The Systems Viewpoint

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Abstract

Systems thinking has long played a role in understanding the natural and man-made world. Since World War II, it has been formalized in systems science and system engineering, but it has also penetrated the development process in informal ways that continue to evolve. We have moved gradually to a view of systems that looks more at how a system works for all of its users, how it can incorporate greater variety in kinds of constituent elements, and how it can respond and adapt to a changing environment.

Advanced planning approached from a systems viewpoint treats projects from the outset as systems problems. Thus predisposed, it is natural to see the problem as hierarchical and to seek first the appropriate system level to address. Steps than progress logically to establishing required functionality, building system solutions incorporating a full range of component types, paying attention to relationships among them, and providing means for adaptive behavior.

Systems thinking has been around for quite a while; in the 1960's it was the subject du jour. Very good articles and books were written then bringing cogent ideas from academic study to the rest of the world—two of my favorite books were C. West Churchman's **The System's Approach** and **The Design of Inquiring Systems**. But times change, and there is good reason to look again at the systems approach.

The interest in systems grew out of the successes of operations research in World War II and the appearance of "computing engines" that, by the 1960's, were escaping the exclusive use of research universities and the Defense Department. Cybernetics was one name for a new synthesis of the engineering, communications and information sciences. Norbert Wiener coined that term and defined it in his book, **Cybernetics, Control and Communication in the Animal and the Machine**. He followed that with a book for the public advocating the value of cybernetics: **The Human Use of Human Beings. Cybernetics and Society**. In parallel, Ludwig von Bertalanffy built foundations for a General Systems Theory from a base in biology. Influenced by these formidable minds and influencing others were such leaders as Churchman, Kenneth Boulding, Russell Ackoff, Jay Forrester, Ervin Laszlo, Ross Ashby, Stafford Beers, Gordon Pask and Anatol Rapoport, among others.

As an enlightening construct, systems thinking was well absorbed and diffused into the academic and professional communities within a decade or so. The Norbert Wiener Prize in applied mathematics was created in 1967. Wassily Leontief got the 1973 Nobel Memorial Prize in Economic Sciences for his work in systems input/output analysis, and Noam Chomsky cited C. West Churchman as the only professor from whom he learned anything in his undergraduate studies... By the 1970's, computers were undergoing rapid commercial development, and computer conferences crossing many disciplines were taking over from their more exotic cybernetic and system theory predecessors. And new exotic subjects were ascending to prominence.

Over the succeeding years there have been both growth in understanding and shifts in interest; after forty years it is time to take another look at systems thinking.

System Properties

The idea of "system" as an object for analysis or synthesis is based on the idea that complex entities can best be thought of as wholes with parts. Rather than focusing on either the whole or the parts as the sole subject of interest, the systems thinker sees both, recognizing that the whole is usually more than the simple union of parts. Churchman illustrated this with a business example:

A department manager in a company might see "excess" inventory as needing trimming to reduce costs and improve efficiency—and, indeed, that probably would improve the performance of the department. But the performance of the company as an overall system would be seriously degraded if demand for the company's products were to suddenly increase and the company were unable

to meet that demand because of the inability of the department to produce components fast enough—compounded by the inadequacy of a now-trimmed inventory of completed components. A shortage of a supplier's significant part for the department's components might similarly degrade system performance through the failure of the departmental inventory to cover temporary production shortfall. Moral: the system is *more* than the sum of its components.

Wikipedia defines a system as "a set of interacting or interdependent entities, real or abstract, forming an integrated whole." The key ideas are multiple entities and interaction. Without both, the object of interest is not a system. For most early analysts, systems worth studying—whether natural or man-made—were tangible, viewed as groups of physical entities organized to achieve objectives that were usually fixed. Among properties of interest were the inputs and outputs of components, transformation processes performed by components and system, the nature of hierarchical organization, and the control model (centralized vs distributed control).

Churchman outlined five basic considerations to be kept in mind when evaluating a system: (1) total system objectives and performance measures for the whole system; (2) the system's environment, the fixed constraints; (3) resources of the system; (4) components of the system, their activities, goals and measures of performance; and (5) management of the system.

New Problems, New Interpretations

In the last forty years, there has been a gradual movement toward a new view of systems and systems thinking. Where the focus previously was "things" and how well they worked together, it is still how well things work together, but now with much more concern for how they work for the system's users. Where the measure of performance was directed toward specific tasks in a specific environment, it is now equally concerned with performance over time in a changing environment. Where system composition was viewed largely as hardware and/or software, it now includes a much wider range of kinds of entities. In more detail, some of the changes to systems thinking are:

Measuring performance.
As Churchman pointed out, system performance is not the sum of component performances; it

also includes overall performance. We accept that definition, but today we also look in detail at how a system performs for its many users—not only "end users", but all who have valid contact with it. For a service, as an example, these users would include those who sell it, those who install it, those who deliver it, those who maintain it, those who update it, etc.—all the way to those who must reconstitute it or close it down.
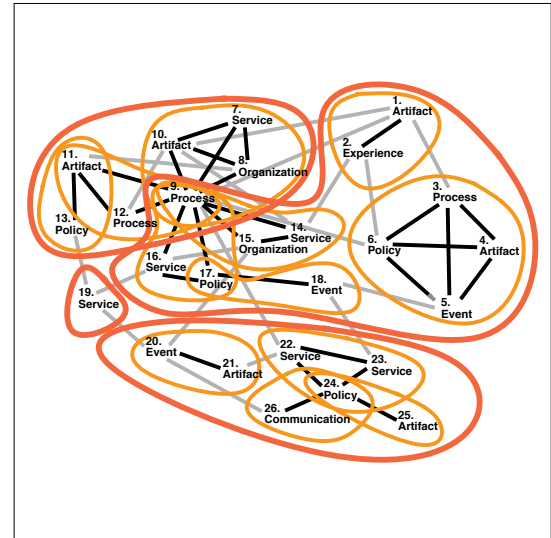

Figure 1 **Systems today: crisis resistant with inter-dependent, inter-supportive component elements of a variety of types.**
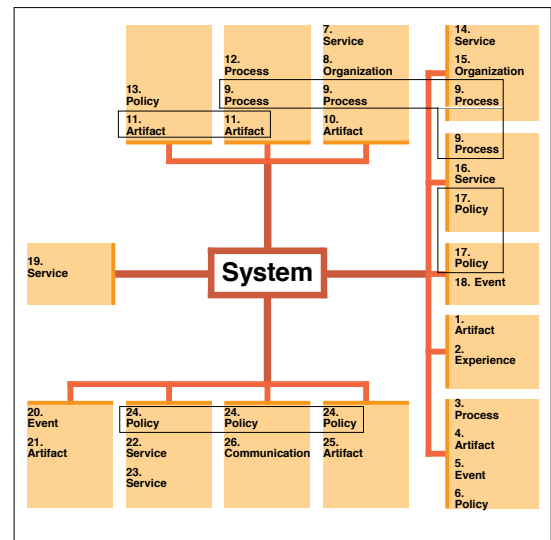

Figure 2 **The system of Figure 1 displayed as a hierarchy.**

Defining system elements.
For early system science, it was natural to characterize systems as organizations of physical entities. That construct has been expanded to include components far less tangible. It is not uncommon now to see systems described with elements that are not only artifacts, but services, processes, policies, organizations, communica-

tions, activities, events and even experiences (see Figures 1 and 2). The impact of the inclusion of such intangible elements should not be underestimated. Marshall Field' s in Chicago and Selfridge' s in London, both legendary department stores, built their reputations on a *policy* that "The customer is always right", an element of their systems that affected the full range of retail operations.

Designing to meet needs.

Outside the fields of engineering design, objects of design in the 1950' s and 60' s were more often artifacts than systems. To the extent that systems concepts were concerned they tended to come after the fact. Consumer products were conceived as artifacts; means for marketing, sales, repair and related aspects of what would be part of the system now were treated as necessary business processes, but not intimately integrated in a system. Today, products, services— virtually any designed entities—are usually thought of from the beginning as systems with all the supporting processes, organizations, policies, etc. conceived in parallel with hardware and software required to achieve overall goals.

Encouraging response to change.

Ashby, Wiener and such other early systems researchers as Warren McCollough and John von Neumann, were deeply interested in feedback and adaptive systems. Robotics is a direct outgrowth of their work, and modern control theory owes much to their research. Their ideas of homeostasis, adaptivity, redundancy and modularity have now reached a wider audience, and system thinking today almost universally considers means for maintaining functionality in the face of accidental or intentional system damage as well as means for adapting to changes in environmental conditions and even system goals.

Innovating New Systems

Advanced planning for new products and services should be thought of from the outset as system planning. Approached this way, the benefits of systems thinking will accrue naturally.

1. Question the level of the project.

Just as system elements are components of systems, systems may be subsystems of larger systems. Designing an automobile as a system may be right—or perhaps the right level should be higher: treating the automobile as a component of an automotive transportation system embodying new concepts for roadways, global positioning systems and control technologies. Or perhaps the right level should be lower: treating the automobile as the environment for an automotive passenger support system focusing on the driver and passengers, their comfort, activities and performance on a journey.

2. Establish the functions the system must perform.

Determine modes of operation, activities to be performed in each, and the functions required within them (see my article: *Covering User Needs*). The resulting Function Structure will guide research into the nature of problems at the subsystem, component and part levels and will suggest trial ideas that, with modifications and refinements, may become elements of the final system.

3. Organize the functions for conceptualization.

Create a new framework reassociating functions on the basis of their likelihood of finding solution together (see my article: *Organizing for Innovation*). This kind of organization places functions together that ought to be seen together to inspire innovative, multifunctional solutions. The new structure—I call it an Information Structure—becomes a road map to a creative, cohesive system.

4. Innovate relationships as well as entities.

A system is made up of *interacting or interdependent* entities. Relationships in modern thinking go far beyond inputs and outputs. In concert with the innovation of component entities, relationships should be studied for what they could be and how they affect the entities they associate. This can lead to changing entities to effect better relationships: What changes could be made to A to make it work better with B? With B to make it work better with A? With both to create an improved relationship?

5. Design the system to use adaptive strategies.

Adaptivity has great value in enabling a system to maintain operations in a changing environment. It also can enable a system to change strategy and tactics to achieve changing goals. A system that can adapt can fit present needs of a

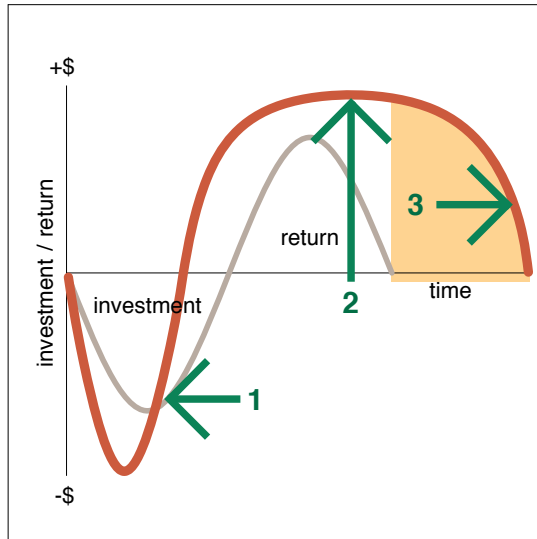range of users—and can evolve as well to meet needs yet unrecognized.

Figure 3 **Design planning with a systems viewpoint (1) shortens development, (2) increases value, and (3) extends life cycle.**

The Value of Systems Thinking

Good planning can have substantial impact on system life cycle. Figure 3 displays a system' s generalized life cycle as a sine curve. Plotted as investment/return over time, the system exists first as investment while under development. When it enters the market, it returns a profit, reaching a zenith as it reaches its greatest audience and then diminishing as it nears the end of its life cycle.

A simple sine curve, of course, would put any company out of business. Profit must exceed investment. But any such curve can be altered dramatically for the better with thoughtful planning.

First, the development period can be shortened by the application of modern planning and design prototyping. Second, value in the market can be increased through the application of user-centered planning and design methods. Customers will pay more for well-planned, well-designed and well-produced products (see my article: *Another Look at Quality*).

Third, of specific interest to this discussion, time in the market can be substantially increased through the treatment of a product or service as a system. Systems are hard to copy and hard to compete against. Crafted carefully, a system solution provides complex, multifunctional services that can fit individual needs and adapt to changing conditions and goals.