ON THE MANAGEMENT OF TECHNOLOGY: OLD AND NEW PERSPECTIVES, PART I

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ABSTRACT
This paper centers on problems which have arisen in the linking of technology with management. It is postulated that technological based issues require different perspectives and paradigms from human based issues and in Part I of the paper presented here some common paradigms are presented and criticised. Part II of the paper, which will appear in the next edition of DYNAMICA, introduces the need for, and an assessment of, multiple perspectives in dealing with the management of technology.

I. INTRODUCTION
This paper deals essentially with a discussion of the state-of-the-art of technology management and initially will deal with questioning some of the cherished "truths" associated with this field.

To begin with, the dictionary tells us that "to manage" means "to control or direct the use of". As Von Foerster (1) notes, this implies that management reduces the degrees of freedom of the technological system being managed. In probing more deeply, it is ominous to find that "manage" is related to the word "manacle, a device for confining the hands, usually consisting of two metal rings that are fastened about the wrist and joined by a metal chain". Much of American industry looks at technology assessment and environmental impact statements in precisely these terms, i.e., efforts to shackle technology.

The management of technology encompasses a wide range of activities — from resource allocation in the laboratory to the disposition of waste, from the drafting of regulation to the education of the public.

I will devote my effort to an examination of fundamental problems which have arisen in the necessary linking of technology with management, i.e., in relating artifact-focused with people-focused activities. It is my theme that these two foci not only use different models, but require different paradigms and perspectives. This does not imply that the technical perspective is of no value in looking at management problems. Rather, it means that this perspective is inherently blind to certain important social and human signals and indicators. The capable manager intuitively knows this and places only modest reliance on such technically oriented input in the decision making process. Here are the words of two effective managers (2):

R.P. Jensen, chairman of General Cable Corp.:
"On each decision, the mathematical analysis only got me to the point where my intuition had to take over".

F. Fetzer, chairman of Fetzer Broadcasting Co.:
"Walk through an office, and intuition tells you if things are going well."

Further evidence of the inadequacy of the technical perspective is provided by two studies.

Green, Newsome, and Jones (3) surveyed the FORTUNE 500 companies to determine the extent of use of nineteen operations research techniques. They included simulation, queuing theory, network analysis, linear programming, factor analysis, statistical sampling, inventory models, Markov chains, regression and correlation, etc. It was found that nine of the techniques were not used at all by 60% or more of the responding organizations and only seven were of frequent use by 25% or more of the respondents.

Balachandra (4) surveyed 103 U.S. firms which emphasize R & D (using R & D expenditures as a criterion) concerning their use of technological forecasting methods. The ten techniques listed included simulation, cross-impact analysis, relevance trees, morphological analysis, signal monitoring, trend extrapolation, Delphi, scenarios, expert opinion, and brainstorming. The technique rated "very useful" by the largest number of firms was expert opinion (26%). Brainstorming was second with 14% and the other eight each were less than 7%! For seven of the techniques at least 45% of the firms said they never use them. Of the three most widely used methods — expert opinion, brainstorming, and trend extrapolation — two have a very strong intuitive component.

This situation strongly suggests that improvement in the state-of-the-art is not to be sought along the lines of bigger and better planning models and computer simulations. History provides some hints. For example, as Jay (5) has observed, Machiavelli had a superb appreciation of management. In his book "Management and Machiavelli", he writes:

"Machiavelli . . . is bursting with urgent advice and acute observations for top management of the great private and public corporations all over the world".

The point we would make is that Machiavelli uses different paradigms; his perspective of organizational behavior is not at all that of modern organization theorists. The successful

manager probably is, and has always been, far ahead of the theorist, uninhibited by scientific rigor and analytic precision.

And, as we shall see, some of our best systems thinkers are also aware of the situation.

II. WHAT IS WRONG?

Science and technology represent the most successful religion of modern times. From Galileo to the Apollo lunar landing, from Darwin to recombinant DNA, the paradigms of science and technology have yielded dazzling triumphs.

These paradigms include the following:

(a)   The definition of "problems" abstracted from the world around us and the implicit assumptions that problems can be "solved"

(b)   Optimization or the search for a "best" solution

(c)   Reductionism, i.e., study of a system in terms of a limited number of elements (or variables) and interactions among them

(d)   Reliance on data and models, and combinations thereof, as modes of inquiry

(e)   Quantification of information

(f)   Objectivity, i.e. the assumption that the scientist is an unbiased observer outside of the system he or she is studying

(g)   Ignoring the individual, a consequence of reductionism and quantification (e.g. use of averages) as well as non-human objectivity

(h)   Time movement seen as linear, i.e. at a universally accepted pace reckoned by precise physical measurement.

A technology and its environment are typically viewed as a system. Systems analysis tools are considered appropriate and the traditional guidelines for analysis apply. Technical impacts are carefully described and where possible, quantified. Benefits and costs are calculated. Frequently, cause and effect modeling is carried out to study the static and dynamic behavior of the variables which describe the system and its environment. Structural models are illustrative of such tools (6). System dynamics modeling and decision tree analysis provide other examples.(7)   At times the models may drive the analysis, i.e., the analyst's modeling background and experience may be instrumental in determining what is analyzed and how. Strong reliance is placed on technical experts as well as technical reports containing empirical data or theoretical models and data. Rationality is assumed to determine decisions, e.g. the alternative with the most favorable benefit-cost relationship will be selected. Fig. 1(a) schematically summarizes the general approach.

The success of this mode of thought and its paradigms has led very naturally to increasing pressure to extend its use beyond science and technology, i.e. to society and all its systems. Organizations become cybernetic systems, utility theory determines preferences, decision analysis provides

the key to decision making, policy analysis selects strategies. There is a mathematical theory of war and, of course, "management science". Fig. 1(b) portrays the situation.

Without question the technical perspective is ideal for well-structured problems in science and technology. Why, then, is there deep trouble in relying on it in managing technology or anything else? To answer this question — we examine the eight paradigms listed above in more detail.

2.1   The Problem-Solution View

When we talk about a "problem" we assume there exists a solution. We have been brainwashed in school; a text book presents a problem only if there is a solution (often in the back of the book). It is not pointed out that in the living world every new solution provided by a technology creates new problems. Public health measures cut the death rate but have led to a global population explosion. Introduction of European agricultural techniques in Africa produces food in the short term and desertification is the long term. It would be more correct to state that we *shift* problems rather than solve them.

2.2   The "Best" Solution Search

Cost-benefit analysis and linear programming are typical of the search for the optimal solution. It comes as a shock to those nurtured on this perspective that complex living systems have not organized themselves in accordance with this principle. As Holling (8) notes, ecological systems sacrifice efficiency for resilience, or avoidance of failure (the *fail-safe* strategy familiar to engineers) for survival over failure (a *safe-fail* strategy). They strive to maximize their options, rather than confine them by selection of the "best" one. They do not "manage" themselves by manacling themselves. Evolution shows that their safe-fail strategy is eminently suited to a world which is inherently unpredictable at certain times.

2.3   Reductionism

Van Foerster's First Law (9) expresses the reductionist process rather well:

> "The more complex the problem *which is being ignored,* the greater are the chances for fame and success".

If a system is complex we simplify it by dividing it into subsystems. If we still cannot handle the subsystems we reduce it further. Finally we arrive at problems we can solve. Fame and success come with publishing: there is a plethora of papers which deal elegantly with unimportant, even trivial, problems. The use of averages (e.g. statistical mechanics in physics, per capita GNP in economics) and probabilities (e.g. cross-impact analysis) has permitted treatment of systems with a very large number of elements, each behaving in a unique way. In technological forecasting there is talk of a "most probable" scenario. Either it comprises so few elements (events and trends) that it is meaningless or so many that, even if each has a 90% chance of occurrence (or non-occurrence), the product has a very low likelihood. For example, for 20 elements each with 90% probability, the scenario has only 12% likelihood. If all alternative scenarios have a lower probability, does this make the 12% scenario a "most probable" one? History is strewn with events which had a powerful impact but were calculated to have a very low probability (e.g. Three Mile Island accident). The clients of technology assessment are
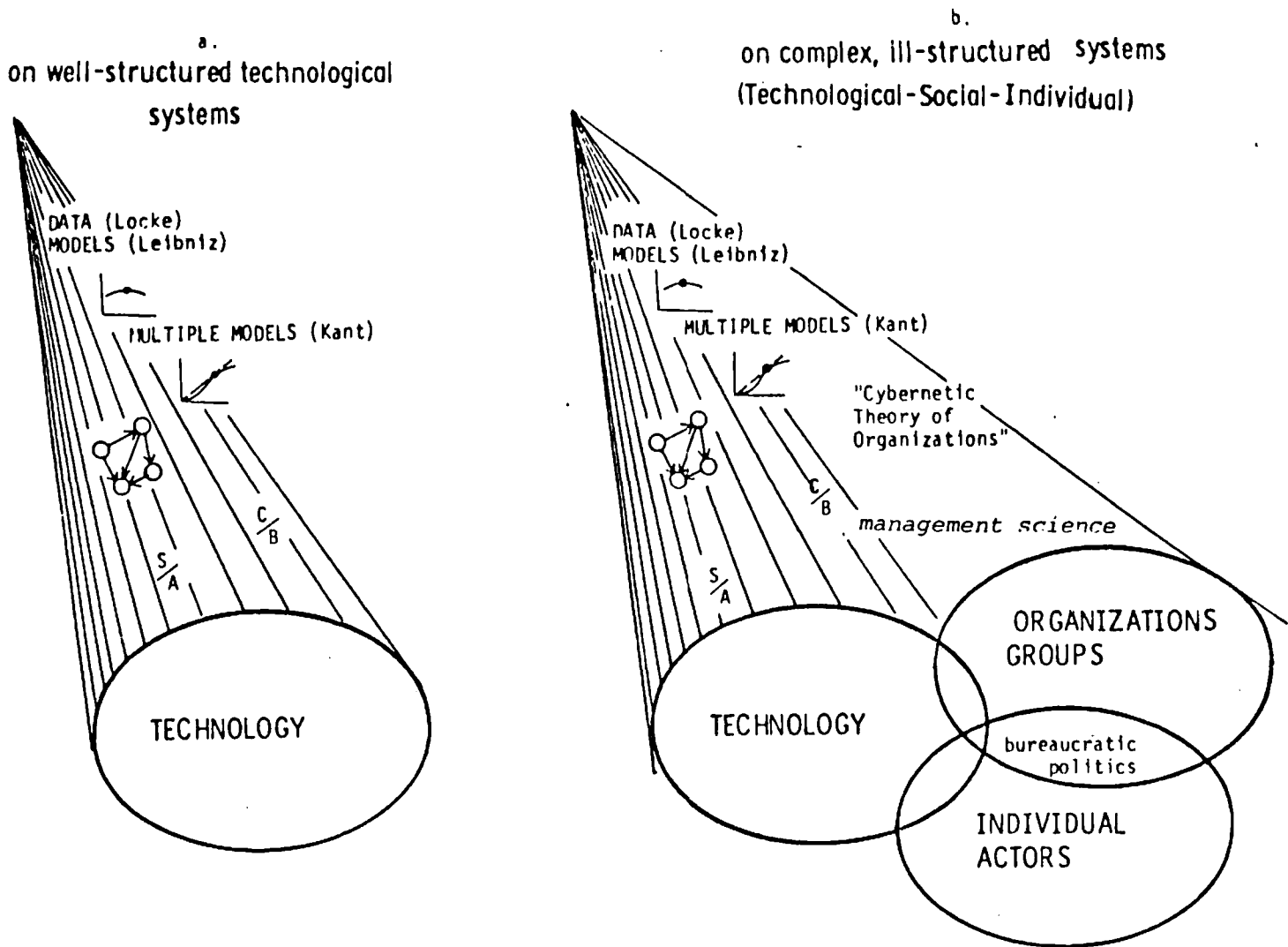
a.

on well-structured technological systems

DATA (Locke)
MODELS (Leibniz)

MULTIPLE MODELS (Kant)

C/B

S/A

TECHNOLOGY

b.

on complex, ill-structured systems (Technological-Social-Individual)

DATA (Locke)
MODELS (Leibniz)

MULTIPLE MODELS (Kant)

"Cybernetic Theory of Organizations"

C/B

management science

S/A

TECHNOLOGY

ORGANIZATIONS GROUPS

bureaucratic politics

INDIVIDUAL ACTORS

Figure 1. The Technical Perspective

less interested in probabilities than in circumventing catastrophe and moderating effects of failure.

Another example of the simplifications common in modeling is the representation of a system as a set of elements with pairwise relationships denoting the interactions. If there are three elements (A, B and C), there are six possible relations (e.g. A-B, C-B). If the pairwise qualification is removed, there are at least 49 interactions (e.g. AB-ABC, B-B, BC-A). Anyone with a family or corporation knows that there are numerous non-pair relationships (e.g. father to children). For a system of 10 elements this number rises to over 1 million. (The formula is $(2^n-1)^2$.)

Modeling often becomes an end rather than a means. The dedicated modeler reminds one of Pygmalion, the sculptor of Greek mythology. He fashioned a beautiful statue of a girl and fell in love with it. Responding to his plea the goddess Aphrodite brought her to life and he married his model. Today's modelers, blessed with vast computer capacity, also become wedded to their creations: the model becomes reality. In a recent survey of structural modeling techniques, Linstone et al.(6) found over one hundred types in this very limited area. Clearly it seems to be fun for the modelers, but it also is a nightmare for the real world problem solver.

A recent fashion in reductionism is the transfer of entire theories from one field to another (often fallaciously presented as an example of interdisciplinarity). One case is the adoption of thermodynamics by some economists, e.g. the "entropy state" of Georgescu-Roegen (10). It is tempting in the context of the science-technology world view to reduce complexity by taking an existing law, albeit derived for closed physical systems, and apply it to open social systems. But the Second Law of Thermodynamics simply does not apply to the evolution of living systems from single cells to *homo sapiens*. Such systems are becoming increasingly organized, oblivious to the running down postulated by the Law. In human beings each fertilized egg recreates potential (i.e. negentropy) and the transfer of information about technology among different

cultures has similar effect.

2.4 Data and Models
Another characteristic of the science-technology world view is the use of certain modes in inquiry. (11)

(1) Lockean –
empirical; agreement on observations or data; truth is experimental and does not rest on any theoretical considerations

(2) Leibnizian –
formal model; theoretical explanation; truth is analytic and does not rest on raw data of an external world

(3) Kantian –
theoretical model and empirical data complement each other and are inseparable; truth is a synthesis, multiple models provide synergism (e.g. particle and wave theories in physics)

In this world view it is difficult to realize that, as we move beyond the pure science-technology domain, other systems of inquiry may prove more fruitful. Following are several candidates:

(4) Hegelian –
dialectic confrontation between opposing models or plans leading to resolution; truth is conflictual as typified in a courtroom trial

(5) Merleau-Ponty –
reality as currently shared assumption about a specific situation; acceptance of a new reality is negotiated out of our experience; truth is agreement which permits action

(6) Singerian –
pragmatic meta-inquiring system which includes application of the other systems as needed; the designer's psychology and sociology inseparable from the physical system representation; ethics swept into design

If we concentrate on the individual we should also mention Kant's noumena

(7) Noumena –
reality beyond the perception of our senses, a world which we can only intuit, to which we are linked through our unconscious mind. In such a world there is no temporal distinction of past, present, and future.

Thus we see that there is much out there beyond data-based, model-based, and complementary multimodel systems of inquiry. As Plamenatz writes in his work on Machiavelli (12),

"The ideas about the great man and his role in history of a sometimes careless historian may be more perceptive and realistic than those of the most scrupulous recorder of facts".

The science-technology world view also places great stress on cause and effect relationships. But pause to consider a comment of Toynbee:

"In my search to the present point, I have been experimenting with the play of soul-less forces . . . and I have been thinking in deterministic terms of cause and effect. Have I not erred in applying to historical thought which is a study of living creatures, a scientific method of thought which has been devised for thinking about inanimate nature? And have I not also erred further in treating the outcomes of encounters between persons as cases of the operation of cause-and-effect? The effect of a cause is inevitable, invariable, predictable. But the initiative that is taken by one or the other of the live parties to an encounter is not a cause; it is a challenge. Its consequence is not an effect; it is a response. Challenge-and-response resembles cause-and-effect only in standing for a sequence of events. The character of the sequence is not the same. Unlike the effect of a cause, the response to a challenge is not predetermined . . . and is therefore intrinsically unpredictable." (13)

Prigogine's (14) concept of "order through fluctuation" posits another source of unpredictability: the phase when a system becomes unstable and experiences temporary "macroscopic indeterminacy" before reaching a new stability state. The new state may depend on one fluctuation which is itself of no significance.

2.5 Quantification
In ancient Greece the Pythagoreans already attempted to preserve the purity of their mathematical expressions by putting to death the man who discovered incommensurables. Today the computer has become the ideal instrument to fuel the drive for quantification. A new version of Gresham's Law states that "quantitative analyses tend to drive out qualitative analyses".

Typical Questions Posed by Inquiring Systems
Suppose we are given a set of technology assessment statements. Our Inquiring Systems can be simply differentiated from one another in terms of the kind of characteristic questions each of them would address to the assessor or to his set of statements. Each question in effect embodies the major philosophical criterion that would have to be met before that inquirer would accept the statement.

– The Lockean analyst or Inquiring System would ask something like:

"Since data is always prior to the development of theory how can one independent of any formal TA model justify the assessment by means of some objective data or the consensus of some group of expert judges that bears on the assessment? What is the probability you are wrong? Is that a good estimate?"

– The Leibnizian analyst or IS might ask:

"How can one independent of any empirical considerations give a rational justification of the assessment? What is the model you are using? How was the result deduced and is it precise and certain?"

– The Kantian analyst or Inquiring System would ask:

"Since data and theory always exist side by side, does there exist some combination of data or expert judgment plus underlying theoretical justification for the data that would justify the assessment? What alternative assessments exist? Which of these satisfies my objectives?"

– The Hegelian analyst or Inquiring System might ask:

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"Since every assessment is a reflection of more general theory or plan about the nature of the world as a whole system, i.e. a world view, does there exist some alternative sharply differing world view that would permit the serious consideration of a completely opposite assessment? What if the reverse happens and why wouldn't that be more reasonable?"

— The Merleau-Ponty analyst or Inquiring System might ask:

"What is the shared reality? How does it facilitate the generation of policy options? How does the assessment create an impetus for desirable action? What kind of reality is most effectively negotiated by the parties at interest?"

— The Singerian analyst or Inquiring System would ask:

"Have we taken a broad enough perspective of the basic assessment? Would other perspective help? Have we from the very beginning asked the right question? To what extent are the questions and models of each inquirer a reflection of the unique personality of each inquirer as much as they are felt to be a "natural" characteristic or property of the "real" world?"

Source (15)

Zadeh's "fuzzy set theory" has even been developed to quantify qualitative terms, and, in the manner of a shoehorn, squeeze them into the computer input format.

The developed nations are, culturally speaking, measuring societies. In the words of Yankelovich (16),

"The first step is to measure whatever can be easily measured. This is OK as far as it goes.

"The second step is to disregard that which can't be measured or give it an arbitrary quantiative value. This is artificial and misleading.

"The third step is to presume that what can't be measured easily really isn't very important. This is blindness."

Compare this attitude with that of another culture, Papua New Guinea.

Fuglesang (17) writes:

"In many villages they do not use measures, because people's life style is such that they have no need for it. In other villages people may measure the size of houses, fields or gardens in 'paces', which are sometimes called 'feet' . . . [The technical expert] will be disenchanted by the fact that a 'pace' is not a fixed standard measure. It will vary with the man who is doing the pacing. In villages I lived in Zambia, people were perfectly happy with that, because they knew the man."

Quantification engenders self-delusion. For example, Tversky and Kahneman (18) have found that

"People tend to overestimate the probability of conjuctive events and to underestimate the probability of disjunctive events . . . (such biases) are particularly significant in the context of planning. The successful completion of an undertaking, such as the development of a new product, typically has a conjuctive character; for the undertaking to succeed, each of a series of events must occur. [This leads] to unwarranted optimism in

the evaluation of the likelihood that a plan will succeed or that a project will be completed on time. Conversely, disjuctive structures are typically encountered in the evaluation of risks. A complex system, such as a nuclear reactor or a human body, will malfunction if any of its essential components fails. Even when the likelihood of failure is slight, the probability of an overall failure can be high if many components are involved . . . people will tend to underestimate the probabilities of failure in complex systems."

2.6 Objectivity

The traditional assumption of objectivity on the part of scientists and technologists is revealed more and more frequently as a myth. Churchman writes of the social sciences:

"One of the most absurd myths of the social sciences is the 'objectivity' that is alleged to occur in the relation between the scientist-as-observer and the people he observes. He really thinks he can stand apart and objectively observe how people behave, what their attitudes are, how they think, how they decide . . . [it is a] silly and empty claim that an observation is objective if it resides in the brain of an unbiased observer." (19)

Mitroff lays to rest objectivity in its traditional meaning in the physical sciences with his study of Apollo moon scientists:

"It is humanly impossible to eliminate all bias and commitment from science . . . [we cannot] pin our hopes for the existence of an objective science on the existence of passionless unbiased individuals." (20)

Von Foerster, himself a cyberneticist, insists that it is humanly impossible to eliminate all bias and commitment from science. Objectivity cannot occur in the relation between the scientist as observer and the people he observes. The claim that the properties of an observer must not enter into the description of his observations is nonsense, because without the observer there are no descriptions; the observer's faculty of describing enters, by necessity, into his descriptions. (1)

If objectivity cannot be assumed for the scientist in his proverbial ivory tower, it would seem foolhardy indeed to carry this assumption over to technology management in a "real world" setting. The real world is a complex system in which virtually "everything interacts with everything" — and this includes the manager. That being the case, the *choice* of model and data, of problem definition and boundaries, is always partly subjective.

2.7 Avoiding the Individual

From Adam Smith to West Churchman there have been expressions of concern with the danger of ignoring the individual, losing him in the aggregate view. Smith said 200 years ago:

"The man of system . . . seems to imagine that he can arrange the different members of a great society with as much ease as the hand arranges the difficult pieces upon a chessboard. He does not consider that the pieces upon the chessboard have no other principle of motion beside that which the hand impresses upon them; but that, in the great chessboard of human society, every single piece has a principle of motion of its own altogether different from that which the legislature might choose to impress upon it."

Churchman in his inimitable way makes the following observations:

"Economic models have to aggregate a number of things, and one of the things they aggregate is you! In great globs you are aggregated into statistical classes . . . .

"Jung says that, until you have gone through the process of individuation . . . you will not be able to face the social problems. You will not be able to build your models and tell the world what to do . . .

"From the perspective of the unique individual, it is not counting up how many people on this side and how many on that side. All the global systems things go out: there are no trade-offs in this world, in this immense world of the inner self . . . All our concepts that work so well in the global world do not work in the inner world . We have great trouble describing it very well in scientific language, but it is there, and is important . . .

"To be able to see the world globally, which you are going to have to be able to do, and to see it as a world of unique individuals . . . [that is, the ability to] hold conflicting world views together at the same time [and be] enriched by that capability — not weakened by it . . . that is really complexity." (21)

In retrospect we encounter instance after instance where individuals were crucial in the interaction of a technology with the society: Wernher Von Braun's leadership in rocket and space vehicle development, Dr. Rachel Carson's book "The Silent Spring". In these cases we have an impact of individuals on technology. Conversely, technology may have a tremendous impact on the individual. Television ended the career of Senator Joseph McCarthy, radio (e.g. the fireside chats) worked powerfully for President Franklin Roosevelt and the space program created the astronaut as a folk hero.

We still understand very little about the impact of telecommunications on the individual's psyche, of the computer as a prosthesis of a part of the brain. The computer may significantly shift the balance between left and right brain oriented functions. (22). The neocortex portion of the human brain can be viewed as comprising two hemispheres, each focusing on different modes of thinking. The left has been identified as the "rational", the right as the intuitive one. The left half is associated with calculation, reading and writing (all linear activities). The right half handles geometric and spatial concepts, pattern recognition and musical ability. The left half is primarily analytic, the right is holistic in mode of thought. Table 1 summarizes the characteristics. As Carl Sagan has observed, "the coordinated functioning of both

Table 1. The Dichotomy

Left Brain Hemisphere	Right-Brain Hemisphere
Sequential thinking	Spatial thinking
Reductionist	Holistic
Analytic	Synthetic
Well-structured problems	Ill-structured problems
Problem solvers	Problem formulators
Perceptual, external experience	Conceptual, internal experience

Source (23)

cerebral hemisphere is the tool Nature has provided for our survival" (24). We know that a lesion on the right side leads to the inability of a patient to recognize his own face in a mirror or photograph; impairment of the left hemisphere may cause an inability to speak or write. It appears to be quite normal to have individual variations so that one individual may be dominated by his right neocortex, another by his left. In particular, those well suited to the analytic, science-technology perspective tend to be left brain types. On the other hand, when chief executive officers of corporations were tested using an electro-encephalograph, the right hemisphere dominated types clearly prevailed, suggesting the significance of holistic, intuitive thinking in contrast to rational analysis. (2) Loye suggests that far-sighted leadership (e.g. Washington, Lincoln) is related on the integration of left and right neocortex functions in the forebrain. (25)

And the make-up of the technology assessment or management team itself may benefit from testing to attain a reasonable mix of left and right oriented types. Loye's experiments further suggest that personality differences (e.g. masculinity-feminity, extroversion-introversion) are reflected in differences in forecasts. For example, a majority of the "tough-minded" types predicted a better future for us by the year 2000, whereas a majority of the "tender minded" predicted our future would be worse. (26) Since forecasting is a significant facet of technological innovation one should not be surprised to find personality make its imprint on the planning process itself, just as it does on the development of the technology.

Finally, we note a striking limitation in the generally accepted view of technology assessment: like its intellectual precursors, operations analysis and systems analysis, it reaches the domain of policy and decision making (often just barely) and almost never deals with the toughest phase — implementation. It is precisely there that the individual becomes most central — and the potential value of the tools is most severely tested.

2.8 The Linearity of Time

The science-technology world view is concerned with physical space-time, i.e. with time as a dimension or variable essential in grasping the dynamics of a complex system. Distortions intrude through relativity theory, e.g. perceptions of time vary with movement speed in an Einsteinian universe. Economists apply a discount rate to future dollars to determine their present value; the basis is traditionally the cost of capital. Aside from such rather mechanistic alterations, this perspective sees time as moving linearly, at a universally accepted pace determined by precise physical measurement. Thus Forrester, Meadows, Mesarovic, and Pestel may exercise their system dynamics models over 50 or 130 year periods, but the computational time increment Δt is independent of society and individuals, geographical locale, and era. We shall use the term *technological time* for this case.

By contrast every individual has a very personal conception of time. Dominated by *biological time* and needs, a person's time horizon is dictated by the expected life span and position in Maslow's hierarchy of needs.

The individual applies a psychological discount rate to his perception of future problems and opportunities which is

totally distinct. from the businessman's dollar discount rate based on cost of capital. The psychological discount rate means in effect that the individual looks at the future as if through the wrong end of a telescope. (23). Distant objects appear smaller than they really are. The highest discounting occurs where personal survival is the prime concern; a low rate in an affluent well-educated family in a Western setting. Time discounting varies with age and with psychological type. Table 2 suggests the Jung typology and related time orientations. As the Marschallin in "Der Rosenkavalier" observes,

"Die Zeit, die ist ein sonderbar Ding" (Time is a strange thing).

Table 2 Jung's Typology and Time Orientations

Jung Type	Time Focus	Discounting
Sensation	Present	Highest
Feeling	Past	Selective bias
Intuition	Future	(high/moderate)
Thinking	Past-present-future	Moderate

Sources (23, 27)

Even our daily newspaper raises the subject:

"The dimension of time has become a great paradox of the modern world. Words and images are transmitted instantly, people almost as fast. But the context and the meaning do not come through the blur of impression which seems to make adjustment slower and more difficult." (28)

The experiments of Tversky and Kahneman demonstrate how human beings apply a discount rate to their own past and thus distort the integration of their personal experience. (18) Recent events are overstressed in comparison to more remote ones.

The importance of such discounting in the technology management context can hardly be overestimated. As shown in connection with the world dynamics modeling (Fig. 2) (29), decisions are drastically altered as the discount rate varies.

Let us now turn from the individual to organizations or social entities. Neither technological time or biological time prevails.

Organizations have a longer time horizon than individuals; they do not expect to die like human beings. This does not mean they use a zero discount rate, merely a lower one than individuals. *Social time* is multigenerational. Organizations are, in fact, a curious blend of long and short time horizons. There is the motivation of perpetuation and the pressure of meeting next month's payroll and protecting next year's budget. As in the case of individuals, organizations have a spectrum of time horizons. Small companies contrast with large ones, medieval Christian with modern American societies, rich European states contrast with poor African governments.

Consider once more the case of Papua New Guinea (17)'

"There is something we could call 'village time'. It is not measured in hours, minutes or seconds, but in seasons or moons . . . Women would tend to measure the time by the chores of the day, which are very regular in a village setting. There is the time for gathering firewood or making the fire. There is the time for weeding the garden and the time for preparing the big meal of the day."

Figure 3 summarizes this discussion of time.

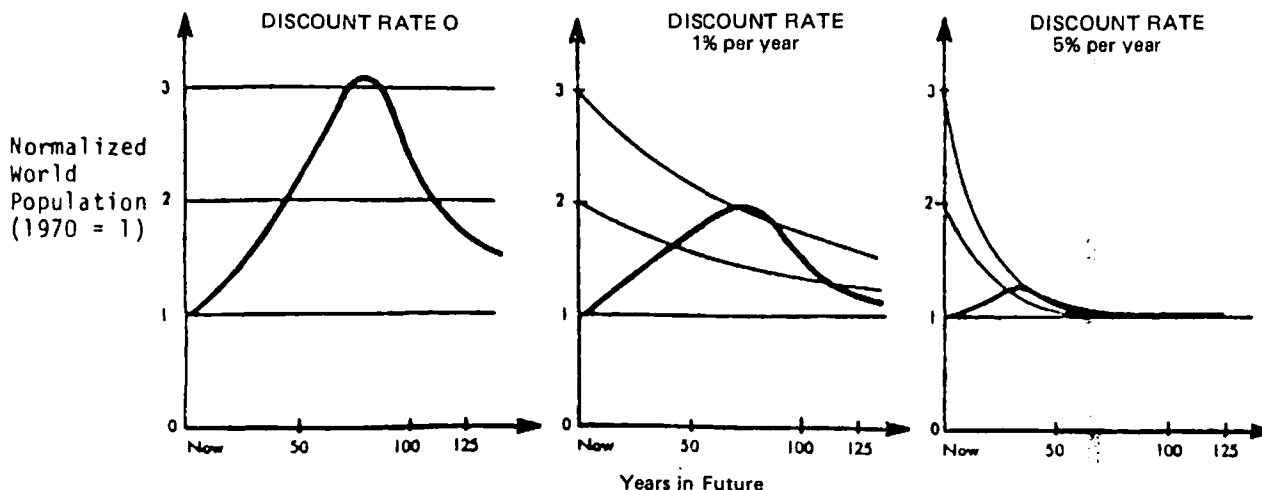*Part II of this paper will appear in the Winter 1982 edition of DYNAMICA.*

Figure 2. The Discounting Phenomenon: World Population Crisis
Zero discount rate case based on Meadows' "Limits to Growth" standard run
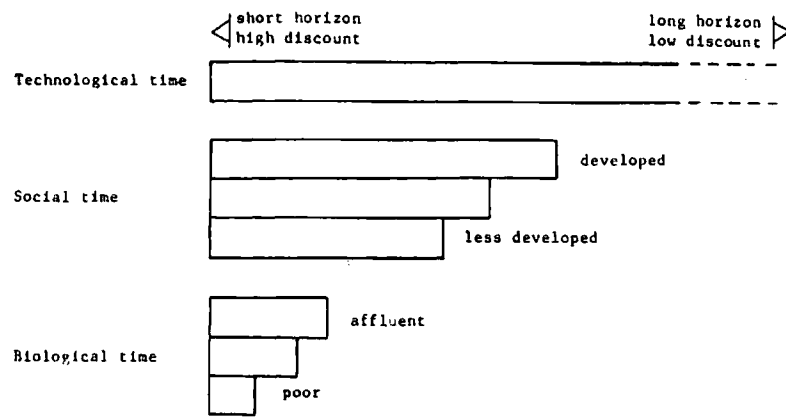
Figure 3. Relative Time Horizons — A Schematic

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