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System Dynamics:
A Possible Artifact for The Systems Age*

by

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System Dynamics: A Possible Artifact for the Systems Age

The purpose of this paper is to expand our thinking about the possible role system dynamics may play in the evolution of western thought and society. While such a theme may seem presumptuous when applied to a tool known to only a small fraction of people at present, it is my intention to give it some creditability by showing that western society may already be in the midst of evolving fundamental assumptions, beliefs, and perceptions more consistent with a systemic world view. Pulled by this undercurrent, tools like system dynamics can focus the forces of change and bring them to bear more directly on pressing societal problems.

Background: Observations of A Quiet Revolution

Pitirim Sorokin, founder of the Sociology Department at Harvard University, predicted over 40 years ago that western materialistic society would eventually stagnate, as people lost their fundamental desire for increasing standards of material well being. Sorokin predicted that the turmoil brought about by this stagnation might eventually lead western society to reemerge as an "integrated culture," a society oriented more toward a balance of material and spiritual values [Sorokin 1943].

In a recently published book, Daniel Yankelovich argues that profound shifts in basic cultural values and attitudes are evident in public opinion surveys over the past 20 years (Yankelovich 1982). He interprets his survey results as showing a fundamental grass-roots shift toward a more "sacred" world view:

I use the term sacred here in opposition ...to the merely instrumental. The distinction is important. We adopt an instrumental philosophy whenever we ask about something: what is it good for? From that perspective a tree is good for lumber, or for giving shade, or for enhancing the appearance of the landscape. A forest no one harvests or sees is not good for anything....People and objects are sacred in the sociological sense when they are valued for themselves, apart from their instrumental use [Yankelovich 1981, p. 85].

Yankelovich points out that instrumentalism as a personal outlook is essential to a materialistic society. He believes that survey

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results clearly show that it is waning, paving the way for "a new social ethic":

There are now scraps and shreds of evidence that American culture is evolving a new ethic of commitment. The word "commitment" shifts the axis away from the self...toward connectedness [underlining mine] with the world. In the interviews conducted, people often express a longing for connectedness [Yankelovich 1981, p. 85].

Similar themes have been articulated by many keen observers of western culture, from Lewis Mumford to Teilhard de Chardin. Recently, Marilyn Ferguson has added a new dimension to the discussion by showing the importance of new perceptions emerging from science. In her recent book, The Aquarian Conspiracy, Ferguson points to modern physics, brain research, systems theory, biology, and chemistry as sources of new views of reality:

Our discoveries about the startling nature of reality are a major force for change, undermining common sense ideas and old institutional philosophies.... [This knowledge] reveals a rich, creative, dynamic, interconnected reality... [Ferguson 1980, p. 145].

Ferguson argues that a primary impact of modern science will be on society's shared assumptions concerning man and the systems he is part of:

If we believe the universe and ourselves to be mechanical, we live mechanicallyIf we imagine that we are isolated beings,...we will lead different lives than if we know a universe of unbroken wholeness [Ferguson 1980, p. 146].

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Insights From Past System Dynamics Research

System Dynamics studies (such as Meadows et al 1972 and N. Forrester 1972) have identified two distinct modes or patterns of economic and social behavior which are combining to create unique pressures for change throughout the world. One is the life cycle of industrial growth. For approximately two centuries, industrial growth has fueled a tremendous economic success story based on abundant natural resources. But, few essential natural resources are unlimited. As growth has begun to run into basic limits of land, water, oil, and other minerals, economic and social stresses have increased. Beliefs of the growth era have been challenged. The cultural shifts identified by Yankelovitch, Ferguson, and others reflect not only the consequences of material progress but also the growing awareness of the interdependencies and limits it encounters.

The life cycle of industrial growth is a very long term process relative to the typical time horizon of human decision making. The transition to a post-industrial growth era may span 50 years or more. However, another dynamic superimposed on the life cycle suggests that the 1980s may be a crucial decade of change. This second behavior mode is the economic long wave. The long wave appears to offer the best explanation for the economic crises evident throughout the world today. The theory of the long wave suggests that the capital base and underlying technologies of advanced economies evolve cyclically. Periods of

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growth eventually result in capital overexpansion and overcommitment to outmoded technologies. Stagnation and even depression may be required to correct imbalances and create conditions for renewed growth. (Forrester 1978, Graham and Senge 1980)

The superposition of these two dynamics makes the 1980s a time of potential crisis when the rate of change to new ways of thinking as well as new technologies will be greatest. The trend back towards political conservatism in the early 1980s mirrors similar political shifts at the beginnings of past long wave transitions (see Senge 1982). As economic stagnation becomes broadly recognized, the first reaction is to "attempt to breathe life into the old structure" -- that is, to go back to what was working well 20 years ago. Studies done by political scientists have shown clear 50 year cycles in political values, characterized by a shift toward conservatism coincident with the ending of a long wave expansion. But, the effort to breathe life into the old structure fails because the "old structure," especially the dominant industries of the past long wave growth phase, are closer to the cause of the problem than to a solution. Within a few years after the conservative resurgence, radical shifts in political philosophy and social institutions can occur. Franklin Roosevelt, originally elected on a conservative platform quite similar to Mr. Reagan's, changed the nation's economic course dramatically when he embarked on the New Deal policies of greatly expanded government intervention. Analogous dramatic shifts in

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economic and social policy may very well occur in the near future as the nation attempts to cope with the pressures of the current long wave transition.

A Hypothesis

The central hypothesis of this paper is that the transition caused by the life cycle of industrial development and the economic long wave may be towards a systems age -- that is, a new era in which more systemic ways of thinking enter the mainstream of western society. Although this transition is only beginning and is difficult to assess, sufficient evidence exists to make this hypothesis a serious proposition. Within this broader shift towards more systemic modes of thinking, system dynamics may play a crucial role because of its capacity to focus developing awareness of the systemic nature of reality on practical problems.

The theme of a societal shift towards more systemic ways of thinking is developed in depth in The Turning Point, a recent book by Fritjof Capra. Capra is the author of the widely read book The Tao of Physics, which traces parallels between the view of reality that has emerged in modern physics and views intrinsic to ancient Eastern cultures. Capra argues that only in the 20th century has modern science returned to the dynamic holistic view that has long characterized many ancient cultures. While The Tao of Physics focused on the physical sciences, The Turning Point

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speculates more extensively about implications for the social sciences and society:

A massive shift in the perception of reality is underway, with thinkers in many disciplines beginning to move away from the traditional reductionistic, mechanical world view to an ecological, holistic systems paradigm...The beginnings of this change are already visible in all fields, and the shift...is likely to dominate the entire decade (Capra 1982b, p. 19).

The emergence of the relativistic view of reality in twentieth-century physics provides an instructive parallel to the pressures and process that may unfold more broadly in our society. This process began when physicists found themselves confronted by experimental discoveries that were difficult to reconcile with basic prevailing assumptions about the nature of reality:

The new concepts in physics introduced at the beginning of this century and still being elaborated in our current theories of matter, have brought about a profound change in our world view, from the mechanistic world view of Leibniz and Newton to a holistic and ecological view similar to the views of mystics of all ages and traditions. This new view of reality was by no means easy to accept for the physicist in the early 20th century. The exploration of the atomic and sub-atomic world brought them in contact with a strange and unexpected reality. In their attempt to grasp this reality the scientists became painfully aware that their basic concepts and their language, and their whole way of thinking, was inadequate to describe the atomic phenomenon. The problem was not merely intellectual but amounted to an intense emotional, and one could even say existential, crisis. (Capra 1982b, p. __)

Capra likens that state of present day economics to Newtonian physics:

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Present day economics, for example, fails to recognize that the economy is merely one aspect of the whole ecological and social fabric. Economists tend to dissociate the economy from the fabric and to describe it in terms of highly realistic theoretical models. ...whereas the surrounding ecosystems are self-balancing and self-adjusting organic wholes, our current economies and technologies recognize no self-limiting principle. Undifferentiated growth is still regarded by most economists as a sign of a "healthy" economy...The material world, according to contemporary physics, is not a mechanical system composed of separate objects, but instead appears as a complex web of relationships. Sub-atomic particles cannot be understood as isolated, separate entities, but have to be seen as interconnections...The notion of separate object is an idealization that is often very useful but has no fundamental validity (emphasis mine) (Capra 1982b, p. 21.)

Capra suggests that the understanding of physical reality in modern physics is most likely to be translated into the social sciences through

general systems theory...not a well defined theory like relativity theory or quantum theory...(but) a particular approach (or) perspective.

The systems view looks at the world in terms of relationships and integrations. Systems are integrated wholes with unique properties of their own that cannot be reduced to or understood by simply combining the properties of smaller units. Instead of concentrating on basic building blocks or basic substances, the systems approach emphasizes basic principles of organization (Capra 1982b, p. 22).

Capra's thesis of a societal transition to more systemic ways of thinking provides a challenging context for analyzing the future of system dynamics. System dynamics practitioners have

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long argued that the methodology should be viewed on two levels: (1) a tool for solving specific problems and (2) a means for developing a more systemic point of view regarding problems. The two objectives are intertwined and may, in fact, be difficult to attain separately. Fundamental problems in a corporation or larger social system are generally interconnected and difficult to solve in a piecemeal fashion. Frequently, system dynamics applications fail to permanently resolve fundamental problems when the tool is narrowly applied as a problem solving device. The benefits of even highly successful applications often prove only temporary, as policymakers drift back into old ways of thinking and operating. (See, for example, Roberts 1981 or Lyneis et al. 1977.)

Evidence for the Hypothesis

If Capra's thesis is valid, it suggests that important changes in the environment may be contributing to a systemic point of view highly compatible with tools like system dynamics. What evidence is there for these changes and how can system dynamicists benefit most from them?

Capra primarily supports his thesis through his background in physics, summary of the work of leading systems theorists such as Prigogine, analysis of social movements like environmentalism, and observations on the breakdown of

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traditional nonsystemic ways of dealing with key social problems. I believe that there is another important source of evidence in the emergence of new thinking and methods for managing large organizations. Moreover, because it deals with the attitudes and perceptions of policymakers, it is especially relevant for system dynamics.

In recent years, organizational innovation, especially occurring in the business sector, has begun to attract increasing attention. The wide spread interest in Japanese management techniques appears to be a symptom of a much deeper reexamination of fundamental assumptions in management. A small number of corporations are emerging as pioneers in a new, more systemic approach to organizational design and management. Relative to Capra's thesis, these organizations are particularly important as loci for operationalizing the underlying shift in systemic awareness. Moreover, they are showing how the shift to more systemic modes of operation can influence individuals throughout a system. That is, they are developing a set of attitudes and beliefs along with a set of design principles and management methods.

One common element to these new organizations is a sharp break with the hierarchical philosophy underlying traditional organizations. The organizations strive for an environment in which each and every individual shares a sense of responsibility and ownership for the system as the whole. As Ray Stata, president of Analog Devices, observes,

"Much of our traditional organizational thinking is derived from the Catholic Church and the Roman Army--institutions predicated on the notion that the person at the top has information and influence not shared by others." (Kiefer and Senge 1982, p. 116-117)

The first step of an organization towards a more systemic orientation is to pierce the illusion of the hierarchy that suggests that only a small number of people are responsible for the performance of the system as a whole, while the great majority are mere "cogs in the wheel." This does not imply the elimination of all authority, but most fundamentally the creation of a new value system. As Stata says,

We're not trying to eliminate all hierarchy at Analog, but to undercut the value system that is linked to the hierarchy. The greatest limitation in traditional organizations is that people further down the hierarchy somehow consider themselves as lesser beings than those above them. (Kiefer and Senge 1982, p. 114)

Many organizations are evolving radically decentralized organizational designs to sustain this new value system. One example is the Kollmorgen Corporation, a \$250,000,000 diversified manufacturing company. One of the key ideas underlying the Kollmorgen corporate design is that whenever an operating unit becomes too large, it becomes impossible for each individual to understand the system as a whole and feel responsible for it. Consequently, divisions continually divide as they grow. Divisions rarely exceed 400 or 500 hundred people. As new business opportunities develop, small sub-divisional groups

initially form. If these "product teams" succeed and grow, they eventually split off from their divisional parent and become a new free-standing business unit.

Corporate control in a company like Kollmorgen is kept to a bare minimum. In a corporation of approximately 5,000 employees, the corporate staff, including secretaries and accountants is around 25. Virtually all operational control is at the divisional and sub-division level. Corporate strategic and financial responsibilities are carried out through a Partner's Group. The Partner's are all Division presidents and corporate officers. The group operates by consensus. Each partner has a veto on all basic corporate decisions.

Managers in companies like Kollmorgen and Analog Devices need to develop new views of management control. Unlike the "top-down" approach assumed necessary for most of our major social issues, these organizations believe strongly in the effectiveness of local initiatives to deal with complex problems in the organization. Stata refers to "organic control" -- a strong emphasis on local control for local problems. This, of course, is consistent with the strong emphasis on personal responsibility. It also means a great deal of freedom and open flow of information within the organization. People at the local level cannot be expected to be effective problem solvers if they do not have good understanding of the problems and the interrelationships within the organization. Bob Swiggett, President of Kollmorgen, stresses the importance that everyone

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within the organization share access to all basic information regarding organizational performance and how the organization operates. Only within an environment with open information can individuals act responsibly. Senior managers like Swiggett must work continually to undermine information monopolies, whereby people traditionally have attempted to solidify power.

Swiggett and Stata are illustrative of the new role for senior managers in the evolving decentralized organization. Whereas chief executives in traditional organizations are above all else decision makers, chief executives in the emerging organizations are, above all else, teachers and designers. They participate in decision making, but their success is predicated on their ability to create an environment where quality decisions can be made by others.

Moreover, their greatly reduced involvement in the daily operations of running the business gives them the time and opportunity to commit themselves to activities that traditional managers rarely do. They have the time to think about how the organization functions as a system, how it interacts with its environment, and how it is evolving. They have the time to teach others how the organization functions, the values that are critical to its integrity, and the philosophy that guides its development. In my experience, senior managers in companies like Kollmorgen may spend 50% to 75% of their time in key strategic and educational activities. By contrast, more traditional control-oriented managers are able to allocate only a fraction of this time to such activities.

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It is impossible at this time to accurately assess how widespread such corporate innovation is. It appears to be quite widespread within the "high-tech industries," where sustaining creativity and innovation is critical. However, current research indicates that many of these ideas are taking hold in industries as diverse as retailing, consumer goods, and traditional manufacturing. Much research needs to be done to better understand this new organizational thinking and practice and to assess its relevance for the public as well as the private sector. (Kiefer and Senge, 1982b, other references.)

The Possible Role of System Dynamics

To understand the possible impacts of system dynamics in this emerging transition to a systems age one needs to understand the more generic problem of the interaction of technology and culture. This problem is an important research area for cultural anthropologists. There have been many case studies of local societies that have made accelerated transitions to new cultural configurations when tools commensurate with the new culture were introduced. Although there is uncertainty if tools alone are sufficient to foster cultural transitions, it is widely believed that appropriate tools can accelerate such shifts when other conditions for the transition already exist.

Inventor, philosopher, and futurist Buckminster Fuller argues that appropriate tools can be of the utmost importance

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when a cultural shift is underway. He suggests that the development of "artifacts" for a new age are among the most important developments to speed societies transition. Such tools allow people to go beyond talking about the need for a new way of operating or even thinking deeply about such a way -- they allow people to act differently (see Fuller 1981).

One can begin to imagine this process concretely by thinking of the possible impacts of the first tool on human evolution. At this stage of his evolution man was undoubtedly the product of his environment with little cognitive realization of his potential to influence that environment. As he developed facility with his earliest tools, his cognitive world began to change in parallel. Eventually he came to see himself as influencing his environment as well as reacting to it. It is impossible to imagine this shift in attitude and perceptions having occurred independent of practical experience. In this sense, the first crude tools were artifacts for a way of life that would put man on a pathway to the modern world.

What is needed today are similar artifacts to facilitate the transition to more systemic ways of thinking and operating. System dynamics seems a logical candidate. Firstly, it has perhaps unique capabilities to be applied to our most important organizational and societal issues. Unlike many other methods within the field of general systems theory, system dynamics is strongly problem oriented. It has already demonstrated utility in clarifying causes of long term corporate, urban, regional, and

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global issues. Of course, the methodology is not without its shortcomings, as one should expect for a field at a very early stage of development. However, few other methods for understanding complex social systems can lay claim to having created as much interest amongst analysts and policy makers into the possibilities of social system modeling.

A second great strength of system dynamics is its educational possibilities. Unlike many systems analysis tools which remain the province of specially trained experts, system dynamics models have repeatedly been used to teach the public at large about systemic issues. One suspects that this potential strength of system dynamics has barely been tapped, since most studies still today are done for specific clients and not public education. But, it is clear that fundamental policy changes can only take place through education. This is equally true in the nation as a whole and within the corporation. Applications of system dynamics which fail to result in broad education generally fail to have enduring impact.

Because of its applicability to key problems and its strength as an educational tool I believe that system dynamics can play an important role as a bridge between old and new ways of thinking. The "systems age" remains a distant abstraction until one begins to see that only through a systemic viewpoint can we begin to understand our most pressing social issues such as economic stagnation, inflation, and the nuclear arms race. Public awareness is developing that these are not isolated

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separate problems created solely through political errors and unfortunate circumstances. Awareness is developing that in some ways these problems are but separate manifestations of the same underlying mismatch between reality and our normal ways of thinking about and attempting to influence reality. If this emerging awareness can be crystallized through tools like the System Dynamics National Model (Forrester 1982), system dynamics can play an important role in the coming cultural transition.

Implications for System Dynamics Practice

Perhaps the most important general implication is for practitioners of system dynamics and similar tools to think of themselves as educators and cultural change-agents rather than problem solvers. While effective consultants often think of themselves in these terms, the depth and scope of the educational process which must occur for system dynamics to be truly effective is rarely recognized.

To be effective in this domain, one must recognize that one's own attitudes and perceptions are often the greatest barrier to overcome. Practitioners of system dynamics are themselves part of a cultural milieu which emphasizes separateness not connectedness. We are like caterpillars attempting to describe to other caterpillars the nature of being a butterfly. We must continually reflect on our own biases and non-systemic perceptions of reality. This can become very

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personal. For example, it may very well be that the unquestioned assumption that individuals are essentially separate entities may eventually be seen as a working construct no more "fundamentally valid" than the assumption that atoms are separate objects. We tend to draw an arbitrary boundary around our "self" configured in time and space. Yet, who among us is not a unique person particularly because of the continual interactions we have had with other individuals and circumstances that have made us unique. Einstein said we need to pierce the "illusion of separateness that holds each of us bound within a prison of our own consciousness." Might this advice not be particularly germane to professional modelers intent upon helping others understand the connectedness of the world?

In addition to the needs for reflection and clearer self definition, the research agenda for system dynamics can benefit from viewing system dynamics as an artifact for systemic thinking. In public sector applications, this will have important implications for who is defined as the audience and how the implementation process is viewed. In many instances, public sector applications of system dynamics should focus on educating the public at large regarding important system problems. All too often, model builders adopt a narrow focus in the misguided belief that answering the "client's questions" is the most sure-fire path to successful implementation of modeling insights.

In a special lecture to international gathering of global model builders, Jay Forrester painted a different picture

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of successful implementation and the role of the model builder.

How does the modeler see himself? what audience does the modeler address?...

I disagree (with common assumptions) ...that "policy makers" constitute the audience for global modeling.

(Modelers assume)...that the world is run by policymakers, apparently referring to people in government. For the great issues now being considered in world modeling, the present people in government are of little consequence. They do not have the power to reverse long-standing tradition. They will not be in office long enough to deal with the issues raised by world modeling.

...the audience for the work must be the public in general. In today's social structures, only in the role of the individual as a private citizen does a person take a long-range view of the future. (Forrester 1981, pp. 22, 23)

To put such a view of the modeler's role into practice takes courage, perseverance, and a long-term time perspective--the very characteristics that system dynamicists repeatedly ask of policymakers. Modelers will be more effective in this role as change agents if they recognize that a sympathetic ear for their message is emerging and learn to speak to that ear.

For corporate applications there are also important implications. If system dynamics is to be used as an artifact for systems thinking, the whole consulting paradigm characteristic of most corporate applications may need to be reexamined. Consulting projects rarely result in a lasting shift in the way managers think about problems. Although

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implementation is almost always the objective, "the implementation stage seldom occurs," in the words of Edward Roberts (1981). Although there may be instances where one or two managers close to the consulting team develop a fundamentally new way of looking at problems, such a shift occurs rarely and never have I seen it occur pervasively within an organization. Corporate applications of system dynamics appear to have realized only a very small fraction of the potential impact of the tool.

To be more effective change agents, it will probably be necessary for the system dynamicist to become closer to the organization in many ways. The few consultants I know who seem to have deep and lasting impacts in organizations work with only a small number of organizations at a time and work very deeply with those organizations. In effect, they live within the organization. They become trusted. They become "part of the team." From this role, they can fill a much broader educational function. In some cases, effective consultants even sign multi-year contracts with clients as a way of guaranteeing long-term in-depth interaction. In Roberts' terms, they stay with the process "until implementation is achieved," perhaps longer.

It may be most effective, for system dynamics to be applied to several corporate problems simultaneously. This would greatly increase the likelihood of a fundamental shift in the way of thinking within the organization. When one is focused solely on an individual problem, pressures to "solve the problem" force

managers to try and "digest" the recommendations of the modeler without altering their own understanding. Valiant attempts by modelers working in the conventional consulting paradigm to educate their clients often reach one or two managers at best and rarely permeate more broadly.

One solution is to insist on top management participation, as suggested by Roberts and many other reviewers of past system dynamics applications. But, top management involvement is insufficient for the purpose of organizational reeducation unless the top managers see this as part of their role. This is one reason why applying system dynamics within organizations already in transition to a more systemic orientation may be important. These organizations appear to offer uniquely fertile soil for the long-term organic viewpoint of system dynamics. A great deal might be learned about both organizational issues and the effective implementation of systems thinking tools out of such applications.

This is one of many reasons why identifying companies developing the decentralized nonhierarchical management philosophy is critical. The research task of identifying and examining these companies is at a very early stage. System dynamics theorists of organizational change may be able to play a central role in the needed research, both beneficiaries and contributors in understanding the principles and methods underlying these companies.

Lastly, it is of critical importance that the development of educational materials in system dynamics and related systems thinking skills continue as rapidly as possible. Surely, there can be no hope for a broad emergence of systemic thinking until tools for such thinking are a central component of public education. In recent years, great strides had been made in this area (see, for example, Roberts et al. 1982). However, much remains to be done, especially in the area of teaching public school teachers how to integrate systems thinking concepts into their classrooms.

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