THE SYSTEMS PERSPECTIVE

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Executive Summary

The system perspective expressed in systems thinking both sets systems engineering apart from the other engineering disciplines and constitutes the substance of its relationship with other systems disciplines. This engineering distinctive and systems common ground is the central concept for systems engineering. It carries power and leverage yet is understood only in a superficial way by most practitioners. This paper addresses the power that the systems perspective and systems thinking bring to the systems engineering practice. A topic regarded as esoteric by its very practitioners is reframed to deliver practical benefit from embracing the systems perspective.

The systems perspective underpins the problem-solving process, guiding the rigorous application of systems principles to build solutions that deliver workable answers to customer and stakeholder needs. It elevates our view, broadening our understanding of the problem and expanding the possible scope of solutions. It enables us to see possibilities for applying systems engineering far beyond its original roots. As such, embracing and leveraging the systems perspective to improve systems engineering – both in the manner and breadth of its application – drastically expands our ability to serve society and address the complex challenges we face today.

Introduction

Why a paper on the systems perspective? Why do we need a theoretical discussion of systems concepts? What can be gained from exploring this subject at the theoretical level?

Anytime we begin a discussion of the principles of systems engineering, we are immediately under pressure from the professional audience to avoid what are cast as esoteric or peripheral discussions. Excursions into the theoretical underpinnings of the discipline are greeted with questions from the polite and outright criticism from the rest. There is among engineers an intense need or desire to "keep it practical."

This is not surprising given the nature of engineering itself. The word engineering has its roots in two related Latin words: ingenium and ingeniare. Taken together these two roots mean to "cleverly devise." Engineers apply their tools and methods to cleverly devise solutions to real world problems. This gives engineering an active, interventional orientation. This orientation provides the differentiator between systems engineering and some of its sister systems disciplines (e.g., systems thinking and systems science) where the emphasis is on studying, describing, and understanding systems without an intent to intervene or modify. In the engineering world, this practical orientation frequently translates into a natural resistance to the theoretical.

But the theoretical has a definite place in the conversation and thought processes. The first level of education is where we learn the answers while at the second level we learn the questions. The questions reside at the theoretical level. It is at the theoretical level where we see the relationships among the concepts and can begin to make judgments.

Why does this discussion matter to systems engineers? There are two major reasons – or categories of reasons – that all practitioners should pursue a basic theoretical understanding of the discipline. First, it is the theoretical that makes sense of the disciplinary process and practice. The theoretical provides the context and rationale behind the values driving the practice. As such, the theoretical becomes the way we identify good and bad practice and make decisions about process improvement within the discipline.

The theoretical also sets the contextual interface of the discipline and the problems that the discipline can/should embrace. If we can learn to recognize our problems at the theoretical level, then we can see opportunity on a broader plane. It is often tempting to see our relationships at the most granular and routinely familiar level. A solid theoretical understanding can be the key to seeing beyond the usual borders as we look for opportunity and challenge.

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Theoretical Foundations

Systems engineering is a systems discipline. As such, it shares systems thinking and the systems perspective with its sister disciplines. Just as systems thinking, systems dynamics, systems science, and others are grounded in the study and framework of systems, systems engineering has its foundation there as well. The systems perspective is used by all of these as the lens through which they see their problems and solutions. That view involves seeing holistically and synthetically.

The systems perspective is the cornerstone of systems engineering. The systems perspective is also what sets systems engineering apart from the rest of the engineering world. Other engineering disciplines are charged with particular slices of design problems, but no other discipline has the management of the overall system with all its interfaces and results as its beat. Whereas systems engineering's thinking is synthetic, those disciplines take a reductionist outlook.

Systems engineering sits astride the two worlds of systems disciplines and engineering. Systems thinking ties it to the systems disciplines and differentiates it from the engineering disciplines. Engineering and its interventionist nature binds systems engineering to the other engineering disciplines while separating it from the systems practices. In order to embrace both charges – to think systemically while intervening to make improvements and solve problems – the systems perspective is absolutely critical to the role of systems engineering.

Despite its critical importance to the systems engineering role and process, systems thinking and the systems perspective are often neglected or compromised. This most often happens when the system definition itself is neglected in the construction of the design process.

Most system definitions share language along the lines of "a construct or collection of different elements which together produce results not possible for the elements alone." There are three important characteristics: different elements, an arrangement in a construct, and results not possible for any of the elements by themselves.

Insight into the nature and results of a system require us to see all three of the system's definitional aspects at once. The central task of the systems engineer is to construct a solution whose results satisfy the requirements that necessitated the creation of the solution. The systems engineer needs to see those results and to do that must see the elements in the context of the construct that holds them in relationship to each other.

The Systems Engineering Challenge - A Mechanistic Heritage

Until the second half of the 20th century most engineering problems were regarded as mechanistic and occasionally complicated. This is an outgrowth of the worldview that emerged from the enlightenment. In that worldview, the operation of the universe was regarded as being the product of a set of natural laws. These laws operated in a largely linear fashion where causes directly produced effects predictable from the application of those laws.

The shift away from the medieval worldview began with the astronomical work of Nicolaus Copernicus in the 16th century and Johannes Kepler in the 16th and 17th centuries. The shift continued through the research and thinking of other scientists like William Harvey and his medical studies. It found full flower in the work of English physicist Isaac Newton and French philosopher-mathematician Rene Descartes.

The common thread running through their work on a variety of topics (the solar system, the circulation of blood, motion, calculus, etc.) was that the operation of natural systems is governed by a set of natural laws that determine the outcome of the interactions of the elements with each other. Therefore, one needs only to understand the relevant laws and the circumstances (conditions) of the interactions to accurately predict the outcomes.

In such a linear and deterministic framework, there can be many elements and a variety of relationships, but the laws governing their interactions still produce predictable results. Such multi-element/multi-relational systems are "complicated" systems and produce complicated problems. But these complicated systems and their attendant problems were addressed mechanistically using the linear cause and effect paradigm.

In order to deal with complicated systems and their problems, scientists and mathematicians resorted to breaking the systems apart and examining the interactions and relationships one (or one set) at a time. The pieces of the puzzle were then aggregated into a complete picture with the total result being a summation of the smaller pieces. This process, which we know as analysis, made thinking about the complicated problem a more manageable prospect. It resembled the way one would disassemble a machine into its constituent parts.

As this reductionist process became more the rule than the exception, it spawned another characteristic of the way that we organize our problem solving: specialization. By dividing the problem (or system) into pieces, it became apparent that there were ways in which the pieces of analysis could be grouped together by their similarity in materials, tools, methods, etc. There were obvious gains in knowledge and skills to be had from this narrowing of focus.

This eventually resulted in bright-line disciplinary specializations. Medicine would see this as the "ologies" (e.g., cardiology, neurology, nephrology), and engineering would see the development of the base disciplines (e.g., mechanical, electrical, metallurgical). It all traces back to the breaking down of systems and problems as a way of understanding them.

Problems with the Mechanistic View

Whereas a medieval doctor would treat the patient as a whole, the modern doctor might treat only a very narrow part of the human system. Many ailments are now addressed in a piecemeal fashion that grows out of the specializations of the physicians involved. But this can highlighted the weakness of the analytic specialization approach. For example, some coronary artery bypass patients develop depression and anxiety which can lead to an increased morbidity rate[1]. Treatment for the unipolar depression typically involves another health care professional with the "appropriate" specialty because the obstructed coronary arteries and psychological processes of the patient fall into two different categories in the medical specialization taxonomy.

In considering the holistic approach of early medicine, it is important not to confuse the value of the approach with the quality of the information upon which it operated. A medieval doctor might have regarded the four "humours" or bodily fluids (blood, yellow bile, black bile, and phlegm) as governing physical and psychological health – a long de-bunked theory – but his holistic approach was not without value. Likewise, the increase in medical knowledge is not a blanket validation of the specialty approach.

Another pressure on the analytic/reductionist approach has been the appearance of complex problems and systems. Instead of the linear strings of cause and effect leading to results that we find in a complicated system, the results in a complex system "emerge." Emergence can be thought of as the manifestation of "properties which are meaningful only when attributed to the whole, not to its parts.[2]" A convenient example of this emergence of behaviors and properties is the water molecule. Neither hydrogen atoms nor oxygen atoms nor even individual water molecules are "wet." But combine a group of hydrogen atoms with a group of oxygen atoms in the familiar two-to-one ratio (H2O), collect the resulting molecules, and the water produced is "wet." Wetness emerges as a property of the combination in a non-linear fashion. Whereas the rotations of watch hands is a predictable result of a series of sequential rotations of its gears, the property of wetness in water simply emerges. That manner of manifesting the properties/results distinguishes the "complicated" watch mechanism from the "complex" water molecule.

Here it would be prudent to note that no rigorous formality governs the use of the words complicated or complex. If we compare their definitions in most sources, "complicated" and "complex" seem to be pretty much the same. The scientific and non-scientific literature tends to use them interchangeably. For purposes of this discussion, the production/emergence distinction highlights a critical differentiation.

The Systems Engineering Challenge - Complexity

The principle challenge facing systems engineering is complexity. Complexity comes in a variety of flavors. One way of dividing it rests on what produces the effect of complexity. In this framework complexity can be either detail complexity or dynamic complexity.

These two types of complexity are discussed by Peter Senge in his book The Fifth Discipline. He first describes the most commonly recognized form of complexity: detail complexity. Senge argues that this form of complexity is the most common and therefore our management tools are generally designed to deal with it, often at the expense of the discovery and management of the second category of complexity, dynamic complexity. Senge writes:

> (The) reason that sophisticated tools of forecasting and business analysis, as well as elegant strategic plans, usually fail to produce dramatic breakthroughs in managing a business (is that) … they are all designed to handle the sort of complexity in which there are many variables: detail complexity.[3]

Senge continues:

> The second type is dynamic complexity, situations where cause and effect are subtle and where the effects over time of interventions are not obvious. Conventional forecasting, planning and analysis methods are not equipped to deal with dynamic complexity. The real leverage in most management situations lies in understanding dynamic complexity not detail complexity.[4]

While Senge's interest in the differences and relative importance of these two kinds of complexity is well taken and important, it is beyond the scope of our discussion. For our purposes, it will suffice to note that these two categories of complexity exist and that they exist at the system level. Detail complexity is the closest cousin to what we have called "complicated." That resemblance may have some bearing on Senge's assessment of the management tools oriented to detail complexity as inadequate for dealing with dynamic complexity.

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Complexity rears its head in systems themselves in at least two other forms. Complex systems can be thought of as complex physical systems or complex adaptive systems. Complex physical systems are typically made up of elements in relatively fixed arrangements or patterns. A given arrangement of the elements is referred to as a "state," and complex physical systems transition from one state to another by a set of "rules." These rules are not necessarily deterministically applied. State A is not necessarily followed by State B, but the transition from State A to any other State X can always be explained in terms of the operation of the rules. Work with these systems has spawned interesting research into patterns, motifs, and memes.

Complex adaptive systems are made up of elements commonly referred to as "agents" that "learn" as the systems accumulate experience. The interaction of adaptive agents in the complex adaptive system produces results which vary over time. Many natural systems (e.g., coral reef ecosystems, the human immune system) are complex adaptive systems. Some of the most exciting and important work in the systems arena is happening in the effort to understand, predict, and even modify their processes.

Complexity can also appear in combination. Complex physical systems often manifest detail complexity. Complex adaptive systems by definition involve the changes over time that characterize dynamic complexity. These combinations add to the intricacy (and interest) of the problems around those systems.

The study of complexity allows us to make predictions about the actions of the systems even in situations where it is not possible to predict the actions of any of the individual agents. This enables solutions to problems of increasing difficulty and provides for the possibility of interventions that can alter the course of system changes over time.

The hope for high quality solutions to these problems lies in acquiring a view of the problems, their environment, and the potential solution set. Understanding complexity over time requires a comprehensive (encompassing elements and relationships) and longitudinal (revealing interactions) view. Anything less deprives the problem solver of critical insight. This is the systems perspective which we see as they key to insight.

By way of a simplifying illustration, return to the example of the clinically depressed cardiac surgery patient. A failure to recognize and address the depression will lead to a worsened morbidity result in the affected patients (15-20% according to Tully and Baker). The need for a systems perspective of the patient is, or should be, obvious. Without a knowledge of the processes and ramifications of depression, the cardiac surgeon would be forced to accept the impact of the depression on the patient's recovery.

While the foregoing discussion of complexity is greatly simplified, it should be sufficient to make the point that insight into the complex problem and its potential solutions lies in the ability to see and understand the complexity in its entirety. The modern systems engineer does not have the luxury of taking a divided path to the problem-solving journey. The intricacy and dependencies of complex systems and their environments makes a comprehensive view absolutely critical for insight.

The physicist Fritjof Capra observed:

> According to the systems view, the essential properties of an organism, or living system, are properties of the whole, which none of the parts have. They arise from the interactions and relationships among the parts. These properties are destroyed when the system is dissected, either physically or theoretically, into isolated elements. Although we can discern individual parts in any system, these parts are not isolated, and the nature of the whole is always different from the mere sum of its parts.[5]

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Capra not only underscores the point that a system must be seen in whole in order to see its properties but goes further in his observation that isolating the elements destroys those properties. Insight into the essential nature of a system depends on viewing it in whole. Viewing it in part(s) denies us the insight.

The criticality of the systems perspective affects our work in two primary ways. First, the systems perspective grounds our practice and helps us to make sense of our processes. We use its insights to keep us on track, moving logically to an effective solution.

Second, taking a systems perspective allows us the insight to better understand the problem, the environment, and the potential solution set. By using the insight of the systems view to broaden our perspective, we can solve the right problem in a way that will work in the system context using the broadest possible set of potential solutions. Hence, we deliver the highest quality solution for our stakeholders.

The Theoretical Makes Sense of the Disciplinary Process and Practice

The fundamental task of the systems engineer is constructing a systemic response to the needs of the system stakeholders that will satisfy those needs. The needs (expressed as requirements) are met through the system behaviors (functions) of the solution system. Those functions are performed by the solution architecture constructed for that purpose.

Traditionally this comes about through the design team gathering requirements, performing a functional analysis of what was needed to satisfy the requirements, and constructing a physical architecture to perform the necessary functions. This is validated (are we solving the right problem) and verified (did we get the solution right) against the stakeholder needs.

When we look at this design process we see that we are making a prediction concerning the results of the system we are designing. Our prediction is the basis of matching the solution requirements and the solution results. To visualize this, imagine that the requirements describe the shape of a missing puzzle piece. Our task is to create the piece itself in the form of solution system results that will fill exactly the hole described by the requirements.

In order to create a piece that fits, we need to understand what the results of the design will be. Those results must be behaviors that satisfy the requirements. Those behaviors result from the interaction of the system elements in relation to each other and the environment. The relationship of the elements is determined by the construct that defines the relationships. To predict the results, the systems engineer must see the behaviors, the elements, the environment, and the construct in a unified picture.

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This is where models enter the picture. Especially in the light of the complexity that makes up the environment and creates the problems to be solved, the systems engineer must have a disciplined and rigorous way to keep the view of elements, construct, and results in focus. A model provides a practical way to accomplish that goal.

Models are limited representations of a given reality. In the case of a systems design project, the model is a representation of the requirements that define the needs, the behaviors that meet the requirements, and the implementation structure that performs the behaviors. A model that does not accomplish that is inadequate as a systems design model.

The statistician George E.P. Box famously observed "All models are wrong but some are useful." Treating a model as a limited representation, the limitations will always make it "wrong" in the sense of being incomplete. But if the limitations create irrelevant incompleteness, the model is "useful" because it is accurate in all respects relevant to its use. Box himself elaborated, "Remember that all models are wrong; the practical question is how wrong do they have to be to not be useful.[6]"

The answer to Box's "practical question" lies in the purpose for which the model is constructed. In the case of systems engineering models, the answer lies at the border of including or not including the essential aspects of the systems perspective – the requirements, the elements, the construct that holds them in relationship to each other, and the results of their interactions expressed as systems behaviors satisfying the requirements. Any model offering a lesser view – that is one that is incomplete from the perspective of a systems view – will not qualify as a system model upon which systems engineering can be "based."

Other models with other limitation sets are not without value. They are certainly fit for their respective purposes, and those purposes may shed valuable light on the systems design. For example, physics-based models can play a valuable role in system design. But, they do not offer a systems perspective.

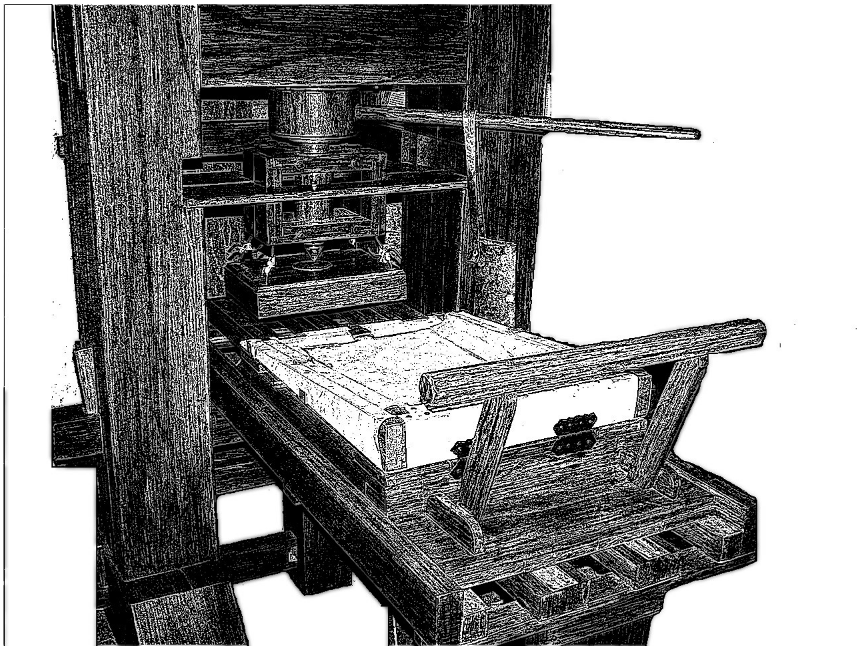
By focusing on maintaining the critical aspects of a systems perspective, the design process can traverse a path to solution that offers an assurance of success in meeting the stakeholders' needs. Leveraging a model to create and develop that view provides a map of the processes through which the design tasks are accomplished. In the context of the systems perspective the processes make sense, and the system design stays in focus.

The systems perspective is invaluable in another sense. Just as it guides our processes and provides the "big picture" for the engineering design, it also provides the systems engineer with a broader view of the possibilities – both in the immediate project and in defining the scope of problems where the discipline can add value.

The Systems Engineer Can Expand the Realm of Possible Soutions

In looking at the requirements and the behaviors needed to fulfill them, the systems engineer is confronted with a creativity challenge. A set of decisions need to be made regarding the implementation structure that will be crafted to perform the necessary behaviors.

"Originality often consists in linking up ideas whose connection was not previously suspected.[7]" Many authors and thinkers have published their conviction that creativity is not so much a process of coming up with "new" ideas as it is a process of combining existing concepts in new ways. From the Italian sociologist Pareto in his work Mind and Society to the more recent work of Arthur Koestler with what he called "bisociation," there is conceptual agreement that creativity and innovation rest on seeing new combinations in existing elements. Albert Einstein called it "combinatorial play."



Johannes Gutenberg's printing press presents a classic example. Gutenberg reached into his knowledge of agricultural production to "borrow" the concept of applying uniform pressure to the printing surface with a screw-based press like those used to extract the juice from fruits and berries. But he went much further with his borrowing. He used his awareness of chemical advances to create superior inks for his printing. The son of a metal worker involved in casting work, Gutenberg used his metallurgical knowledge in casting metal type with a consistent look that would allow him to print entire pages at a time. He used a large team of workers to set up a division of labor and increase his production rates. Those teams used his error-checking innovation – a straight line on one side of each piece of type so that any letters set upside down could be instantly spotted – to maintain the quality of his printed material. Gutenberg drew from a cross-disciplinary pool of ideas and combined his selections into an invention that fostered a turning point in western history.

The greater the number of choices, the wider the range of combinations that are possible in a creative process. Even a simple calculation of possible combinations is expanded exponentially by the addition of elements to the pool feeding the process. In the book A Technique for Producing Ideas, advertising executive James Webb Young lays out a five step process for generating new ideas. His very first step addresses the need to acquire the deepest possible pool of ideas from which to draw. He calls this gathering the raw material.

This process, according to Young, is not an easy path:

> Gathering raw material in a real way is not as simple as it sounds. It is such a terrible chore that we are constantly trying to dodge it. The time that ought to be spent in material gathering is spent in wool gathering. Instead of working systematically at the job of gathering raw material we sit around hoping for inspiration to strike us. When we do that we are trying to get the mind to take the fourth step in the idea-producing process while we dodge the preceding steps.[8]

It may not be simple, but it is critical to building creativity.

The other critical component is the ability to see relationships. The "raw material" must be organized and reorganized in different ways to create new combinations. According to Young, ". . . the habit of mind which leads to a search for relationships between facts becomes of the highest importance in the production of ideas.[9]"

The results produced by a system rest on the relationships among its elements. The ability to see and then instantiate those relationships is critical.

Gathering the raw material and thinking about the possible relationships both require a high-level point of view. Taking the problem and potential solutions at a high level of abstraction – the systems perspective – opens our eyes to the possibilities. If we think about problems and solutions at the low, "bending metal" level, we will have difficulty seeing and creating new relationships.

A low-level orientation tends to confine our thinking and knowledge gathering. We need to broaden our thinking to encompass other domains. Curiosity must become an integral part of our "work" frame of mind rather than a distraction to be eliminated. Systems engineers need to intentionally feed the pool of ideas with new knowledge. By learning to adopt the systems perspective and think synthetically, we can promote the curious, exploring mind-set. This allows the systems engineer to expand the realm of possible solutions and leads to higher quality results.

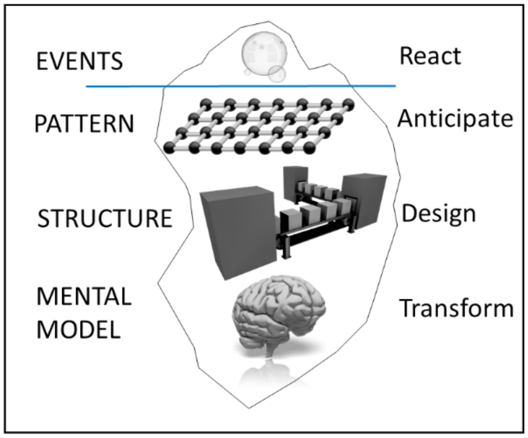
We Can See Opportunity at a Broader Level

If we see our discipline within the context of whatever particular application we are making of the practice, we tend to see the scope of its applicability as defined by the subject area. Thus, if we are using systems engineering in the design of an aircraft avionics system, we might see how it is applicable to the design of other control systems. The comparison we make at the application level focuses the comparison on the projects themselves rather than on the ability of the discipline to understand and solve problems.

If we look instead at the applicability at the theoretical level, we can see more broadly. In that case, we are looking at the characteristics of the discipline itself rather than the particular processes in which it may be engaged. The question of where the discipline may engage turns on the definition of the discipline rather than the definition of the problem.

As we look at problems, the systems perspective helps us think more deeply about the problems and their possible solutions. Our attention is generally attracted by problematic events that occur within our vision. We see them and wonder about their causes. Many, if not most, people stop here. This is what is known as event-oriented thinking. It assumes that any given event will have a particular cause. If this cause can be uncovered and redirected or removed, the event will not recur in its present form.

But there is a deeper path for thinking about problems and the systems in which they occur. The "iceberg model" provides a framework for systems thinkers to visualize the system from the way in which system behavior in a given system is produced. Used to approach and comprehend an existing system, the iceberg model begins with the manifestations of that system which are observable. These manifestations are referred to as events. In the context of the iceberg, these are behaviors, facts, data points, etc. which can be seen and associated with the system. They are the "above the waterline" part of the iceberg. Left as such, they are only able to support a reaction by the observer who may go look for "the" cause.



The Iceberg Model

But these behaviors or data points are visible manifestations of an underlying pattern of activity. Together with other unseen, unobserved data or actions, they make up a pattern produced by the system. In order to be correctly understood, they must be set into the context of the pattern. Without their context they have no meaning or, worse, they might be assigned a meaning that is invalid.

The same is true of observations in any system. There must be enough information to identify the underlying pattern. At best, the presence of events without a picture of the underlying pattern can support only a reaction. While the effort to understand and/or modify a system often begins with these "above the waterline" observations, it can only begin to accurately take on meaning when those observations can be set into the context of a behavioral pattern.

Once the pattern is identified, further observations can be predicted. Often the pattern can be posited from the data and the hypothetical pattern tested by checking it for consistency with other information gathered for that purpose. ("If this pattern is correct I would also expect to see ______." The presence or absence of ______ would tend to confirm or deny the existence of the pattern.)

The behavior pattern of the system is produced by its structure. In the iceberg model, this layer underlies the pattern beneath the surface of the water. It is often out of sight, as is the case, for example, with a criminal enterprise. In fact, in most criminal investigations it is this structure which is the real object of the investigation. Who is producing the pattern and how are they doing it are the central questions. The criminal investigator is seeking to interdict the structure and disrupt its function as the producer of the pattern. Similarly, an engineer may be seeking to alter, correct, or (in the case of clean sheet design) create the structure. By grasping the structure, the systems engineer can redesign it, thereby altering the pattern produced.

Where appropriate, it is possible to drill even deeper into the system. Although sometimes it is enough to move from reacting to events through anticipating the pattern to changing (dismantling, disrupting, redesigning) the structure, there are cases where we wish to go further. This takes us from the design into the transformation of the system. This is where solutions to really wicked problems – such as those around sustainability – live.

Such deep dives lead the systems thinker to the mental model that produces the structure. This mental model contains the values, assumptions, and worldview that drive the creation and maintenance of the structure. Just as in the familiar systems design solution the system structure is created to produce the behaviors that drive the system results to satisfy the requirements, the events are manifestations of the patterns that are produced by a system structure that comes into existence in response to a mental model. Changing this produces transformation.

Understanding this connection between the iceberg model and the systems engineering schema is the key that unlocks a broader application of systems engineering principles to real world problems outside the usual problem spaces. The opportunity for systems engineering to add value to the problem solving process lies wherever mental models produce structures that create patterns that show themselves in events. Translated that means that systems engineering has the opportunity to add value everywhere systems exist whether they be products, services, enterprises, or social systems.

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Take the issue of drug addiction for example. The pattern is one of addiction with visible events surfacing from the pattern as unlawful or unacceptable behavior. The addict may be found in possession of an illegal drug having had attention drawn to him by some drug-use induced misconduct. Children may be born with problems resulting from the mother's drug use. Such behaviors are the result of the pattern produced by addiction.

Typically, society responds to these problems by directly impacting the event behaviors themselves. Terms of imprisonment are imposed for the misconduct that drew attention to the drug addict and for the possession of the illegal substances. The design is to discourage the event behavior directly through negative consequences.

But this fails to recognize the pattern underlying the event behaviors. Addiction behaviors that become events (become visible to others) are a part of a larger pattern. If we think about the problem as systems engineers, we recognize this. We realize that the pattern is produced by an underlying structure. If we want to change the behaviors in any meaningful way, we must target the structure. Strategies aimed at the individual event are mostly, if not totally, ineffective because they leave the pattern intact and producing other events. At best, we can use the event-specific disincentive to drive the behaviors beneath the surface where they still exist but are hidden from view.

If we think in terms of events, we can hope only to react to them. Understanding that they are part of a pattern and discovering that pattern allows us to anticipate other events based on the pattern. We can begin to intervene at the structural level. If we change the structure we can alter the pattern and exert control over what events do and do not occur. Systems engineers understand this in the context of an architecture that performs behaviors. We regularly change system behavior by creating or changing the implementation structure (architecture). We even do this in order to meet specific requirements which are satisfied by particular behaviors.

It should be obvious that meaningful change in a social policy setting can be achieved through the application of this same framework. The requirements specify the desired behavior. The structure that produces that pattern of behavior can be achieved through intentional alterations. Designing the structure to produce the pattern that will meet the social requirements is pure systems engineering work. The content and supporting science are simply different from the usual application of systems engineering.

It is not possible to come to a realization of that correlation without adopting the systems perspective on problems and solutions. The systems engineer who thinks in terms of specific solutions applied repeatedly to particular problem sets will tend to make connections only at the most granular level, if at all. After all, what does sonar design have to do with drug addiction?

The world of opportunity lies beyond the familiar. The bridge to that world is constructed on the realization that systems perspectives, systems thinking, and the systems view have application to a broad range of problems – everywhere the iceberg model is active in creating a systems environment that can be improved.

Summary and Conclusion

Systems engineering is based on the systems perspective. This perspective creates a commonality with other systems disciplines and, at the same time, is distinctive among its fellow engineering disciplines. While this perspective is, at times, not well understood and is often honored more in the breach than the observance, it is both important and powerful in the systems engineering practice.

In our world of increasingly complex problems, the systems perspective offers a way to meet those challenges that is comprehensive and effective. The perspective underpins the problem-solving process, guiding the rigorous application of systems principles to build solutions that deliver workable answers to customer and stakeholder needs.

In addition, the systems perspective provides a way to achieve a high level of quality by broadening the choices of solutions. Ideas that would go unnoticed come to light through the system thinking processes that allow the problem solver to consider a wider range of elements and relationships. This improves solution quality.

Finally, the systems perspective enables us to see the possibilities for applying systems engineering. While the profession tends to see itself in terms of its origin, that is the result of comparing applications at the most granular level. The systems perspective allows systems engineering to raise its perspective and see the possibilities wherever there are systems and problems to be solved.

References

1. Tully, P and Baker, R. Journal of Geriatric Cardiology, (J Geriatr Cardiol. 2012 Jun; 9(2): 197–208.)
2. Checkland, Peter. Systems Thinking, Systems Practice, 1999.
3. Senge, Peter. The Fifth Discipline, 2006. p. 71.
4. Senge, Peter. The Fifth Discipline, 2006. p. 71.
5. Capra, Fritjof. The Web of Life, 1996. p. 29.
6. Box, George E.P., Empirical Model-Building and Response Surfaces, 1987.
7. Beveridge, W. I. B. The Art of Scientific Investigation, 1957.
8. Young, James Webb. A Technique For Producing Ideas, 1939.
9. Young, James Webb. A Technique For Producing Ideas, 1939.

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Zane Scott, Vice President of Professional Services, manages Vitech's consulting and training organization. For the past twenty-five years, Zane has built a skill set which enables him to provide insight and guidance to individuals and companies as they improve organizational processes and methodologies.

Zane has also taught systems engineering methodology in a variety of settings, is a frequent blogger and webinar presenter on MBSE, and is co-author of Vitech's book *A Primer for Model-Based Systems Engineering*.

Vitech provides systems engineering solutions including software, services, training and support for global customers with diverse applications. Zane brings a unique perspective to Vitech and its customers. With a professional background in the litigation field, Zane is also a trained negotiator, labor management facilitator and mediator. He has practiced tactical negotiation and interventional mediation, and taught communications, conflict management and leadership skills at both the university and the professional level. Before joining Vitech, Zane worked as a senior consultant and process analyst assisting government and industry clients in implementing and managing organizational change.

About Vitech

For over two decades, Vitech has helped organizations raise their systems engineering proficiency through a tailored combination of training, services, and software. By engaging with Vitech, organizations around the globe increase their productivity, enhance agility, and reduce project risk.

Unlike siloed approaches and products that mask critical context and system interactions, Vitech's approach and its GENESYS™ and CORE™ software embrace the holistic aspects of systems engineering. These solutions enable teams to clearly capture and address systems concerns from problem identification through requirements, architecture, and test in an integrated model, managing the critical interrelationships to guarantee consistency and design integrity. The result is a team empowered to engineer with confidence, free to focus on creativity, innovation, and analysis to effectively deliver against stakeholder needs.