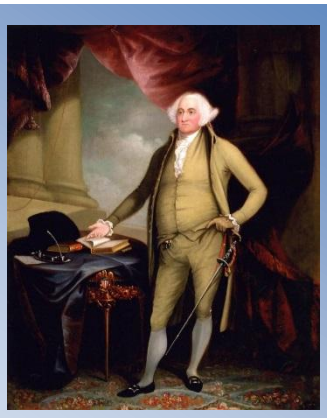
THE SCIENCE OF LAWS JOURNAL

- Excellence in Governance through Science -

VOLUME 1, ISSUE 1



"While all other sciences have advanced, that of government is at a standstill – little better understood, little better practiced now than three or four thousand years ago." *–John Adams*

THE SCIENCE OF LAWS JOURNAL

Excellence in Governance through Science

IT IS TIME TO ADVANCE THE SCIENCE OF LAWS

With great pleasure, I introduce the first issue of *The Science of Laws Journal*! While all scientific journals increase humankind's knowledge, this journal has the unique ability to provide knowledge that positively affects the daily life of all humankind residing under the jurisdiction of a set of laws. As John Adams accurately captured above, the current knowledge of how and why laws work, or fail to work, is largely unknown. To put this in context, a previous study found that between the years 1800 and 2006 there were only 1,850 scientific, peer-reviewed articles written about laws and their effect or outcome. Considering there are millions of laws already in effect and more being released every year, this scant amount of scientific investigation is inadequate. Further, the articles that do exist are scattered among several journals of varying primary topics such as medicine, automotive engineering, and criminal justice. The need for a dedicated scientific field to study the effects of laws is real and this journal is a major step forward in reaching that goal.

This inaugural edition of the *Journal* is filled with the proceedings from the First Annual Science of Laws Conference held at the University of California, San Diego in conjunction with the International Council on Systems Engineering. Future issues will contain peer-reviewed research papers on topics related to the investigative science of laws as well as the creative science of laws. Investigative science articles will examine the effects of laws while the creative science articles will examine the design methodologies needed to create laws that optimally achieve the desired outcomes.

Hundreds of years ago, John Adams recognized that the science of laws had been stagnant for thousands of years. We at The Science of Laws Institute are excited to be taking positive steps to revive and advance the science of laws. We also invite and encourage others to participate in the science of laws by serving in a voluntary role (see our "Call for Volunteers") or by simply encouraging meaningful dialogue on the subject of science in lawmaking with friends, neighbors, and/or co-workers about the current lack of science-based lawmaking. Together, we hold the potential to make dramatic improvements in the quality of life of nearly all humankind.

–John N. Wood, Editor

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PROCEEDING

The Science of Laws: Introduction and History

David Schrunk*

INTRODUCTION

In 1995, the Science of Laws Institute, a California Nonprofit Public Benefit Corporation, was founded and dedicated to the establishment and growth of the science of laws. The traditional method of lawmaking, now used by legislative assemblies, has not been able to produce laws that consistently solve societal problems. To improve the performance of governments, a new science, the science of laws, is proposed as a means for deriving knowledge of laws and for creating new efficacious laws that satisfy the purpose of democratic government.

TRADITIONAL LAWMAKING

The impetus for the creation of the science of laws by the Science of Laws Institute came from the observation that governments, through their lawmaking institutions, create laws (e.g., legislative statutes, regulations, ordinances…) in an attempt to solve societal problems that degrade or threaten to degrade the well being of the people. However, unlike other productive industries that make useful products, the lawmaking industry has not been successful. Societal problems such as war, crime, poverty, and illiteracy remain as serious challenges for governments despite the continuous production of large numbers of laws and the resulting expenditure of substantial resources. In response to problems that are not solved by existing laws, legislative assemblies enact more laws and add them to the existing bodies of laws. The result of this process is that the bodies of laws grow in size, cost, and complexity but societal problems remain unsolved, and governments thus fail to satisfy their public-benefit purpose.

A review of the lawmaking process of government ("the traditional method of lawmaking") reveals that it is seriously flawed as a problem-solving process. The traditional method is prolific in the production of new laws; however, it has not been successful in satisfying the public need to solve or mitigate societal problems. The reasons for the failure to solve societal problems include the following list of flaws and omissions of the traditional method of lawmaking:

1. It substitutes the creation of laws for the solution of problems,
2. It does not require societal problems to be defined,
3. It does not assign priorities to problems,
4. It does not set goals for laws in terms of measurable outcomes,
5. It does not require law designers to have design expertise,
6. It does not require modeling or computer simulation of law designs,
7. It does not require an accounting of all related costs of laws,
8. It does not require an accounting of risks and side effects of laws,
9. It tolerates design defects and "intentional vagueness" in laws,
10. It tolerates the inclusion of "pork barrel" and political agenda provisions,
11. It is based upon opinions (ideology) rather than reliable knowledge,
12. It does not require the citation of references, and
13. It does not require the evaluation of outcomes.

These defects of the traditional method of lawmaking render it incapable of solving complex societal problems by means of laws. It employs speechmaking, debate, and compromise, and observes parliamentary protocols for the creation of laws. However, the end result of this process is the enactment of poorly designed laws that are, variously, defective, vague, wasteful, unnecessary, or ineffective in the solution of problems. On occasion, it produces laws that are effective, such as tax laws that raise revenue for government operations. However, those laws are, as a generalization, unnecessarily costly and complicated. In terms of producing bodies of laws that efficaciously solve problems for the benefit of the public, the traditional method of lawmaking is a failure. 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.

THE SCIENCE OF LAWS

Although the flaws and omissions of the traditional method are serious, they can all be corrected by the simple expedient of applying well established scientific investigative and problem solving expertise to laws and lawmaking. In other words, the opportunity exists to make a significant improvement in the performance of laws – hence governments – by simply expanding science to encompass laws and lawmaking. Based upon this premise, the Science

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of Laws Institute is moving forward with the establishment and growth of the science of laws. The science of laws consists of two coequal branches: 1) The creative science of laws and 2) The investigative science of laws.

Creative 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, and transform lawmaking into a knowledge industry. Eventually, the creative science of laws will supplant the lawmaking task of legislatures.

Investigative Science of Laws: The purpose of the investigative science of laws is to derive, record, organize, and promulgate scientific knowledge of the structure and mechanics (cause and effect mechanisms) of the laws of government. Every law of government is created on the universally-held premise that the law, when enforced, will produce a desired change of human behavior. A law of government is thus an experiment of human behavior based upon the hypothesis that the law, when enforced, will produce a beneficial societal outcome. However, this "experiment" is incomplete in that governments do not routinely measure, analyze, and record the outcomes of law enforcement. The result is that the effects of laws are unknown and some laws may, in fact, be harmful to the public.

To end the ignorance of the outcomes of laws, the investigative science of laws uses scientific methodologies to derive and accumulate reliable (i.e., scientific) knowledge of the structure and mechanics of laws. With this knowledge, governments will be able to create quality assurance (QA) programs that identify, and thus lead to the repeal of, those laws that cannot be demonstrated to provide a net benefit to the public. In addition, the accumulated knowledge of the outcomes, or history, of laws will enable governments to avoid the mistakes of previous failed laws, and will serve as a useful data base for the creation of new laws.

Synergism between Legislatures and the Science of Laws: The implementation of the creative and investigative sciences of laws will cause the traditional lawmaking method to be transformed from the present opinion-based feed-forward control system that merely produces laws (Figure 1) to a knowledge-based feedback control system that solves problems in the public interest (Figure 2). By this process, legislatures will identify and prioritize problems for solution and set problem-solving goals (i.e., "make policy"), the creative science of laws will design laws (under contract from the legislature) that optimally accomplish legislative goals, and the investigative science of laws will measure, analyze, and report the outcomes of laws. The synergism between legislatures and the science of laws may be expected to produce the favorable scenario where, at any given point in time, societal problems are being solved by ever-improving means, and problems of the next higher order of complexity are in the process of being solved.

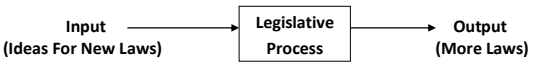

Figure 1. TRADITIONAL LAWMAKING: A Feed Forward Control System That Creates Laws. The traditional method of lawmaking is a simple feed forward control system that creates laws of government. Note that this system of lawmaking can operate indefinitely without reference to societal problems.

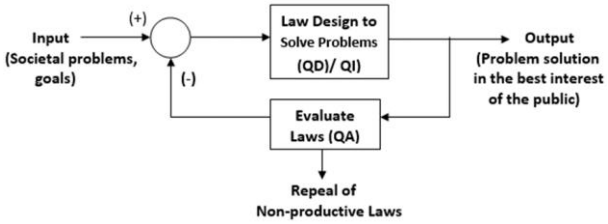

Figure 2. SCIENTIFIC LAWMAKING: A Feedback Control System That Solves Problems. The inherent quality programs (QD, QA, and QI) of science will transform the lawmaking process into a problem-solving feedback control system under the direction of the legislature.

NEXT STEPS

The next steps of the Science of Laws Institute include the following:

1. Publish a journal of scientific abstracts and articles of the investigative and creative sciences of laws,
2. Accumulate and publish a list of reports of methodologies and best practices for the investigative and creative sciences of laws,
3. Form a scientific society of the science of laws,
4. Conduct annual scientific meetings for the presentation of topics related to the science of laws and for the exchange of ideas,
5. Establish links with science and engineering institutions such as the National Academy of Engineering to exchange information and coordinate efforts to improve knowledge of laws and to improve the efficacy of laws,
6. Establish links with universities for the development of multi-disciplinary programs for modeling and computer simulation of laws of government,
7. Communicate with universities for the development of college curricula for the science and engineering disciplines of the science of laws.

CONCLUSION

The science of laws holds the promise of creating and maintaining bodies of laws that enable governments to satisfy their public benefit obligations. If, as expected, it meets its objectives, the performance of the laws of government in the solution of problems in the best interests of the people, will come to parallel the patterns of success that typify every other field of science.

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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

A Technocratic Approach to Effective Decision Making in Policy Design

Nargis Hossain*

ABSTRACT

Societal changes, technological innovations and economic opportunities present endless opportunities and challenges in the fluid policy making environment. In this environment of uncertainty, decision makers defined in this study as policy makers, make complex decisions under bounded rationality. Coupled with temporal constraints, decision makers do not fully consider the potential consequential outcomes of ineffective decision making. This study will focus on demonstrating modeling and simulation to optimize the decision making process and policy design. Using a generalized constraint based uncertainty model; the study will illustrate through simulation, the efficacy of systems engineering approaches in not only maximizing outcomes but also minimizing the unintended consequences of bounded rational decision making in uncertain conditions.

Keywords: bounded rationality, simulation, policy design

INTRODUCTION

Scientia est potentia: Knowledge is power; a phrase coined by Thomas Hobbes in 1668 in his book *Leviathan* (Lee, 2013). Knowledge is power has many interpretations; knowledge in theory is not power, rather said power lies within the utility of the information. As a political philosopher, Hobbes understood that the utility of information and knowledge by a strong undivided government was the foundation of a legitimate government. However, Hobbes could not have forecasted the amount of information that would define the current makeup of policy design. With the emergence of complex information flows, policy makers need to have a distinct fund of knowledge to make effective decisions on policy design. The challenge lies within the realms that these policy makers operate under bounded rationality and are unable to know or process the relevant information in a time critical manner needed to facilitate a law. The fluid nature of our geopolitical environment means that crises are happening every day; and as the world's largest oldest constitutional democracy, the citizens mandate that problems be solved. Due to intellectual resource scarcity and temporal constraints, we as a socio technical society have to find ways to augment effective decision making to address these issues in a timely and effective manner.

The aim of this study was to illustrate the significance of systems engineering and public policy convergence and its outcomes in decision making productivity. Using a generalized constraint based uncertainty model, the study illustrated through simulation the efficacy of systems engineering specifically knowledge management approaches in not only maximizing outcomes but also minimizing the unintended consequences of bounded rational decision making in uncertain conditions.

POLICY MAKING AS A COMPLEX ADAPTIVE SYSTEM

Laws and public policy issues are by nature, complex; they operate in changing geo-political situations and are filled with uncertainty. To exacerbate this complexity these laws are formed by people who not only lack the fund of knowledge but are overtly biased in their decision making strategy. The complexity of this system means that the environment is no longer controlled and predictable, therefore the simple cause and effect rules did not apply. Decision makers had to be adaptive.

The linear approach to understanding complex systems was no longer viable and could not be applied to the adaptive system. In order for decision makers to understand complex adaptive systems, they had to embrace a new way of thinking. For this study, we define complex systems as the policy making environment. The complex adaptive system is comprised of agents. Agents defined in this study as policy makers. They are considered the building blocks of the complex adaptive systems (Bedau, 2000) and are self-organizing thereby creating patterns. Each agent behaves by a set of rules (Bowles, 2004) and adjusts their behavior to that of other agents, and by definition, they interact and adapt. As a result, the decision makers responsible for creating and implementing policies must be able to adjust, adapt and make decisions that are not well defined, have more than one correct answer and interact with agents that have conflicting interests.

The fluid nature of integration and adaption amongst agents in the public policy arena has been the point of research in

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scholars across the field (Formaneck, Cozzarin, 2013). The underlying theme in literature has been the impact of information and cultivating said information into knowledge to design policy. To move forward we must look beyond the status quo of the policy design process, detect the challenges in the system and provide solutions to optimize results.

DEMOCRACY + MERITOCRACY = TECHNOCRACY

Ah, democracy; perceived as one of the ultimate principles that societies strive to create and sustain; defined as "rule by the people." In theory, the principles of democracy are governance by the people for the people through elected representation. The democratic process as represented in Figure 1, of policy design focuses on three aspects: (i) formulation, (ii) implementation, and (iii) modification.

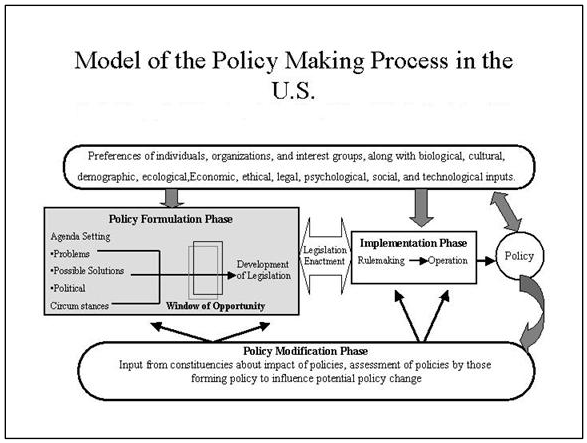

Figure 1. Model of the Policy Making Process- The Texas Politic Project

Classical approaches to policy design focused on the formulation of the law; and were based on forecasting, analysis and bureaucracy (Morelli, 2004). The planning theory then moved towards the implementation stage where the focus was heavily placed on the efficacy of the analysis and the unintended consequences of bureaucracy (Winter, 2003) which often led to modification. The process was long and tedious and often times ineffective. The classical approach tried to take a chaotic and ineffective bottom up approach and hoped to make it a productive dynamic. The challenge in this dynamic was that the decision makers were designing laws based on ideology and limited political knowledge of the topic without considering the long term unintended consequences it would have in policy design. The fundamental understanding is that these decision makers did not possess in its entirety the intellectual capital to make sound decisions.

The decision making process does not occur in a bubble, the complexity of the actors associated in this process means that circumstances like legalities, expert consultation and communication is integral. These circumstances could not be addressed without the knowledge and the qualifications to provide solutions. Moving from the more classical approach of the democratic process, the idea that a more meritocratic process was necessary to tackle these circumstances (Bovens, et al., 2009)

Meritocracy is defined as a system of rule characterized by those best qualified by notion of their technical expertise. In current literature (Bovens, et al., 2009) a meritocratic system is said to hold that most promise in governing networks. The meritocratic system is not an independent system but states that not only do the people elect representatives that share a similar ideology but they are also the most qualified and informed in geopolitical issues. However, merit is based on the eyes of the beholder. To measure merit in an environment of democratic process is hard. There is no tangible calculation that can be appropriately measured in which the democratic process can select a candidate. Thus, for a meritocratic system to work there has to be an objective consensus on how the process should flow. The underlying fact here is that the policy design system does not have to be an either/or solution but one of convergence; an amalgamation of both democracy and tangible measures of meritocracy forge together to bring the technocratic system.

Technocracy is a system of governance where decision makers are selected on the foundation of technological knowledge (Howse, 2002). In a technocratic system, the decision makers facilitating policy design is chosen because of their knowledge rather than political profile. Having subject matter experts who have the technical expertise and political background in the policy making process, addresses the resource scarcity in both intellectual capital and time. In theory, we can have our cake and it eat it too. What technocrats bring to the policy making process is a specialized set of skills (more often they are scientists and engineers) to effectively address spaces of uncertainty in the decision making process.

Uncertainty in processes coupled with political and ideological interests has led to a more constrained based model of policy design.

CONSTRAINT BASED UNCERTAINTY

Most decisions are made, at some level in an environment of limited knowledge, partial truth and uncertainty. As the progression towards a more systems engineering approach to augment decision making grows; the need for a foundation of understanding how to deal with uncertainty is crucial.

Literature on generalized uncertainty principles state that uncertainty is a characteristic of information and that uncertainty can successfully be measured through statistical analysis (Zadeh, 2005). Can these classical approached be redefined in a more efficient manner through a more systems engineering approach of modeling and simulation? If we look at the classical decision making process in Figure 1, we can predict where possible areas of uncertainty can affect the policy making process as noted in Figure 2.

Identifying the uncertainty and constraints in the policy making process, we can then create this environment in a systems dynamic environment. Modeling and simulation discipline was introduced so scientists and researchers could have a more in-depth understanding of the interactions of parts of the system and of the system as a whole (Jönsson,

Edholm, Salmonson, Henningsson, 2012). A model is defined as a simple representation of understanding of an actual system (Ahmar Khodja, et al., 2003). The makeup of the model is in the details (Birta, Arbez, 2007); the details should represent reality in some capacity and should reflect all the characteristics to model a particular system. Having a model with too little or irrelevant information will affect the interactions (Birta, Arbez, 2007) and thereby not promote an accurate representation.

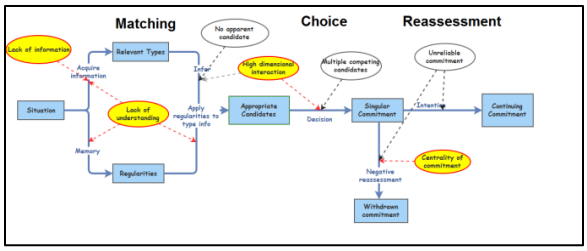

Figure 2. Generalized constraint based uncertainty model – guided by Cohen, 2013

Simulation on the other hand, refers to the method of computerizing models which can be run over a period of time to study the inferences of defined interactions (Head, 2009). Simulations are iterative in nature and are synonymous with model development. Modeling and simulating an environment by trial and error allows the developer to understand the nuances of the system interactions and how the state of the system reacts given the agents involved (Dias, 2007). In Figure 3 we see an example of the simulation output whose variables are measured according to certain guidelines. By adjusting the parameters as noted to the right, this systems dynamics tool can help optimize decision processes in policy design.

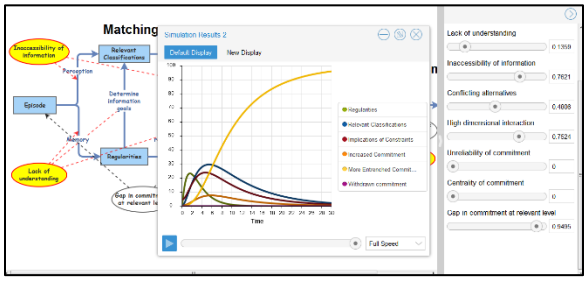

Figure 3. Generalized constraint based uncertainty model simulation – guided by Cohen, 2013

Having efficient decision processes is dependent on the information and knowledge that drives the system. Having effective knowledge management tools that help optimize the decision process can increase decision productivity as well as account for risks. Modeling and simulating knowledge knowns and unknowns can lay the foundation of the actual knowledge base from which these decisions will be derived from. In Figure 4 we see a generalized knowledge management model that will simulate the knowns, unknowns and assumptions of information being processed.

When simulating this model we can note where there is a gap in information, the relevance of the information and the amount of assumptions are being made. This helps the decision maker understand the utility of the information and how he or she can effectively use this information in the policy design. Outcomes in productivity are a good measure of growth; and, if used effectively, could help facilitate an optimal design process.

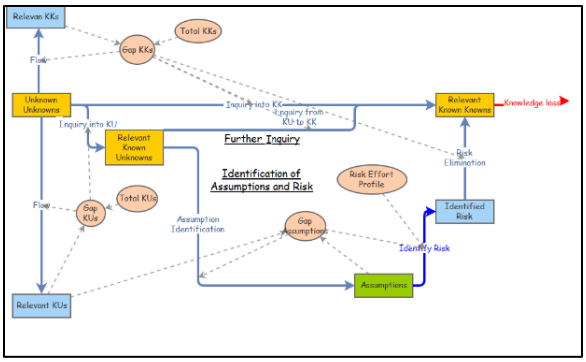

Figure 4. Knowledge Management Knowns and Unknowns Model – guided by Crawford, 2012

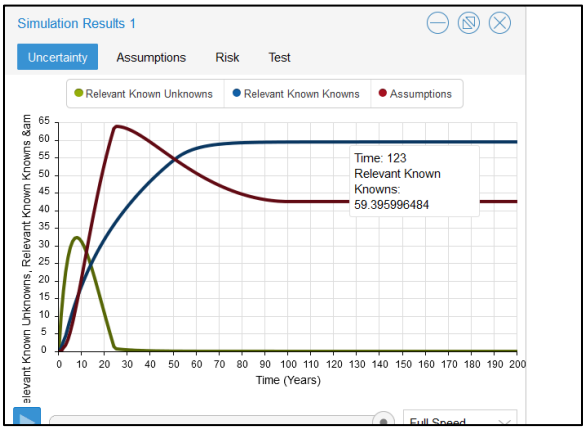

Figure 5. Knowledge Management Knowns and Unknowns Simulation – guided by Crawford, 2012

CASE STUDY: KNOWLEDGE MANAGEMENT AND OUTCOMES OF PRODUCTIVITY

To exemplify the impact of systems engineering applications, especially knowledge management applications on productivity in large scale institutions, a longitudinal study, being considered for publication was conducted of the association between a University's adoption of KM tools and research productivity at the SUNY's four centers of excellence.

The adaption of KM software by SUNY centers of excellence produced a significant increase in the rate of grants and publication. The empirical inquiry that drove this study was to validate that the adoption of these KM tools significantly increased the productivity of researchers at the

university center. This study confirmed a gradual increase in productivity pre-KM adoption, which we associated to the marginal increase in total principal investigators. The notable change was evident post-KM adoption when principal investigator resources decreased and productivity significantly increased. The ANOVA calculation suggested a statistically significant difference in the mean publications and grants per PI rate for the four university centers after the adoption of information sharing tools. While causality was not firmly established between the adoption of KM tools and the increase in PI productivity, the data and analysis presented here suggest a link between KM tool adoption and this productivity increase.

When applying this systems engineering approach to the policy making process, an association between the impact of knowledge and policy design can increase the decision making productivity significantly.

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Dr. Hossain has served as the Administrator for the State University of New York at Buffalo, Department of Surgery for over 5 years. Dr. Hossain's primary responsibilities include the fiscal management of both State and Foundation departmental resources, and responsibilities relating to faculty recruitment, appointment/reappointment, promotion and retention. Dr. Hossain works with Division Leaders, Practice Plan Administrators and other Senior Leadership to support the development and implementation of the Department of Surgery's strategic initiatives.

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PROCEEDING

Two Essential Sources for Application of Systems Engineering to a Science of Laws

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ABSTRACT

To increase systems engineering potential for contributing substantially to law, legislation and public policy (LL&PP), two fundamental and indispensible knowledge bases, not yet present in SE practice, must be learned. First, SE would need to study the long history of precedent for science influencing lawmaking and Congress and the practical lessons those early experiences provide. This new attempt should learn from this pertinent past. Second, SE would need to incorporate a rigorous, evidence-based natural systems science in its education, post-graduate training, praxis, and certification programs. Regarding the first, this paper will describe the build-up of influences in the '60's that led to legislation establishing the Office of Technology Assessment (OTA, Public Law 92-484) [this author participated in those deliberations], recap its reports and their influence, outline forces that caused its demise, and concisely summarize some of the lessons learned. It will also describe some of the experiences of the institutions that attempted to substitute for the dissolution of OTA in terms of science counseling legislation. Regarding the second, this paper will describe a new natural systems science (Systems Processes Theory) that provides a very detailed list of 100+ isomorphic (patterns) that describe how systems work and also provide a spin-off of how systems don't work (Systems Pathology). Development of this research framework is one of the official projects of INCOSE's SSWG (Systems Science Working Group). This thorough list of desirable features of workable systems would be essential to evaluating models of proposed legislation or public policy positions.

Keywords: science and the law, Office of Technology Assessment, OTA, natural systems science, systems processes theory, modeling & simulation, checklists for modeling

INTRODUCTION

A selection of systems engineers and medical doctors who are members of INCOSE have decided that since laws, legislation and public policy (hereafter LL&PP) literally result in new social systems, they should be consulted to ensure that these new social systems are fair, efficient and sustainable. They would like to apply what they have learned in engineering complex systems to the complex systems problems faced by our nation. The INCOSE San Diego Chapter's annual Mini-Conference kindly dedicated an afternoon to this topic. The central objective would be to evaluate the potential of Systems Engineering (SE) to inform LL&PP.

This laudable and sensible objective is not new to history. Scientists, in general, have been trying to influence laws, legislation and public policy (LL&PP) for generations.

One objective of this paper is to raise questions about the readiness of SE as currently practiced to influence LL&PP. Some of these questions include the following: Is there a fundamental knowledge base in systems science (SS) underlying SE that describes how systems work and don't work to use in advising Congress? Is there sufficient understanding in SE of complex, hybrid (nature + human) systems to use to advise specifically how laws and public policy could be improved? Are there exemplars of successful application of SE to LL&PP? Do systems engineers generally have a good sense of how to influence LL&PP, the obstacles and possibilities involved, and have they studied past attempts and the lessons that could be learned from those past attempts? This last question is the main focus for this paper.

First, it may be important to note that historically the strongest effort by science for influencing public policy was in its own interests. Each year the budget proposed by the U.S. administration includes funding for many science research institutions. At the present time, the amounts of this funding are very significant, ~140 billions of dollars (~2.8% of GDP). So it is understandable that scientists and engineers,

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their corporations and universities, and their professional societies invested great energy in ensuring that Congress approved and authorized (two different steps) this funding at adequate levels. A short list of the research entities involved indicates how influential the research they conduct is to the health of our economy and the health of our people. The list also demonstrates the depth and breadth of involvement of science in our society.

- National Institutes of Health (NIH): ~$30 billion per year
- National Science Foundation (NSF): ~$7 billion per year
- National Aerospace and Space Administration (NASA): ~$17 billion per year
- National Oceanic and Atmospheric Administration (NOAA): ~$6 billion per year
- Center for Disease Control (CDC): ~$7 billion per year

But a second task soon emerged that was equally important to the health of our society and its individuals. Increasing numbers of laws concerned problems, topics, and issues that involved sophisticated science and technological components. The elected politicians and administrators had little preparation for understanding these new sci-tech components that they were obliged to vote upon and decide. So this paper focuses on the role of science and engineering in advising LL&PP rather than securing its own funding for research.

REDUCED COVERAGE OF SOURCES: THIS PAPER ONLY ON OTA HISTORY & LESSONS

Reviewers of the original version of this paper and presentation stated that both sources explained in the abstract would be useful information for this new SE initiative. However, time and length limitations required coverage of only the history and lessons portions. So this paper and presentation now only cover the first source. A handout of seven "posters" covered the second source, a science of systems and a general theory of how systems work and do not work. Some references also contain information on this candidate science of systems that would serve both as a foundation for systems engineering and for its advice to LL&PP. A brief overview of this theory and its spin-off Systems Pathology is given in the last section of this paper.

CURRENT STATUS OF SCIENCE REPRESENTATION IN CONGRESS

A first step in considering the history of science advising LL&PP would be to outline how many current politicians have a STEM (Science, Technology, Engineering and Mathematics) background. Representatives and Senators are elected to Congress for a multitude of reasons, but rarely for scientific expertise. There are only 3 conventional scientists (2 physicists; 1 microbiologist) in the current 535 members of the 113th Congress. All are in the House, none in the Senate. This is not counting the 6 engineers and 19 M.D.'s in Congress because if I have learned anything in my current research in INCOSE, it is that engineering feels itself to be quite uniquely different from science. I would praise the double blind control studies of medicine as an ideal of the scientific method, but it too is an applied science field with many objectives different from science. Science research M.D.'s are ony a small percentage of all M.D.s. Both of these specialties have a particular perspective and knowledge base useful for a subset of problems our nation faces. Neither has the breadth of systems-oriented studies because the crisis problems we face are complex systems problems.

It would be misleading to point out that scientists comprise only 0.5%, engineers only 1.1% and medical doctors only 3.5% of Congress - 5.2% all together. Scientists and engineers are less than 5% of the U.S. population. Percentages are irrelevant. We are concerned here about providing studies and research that inform all Representatives and Senators about the science and engineering background for a wide range of issues, not direct representation of the sci-tech population. In addition, the range of topics in sci-tech related legislation is far greater than the range of expertise of even the few scientists, engineers, and medical doctors in Congress.

CASE STUDY: OFFICE OF TECHNOLOGY ASSESSMENT

If INCOSE in particular, and systems engineers and systems scientists in general, seek to provide their expertise for improving LL&PP, then it would be useful for them to become savvy about the pitfalls and potentials of that intervention space. In this paper, we use the experience of the Office of Technology Assessment as a case study that contains many of the key features of such an endeavor. The case study approach is characterized by deep study of a single instantiation of a particular problematique with the hope that it will provide guidelines for similar situations. The OTA story is rich in detail and occurred at the very highest levels of science and technology studies in the service of LL&PP. It is also well documented, archived, and about to become an issue in current politics. So here we use OTA as a stand-in for the general class of activities involving science and engineering advising LL&PP.

Pre-OTA Debate; Development of Awareness of Need: Around the sixties, the politicians of Congress realized that they were voting on very specific legislation that far exceeded their knowledge base. Sworn to provide for the security and stability of our civilization, they were increasingly called on to make decisions about technical advances. They became sensitive to the need to anticipate negative consequences of their decisions and to various technological developments. Weisner, science advisor to President Kennedy, emphasized the need for the "early warning" function that science could provide on many issues. Congress recognized that we suffered a lack of deep, intense research on the crisis societal problems we were facing. Our country benefited from becoming the most accomplished innovation engine internationally, but this achievement simultaneously required that we vetted the innovations produced.

Ironically, one of the main needs that became apparent was an imbalance between the separate powers in our nation. The executive branch moved quickly to increase the availability of science and engineering advice (President's Science Advisor; President's Science Advisory Committee; PSAC since

Truman and Eisenhower) but the Legislative Branch of government was falling behind. Consider the allocations to the various science agencies listed above in each annual budget request. Such issues a anti-ballistic missile systems or not, Environmental Protection Agency or not, supersonic transportation or not put Nixon administration initiatives on the table. PSAC made requests according to reports from experts. But how was the Congress to decide on these requests without advice of its own? While we in science and engineering might see expert advice as leading to something like truth and accuracy, the Congress was actually more focused on power and making sure the power was balanced by equal, but independent technical studies. Another purely political aspect was the growing awareness that Congressional Committee Chairs needed to expand their control over sci-tech matters. LL&PP derives from Congressional Committee hearings and draft legislation. Congress also needed to consider the international dimension of competition with other nations over new sci-tech developments.

As a result of the above growing awareness and specifically because of the shock of Sputnik and Russian space science advances in 1957, Congress created the SRD, Committee on Science Research and Development, its first exercise at influencing science and hearing from science directly. In 1963, the House named E.Q. Daddario (D-Conn) as the Chair of the House SubCommittee on SRD. At first, its main role was running hearings on funding authorization for the National Science Foundation. Then hearings migrated to government-science relations in general. At these hearings, Yaeger introduced the name "technology assessment" which became standard internationally. Using three reports from the Library of Congress, the National Academy of Sciences and the National Academy of Engineering, Daddario's Committee proposed foundation of a Technology Assessment Board (TAB) in 1966 to identify new technology potentials, possible undesirable consequences, and transfer of basic research to applications. TAB was to be "neutral and detached" from political influence, "insulated from policy making," and "reflect both public and private interests." But TAB was altered significantly by Congressional hearings in 1969. It was refined to be serving Congress solely, and the feature of Presidential appointees was eliminated. Later other features, such as appointment of seven members of the public, and Directors of other science advisory organizations, was lost. Still no action was taken. Later Senator Bartlett (D-AL) proposed founding an Office of Science and Technology like the organization serving the executive branch. That proposal died in committee. It is really important in the context of this paper to recognize that all these changes were made for reasons of pure politics and power, not for improving how science influenced LL&PP

This author played a tiny role in the spread of awareness of the need for Congressional science advising at this time. (See the handout article distributed during the talk.) I was a graduate student in Cell and Molecular Biology at Catholic University just a short distance from the Capital. I had kept a personal file on Science and Public Policy debates as a side interest from my wetlab and theoretical systems science research. I decided to volunteer to help the key funding committee for NSF chaired by Daddario. So I walked into his office and was assigned to ghostwriting short floor statements -- some that made it into the Congressional Record. Rep. Daddario had been asked to give a speech at the dedication of the new Science Center at Wesleyan University. Apparently he liked my writing so he gave me the title, "Academic Science and the Federal Government" and entrusted writing the speech to me. From my personal file I spontaneously dictated a speech to his amazing secretary who typed as I talked. He adopted and very effectively delivered that speech and it yielded unexpected results. In the speech, I "outline(d) the characteristics of a structure that is needed to promote this partnership" (between academic science and government). It sounded much like what the OTA came to be. Those scientists attending the dedication thought the speech should be published as a feature article in Science (the most-widely-read journal of multidisciplinary natural science worldwide). The editors accepted the exact words I had written for the article – I had composed all but the title words. Clearly it was because Daddario, an authority of such influence, was saying those words that they were listened to at all. But it is ironic that as a mere graduate science student I was influencing national policy (if even by stealth). (Daddario passed away in 2010 after successfully founding OTA, becoming its first Director as well as President of the AAAS otherwise I would not disclose this ghostwriting, nor should you beyond these notes. My words, in any case, were derived from his past official positions as reported in the press, both scientific and public.)

Although Daddario led debate in the House for the predecessors and build-up to the proposed law that resulted in foundation of the OTA, he had decided in 1970 to leave Congress and run (unsuccessfully) for Governor of Connecticut.

Bi-Partisan Legislation (PL 92-484): Harvey Brooks, chair of the original National Academy of Science study requested by Daddario in 1968 wrote most of the bill. Rep Davis (D-Ga), who succeeded Daddario as Chair of the SRD introduced it as independent legislation, not a rider on other legislation as before. The bill simplified OTA administration; eliminated Presidential appointments so it was Congress's own agency; removed the outside public representatives; and perhaps most importantly limited referrals (requests for reports) to standing Congressional Committee Chairs only. It also contained unique bipartisan compromises. The TAB Chair and Vice Chair were to alternate between the political parties (Dem/Rep) and also between the House and Senate. The foundation of OTA finally passed Congress in 1972 and was signed by President Nixon. Unlike today, it was an era of bipartisan cooperation.

Relevance to Science & the Law: It is important to emphasize how key these changes were to the success of the legislation and how they are signals to any current effort to influence LL&PP. All six changes cited above secured start of OTA as a creature of the legislative branch exclusively, balanced between parties and houses, and coupled tightly to the direct concerns of Congress and its committee-chair-dominated system. Similar influences will effect INCOSE/SE.

ACTIVITIES OF THE OFFICE OF TECHNOLOGY ASSESSMENT

Despite his absence from Congress when OTA was initiated, Daddario became its first Director. OTA had an annual budget of ~$22M and 143 full time staff at its maximum, more than half Ph.D.'s, with a temporary ad hoc, part time staff approaching 200 at its peak in the 80's. A 12-member governing Board (the aforementioned TAB) of 6 Democrats and 6 Republicans each,, 3 from the House and 3 from the Senate, administered OTA. TAB appointed the OTA Director, approved the budget, approved and delivered reports after they were produced, and chose the individual projects from a list provided by congressional committee chairs, and only those chairs. No other individuals, agencies, or units could suggest projects. Any input from scientists or the public was relegated to the external Technology Assessment Advisory Committee (TAAC). Both the informal nature of OTA and its empowering legislation enabled and required it to seek to fulfill the following characteristics, "tuned carefully to language and context of Congress," "no recommendation of specific policies," "stakeholder bias minimized." For most of its lifespan, OTA appeared to succeed in achieving these ideals of "objectivity" and "neutrality." An advisory panel of experts, a core OTA team, stakeholders, and a dedicated, individual Project Director usually produced each of the OTA assessments. Many involved outside contracts for major analytical tasks as well as an in-house research team. Many also convened workshops, extensive external peer reviews, and continual rewriting as well as dissemination tasks.

Measures of Productivity: OTA conducted its studies for 24 years, 1972 to 1995. In this period it completed more than 755 studies on a very wide range of topics. These included such problem areas as health systems; assessment of polygraph reliability; space; defense; global climate change; acid rain; energy systems; information technology; environment; the textile industry; nuclear systems; weapons of mass destruction; biopest control; global telecommunications, etc. Some of these studies were massive. For example, one study alone consisted of 2 volumes, another 3 volumes, and still another 12 volumes. The average time taken to produce a study was 18 months at an average cost of $500,000. Notice the topics. Many of these studies have "staying power" and are as significant today as when they were completed.

The trends documented across the lifespan of the OTA indicate that reports increased steadily rising six-fold from the beginning to the end. The increase was from 10 per year at the onset to ~60 per year at the end with an average of 32 reports per year. The average doubled in the first two decades. But the official large-scale studies were only the tip of the iceberg. Many more interim reports, summaries, special reports, background papers were also produced. The inside joke around OTA was that the most often produced items were "senator-sized" (2-page) briefs. One way to evaluate OTA productivity is to compare it with Congress itself by noting that OTA used up $20M compared to Congress's $3,200M or half of one percent of its parents budget. A scientists'/engineers' conclusion would be, "sci-tech advising pays off with much value-added."

Measures of Influence: It is difficult to measure efficacy in an area so burdened with ideology and currently with partisan bias. Here are two measures, one from government staff observers and one from an external entity. The first involves assessment of the most political part of OTA, namely TAB consisting entirely of politicians. At the beginning of OTA it was predicted by some observers that the very busy, highly politicized members of TAB would inevitably become, "disinterested" and/or "dysfunctional." In most observers view, neither negative outcome happened. TAB continued to meet every six weeks and even more often as the workload increased. You would be surprised and pleased if you looked at a history of TAB members. It consisted of many well known and senior Congressional members of the House and Senate. Rather than opposing each other, they shared staff, and participated "vigorously." Important national topics were one of the stimulants for this performance. No member could ignore/avoid learning about ICBM information, or drug costs, or explosive agents. The analytical became an important extension of the conventional rhetorical arguments. In fact, sometimes both opposing sides in congressional debate used the same OTA report to support their positions.

The rigorously independent Union of Concerned Scientists conducted an external assessment of OTA. They pointed to four specific examples where OTA studies had resulted in a important service to the nation. First, in 1985 it warned about huge oil spills and our unpreparedness to handle them. This was four years before the Exxon-Valdez oil spill occurred in Alaska and much longer before the great Gulf disaster. We were still not ready. Second, compare the scientists stating that the missile defense system was costly and ineffective which was still deployed despite this advance warning yielding $9,000,000,000 to the providing industries. Third, OTA reports warned the newly formed Dept. of Homeland Security that its proposed radiation detection systems were defective but they were still purchased at a cost of billions. Fourth, OTA popularized the use of electronic distribution systems for government documents and that saved the taxpayer vast amounts of money. The UCS stated OTA saved or could have significantly saved taxpayers money while contributing to "better economic well-being, safety, and health."

DISSOLUTION OF THE OFFICE OF TECHNOLOGY ASSESSMENT

Evolution: The OTA changed across its history. Unexpectedly, both TAB members and their staffs became highly involved. Exactly oppositely, TAAC became marginalized. They had no vote and so direct public input disappeared. The vital and anticipated "early-warning" aspect was muted. The limitations of funding caused the OTA to spend more and more on pre-studies to ensure that they could do an adequate assessment of many topics. Focus changed from the "policy recommendations" of the first study (on drugs) to providing a range of positive and negative alternative policies. Some of these developments were good

and some were not so good given the original objectives of the legislation.

History and Issues: About the time of the Reagan administration, voices were raised to criticize the OTA. For example, one book (*Fat City* by D. Lambro) tried to prove that OTA duplicated other existing agencies. Other more polemic criticisms were that: (i) OTA mission "was not fully integrated with well-established congressional processes;" (ii) accusation that Daddario favored liberal legislators; (iii) OTA staff harbored bias against some members; (iv) Ted Kennedy dominated OTA work; and (v) decried as a tool for Kennedy to attack the Nixon administration. Additionally the concentration of power of referral in Committee Chairs may have helped get the law passed, but in the end it meant that OTA provided very little contact or service to individual members and so it made it easier to find the votes to dissolve it.

As a matter of timing, these mounting criticisms occurred at the same time as the Gingrich "Contract with America" movement and a Republican resurgence gaining decisive control of power. The drumbeat that "government" must be scaled back arose and a "zero-sum" mentality proliferated. New power holders were looking for agencies to eliminate. They could not eliminate the Congressional Budget Office (it prepared their budgets), or the Congressional Research Service (it served all members; not just reports for Committee Chairs), or the GAO (mandated for audits and management), so they eliminated OTA that had a much smaller base of support. This earned the new powerbrokers a symbolic victory, some said only "brownie points," yet they could say to the public that they had eliminated an entire agency and accomplished otherwise elusive budget austerity.

It is amazing to read the very close votes (sometimes by ruling that a couple of members enroute were absent) and extensive background maneuvering that led to OTA defunding. That is an important point. OTA was not completely eliminated – technically it still exists on the books. It was just stripped of funding and so of service. A more skeptical view has emerged in recent times. Politicians just found that analysis too often led to information that opposed their set ideological positions. Seeing our current stalemate on several issues like climate science, abortion, same sex marriages and raising children, on and on, such a skeptical view appears warranted to some. Generally it was not proved that OTA research reports were biased, inaccurate or imperfect. OTA fell from political partisanship, not research malfunction.

Reactions to Closing OTA: Reactions of the minority party of the time were predictable. G. Brown (D-Ca) described it as "shameful," that it eliminated Congress' "defense against the dumb," that other agencies could not substitute for OTA reports (a conclusion that was later proven true in my opinion). But even the other side of the aisle had dissenters. Houghton (R-NY), though a part of the majority said this about dissolution of the OTA: "We are cutting off one of the most important arms of Congress when we cut off unbiased knowledge about science and technology." Other observers claimed that this event was a case of "politics overriding science." It would be useful for INCOSE and systems engineering to recognize this history because these obstacles remain in force and any ambition vis a vis science and the law must overcome them.

Consequence of Closing OTA: Dissolution led to several effects: (i) Congress had to rely more on experts with a stake in the outcomes (lobbyists, industry); (ii) there was more centralization of power in the House of Representatives; (iii) influence from other government agencies was reduced because they did not have the OTA mechanism of producing extensive reports; (iv) the power of the Speaker of the House increased as power of committee chairs was reduced; (v) political party leaders influenced overall policy more than before; (vi) there was an immediate reduction in inclusivity; (vii) there was an immediate loss of systems-level interdisciplinary inquiry for complex systems problems. All of these effects are in play today.

Relevance to Intentions of INCOSE & SE: What does the ending of OTA say to the ambitions of INCOSE, scientists, and systems engineers to influence LL&PP? The objective of this special session of this mini-conference seems to be exactly what OTA was doing before disbanded. So every itemized problem above becomes either an obstacle or opportunity for future initiatives.

OTHER INSTITUTIONS ATTEMPTING TO FILL OTA ROLE POST-OTA

Where does the current Congress get science and engineering advice in the absence of OTA? That it still needs such advice, anticipation of problems years in advance, and accurate analysis is an argument against the original criticism that OTA was only providing services already available. Clearly the remaining advisory groups such as the Library of Congress (LOC) and the Congressional Research Service (CRS) were not authorized or set up to perform the intensive and extensive studies OTA performed. For a time (circa 2001) Congress requested the GAO (General Accounting Office) to experiment with Technology Assessment. It has a small TA unit producing only 1 report per year. But this attempt was short-lived, under funded, under staffed, and too narrow in focus. This inadequate response continues. GAO has no TAB to guide and focus referrals, no similar connection with Congress, no way to establish priorities, and no targeted funding for focused analyses on particular critical topics. The National Research Council (NRC), which is the research arm of the National Academies (NAS)(NAE) and the Institute for Medicine, more than doubled their reports to >50 per year from ~20 per year in the first year OTA was inoperable, but dropped back to the 20's in 1 year. NRC services the executive branch more than the legislative and its reports are quite different in coverage than the OTA. The President's Science Advisory Committee (PSAC) provides science advice for public policy but again it is a part of the executive branch leaving the legislative branch in the weakened position it was in before OTA. Some Think Tanks have objectives that sound similar to the OTA, but most are considered far from neutral. Most inhabit the extreme parts of the spectrum from liberal to conservative. After OTA some of its staffers formed the Institute for Technology Assessment (ITA) thinking there would be a market for it. But it never attracted sufficient funding, had no direct connection to Congress, and folded

quickly. If INCOSE and SE want to influence LL&PP. then these several needs must still be fulfilled.

RE-ESTABLISH OTA? PLAYERS AND ODDS OF SUCCESS

What are the chances that a new OTA could be reinstituted? It would only require refunding since the enabling legislation is still in effect. There remains considerable documentation of the OTA. In its last year it produced 61 reports, the most ever. Archives have been maintained at Princeton University (OTA Legacy site) and the Federation of American Scientists (FAS) that have records of many interviews as well as the publications and reports. TA never took off in Europe possibly due to having the parliamentarian form of government rather than the balance of powers in three branches of the U.S. TA activities exist in Austria, Denmark, Great Britain, Sweden, the Netherlands, and the European Union as a whole (see EPTA). But TA never quite achieved the scale there as here. Ralph Nader has criticized Pelosi, minority leader of the House, on his blog for not pushing resurrection of the OTA. But this seems like grandstanding on his part given the current stalemate in Congress. Holt (D-NJ) has also called for the restart of OTA. It is very interesting that Hillary Clinton stated she would reinstate the OTA during her past presidential campaign. It will be even more interesting if she makes it one of her goals if she runs in 2016. The aforementioned Union of Concerned Scientists has called for OTA rebirth and its campaign for this has been backed by a significant coalition of >100 citizen, technical, and academic groups. Other allies for INCOSE and SE in formulating a science of laws might be the Woodrow Wilson International Center and its report on restarting OTA, the Science Cheerleader Blog, and the ECAST network (Expert & Citizen Assessment of Science and Technology). Overall, this author concludes that the INCOSE and SE effort to start a Science of Laws is a matter of timing and change of context. The environment is not strong at present for such an effort but preparations must be started now to capitalize on changes in the current situation.

POSSIBLE LESSONS LEARNED FROM OTA AND HISTORY

This section is the pièce de résistance of this paper. It briefly summarizes 30 lessons or insights taken from the above analysis and the considerable experience of the authors of the texts on TA found in the background references section. These are ideas, problems, obstacles, potentials, and pathways that INCOSE and SE might consider in increasing the influence of either systems engineering or systems science on laws or in initiating a foundation for a Science of Laws. The insights are not listed in any priority order and all may be regarded as equal in impact. In all of these "Pols" means all legislators and administrators who write and execute legislation and "SEs" means all external public citizens especially systems engineers and systems scientists.

Opposite Objectives: While attempting to influence LL&PP, SEs should keep in mind that everything written and said might be heard in entirely different ways. Experts studying TA, for example, have jokingly referred to a sarcastic twist on the medical Hippocratic Oath, "do no harm" as the political Hypocritical Oath, "do no harm to one's established interests." Pols seek results that agree with their positions, not necessarily scientific fact.

Role of Power: Experts advising Congress and the Administration likely have a self-image of having the truth on their side, and think the truth is powerful. The Pols who they advise, however, are the one's who have the power as invested in them by their election.

Personal over Written: Science experts have lived lives completely dedicated to doing work that resulted in written publications. To them power and influence comes from the written word, but study of OTA's history indicates that it was the personal interactions and loyalties of OTA staff with Congressional staff that over and over again proved the most influential. Oral and face-to-face methods were dominant in effecting change in LL&PP.

Objectivity Rejected: The SE expert's orientation and value lies in objectivity, but the Pols of the LL&PP audience have an orientation and value of subjectivity and special interest.

Winning over Neutrality: SE experts try to achieve neutrality to identify, discover, and develop facts; Pols gather "facts" to win. These unlike mindsets can inhibit communication. SE's & SS's try to start with neutrality; Pols try to end neutrality.

Consensus Difficult: Science is based on competition, challenge, self-correcting criticism. This is often misinterpreted by Pols who use any dissension as evidence for non-consensus and lack of factual basis. It is hard to communicate relative proportions to non-scientists.

Complexity of Problems: SE and systems science experts have to recognize that not all problems are soluble by application of the scientific method. Often societal crisis problems are beyond the reach of conventional science. Problems are "messy" in systems science jargon.

Variety over Truth: The search for consensus in science leads to a reduction of variety. Other branches of government focus decisions and so also reduce variety. But the whole goal of Congress is to increase variety through representational government. Variety dilutes factuality.

Alternatives over Conclusions: Science often continues experiments until it reaches a conclusion or set of facts. But Congress wants a range of alternatives, not a single conclusion.

Unexpected Influences: Pols in general have many competing pressures to balance (Committee Chairs; special interest groups; balance of powers of competing Branches) so experts have to be alert to a wider range of influences and consequences than they usually consider. Advising government is not like designing a "controlled" study.

From Political to Depolitical: OTA attempted to avoid politicization and even Orrin Hatch and Ted Stevens praised it as neutral. Expert advice has to be depoliticized to succeed.

Experts under Pols: History shows Pols want experts "on tap, not on top." Purporting to have the facts, experts easily appear to be dominant. This is counterproductive in this arena.

Need for Courage: Example, Hollings (D-SC) voted to authorize and release the OTA report on Textiles even though negative for his state. He later spoke out against its findings and recommendations; but he did not use his power to stop the study from being done or released.

Three Branches in U.S.: Experts must be sensitive while doing studies that the facts they compile might be seen and used differently by each of our three Branches of government in fulfilling their roles of checking and balancing the power of each other. Facts take on a different nature when viewed in this special light of competing power centers.

Other Key Issues: Experts tend to study isolated issues. It is very difficult to establish patterns and regularities without controlling the study area. But Congress has to consider a much wider range of influences including many trade-offs, value judgments, and public opinion.

Ideology over Science: Current studies show that most humans actually become more tied to their pre-existing errors when presented with facts rather than alter their original ideas. Pols are human. Expect established orthodoxies to compete well with facts whether true or not.

Inform don't Decide: OTA's experience showed that providing Pols with the maximum number of alternatives was more successful than providing them with a conclusion. Better to inform the debate than to resolve the debate or recommend a specific pathway or action.

Importance of Prioritization: With so many influences beyond the factual and always subject to very limited resources, experts must work hard to establish fact-vetted priorities.

Early Warning Critical: Experts must help government at all levels become much more proactive than its current state of being chiefly reactive. But dealing with problems not yet here is discounted by the public and so also by their representatives.

Expose Ideology: Experts have to be more aggressive in challenging faulty ideologies, immediately confronting faulty rhetoric as well as combating them not only in advising Pols but also in education and culture looking toward a generation less hobbled by limited thinking.

Reverse Anti-Science Positions: It is obvious that certain factions today are against any method or tool that results in unassailable facts. How to advise without a substantive change in this climate is a significant obstacle that any Science and the Law initiative must overcome.

Tightly Couple to Congress: It is an inherent paradox to improve the strength of external advising and yet have that advice be accepted as internal. But the OTA history indicates that for science to have any significant effect on LL&PP its counsel has to appear indigenous.

Lessen Time Delays: Many OTA reports took so long to produce, their effect on particular issues was lessened. At the other end of the process, advice often was implemented soon enough to resolve the problems. Perhaps exemplars would increase this recognition

Interdisciplinary Teams: Many of the complex problems faced by society are hybrids of natural and human systems that demand the broadest range of disciplines, but science appears to be virtually enslaved by disciplinary boundaries and isolated silo or stovepipe thinking. My experience with the current status of SE is that they are as hobbled by stovepipe thinking and reliance on tools as the disciplines, even though they criticize silo thinking.

External Peer Review: Pols are not accustomed to peer review, but SEs and science are built on the necessity of peer review. Advisors must reconcile these opposite worldviews.

Use Proven Features: OTA showed that it is important to (a) do studies highly relevant and tied to Congressional needs and concerns; (b) prove its neutrality in both experts and methods; (c) prove evidence-based rigor; (d) communicate in direct, simple, clear language; and (e) employ personal relations in addition to written reports. SE should employ these features.

Increase All Advisory Units: Any efforts of Science and the Law should involve and seek complementarity with other advising units, like the GAO, CRS, CBO, and any new OTA.

Beyond Conventional Science: Most experts from the NAS and NAE are dedicated silo scientists of the reductionist orientation. But the crisis problems faced by society all are on the complex systems level. Advice must go beyond the conventional sciences represented so well in NAS and NAE. Thus the new role and importance of systems engineering & systems science.

Bridge Natural & Social Science: The conventional disciplines are generally clustered into these two super groups. But the crisis problems have major elements of both and involve all disciplines. So the studies need to have experts who can work across these usually separate super groups. SE and systems science potentially have that feature though not yet unified.

Bridge Linear & Non-Linear Causation: The two super groups, especially the natural sciences explain mechanisms mostly with linear causation. But our crisis problems are often complex systems based and characterized by non-linear effects. Conventional sciences need the systems sciences and systems engineering to study these special system problems.

Medical doctors serving patients in end-of-life situations often face unintended negative effects of competing treatments. The above many insights also often compete with each other. For example, in studying the OTA case we learned that having referrals come only from the powerful committee chairs helped get the original OTA legislation through Congress and promoted greater involvement of powerful Senators and Representatives. But it later had the negative effect of removing OTA popularity from the rank-and-file Congressmen and that helped get votes for dissolution. Likewise satisfying one of the needs above might inflame other needs.

PRACTICAL ADVICE TO INCOSE AND SE RE: SCIENCE AND THE LAW

So what can be accomplished? In the near term and without extensive resources the Systems of Law Institute could: (1) Initiate a long-term study group within INCOSE. These are already a tradition as Working Groups. Procedures exist for starting new WG's. They organize a self-selected set of the 9,000 INCOSE members, and conduct activities throughout the year studying a particular sub-topic under the umbrella of systems engineering. They hold international Webinars,

organize four days of Workshops once per year, sponsor papers at a range of annual conferences, and invite outside speakers and experts. (2) Once established, this Systems Engineering and the Law WG should meet and share work with already well-established INCOSE WG's on related topics like the Systems Science WG, the Complex Systems WG, the Natural Systems WG, etc. (3) A section on Science and the Law might be written and submitted to the ongoing SE workbooks, SEBoK and courses developed for SE curricula. (4) Science and the Law Institute needs to make very specific alliances with key institutions with the same objectives such as ECAST, Union of Concerned Scientists, Federation of American Scientists, and the EPTA. (5) Science and the Law Institute could offer help in any capacity needed to the National Academy of Sciences and the National Academy of Engineering. (6) The Science and the Law Institute needs to identify and write proposals to funding agencies, both public and private, for support of its projects. (7) Write and publish a range of books, reports, editorials, and research articles to establish credentials in this new area and to disseminate Science and Law ideas.

PREVIEW OF A RIGOROUS SCIENCE OF SYSTEMS FOR SE AND LL&PP

This section was intended to be the new secret weapon in establishing a rigorous, evidence-based science of laws. My collaborators think of LL&PP application as a significant spin-off of our Systems Processes Theory (SPT). However, reviewers sensibly suggested that only one of the two sources described in the abstract could be developed within the limitations of length and time. So this section is now merely a teaser. It is based on three simple observations. Laws, legislation and public policy (LL&PP) build new systems. It would be best then to build these systems using the very best knowledge we have of how systems work (a science of systems = SPT) and don't work (a new Systems Pathology, another spin-off of SPT). These would provide a strong systems theory and universal patterns to guide formation and curation of sustainable systems. But these guidelines (it is presumption to call them either laws or principles) would have to be very detailed to add value to our current practices. At the talk, the following nine mini-posters were distributed to give an introduction to a Systems Processes Theory from systems science and a Systems Pathology that would be a strong candidate for the above strategy. They would be the basis not only for a stronger systems engineering, but also for sustainability studies, a medicine of systems, and for application to public policy formation. These posters were once presented at ISSS, NECSI, ICCS, NSF, and Education conferences. Here is a summary of topics covered.

Intro to Systems Processes Theory (SPT) (includes: SPT = GST, Identification of Isomorphic Processes, What are Linkage Propositions (LPs), Sample LPs, Classes of LPs, Tools to Use SPT, Applications)

Linkage Propositions (LPs) of the SPT (includes: Limits of GST, Defining LPs, Sample LPs, Dependency of LPs, LPs Better than Text Descriptions, LPs from Science, Outline of 134 LPs, Uses of LPs)

Systems Processes and Pathologies (includes Problem of Unintegrated Sources, Common Framework for Unifying, Systems Processes Theory, Classes of Systems Pathologies based on SPT Systems Processes)

Natural Sciences Test SPT (includes: Case Studies from Natural Sciences, Tests by Comparison, Types-Classes-Extent of Isomorphies, Listing of Discipline Case Studies, Empirical Base for Systems Science)

SPT Prerequisites, Discinyms, Discriminations, Mutuality (includes: SPT Tenets, Pre-requisite Chains of Processes, What is Mutuality, What are Discinyms, Discinym Examples, Key Discriminations)

Clustering of Systems Processes in SPT (includes: Clustering in Systems Biology, Clustering Systems Processes by Function, by Prerequisites, by Stages of Systems Life Cycle, by Stages of Development)

SOS in Engineering: An NSF Report (includes: NSF Challenge, What is SOS? Importance of SOS, Natural Science and SOS, Science of SOS? Development Needs of SOS, SPT and SOS, Conclusions)

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APPENDIX A: ACRONYMS USED IN THIS PAPER

AAAS = American Association for the Advancement of Science *[Public-Citizen]*
ABM = Anti-Ballistic Missile Systems
ASCB = American Society for Cell Biology *[Public-Citizen]*
CBO = Congressional Budget Office *[Congress]*
CDC = Center for Disease Control *[Executive]*
CEQ = Council on Environmental Quality *[Executive]*
CRS = Congressional Research Service *[Congress]*
CS = case study or studies
CSA = Committee for Science and Astronautics (→ CST, then CSST) *[House]*
CxSWG = Complex Systems Working Group of INCOSE *[Public-Citizen]*
DARPA = Defense Advanced Research Projects Agency *[Executive]*
DHS = Department of Homeland Security *[Executive]*
DOE = Department of Energy *[Executive]*
ECAST = Expert & Citizen Assessment of Science and Technology *[Public-Citizen]*
EPA = Environmental Protection Agency *[Executive]*
FAS = Federation of American Scientists *[Public-Citizen]*
GAO = General Accounting Office *[Congress]*
ICJ = International Court of Justice
ICRW = International Convention for Regulation of Whaling
INCOSE = International Council of Systems Engineers *[Public-Citizen]*
ITA = Institute for Technology Assessment *[Public-Citizen}*
IWC = International Whaling Commission (also Int'l Confederation of Wizards)
LL&PP = Law, Legislation and Public Policy
LOC = Library of Congress *[Congress]*
LP (LPs) = Linkage Propositions of SPT
MD = Medical Doctor *[Public-Citizen]*
NAE = National Academy of Engineering *[Public-Citizen]*
NAS = National Academy of Sciences *[Public-Citizen]*
NASA = National Aeronautics and Space Administration *[Executive]*
NIH = National Institutes of Health *[Executive]*
NOAA = National Oceanic and Aeronautics Administration *[Executive]*
NRC = National Research Council *[Public-Citizen]*
NSB = National Science Board *[both]*
NSF = National Science Foundation *[Executive]*
NSWG = Natural Systems Working Group of INCOSE *[Public-Citizen]*
OECD = Organization for Economic Cooperation and Development
OMB = Office of Management and the Budget
ONR = Office of Naval Research *[Executive]*
OST = Office of Science and Technology *[Executive]*
FDA = Food and Drug Administration *[Executive]*
OSTP = Office of Science and Technology Policy
OTA = Office of Technology Assessment *[Congress]*
PSAC = President's Science Advisory Committee *[Executive]*
S&T = Science and Technology *[Public-Citizen]*
SE = Systems Engineering *[Public-Citizen]*
SEBoK = Systems Engineering Body of Knowledge Library *[Public-Citizen]*
SP (SPs) = Systems Processes (Isomorphies of a general theory of systems)
SPT = Systems Processes Theory
SRD = Science Research & Development *[Congress-House]*
SS = Systems Science or systems sciences
SSWG = Systems Science Working Group of INCOSE
TA = Technology Assessment (or Technological)
TAAC = Technology Assessment Advisory Council *[Public-Citizen]*
TAB = Technology Assessment Board *[Congress-House]*
UCS = Union of Concerned Scientists *[Public-Citizen]*

Dr. Len Troncale is Professor Emeritus of Cell and Molecular Biology, and past Chair of the Biological Sciences Department at California State Polytechnic University (CPP/Cal Poly). He is also Past Founding Director of the Institute for Advanced Systems Studies, and Coordinator of its NSF-supported Systems-Integrated-Science General Education (ISGE) Program at CPP. He served as VP and Managing Director of the International Society for General Systems Research (SGSR) for six years, and President of the International Society for the Systems Sciences (ISSS) for the three-year cycle. He has served as Visiting Professor at the University of Vienna, Austria, CSU Monterey Bay, and CSU Sonoma and as Research Associate at IIASA Austria (the International Institute for Applied Systems Analysis). He was a member of the Board of Directors of IFSR (International Federation for Systems Research) for several years and still serves on the Board of Trustees for ISSS. He is on the editorial board of several systems publications, for example, Systems Research and Behavioral Science. Currently he has been presenting talks, research papers, posters, and webinars for INCOSE (the International Council on Systems Engineering) and at Systems Biology conferences and serves as Lead for two official projects of the Systems Science Working Group of INCOSE. Most recently, he has been named Lecturer for the new Master's in Systems Engineering of the College of Engineering at Cal Poly teaching the new core course Introduction to Natural Systems Science for systems engineers. Dr. Troncale has published over 137 research articles, abstracts, editorials and reports, 33 conference posters, served as Editor on 11 projects, delivered 125 invited and computerized presentations and demonstrations in 23 countries and served as P.I. on 52 grants and contracts for $5.3M from a variety of federal, state, and private organizations such as the NSF, DOE, ONR, HUD, the HHMI and the Keck Foundation, as well as the CSU System. A history of his contributions may be viewed at lentroncale.com, Wikipedia, and five other linked website/blogs.

PROCEEDING

Requirements, Specifications, and Design: Improving Efficacy of Lawmaking through Requirements Management

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ABSTRACT

Is a tomato a fruit or a vegetable? Should same-sex couples be allowed to marry or adopt? Can employers ask for your Facebook password? Should for-profit universities qualify for federal student loan and G.I. Bill benefits? By attempting to keep laws current with advances in science, technology, and innovative business practices, they fail in two ways:

1. Lawmakers generally lack the scientific background to understand the implications of their laws
2. The timeline to develop laws simply cannot keep pace with advances in technology, becoming obsolete as soon as they are passed

This paper will investigate the problems caused when lawmakers over-specify the intent of laws. The efficacy of lawmaking can be improved dramatically by applying the Systems Engineering best practices of Requirements Management. In this way, laws would define the intent of the regulation and expected results, leaving out verbiage regarding specific implementations or designs.

Keywords: Requirements, Lawmaking, Technology

INTRODUCTION

The United States of America was founded on the ideals of freedom and liberty. Each citizen has the right to live and prosper. These ideals are defined in the foundational documents that outline the goals of our government.

> *We hold these truths to be self-evident, that all men are created equal, that they are endowed by their Creator with certain unalienable Rights, that among these are Life, Liberty and the pursuit of Happiness.* (Declaration of Independence, National Archives, n.d.)
>
> *We the People of the United States, in Order to form a more perfect Union, establish Justice, insure domestic Tranquility, provide for the common defence [sic], promote the general Welfare, and secure the Blessings of Liberty to ourselves and our Posterity, do ordain and establish this Constitution for the United States of America.* (Constitution of the United States of America, National Archives, n.d.)

If only lawmaking were this simple. Since the signing of the Declaration of Independence and ratification of the Constitution, lawmakers have served to draft laws to fulfill these simple ideals while governing a country of increasing size and complexity. Because lawmakers struggle with balancing the desire to fulfill the laudable goals of establishing a nation of freedom with the practical need of serving their local constituency, the laws that result from the democratic process sometimes fail to serve these goals (Silver, 2012). As social consciousness and technology have evolved over time, so too have the laws of the nation. The lawmaking process has generally failed to support the pace of evolution of both social consciousness and technology, resulting in laws that are overly specific and brittle. This brittle structure framed by the crooked timbers of humanity simply cannot keep pace with technology and social evolution (Berlin, 2013). Laws can become more effective by applying Requirements Management best practices from the Systems Engineering discipline. This paper will analyze historical examples of lawmaking and propose a new model for lawmaking that is less fragile and would result in more effective lawmaking to support rapid changes in technology.

LEGISLATURE THROUGH NEGOTIATION: A FLAWED APPROACH

The current process for developing laws in the United States is a flawed approach involving elected officials, lawyers, and professional lobbyists, all competing and negotiating on behalf of their respective stakeholders. A simple stakeholder analysis would demonstrate that these three groups have competing needs. While the intended aim of our elected officials is to represent their constituency in government, they often struggle with the competing need to please the leaders of their political parties in order to maintain the support of the party juggernaut during elections. This competing need often results in hyper-focus on partisan issues

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of local interest rather than a true consideration of the need for service for the good of the country (Silver, 2012). As supermajorities have become more prevalent in Congress, bullying tactics such as the filibuster have become increasingly popular to prove political points and further the cause for partisan issues (Jacobi & VanDam, 2013). These tactics, while not particularly productive in terms of passing legislature, are extremely effective in securing local support from an increasingly bifurcated citizenry (Silver, 2012).

Lawyers have the unenviable task of providing language in laws that meets the intent of the law but also operates within the framework of the judicial system. Plain language considered too broad for lawmaking is often abandoned in favor of overly specific verbiage that leaves loopholes in the system. In 1999, Presidential Candidate Steve Forbes proposed a radical change to the nation's income tax system: the flat tax. This tax would apply to all working citizens and be a simple percentage of income. The proposed tax code written in plain language could have been executed in a handful of pages. In comparison, U.S. Title 26 of the Code of Federal Regulations defines the governance structure for the U.S. Tax Code, and is presented in 20 volumes (U.S. Government Printing Office, 2013).

Lobbyists represent the needs of corporate sponsors or public organizations. These lobbyists spend time discussing the interests of their specific stakeholder groups with lawmakers attempting to influence the intent and nature of laws. Because these lobbyists are paid by the industry groups or socio-political organizations that represent them, they vary in skill and power based on the amount of funding backing each organization – multinational corporations can generally afford more influential lobbyists than can grassroots political campaigns.

Is a tomato a fruit or a vegetable? This question is more than just a topic for academic debate classes; it underscores the competing needs that drive lawmaking. From a scientific classification perspective, a tomato is unequivocally a fruit; it is the product of the ripening ovary of a flower. This was not a trivial distinction to the Nix family of New York, who were importing tomatoes and Port of New York Tariff Collector George Hedden attempted to impose a 10-percent vegetable tariff on the business (Sterbenz, 2013). In 1893, the U.S. Supreme Court ruled that a tomato is a vegetable because it serves the purpose of a savory addition to a main meal rather than a sweet complement in a dessert (*Nix v. Hedden*).

EQUAL PROTECTION UNDER THE LAW

Despite the Declaration of Independence assurance that "all men are created equal," lawyers immediately began the process of negotiations when drafting the U.S. Constitution to back away from this assurance. Article 1 Section 2 of the Constitution states that the number of Representatives of a state shall be determined by the full count of free persons, three-fifths of the number of slaves, and completely excluded the number Indians in a given state. Further, the Constitution included language in Article IV to ensure that commercial slavery would be a legal practice (National Archives, n.d.). These compromises were necessary in order for the ratification of the Constitution by states in the agricultural South, whose economy was supported by slave labor.

After the U.S. Civil War, Congress ratified the 13th, 14th, and 15th Amendments, which abolished slavery and established the equal rights of all citizens regardless of race or color; however it was not until 1920 when women received the right to vote under the 19th Amendment (National Archives, n.d.). It would seem that even though all men are created equal, all citizens are not.

MARRIAGE EQUALITY

The struggle for equal protection under the law did not end with these Constitutional Amendments. Segregation in the American South continued well into the 1960s, and only in 1967 was the right to marry guaranteed to all citizens regardless of race or color. In *Loving v. Virginia* (1967), the U.S. Supreme Court ruled that marriages between members of different races were protected under the 14th Amendment. Again, the right to marry is far from an academic distinction. Over 179 tax provisions, employee benefits to family members of federal workers (including military), coverage under the Family Medical Leave Act, Social Security benefits, immigration status, and decisions regarding medical treatment of loved ones are among the many rights provided to U.S. citizens that are affected by the legal designation of marriage (Human Rights Campaign, 2014).

Society has changed its views on the legal definition of marriage. Recent polls indicate that a majority of citizens support the right for same-sex couples to marry (Saad, 2013). Despite this majority view, organizations supporting a "traditional" definition of marriage as being a relationship between one man and one woman lobbied U.S. Congress to pass the *Defense of Marriage Act* (DOMA). DOMA officially excluded providing the same federal benefits to same-sex couples married under state laws (Human Rights Campaign, 2014). This is despite the fact that the definition of marriage under DOMA is not necessarily the "traditional" or Biblical definition of marriage that many politicians claim. In many cultures, polygamy is not only accepted, but it is considered a necessary mechanism to preserve culture, and was an accepted practice in the Judeo-Christian tradition of marriage (Genesis 6:3, Genesis 25:1, 1 Samuel 25:39 – 44, 2 Samuel 5:13). Both polygamy and the real target of DOMA (i.e., unions between homosexual couples) run counter to the beliefs held by the extremely influential (and well-financed) Christian Coalition. Christian Coalition lobbyists spearheaded the campaign to pass DOMA when a number of states began to provide marriage benefits to same-sex couples. Despite equal protection under the law provided by the 14th Amendment, specific laws such as DOMA work to exclude the rights of citizens to meet the political aims of certain stakeholder groups holding a minority opinion, but wielding great political and financial influence.

FREE SPEECH, COPYRIGHT LAW, PRIVACY, AND THE INTERNET

According to Article I, Section 8 of the U.S. Constitution, Congress is empowered to "promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries" (National Archives, n.d.). In order to protect this right for authors and inventors, Congress passed the Copyright Act of 1976, which became incorporated into the U.S. Code of Federal regulations as Title 17 (U.S. Copyright Office, 2014). This law gives exclusive rights to usage and distribution of original content developed by a person or organization and encourages creative thought, invention, and scientific progress. The protection under copyright laws is central to many industries, including arts and entertainment.

As technology to reproduce works of art, science, and technology advanced, copyright law evolved. In less than 40 years since its original passage, U.S. Copyright law has been amended nearly **70 times** (U.S. Copyright Office, 2011). These amendments focused mainly on clarifying copyright law in terms of technology advances. For example, in 1984, copyright law was amended to accommodate the video rental industry. In the same year, copyright protection was extended to semiconductor design, as the personal computer industry began to blossom and semiconductor manufacturers were struggling to preserve their intellectual property. With the rise of the Internet as a medium for public communication, copyright law became tested in ways never imagined. Copyright law had been amended so many times to account for changes in technology, that in 2010 Congress passed an amendment simply to consolidate changes made to Title 17 over the previous 34 years (U.S. Copyright Office, 2011).

As Napster and other file-sharing technologies rose, the entertainment industry fought to protect their rights to claim royalty payments for distribution of their work. Something had to be done to account for the easy access to sharing information via the Internet, and therefore protect Internet Service Providers from liability when end users violate copyright law. Congress passed the Online Copyright Infringement Liability Limitation Act to ensure that the companies responsible for providing Internet access to millions of users would not be held legally responsible for Napster users (Berschadsky, 2000). In the same vein, the Recording Industry Association of America (RIAA) was suing Napster for enabling massive violations of copyright law. In a landmark case, the U.S. Ninth Circuit Court of Appeals decided that Napster was liable for the legal violations of its users (Blackowicz, 2001). Napster subsequently ceased operations.

The First Amendment to the U.S. Constitution states that Congress "shall make no law … abridging the freedom of speech, or of the press" (National Archives, n.d.). With the advent of Web 2.0 and social media as a platform for users to express their right to free speech came new challenges to privacy. As more people began posting their private information on social media sites such as Facebook, Twitter, Pinterest, and Instagram, the need to draw the line between free speech and privacy became more prevalent. Since 2000, stories of people being fired or denied employment opportunities because of blog and social media posts have become more prevalent. Employers began requesting access to applicants' social media accounts as part of the interview process. In 2012, Congress considered the Password Protection Act, but failed to pass it as a federal law. A number of states have passed protections of free speech specifically dealing with protecting social media posts by employees and applicants; Congress has left this debate to be an issue to be resolved at the state level (Kravets, 2013; Greenberg, 2014).

In addition to Freedom of Speech, the U.S. Constitution ensures the rights of all citizens to be protected against unreasonable search and seizure. The Constitution's Fourth Amendment guarantees that citizens will be "secure in their persons, houses, papers, and effects, against unreasonable searches and seizures" without a warrant based on probable cause (National Archives, n.d.). This right not to be searched without probable cause was tested in San Diego, CA recently. In 2009 David Riley was stopped for a traffic violation (expired tags) and was eventually arrested for driving with a suspended license (Ford, Ayer, Day, & Fisher, 2014). Upon his arrest, officers opened his smartphone and found text messages using slang associated with gangs. After a much more thorough search at the stationhouse, police determined that Riley was associated with a previous shooting incident and arrested him on weapons and gang violence charges (*Riley v. California*). At issue is whether it was reasonable for officers to search his smartphone in the first place without a warrant. There were no weapons visible in the vehicle and he had not been an active suspect in a crime. Officers contended it was necessary to search the phone in order to establish his identity, but his identity had already been established using a Driver License (Ford, Ayer, Day, & Fisher, 2014).

In June 2014, the U.S. Supreme Court sided with Riley in stating that police officers needed to secure a warrant in order to search a person's smartphone (*Riley v. California*). The nature of the data included in a smartphone far exceeds the detail that would normally be available by searching a person's wallet and other easily accessible documents. The presence of text messages, geo-location services, pictures, and social media make the smartphone an ideal tool for linking people to crimes. However searching a smartphone without first establishing probable cause through other means of police investigation is a violation of the rights guaranteed by the Fourth Amendment.

In a move to protect the rights of its customers, both Apple and Google announced that the latest versions of the Apple iOS and Android operating system would be encrypted by default. Both companies further stated that they would not have the technical ability to decrypt the contents without interaction by the owner. Based on this, it would be nearly impossible to search a smartphone even with a warrant without the owner's cooperation (Timberg, 2014). This move can be considered a step in the right direction of protecting the privacy of private citizens from government encroachment. However, law enforcement officials including the U.S. Federal Bureau of Investigation Director James Comey have stated concerns that this will serve to shield terrorists, pedophiles, and other violent criminals, placing them beyond the reach of law enforcement and making these the "phone[s] of choice for the pedophile" (Timberg & Miller,

2014). The question of privacy with regard to smartphones is still very much and issue of balancing free speech with the need to protect the public.

FOR-PROFIT EDUCATION

The rise of the Internet as a communication medium has resulted in a dramatic shift in the face of postsecondary education. For-profit colleges and universities have been making significant headway in the realm of higher education. A recent *New York Times* article noted that the equation was simple: more education yields more money for employees (Porter, 2014). Unfortunately, the data do not match the hype promoted by the for-profit schools. For-profit schools are simply not effective in providing education to their students and do not prepare students for a career in commercial industry.

Why is any of this relevant to lawmakers? People have a choice of educational options, and for-profit schools should be considered viable. The theory behind for-profit education is that these schools are more closely aligned with the needs of employers as they themselves represent the commercial industry.

A significant amount of taxpayer funding goes to postsecondary education in terms of Federal Student Loans and G.I. Bill benefits to veterans. According to a U.S. Senate investigation, of the top ten schools receiving G.I. Bill benefits to pay for education, more than 90% of the funding goes to for-profit schools (United States Senate, 2014). These statistics alone should grab anyone's attention. When combined with federal statistics regarding the success rate of for-profit purveyors of postsecondary education, these numbers highlight the need for serious legislative intervention to prevent the continued fleecing of the American taxpayer. While students of for-profit universities account for only 13% of all students enrolled in postsecondary education, they represent nearly 50% of all defaults in federal student loans (United States Senate, 2014). Students of for-profit universities pay at least 50% more for their education, are half as likely to graduate, and carry twice as much debt than their colleagues attending public universities (Kena, et al., 2014, OECD, 2014).

Even while ignoring the financial issues that directly affect the American Taxpayer, for-profit universities are not effective in preparing students for success in commercial industry. Between 35 and 57% of the programs at the four for-profit universities receiving the most G.I. Bill federal funds (67% of the top-ten schools receiving G.I. Bill funds) fail to meet proposed federal standards to demonstrate that their programs prepare students for employment (United States Senate, 2014). Congress has not officially sanctioned these federal standards in large part because of the significant power of lobbyists by these corporations. Despite federal investigations and lawsuits, for-profit education remains a billion-dollar industry (United States Senate, 2014).

The data clearly indicate that for-profit colleges and universities are a drain on taxpayer dollars and ineffective in producing results. The power of the industry lobby combined with Congressional unwillingness to threaten jobs in their districts has resulted in complete inaction to resolve this problem and force for-profit colleges and universities either to improve their programs or cease their operations. Again, the complexity of competing needs by stakeholders allows these corporations the legal maneuverability to survive on taxpayer dollars while providing almost no tangible benefit to the U.S. economy, but at great cost to the taxpayers.

REQUIREMENTS-DRIVEN LEGISLATURE: A NEW APPROACH TOWARD LAWMAKING

The core problem that drives the lack of efficiency of laws in the cases above is that the laws were written to be specific to a particular circumstance and did not focus on the needed results. Laws should focus not on the specific technologies, but on the desired results. In this way, laws can withstand the test of time and need not be updated continuously to follow the pace of technological evolution. This can be accomplished by aligning lawmaking techniques with the Systems Engineering discipline of Requirements Analysis.

In classic Systems Engineering best practices, the primary difference between Requirements and the Implementation is that Requirements are results-driven, while the Implementation is technology-specific. Technology changes over time, and establishing requirements that focus on the technical solution will lead to an inflexible, fragile architecture that cannot withstand technological innovation. By setting requirements that model a specific technical solution, those requirements prevent the adoption of disruptive technology that meets the end goals, improves overall performance, but fails to meet technology-specific requirements (Sahlin, Sarkani, and Mazzuchi, 2012).

By aligning lawmaking with Requirements Analysis, legislators can first establish a framework for defining the desired end-goal, without focusing on the specific implementations. Well-defined requirements for systems are:

- Necessary
- Implementation independent
- Clear and Concise
- Complete
- Consistent
- Achievable
- Traceable
- Verifiable (INCOSE, 2011)

Requirements for laws should follow the same guidelines. In this way, lawmakers can spend time focusing on defining the end-goal before focusing on specifics. Legislators should follow the same process of Requirements Analysis used by Systems Engineers to define the desired outputs of any system. Figure 1 below identifies the Inputs, Controls, Enablers, Activities, and Outputs associated with the Requirements Analysis process. Note that in this process, the outputs define measures of effectiveness and performance but do not define a specific technology solution. Requirements focus on the outputs, not on the solution.

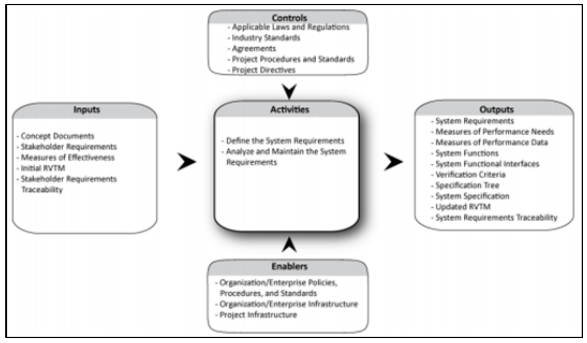

Figure 1. Context Diagram for Requirements Analysis Process (INCOSE, 2011)

This process would involve the same stakeholder analysis followed by traditional Systems Engineers, including all affected parties of the process, including the end customer (i.e., the constituency requesting said law), the implementation team (i.e., Legislative, Judicial, and Executive branches of Government), and any other party that may be affected by the project's outcomes. Figure 2 below identifies the role of the Systems Engineer at the center of the action, eliciting requirements from stakeholders, maintaining a working relationship with the Implementation Team to ensure the solution meets the needs, and supporting lifecycle processes to execute and maintain the resultant system. When eliciting the requirements from stakeholders, it is critical to understand the semantic nature of the requirements. By focusing first on the semantic nature of the requirement, the Systems Engineer can identify the root need of the system (i.e., the Mission). Once establishing the Mission, the Systems Engineer can derive Task and Activity requirements that flow from the main goal, establishing a flexible and extensive baseline to meet current needs and support advances in technology (Zhang, Liu, Wang, & Chen, 2012).

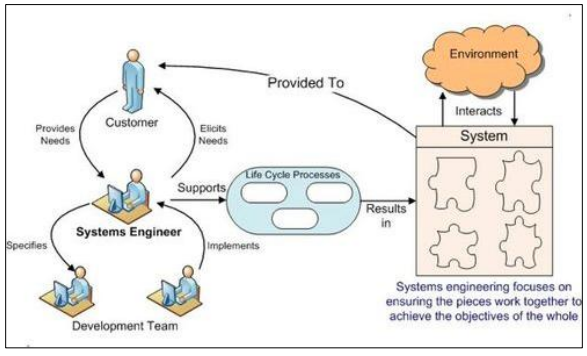

Figure 2. Engineer balances Requirements and Solution (INCOSE, 2011)

It is important to consider not only the needs of the direct "customers" of this process, but also the customers of your customers to ensure a thorough investigation of stakeholder needs (Wood, Sakrani, Mazzuchi, & Eveleigh, 2013). Legislative deadlock has been an increasingly common issue in politics over the past 20 years. At least one reason driving the increase in deadlock is the fact that local constituencies have become more partisan. While legislators are charged with serving all citizens, they also have the need for re-election. In highly polarized constituencies, legislators feel the need to play politics and serve the needs of the party rather than the needs of the people (Silver, 2012). Figure 3 below identifies the increasing polarization of U.S. Congressional Districts since 1992. This polarization encourages legislators to put the needs of their party before the needs of the polity, as the party machine is responsible for funding elections. Unless legislators can find a way to engage not only their direct customers (i.e., voters and the party) but also the extended stakeholder view, this trend toward legislative deadlock will continue.

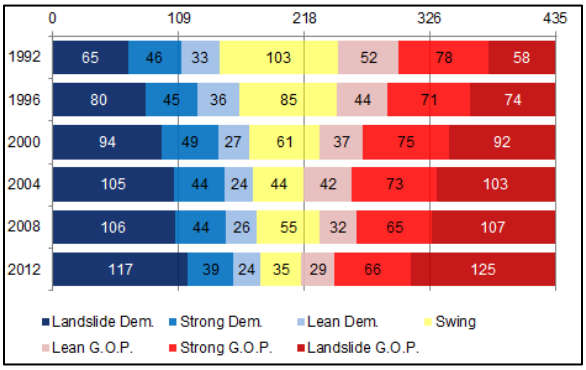

Figure 3. Polarization of U.S. Congressional Districts (Silver, 2012)

This process of stakeholder involvement is recognized not only in Systems Engineering best practices but also in studies of improving the legislative process. Researchers from Princeton University conducted an evaluation of legislative actions involving the collective bargaining involved in the development of laws. The research team found that involving the minority party during negotiations to establish a resource-based collective bargaining (i.e., Competitive Partisanship) was far more effective in reducing legislative gridlock than focusing merely on procedural and partisan grounds (Krehbiel, Mierowitz, & Wiseman, 2014). This theory of Competitive Partisanship is effectively the same process as requirements elicitation by the Systems Engineers of affected stakeholders.

After establishing the desired end-goal with the affected stakeholder community, the Legislators (i.e., Systems Engineers) must continue to participate with the remainder of the Implementation Team (i.e., Judicial and Executive branches) to realize the vision of the end-goal. This implementation must be executed in a manner consistent with the desired end-goal, but also must exist with the context and framework of the system's overall environment (i.e., current body of law, ability to execute, enforceability, etc.). Just as a system must be feasible form a cost/schedule/technical perspective, laws must also be feasible and realistic to execute, enforce, and maintain. By involving the Judicial and Executive branches in the Legislative Requirements Analysis process, legislators can avoid delivering a system that is not likely to coexist within the overall system (i.e., an

unconstitutional law). Legislators should adopt the Systems Engineering best practices of Requirements Analysis and stakeholder engagement to define the desired end-goals of laws in context of the current system environment. While no guarantee, the Legislative Requirements Analysis process would dramatically reduce the passage of laws that are fundamentally flawed, run the risk of being unconstitutional, and are anathema to the foundational principles of our government – to serve the needs of the polity, preserve its freedoms, and protect its members from threats to Life, Liberty, and the Pursuit of Happiness.

CONCLUSION

Because the issues of technology have dramatically changed the meaning of publication, the press, and distribution of content, laws such as copyright and protection of free speech have become the focal point of law and technology. Technology changes far more rapidly than the lawmaking process can support. Therefore, change to the overall process is necessary to ensure that laws not only serve the needs of the citizenry today, but are extensible enough to handle the rapidly changing face of technology. Legislators should adopt the best practices of Systems Engineering to improve the overall process of lawmaking.

Competitive Partisanship and other forms of stakeholder engagement during the Legislative requirements Analysis process not only help reduce legislative gridlock, they consider the system environment issues of enforceability, feasibility, extensibility, and Constitutionality to improve the overall quality of the system. Specifying the end-goal without regard to specific technologies allows lawmakers to fulfill their charge – establish laws that "provide for the common defence [sic], promote the general Welfare, and secure the Blessings of Liberty to ourselves and our Posterity" (National Archives, n.d.).

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