focused on combat system engineering and combat system architectures. In the 15 years since the inception of the MSSE program, he has advised over 60 MSSE Capstone projects of three quarters duration each. Prior to this he worked in industry for 18 years. He was Manager of Advanced Systems at ITT Gilfillan in Van Nuys, CA where he led a team developing concepts for high power solid state radars and he also worked for Lockheed Martin in Moorestown, NJ where he was Technical Director for the Norwegian Frigate project and System Engineer for the Taiwanese PFG-2 Class Combat System design. He also worked several data fusion projects including CEC and JCTN. During his Navy career, he served on a variety of ships including six submarines rising from Seaman Recruit to Lieutenant Commander. He is a 1982 graduate of the Naval War College, College of Command and Staff.

His MBA (1998) and MS in Computer Science (1986) are from the University of New Haven. He also has a MA in International Relations from Salve Regina College (1984), a BS in Physics from Saginaw Valley State University (1972) and an AS in Electronics from Southwestern College (1969). He is current pursuing a doctorate in Systems Engineering from SMU.

He is a Senior Member of AIAA and a member of the Military Operations Research Society, the American Society of Naval Engineers, the Institute for Operations Research and Management Science, the Association of Old Crows, SPIE, ISIF, and the International Council on Systems Engineering.

Maturing Humankind Through the Sciences of Law, Policy, and Space

PROCEEDING

Bob Krone*
Kepler Space Institute

ABSTRACT

Humanity's future hinges on the success of efforts to ensure a supportive environment, needed resources, and continuous improvement of health and welfare for all its citizens. The Law of Space Abundance was formulated by leadership of Kepler Space Institute in 2009. The Law states: "Space offers an abundance of resources for humankind's needs." The law was not legislated by humans. It accurately describes what exists in the universe. The capturing of those resources has begun. The design and planning for ever increasing multiple resources to meet humanity's needs is also underway. Historically unprecedented efforts to do so will involve entirely new systems for Space exploration, development, and governance systems for human settlements in Lunar Orbits, on the Moon, Mars, and elsewhere in the Solar System. This paper addresses the needs for leadership, law, and governance for the control and management of that massive future effort.

This is not a traditional research paper. The main purpose of the paper is to recommend to leaders of the Science of Laws the addition to their research base of the Policy Sciences and the Space Sciences. That trilogy knowledge base will provide a mix of the soft and hard sciences, understanding of the political feasibility domain (which will be essential for implementing the Science of Laws and causing significant improvements) and the complex mix of theory and practice needed for society to advance from that valuable vision to real-world achievement of that vision. There is also an invitation from Kepler Space Institute for future partnering with the Science of Laws Institute.

Keywords: Humanity's needs and future, Science of Laws, Law making, Policy Sciences, Space Sciences, Vision, Law of Space Abundance, Leadership, Science and Technology, Benefits and Risks

THE SCIENCE OF LAWS CHALLENGE

Dr. David G. Schrunk, President of the Science of Laws Institute, has captured the following opportunity, which includes Space, in the paragraph below [1]:

To avoid the poor performance and dysfunction that currently typifies the bodies of laws of Earth's governments, a new science, the Science of Laws, is proposed as the basis for creating and maintaining the bodies of laws for Space governments. For the people who become permanent citizens of new worlds in Space, the Science of Laws will produce a consistent and just rule of law that optimally serves their best interest and reflects their highest aspirations.

The Science of Laws Institute research has identified the following flaws and omissions as law has evolved on Earth:

- Societal problems are not required to be defined and solutions to those problems are randomly addressed or inadequately addressed in law.
- War, crime, poverty, discrimination and human rights abuses, economic crises, violence, terrorism, and environmental pollution continue as major problems. The ever-increasing body of laws fails to prioritize or solve those problems adequately. Random amelioration may occur for a while. But failure to include sunset terms consistently insures that the ever-increasing volume of laws makes full implementation administratively impossible.
- Laws seldom define tools to measure or evaluate outcomes of implementation.
- There are no skills required for law design by those drafting the laws.
- Computer modeling or simulation is not a requirement, and accounting of costs of implementation rarely occurs.
- Probabilities of risks, negative results, or side effects are not required.
- Laws that tolerate the inclusion of "pork barrel" and political agenda provisions.
- Laws too often based upon opinions (ideology) rather than reliable knowledge, and do not require the citation of references, are often passed. [2]

These defects of the traditional method of lawmaking render it incapable of solving complex societal problems. It employs speechmaking, debate, and compromise, and it observes parliamentary protocols for the creation of laws.

The Science of Laws Journal, Vol. 4, No.1, (2018): 34-38.

*Author to whom all correspondence should be addressed (e-mail: bobkrone@aol.com).

The traditional method of lawmaking continues to fail to resolve societal needs. More ominously, the continued growth in the size and chaos of the bodies of laws causes governments to enforce laws selectively in a drift towards arbitrary rule, in violation of the rule of law.

Avoiding repeats of the historic weaknesses and failures of Earth's governance as humans explore, develop, and settle in Space is an associated huge challenge.

What can rectify this history of lawmaking failures? The most critical first answer is leadership.

LEADERSHIP IS NEEDED FOR LAWMAKING IMPROVEMENT

A consistent failure throughout human history on Earth has been the employment of destruction, violence, genocide, death, and war. Laws have reduced, but not eliminated, those failures. The subject is public policymaking. So, we must include policymaking knowledge in our analysis. The subject is also linked to the evolution of social culture. Laws are made daily around the world. The culture does not automatically change when laws are passed. Cultural changes sometimes stem from people who need them, but leadership is the predominant catalyst that moves societal changes.

So, we need to look to the Policy Sciences for knowledge about policymaking and about the leadership that makes policy. Our best reference is the co-founder and leading Policy Sciences scholar, Professor Yehezkel Dror, of Hebrew University, Jerusalem, Israel. Ten of his fifteen books, published beginning in the 1960s, are now on Amazon.com. For this article, I reference his two latest works, *Avant-Garde Politician* (2014) and *For Rulers: Priming Political Leaders for Saving Humanity from Itself* (2017), plus his published articles in the *Journal of Space Philosophy*. [3, 4]

I have been driven and inspired to write this missive by three appraisals maturing in my mind on the basis of lifelong multidisciplinary study of senior politicians, combined with intense personal involvement in efforts to mentor them and improve their choice processes, in a variety of countries: (1) There is increasing cause to worry about the future of humanity and its subparts; (2) the importance of senior politicians in influencing the future, for better or worse, is intensifying and becoming fateful; but (3) the qualities of even the all-too-few relatively good historical and contemporary senior politicians are becoming more and more inadequate for coping with the emerging and largely unprecedented challenges facing humanity. These three considerations add up to the conclusion that a new genre of senior politicians is urgently required; and to a personal feeling of moral duty and professional obligation to make whatever contribution I can, however minor, to their gestation.

Dror's three appraisals, above, are valid. Readers wanting the details of Dror's decades of brilliant study, analysis, and prescriptions over the past sixty years can find them in his publications. I concur and accept them as givens for this Science of Laws article. Improved leadership is one third of the formula for achieving future improvement in lawmaking. Moral leadership is the essential need. The three essential variables for breakthrough improvements for humanity are, therefore, shown in Figure 1.

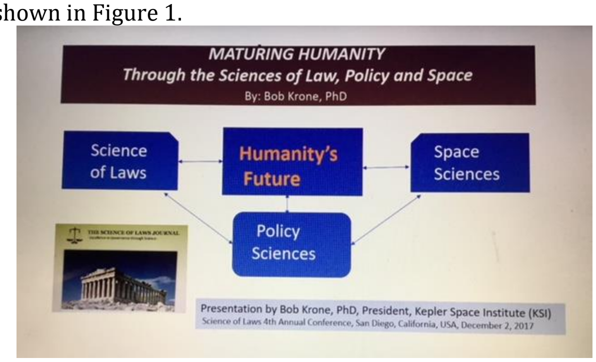


Figure 1: Humanity's Future

SCIENCE OF LAWS SOLUTIONS

The science of laws consists of two coequal branches: (1) the creative science of laws and (2) the investigative science of laws. The purpose of the creative (i.e., engineering) branch of the science of laws is to solve societal problems that degrade or threaten the well-being of the people (in terms of human rights, living standards, or quality of life) within the jurisdiction of a government. To accomplish this task, it employs knowledge, tools, and design expertise, such as modeling and simulation, to create and optimize laws of government. It also derives, records, organizes, and promulgates reliable knowledge of design methodologies and best practices that are applicable to the creation of laws of government. The creative science of laws will correct the defects of the traditional method, establish quality design (QD) standards, quality improvement (QI) standards, and ethical standards for the creation and optimization of laws. Quality assurance (QA) will evaluate the process and improve it over time [5]. The process is shown in Figure 2.

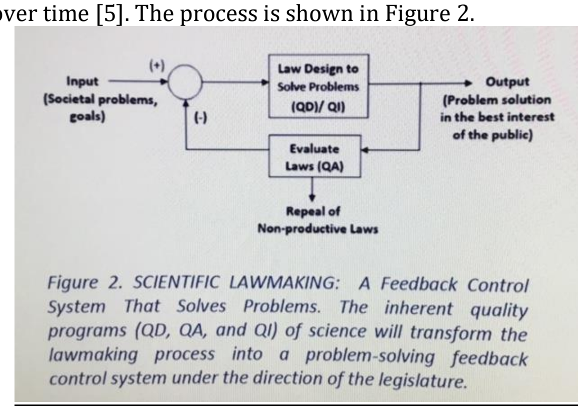


Figure 2: Scientific Law Making

Readers will find details and descriptions of this process in the articles in the *Science of Laws Journals*, 2015, 2016, and 2017.

POLICY SCIENCES SOLUTIONS

Leaders skilled with governmental and public policymaking skills will be essential for the sciences trilogy herein prescribed: (1) Science of Laws, (2) Policy Sciences, and (3) Space Sciences. Throughout human history, leadership has been the primary variable responsible for outcomes of good or evil, for the creation or extinctions of societies, for progress or decline, for harmony or conflict, for the outcomes of war, for the advances of science and technology, and for the influence of religious theology resulting in happiness or tragedy. It will be the same for the future of humankind.

Yehezkel Dror, in his two latest books, *Avant-Garde Politician: Leaders for a New Epoch* (2014) and *For Rulers: Priming Political Leaders for Saving Humanity from Itself* (2017), uses a long-term evolutionary time horizon and prescribes a radical new model for leadership to put priority on shaping the future of humanity. His six decades of study, writings (in several languages), and teaching on public policymaking systems around the world put him in an exclusive Policy Sciences expertise category.

This article only summarizes Dror's description and prescriptions for leadership. Readers should delve into his writings for his in-depth introductions, analyses, evaluations, theories, conclusions, and prescriptions.

Yehezkel Dror's leadership values, understandings, characteristics, talents, and skills [6]:

1. Operate from the understanding that Earth's global problems are increasing, that history has no evidence of solution capabilities for those problem, and that some kind of radically innovative global regime will eventually be necessary. If that movement fails, the quality of life for Earth's humanity will decrease and conflicts will result in human catastrophes, ethnic genocide, and an increased probability of human-produced human extinction.
2. Have a leadership calling-related inner philosophy that is freely chosen and that dominates the whole of life [7].
3. Have a realistic comprehension of humans and humanity.
4. Understand that your legacy for the future will be your positive impact on historic processes.
5. Have both ethical basics and utilitarian skills, giving priority to bona fide efforts for the needs of humanity and measures needed to advance them.
6. Study to understand the potential future dangers of technology to humanity as well as its blessings [8].
7. Study past and present leaders' successes and failures to cope with serious problems.
8. Analyze and forecast the implications of continuing and increasing change in society, including global, and beyond Earth, long-term political issues.
9. Be an agent to help to prevent science from providing an immature humanity with instruments to destroy itself.
10. Have a capability for research and evaluation of desirable scenarios for the future and for disastrous scenarios, as well as knowledge of the political feasibility domains for decision clusters addressing those scenarios.
11. Understand that the preparation and training for people choosing avant-garde leadership as a career will need lifelong formal and real-world learning to a degree that has not previously existed.

In his latest book, *For Rulers*, Yehezkel Dror states [9]:

[A] much improved genre of political leaders is urgently needed. Without it survival and thriving requirements cannot be met and the long-term existence of the human species is seriously endangered.

Dror created the title Homo Sapiens Governor (in short HSG, plural HSGs) for those who will become leaders for the mission of saving humanity from itself [9]. The 103 pages of the book are dedicated to a definition of that leadership and prescriptions for their behavior.

HOW SPACE WILL PROVIDE SOLUTIONS

Given the above, what positive impacts could the Space Sciences contribute? Attempts to improve lawmaking within governments have been under way for centuries. The results are not adequately meeting the challenges that face global decision clusters. How could Space offer new original solutions?

Drawing on Space Sciences and the research, exploration, and successful missions over the past half-century leads us to entrepreneurial and paradigm shift thinking for proposing needed remedies. These remedies will not be new to the Founders of the Science of Laws Institute – review the quote of President David Schrunk beginning this article. But they will be new to most public policy lawmakers in the United States and throughout the world.

This section of the article begins with the assumption that the improvement and survival of homo sapiens will depend heavily on a successful Space Epoch. In 2017, that assumption is not universally accepted. It can be found today, however, in the visions and missions of major Space organizations around the world, including our Kepler Space Institute.

As knowledge accumulates under the *Law of Space Abundance* – which states: "Space offers abundant resources for humankind's needs," as Earth's non-renewable resources decrease, as Earth's population increases, and as extra-terrestrial threats to Earth are better understood, disagreements with that assumption will disappear [10]. A critically important research question today is:

Will the potential benefits of the forthcoming Space Epoch be unknown by leaders until beyond the time when those benefits can be captured to solve Earth's and humanity's needs?

The Space environment has many aspects, other than resources, that will be dependent variables, helping to achieve the vision outlined in this article:

1. There is no history of war, conflict, or pathological behavior in Space despite the fact that the Star Wars film series was top entertainment. Space is essentially a vacuum waiting for innovative governance, laws, and unprecedented positive human experiences.
2. Humans living in Space will be isolated from natural or human-created pollution or disasters on Earth.
3. Population growth will not be a problem in Space.
4. Human intelligence, wisdom, and judgment will be the only constraints to achieving this vision for humankind.

CONCLUDING THOUGHTS

The formation of planet Earth happened 4.5 billion years ago after the Big Bang 13.5 billion years ago. Organisms and the beginning of biology happened 3.5 billion years ago. Living ancestors of humans appeared 6 million years ago. Humans spread from Africa to Eurasia 2.5 million years ago. Neanderthals evolved in Europe and the Middle East 500,000 years ago. Homo Sapiens appeared in East Africa 200,000 years ago. History began 70,000 years ago. Homo Sapiens settled in America 16,000 years ago and became the only surviving human species 13,000 years ago. The first kingdoms, script, and polytheistic religions began 5,000 years ago. Europeans began to conquer America and the oceans 500 years ago. The Industrial Revolution began 200 years ago, along with the extinction of many species of plants and animals. Humans transcended the boundaries of planet Earth 60 years ago [11]. In 2017, humans still have not learned to live and grow together in peace and harmony. There exists much social pathology. Humankind has need of much maturing and requires much learning to prevent its extermination.

The Science of Laws Institute was incorporated in California in 1995, and it began holding annual conferences and publishing the *Science of Laws Journal* in 2015. Its mission is to establish the science of laws on the conviction that the laws of government may be counted among the most important works of humankind.

This paper is a contribution to the developing Science of Laws knowledge base with the recommendation that the Policy Sciences and Space Sciences join the Science of Laws to form a trilogy working towards a common vision for a future humankind containing the values, principles, legal system, foundations, concepts, and policies necessary for improvement and survival – in perpetuity.

I have a personal invitation to the leadership of the Science of Laws Institute to partner with the Kepler Space Institute to sponsor graduate research toward the "*Promethean Mission*" in Yehezkel Dror's *The Rulers: Priming Political Leaders for Saving Humanity from Itself*. Dror states that mission as [12]:

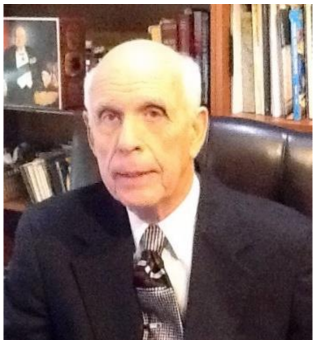
> *The emerging leap in human power, supplied by science and technology, can enable unimaginable pluralistic thriving and perhaps steps toward the stars. But it also poses serious and even fatal risks to human species. Never before has humankind faced such fateful choices on how to use its power.*

Legal systems would be the focus for the Science of Laws Institute. The abundance of resources in Space for humankind's needs would be the Kepler Space Institute's focus.

Our joint efforts toward that common vision could contribute to creating a legacy for positive impacts on historic processes. We should always keep in mind Arthur C. Clarke's quote: "One cannot have superior science and inferior morals." [13] That quote is directly linked to this paper's emphasis on required moral leadership.

REFERENCES

[1] The Science of Laws: Essential Foundation of Space Governance, David G. Schrunk, e-mail to Bob Krone, October 14, 2017.
[2] David Schrunk, "The Science of Laws: Introduction and History," *Science of Laws Journal* 1, no. 1 (2015): 2-4. (Minor edits applied.)
[3] Yehezkel Dror, "Preventing Hell on Earth," *Journal of Space Philosophy* 4, no. 2 (Fall 2014): 16-27.
[4] Yehezkel Dror, "Overture," *The Rulers* (2017). Bob Krone note to readers: Yehezkel Dror has been my academic mentor and professional colleague since 1968.
[5] *Science of Laws Journal* 1, no. 1 (2015).
[6] Bob Krone, "Leadership will be Key: Applying Yehezkel Dror's Avant-Garde Politician: Leaders for a New Epoch," *Journal of Space Philosophy* 3, no. 2 (Fall 2014): 15-16. (Minor edits applied.)
[7] This aspect of Yehezkel Dror's model for avant-garde leadership, innermost philosophy, is the subject of Chapter 19 in his 2014 book.
[8] Yehezkel Dror, "Preventing Hell on Earth," *Journal of Space Philosophy* 4, no. 2 (Fall 2015): 16-27.
[9] Yehezkel Dror, *For Rulers: Priming Political Leaders for Saving Humanity from Itself*, Washington, DC: Westphalia Press, 2017, 2.
[10] The Law of Space Abundance was formulated by Kepler Space Institute leadership in 2009 after studying the extensive research into the resources in our Solar System and beyond. Those resources can be mined for Earth's needs, as well as for constructing human settlements in Space. The Sun's energy is only the most obvious and dramatic resource.
[11] Yuval Noah Harari, *Sapiens: A Brief History of Humankind*, New York: Harper Collins, 2015.
[12] Yehezkel Dror, *The Rulers*, 3.
[13] Bob Krone, "Arthur C. Clarke's Philosophy for the 21st Century," *Journal of Space Philosophy* 3, no. 1, Spring 2014: 97-102.



Dr. Bob Krone, currently 87 years old, is in his fourth professional career. Those four careers were: The United States Air Force (1952-1975), The University of Southern California in Los Angeles (1975-1993) , a mixed career with La Sierra University and the University of South Australia (1993-2007), and The Global Space Community (1980 - present). Bob has authored or co-authored twelve books and ninety professional journal articles, including twenty-seven articles in the published issues of the *The Journal of Space Philosophy*, accessible at:.keplerspaceinstitute.com/JSP.

Bob reviews his 87 years in his article, "*A Personal Philosophy: Know Thyself*" in the Spring 2015 Issue, Vol 5, No. 1 of *The Journal of Space Philosophy*.