LINKAGE PROPOSITIONS BETWEEN FIFTY PRINCIPAL SYSTEMS CONCEPTS

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1.0 INTRODUCTION: THE NEED FOR LINKAGES BETWEEN GENERAL SYSTEMS CONCEPTS

Ackoff states that "the concepts and terms comonly used to talk about systems have not themselves been organized into a system [1]." Margaret Mead can be heard meeting after meeting criticizing the field she helped popularize for not applying the "systems approach" to itself. The comparatively slow development of a paradigm in general systems theory [compare with fields described in (2) and especially (3)] is characterized by endless redefining of the same few terms followed by the rediscovery, and often rewording of the most comon of these terms in each new discipline as it "popularizes" the systems level for itself. The result has been confusion in terminology, a highly fractured and "fuzzy" paradigm, and a set of introductory texts [4, 5, 6, 7] none of which can be expected to cover more than a part of the whole set of concepts available. The fragmentation of concepts between disciplines and approaches has stifled the widespread awareness of the consistent set of linkages that potentially exist among the concepts.

Some subsets of such a total linkage system can be found for certain classes of systems. For example, Miller has developed one for information-based living systems [8]. But he does not consider all available systems concepts or consider the ones he has included at a sufficient level of abstraction. Wood has devised a graphic display which shows how such unifications as Miller's do not circumscribe all the classes of real systems necessary for it to qualify as a truly <u>general</u> systems model [9]. Thus, even in well-developed cases such as this, no total linkage system of all major systems concepts has emerged.

With Iberall's systems evolutionary process as a notable exception [10], most systems monographs are compendia of separate contributions describing different systems (e.g., [11], [12], which are good in themselves but do not provide the unification required for the future progress advocated here), or are philosophical discourses with questionable relation to real empirical systems [13, 14], or are partial lists of systems concepts which are explained but not adequately connected (see [4-12]). Yet if a general theory of all systems exists, one would expect its form to be a set of intimately interlocked and mutually self-defining concepts that could be empirically refined by correspondence tests with real systems. Such a unified linkage-system of systems concepts is much needed to provide a better paradigm for future GST research and its application to understanding design and optimization of "real" systems. This paper is the first public report of an attempt to form such a linkage system [15].

2.0 TOWARD A COIMPREHENSIVE CATALOGUE OF PRINCIPAL SYSTEMS CONCEPTS

The first step at formulating a linked system of system concepts requires exhaustive and critical compilation of the most important systems concepts. Three questions were asked at this phase of the work. Where should one look to find all relevant systems concepts? How do we know that a candidate term is a principal systems concept? And finally how do we best "structure" the list of principal systems concepts once they are found?

Subsequent to our own investigations [15], two new catalogues of systems techniques and "buzz" words were sent to us [16, 17]. (Doubtless others are in progress; all should be publicized and cross-referenced as much as possible to promote progress in the field.) In the course of this section these other lists will be preliminarily compared with the criteria we propose for a catalogue of principal systems concepts. It is important to note that the Portland State University and San Jose State University workers are preparing their own lists based on different purposes than ours. These lists are not expected to fulfill those criteria listed here. Yet the comparison is helpful and instructive, and is not intended as a criticism of their distinct efforts--only as promoting wider awareness and interest in their growing listings.

2.1 The Morphology of GST and Related Fields

There are many fields of interest that could contribute to the comprehensive list of ideas for a linked-system of "principal systems concepts"--twenty-three by our present conservative estimate. Two classes of fields are distinguishable. One class stresses synthetic, theoretical and holistic techniques. In this essay they are termed "holistic intellectual movements" (h.i.m. 's) for convenience. Another class of fields emphasizes analytical and applied techniques focused on a specific area of human concern. In this essay they are simply termed fields of "applied systems analysis" (a.s.a.'s).

The holistic intellectual movements we are studying include literature on General Systems Theory; General Morphology; Brain Modelling (including Artificial Intelligence, general-problem-solver techniques, pattern recognition, heuristic programing, etc.); Hierarchy Theory; Cybernetic Theory; Information Systems Theory; Mathematical Systems Theory; Subatomic Field Theory; Synergistics; Graph and Network Theory (in only their general approaches) and the overall field of General Simulations (including world modeling, technological assessments, futures research, etc.).

The fields of Applied Systems Analysis under survey are Energy Systems Analysis (P.P.B.S. as well as new modeling attempts); Systems Analysis of Man-Environment Systems; Systems Analysis in Urban Planning (including Ekistics and Synektics); Systems Analysis in the Behavioral and Social Sciences; Ecological Systems Analysis; Systems Engineering (including only "hard," physical systems); Systems Analysis of Health Systems; Management Systems Theory (including Industrial Engineering, Operations Research, PERT, CPM, GERT Techniques, Queuing Theory and Decision Theory); Systems Analysis of Biological Systems; Educational Systems Analysis and Defense Systems Analysis. Obviously some of these particular fields overlap considerably--the purpose here is "completeness of coverage" not the formulation of a defensible ordering which is probably impossible in any case. Computerized bibliographies and data bases for each are in preparation to help in detailed comparisons [18].

Taken together, these twenty-three fields make possible a "morphological" picture of the systems approach. Figure 1 shows the name and approximate date of inception of each field, relationships to each other, and their relative positions on a two axis graph showing the opposing polarities of "holistic/vs/reductionist," and "theoretical/vs/applied" emphases. We are presently only at an initial stage of "mining" these fields as sources for principal systems concepts.

2.2 What Is A Principal Systems Concept?

The following criteria have been designed to provide the most parsimonious list of systems concepts. Terms which are not "principal" or "central" to the operation, stabilization, evolution, growth and development of systems should be eliminated by

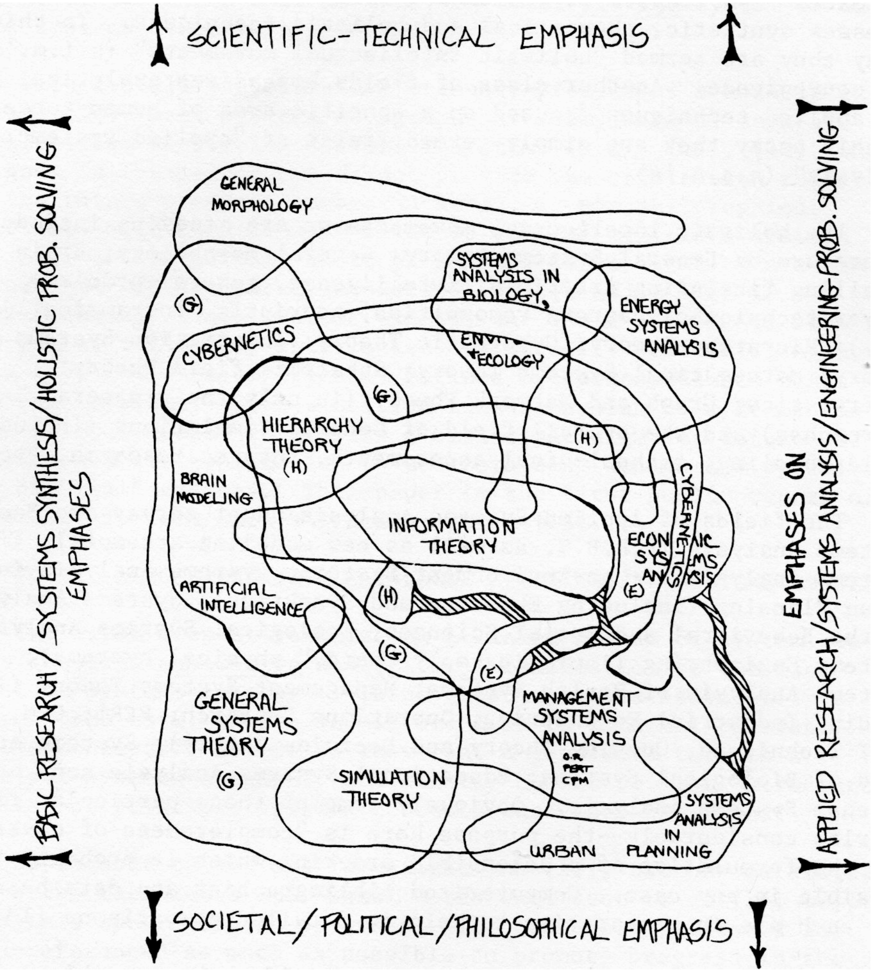


Figure 1 A "morphological" picture of some of the 23 fields involved in systems or holistic studies which contribute P.S.C.'s to this model. Size of the field's boundaries is not related to its numbers of practitioners. Overlapping of the boundaries of two or more fields indicates their mutual use of some systems concepts. Note that some fields are totally isolated from each other, while a true G.S.T. requires synthesis of abstract ideas across all. The positioning of a field on the theoretical vs applied axis, or on the scientific vs philosophical axis is meant to portray its particular emphasis. For example, cybernetic theory <u>favors</u> the scientific over the philosophical, but is used in both theoretical and applied contexts.

application of these criteria. This makes the task of formulation of important linkages easier by elimination of conceptual "noise."

Principal systems concepts (P.S.C. 's) should

(1) have appropriate level of abstraction (sufficient to be comon to all systems, but specific enough to correspond to experimental systems),
(2) be non-humanocentric (not solely man-oriented),
(3) be phenomenologically-based,
(4) be anasynthetic,
(5) not be purely methodological in origin,
(6) be process-oriented,
(7) be able to contribute to self-definition of other P.S.C. 's,
(8) be rich in interaction with other P.S.C. 's,
(9) be truly transdisciplinary,
(10) be simplifiers of systems complexity (i.e., imensely variable in particulars but invariant in general),
(11) be primary generators of systems stability, optimization, operation, evolution, growth, and development.

In this short comunication only some of these can be discussed.

Criteria (2), (3) and (5) are important for constraining the list of P.S.C.'s to workable limits and to fundamental concerns. Since other lists do not introduce these restrictions (e.g., see [16] and [17]) they include words that we have excluded from the P.S.C.'s. Examples of these excluded words are:

(man-oriented) humanocentric terms	non-phenomenological terms
e.g.,systems artifact systems epistemology systems axiology	e.g. , "systems" behavior "systems" causality
[i.e., words related to exclusively man-centered interpretations, awareness or manipulations of systems]	[i.e., words that do not have direct correspondence to real systems phenomena; or words too general to distinguish systems concepts from any other]

descriptive or taxonomic terms	methodological terms
e.g., Artificial Intelligence dynamic complexity, holistic, isomorphic	e.g. , forecasting analysis, modeling, simulation, flowcharting
[i.e. , names of overall systems features which require other descriptors to exhibit correspondence to experiential systems]	[i.e. , names of representative processes or techniques for studying systems, but which are not processes found within the system]

All of these words are useful "buzz" terms; but none of them allude to real, operational primary parts, patterns, or processes of real systems. As such, linkages between them would not be instructive. Important secondary or tertiary-level terms such as systems behavior, systems complexity, or systems causality must be defined in other terms to have much meaning at all. Repeated use of such very general words without reference to more fundamental terms capable of association with real systems is what leads to attacks on the systems approach as ethereal or meaningless [19]. This, at least, is a valid criticism among many others that are not in Berlinski's folksy diatribe.

Other terms can be eliminated by linking them to man's tendency to interpret natural systems in the guise of goal-oriented structuring when virtually all well-studied natural phenomenon reveal themselves to be largely process-dominated. More awareness of the essential unity of the structure vs. process distinction as one thing--"structurprocess"--is needed. (See ref. [20] for a discussion of goal-dominated vs. process-dominated explanations and how man often misunderstands nature by missing the distinction.)

Additional terms have been eliminated because they have not passed the "anasynthesis" criterion. The word anasynthesis is here used to describe a "concept" that can serve dual roles. An anasynthetic concept contributes to analytic reduction of more abstract concepts. Simultaneously it "names" a vast "set" of specific and real processes in natural systems (each bearing their own specific names), thereby synthesizing their diversity into one notion. Western man needs to balance his intense devotion to analytical reductionism with anasynthetic words which link his success at reduction to needed successes in holism [21].

2.3 A Hierarchical Listing of Principal Systems Concepts

Table I is merely a convenient hierarchical listing of the fifty-seven principal systems concepts which have currently survived the criteria tests. These are the P.S.C. 's we utilize to construct the linkage propositions and the system of systems concepts. A hierarchical tree implies "linear" reductionism, and, in some cases, causality. This is not intended in Table I because many alternative hierarchies among P.S.C. 's could be logically supported and empirically demonstrated for real systems. The existence of these multiple alternative hierarchies indicates two important things. First, the P.S.C.'s indeed are related as networks to each other and not only by single or even dominant linear chains of causality. It should be clear that many alternative trees can be derived from a complex, digraph network. (This is in direct contradiction to some interpretations of network (to) hierarchical transforms advanced by Goguen and Varela.) The existence of many equally plausible trees is a rationale supporting the need tor multiple linkage propositions which express the many interconnections among P.S.C.'s and provide the true "nestings" or "contexts" for each P.S.C. Second, the existence of alternative hierarchies suggests that individual man's inborn limited span of attention and depth of awareness (see [8] and [22] for discussions) often inhibits mankind's awareness of "networks of" or holistic interactions. A corollary of this insight would focus on the role man's bias, judgement and "perceptive fix" play in interpreting and endlessly arguing over alternative systems of systems concepts.

3.0 THE ROLE OF LINKAGE PROPOSITIONS BETWEEN SYSTEMS CONCEPTS

Ongoing examination of the P.S.C. 's using a "modest" general morphology [23] and [24] has led to the formulation of 142 preliminary linkage propositions to test their utility for providing a linked system of systems concepts. Some are well known in the field. Others are new. New links arise from comparing any two P.S.C. 's based on their sharing a comon intersect in a "modest" morphological matrix and exploring possible mutual impacts between the two P.S.C. 's (see [15(a)] for description). This methodology could generate many more additional linkage propositions if this initial test and response from the field indicate that the strategy is productive.

3.1 What Is A Linkage Proposition?

A linkage proposition is a semantic description on a theoretical level of a relationship between two or more principal systems concepts which tentatively holds for all known observational entities in real systems that correspond to the theoretical concepts. It is important to note that some of these "linkages," which are described in sentences of logical form, need not be causal, nor linear, nor directional as will be illustrated shortly. Further, these interrelationships are defined as "tentative," not known, both because of an everlasting need for continued empirical refinement, and because of the macro-uncertainty principle [25]. This and their network or non-linear causality feature implies that linkage propositions are testable in many real systems, but never quite isolatable/controllable as demanded by the normal scientific method. They are not equivalent to theorems. Linkage propositions, therefore, are in the realm of metascience as exemplified by evolution and discussed in [20]. They are also anasynthetic. Taken alone they are analytic reductions of the next higher level of systems behavior. Taken in groups or together, they synthesize discrete and recognizable subsystems and processes into functional "wholes" of behavior. Taken as a whole they are truly "autopoietic" in the sense of the Greek roots (auto = self; poietic = generative); i.e., they are self-generating. The network of inborn relationships which arise from the very natures of the surrounding concepts actually bring forth the concept upon which we focus. We are not sure how this "maps" with the use of the word by Varela [26], which is based on a unique methodology, but exploration of the correspondence would be interesting.

3.2 Precedents for Linkage Propositions

Linkage propositions are by no means entirely new. Two strains of work, one in the behavioral sciences and one in the philosophy of science, provide extensive precedents. Still, the model now being constructed at the Institute for Advanced Systems Studies (I.A.S.) at Cal. Poly, Pomona, is different and designed to be more general and inclusive than the former strain, and has a synthetic and metascientific intent rather than the reductionist-scientific intent of the latter strain.

The behavioral science precedent can be found in Miller's work on living systems [8]. It is based on many interlocking sets of relationships, all of which focus on information processing. His statements, however, are in the form of theorem and corollary, and do not cover as wide a spectrum, or as generalizable a system as intended by this model, as pointed out by Wood [9] and others. Information flows in the inanimate systems of physics and chemistry and even lower life forms, for example, if they exist at all, do not follow many of the detailed relationships he cites. This is not a broad criticism of his work, for it is an extensive and valuable development of a specialized portion of a class of systems under what may someday be a general theory of systems. Further, many of his statements are examples of precedent "linkage propositions."

The philosophers of science have long recognized the existence of "correspondence rules" in scientific theories and practice (sometimes called "C-rules" or "bridge principles") [27]. Schaffner makes careful distinctions between the origins of the "linkage" concept in the "operational definitions" cited by Frank [28] from reflections on Einstein's general theory, and its use in other formulations such as Campbell's "dictionary" and Hempel's "interpretive systems [29]." Although study of the work of Nagel [30] and the illustrations which Schaffner constructs of the use of C-rules in biology [31] and physical science [32] is helpful, they appear to confirm that C-rules are not exactly the same as "linkage propositions." First, C-rules, though also tentative, are supposedly confirmable by normal applications of the scientific method which "linkage propositions" are not. Second, "linkage propositions" are operational at much higher levels of abstraction from the real systems they portray, than are C-rules. Third, C-rules are predominantly causal and vectorial while "linkage propositions" can exhibit several other interrelationship categories (see Section 3.4). Fourth, C-rules are reductionist oriented, while "linkage propositions" are anasynthetic.

It is these dissimilarities that lead us to use the term "linkage propositions" rather than "C-rules." Still, the theorems in Miller's work and the C-rules of the philosophers of science represent a family of precedents in whose traditions "linkage propositions" follow.

3.3 Examples of Linkage Propositions

For a current list of the initial 142 linkage propositions (L.p.'s) see reference [15]. A more extensive discussion and application of each linkage proposition will be contained in [33] and[34]. The examples given here are selected to represent some aspects of the set which is not given here due to space restrictions. (Systems concepts are underlined.)

A. Some L.p. 's are already well known in, and supported by, the literature. Their value here is adding to the complete set. For example,

> <u>Positive</u> <u>and</u> <u>negative</u> <u>feedback</u> mechanisms are often found <u>coupled</u> together as a partial cause of <u>dynamic</u> <u>equilibrium</u> <u>and</u> <u>stability.</u>

> Similar <u>linkage</u> strengths, times and distances <u>(incremental</u> <u>parameter</u> <u>trends)</u> characterize the entities within a level of the hierarchy and help to define hierarchical <u>levels</u> empirically and non-humanocentrically.

> <u>Linkages</u> are the medium by which <u>subsystems</u> become <u>systems,</u> and systems become <u>supersystems.</u>

Positive feedback contributes, in part, to growth. Negative feedback contributes, in part, to equilibrium.

The energy flow required for maintenance is proportional to negentropy of a system. (Odum, 1976.)

B. Some L.p. 's can be arranged in sequential series, adding greater levels of explanation to a P.S.C. This can be called "tracking" or "tracing" among the complete set of L.p's coursing to or from a particular systems concept. For example ....these selections from an entire page on Boundary Conditions ....

Boundary conditions contribute in part to the cause of exclusion principle.

Hierarchical relativity is in part the result of applying different boundary condition parameters and getting different coupled subsystems.

Awareness of incremental trends are in part the result of comparing the magnitudes of parameters of boundary conditions across the levels of modular hierarchies.

Temporal boundaries in a system result from selection by its environment for the most optimal cycling time. This means that temporal boundaries and cycling time are types of externally-generated goals of the system.

Recognition that a system has components/entities/elements which are sometimes called subsystems is the same as recognizing the system is decomposable.

C. Some L.p. 's describe conditions that must be realized either (i) for an appropriate and rigorous formulation of another P.S.C. or (ii) as a condition for a systems feature. For example,

Boundary conditions must be known to properly define internal or external generated goals/purposes.

Metastability inhibits recycling of elements/components/entities.

D. Some L.p. 's are useful for recognizing close correspondence between two P.S.C. 's often used by somewhat isolated groups of the 23 fields impinging on GST. For example,

Cycling of a system (Life Cycle type) is the same as temporal boundaries of the system in question.

Hierarchical levels determined in part by incremental parameter trends are in part the cause of the exclusion principle.

E. Some involve new ideas and/or linkages which would require much discussion and testing before acceptance.

Concrescence ratio can lead to establishment of new boundary conditions as well as the associated features of transgressive equilibrium and transgressive attribution/ emergence.

Transgressive equilibrium is in part the cause of levels of hierarchies.

Instability in the form of unsatisfied counterparity leads, in part, to systemic evolution.

Recycling of systems components/entities after systems lifecycle decay contributes to equilibrium of the next higher level of hierarchy.

Flatness in a hierarchy is stable for static systems but unstable in dynamic systems.

Cycling reduces the energy flow necessary to maintain a negentropic deterministic succession of states or modes in a system. Cycling is a special case of synergy.

F. Some L.p. 's link more than two P.S.C.'s together producing a multi-concept "trace" (see Figure 3) within one statement. For example,

Temporal capture of energy flux is a function of increases in linkages which in part causes trans temporal stability.

Temporal capture of energy flux is, in part, the result of an open system condition which also exhibits mechanisms of dynamic equilibrium and a relative complexity of subsystem couplings.

A small amount of unsatisfied counterparities in a population of entities that are within a hierarchical level characterized by mostly satisfied counterparities partially causes concrescence.

At this early stage in formulation several strong disclaimers are required. Not all types of L.p.'s are represented in the current 142. None of the L.p. 's presented here are in a refined form. These 24 are merely examples of the possibilities inherent in L.p.'s for making discrete and testable hypotheses about how systems concepts work together as a whole. Much more time and many cooperating, probably even competing, minds will be necessary to discredit some of the L.p. 's,suggest new ones, and generally improve the linkage model.

3.4 Association Classes of Linkage Propositions

Although each linkage proposition is completely unique to its coupling of two or more principal systems concepts, the semantics used to describe each specific coupling sometimes falls into one of several discrete classes. Groups of linkage propositions use the same action verb forms or prepositional phrases to describe the coupling. For example, the following phrases and linkage types turn up often:

Congruence/comonality relationship: "can substitute for;" "is analogous/homologous to;" "is isomorphic to (*);" "is the same as;" "is identical to;"

Linear or conventional ordering relationship: (*) "is, in part, the cause of (*);" "is, in part the result of (*);" "contributes to;" "is a partial function of;" "acts among/or/within;" "is a condition necessary for;" "probabilistic influence on;"

Inversion/or/reciprocality relationship: "negates;" "opposes;" "enhances;" "inhibits;" "increases;" "decreases;"

Dual opposite relationship: "is a counterparitor to (*);" "is a symetrical counter to" (note the duality aspect of several entries in the other relationship categories; for example, increase/vs/decrease, or cause/effect);

General/specific/grouping relationship: "is a type of;" "sub/super;" "micro/macro;"

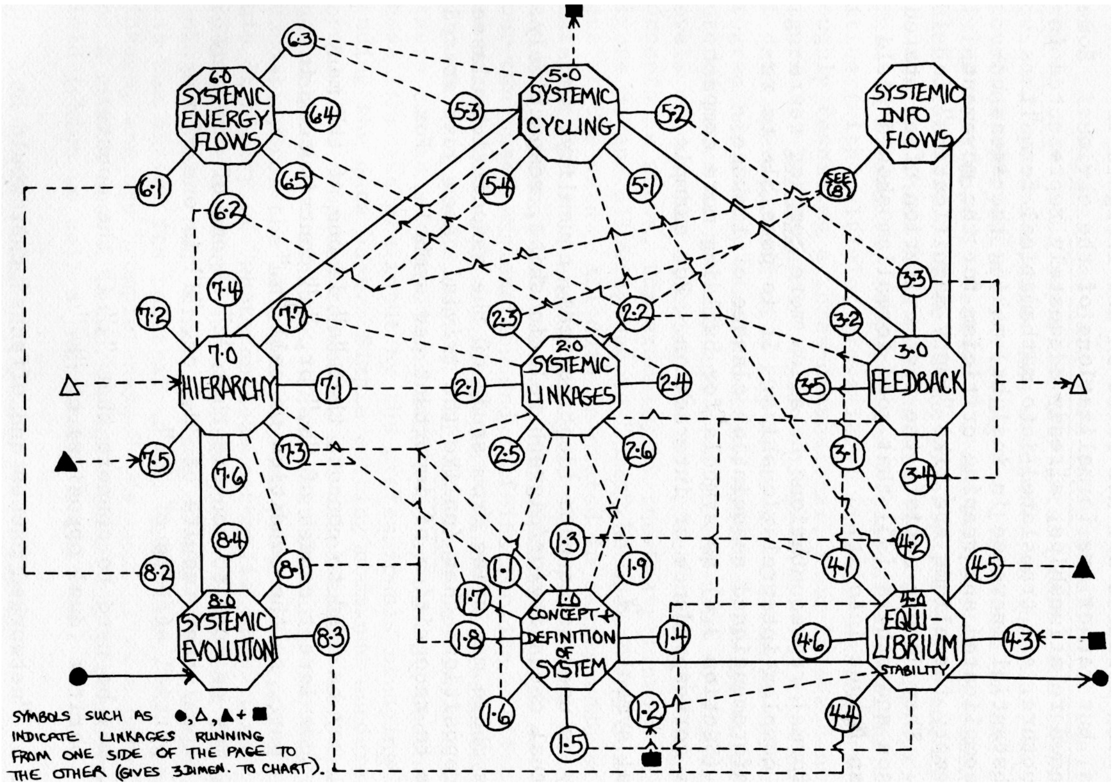
Some of these phrases are quite comon to reductionist logic, others, I believe, are quite new (starred,*). Used together, though, they help build a stable complex network of interconnected ideas. The existence of these common phrases implies on purely linguistic and theoretical grounds that discrete "classes" of coupling exist in real systems. These coupling types deserve attention themselves as P.S.C. 's. The exciting possibility emerges that a holistic meta-language can be constructed which emphasizes very dynamic and fundamental transformations in natural systems. These "transforms" or "association classes" will undoubtedly be holistic, process-oriented, time-telescoping concepts rare in our Western world and its reductionist-dominated language. The new P.S.C. 's may help expand our awareness from its usual emphasis on static, taxonomic names (e.g., nouns like corn) to awareness achieved by the Indians in their more dynamic process-oriented words for describing the same natural event (i.e., several names for "corn" based on the stages of its full developmental cycle).

3.5 Alternative Representation of Linkage Proposition for Human Use

Since the human mind cannot hold more than a very few connected concepts in its consciousness at one time [8 and 22], several graphic aids were devised to encourage use of the linked system of systems concepts. Without these aids users would experience difficulty "seeing" the wholeness of the linked set of concepts. In our experience, students attempting to trace pathways from one concept to others can easily lose their place. The existence of a physical form of the full linkage model, characterized by long-term stability, would help achieve (i) easier awareness of the "connections" as an integral part of the meaning of each principal systems concept, (ii) easy referral to data on these connections found in the literature, (iii) easy reference to data and/or insights on the concepts themselves and, most importantly, (iv) would provide a stable foundation for further detailed development and evolution of the model. The graphic forms currently being explored include in ascending order of utility: network graphics, symbolic models, and computerized models.

3.5.1 Graphic representations of lingage propositions. Pictures encompass large amounts of data. They are superior for comunication of meaning, patterns and trends. Even holistically-based sciences, such as Artificial Intelligence, much less the reduction-oriented sciences, cannot yet explain pattern recognition in a series of reduced causes and effects. Graphics have become, therefore, a standard tool in systems-oriented, holistic studies.

An initial picture of the linked system of systems concepts is shown in Figure 2. Although some are greatly comforted by a view of the total picture of the linked concepts, others are intimidated by even this early simple graphic version probably due to its detail and complexity. This last objection may be answered by use of what computer programmers call "stepwise refinement." This will involve preparation of many transparencies which carry only parts of the total graphics and can overlay each other. This allows building Figure 2 step-by-step from successive simpler versions that use only one concept or one class of connections and then add the others (with explanations) until the more total



<u>Figure</u> <u>2</u> A preliminary graphic display of some of the linkage propositions and the connections they make between principal systems concepts. The numbers in circles correspond to the numbered systems concepts in Table I. A continuous line means linkage between a systems concept and its packet name or between packet names. A dotted line means linkage between systems concepts. A_/_ means "not connected at nexus."

version is complete. It is intended that this graphic capability be added to the computer program and model discussed in 3.5.2.

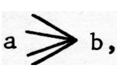
3.5.2 Symbolic representations of linkage. Mathematical formalisms are widely used in systems synthesis and analysis. Unfortunately, many such formulae are not based on new insights or relationships, but rather are formalizations of the obvious. Sometimes well-known relationships, already adequately represented in semantic structure, are translated into mathematical formalisms without a substantial increase in insight, making the ideas unnecessarily complicated and reaping criticism for the movement [19]. Such empty formalisms are like "empty magnification" in cell biology. They do not satisfy the test criterion often stated by A. G. Wilson and others [35] that good formalism should yield much more than is put into it.

Still, formal representations do allow more compact representation of complex interrelationships. It is possible to represent the aforementioned association classes of linkage propositions (Section 3.4) as symbols for building more compact statements of correspondence or interaction. For example,

the usual symbols $\cong$, $\rightarrow$, $\leftrightarrow$

may be used to connote identicalness, causality, and mutual causality/or/digraph relationships, respectively.

Still other symbols may arise from study of the association classes of linkage propositions that (unlike the trivial cases just stated) may give rise to recognition of important new symbols. For example,


may be used toconnote that "a" is one of the many coexistent causes of "b," or, "a" contributes, in part, to the condition we call "b."


may be used to connote that "c" is one of the many coexistent results of "d," or, "d" is one of the partial effects of "c."


may be used to connote that "j" is the counter-pari tor (dual opposite) of "k."

The awareness of "networked causes and effects" that would be promoted by popularization of these last symbols may be quite a step for those comitted to single, isolated and linear causes and effects. Formalism and reductionist science often go hand-in-hand leaving out the analogue systems that might be better represented by these symbols. Further, they might fulfill the

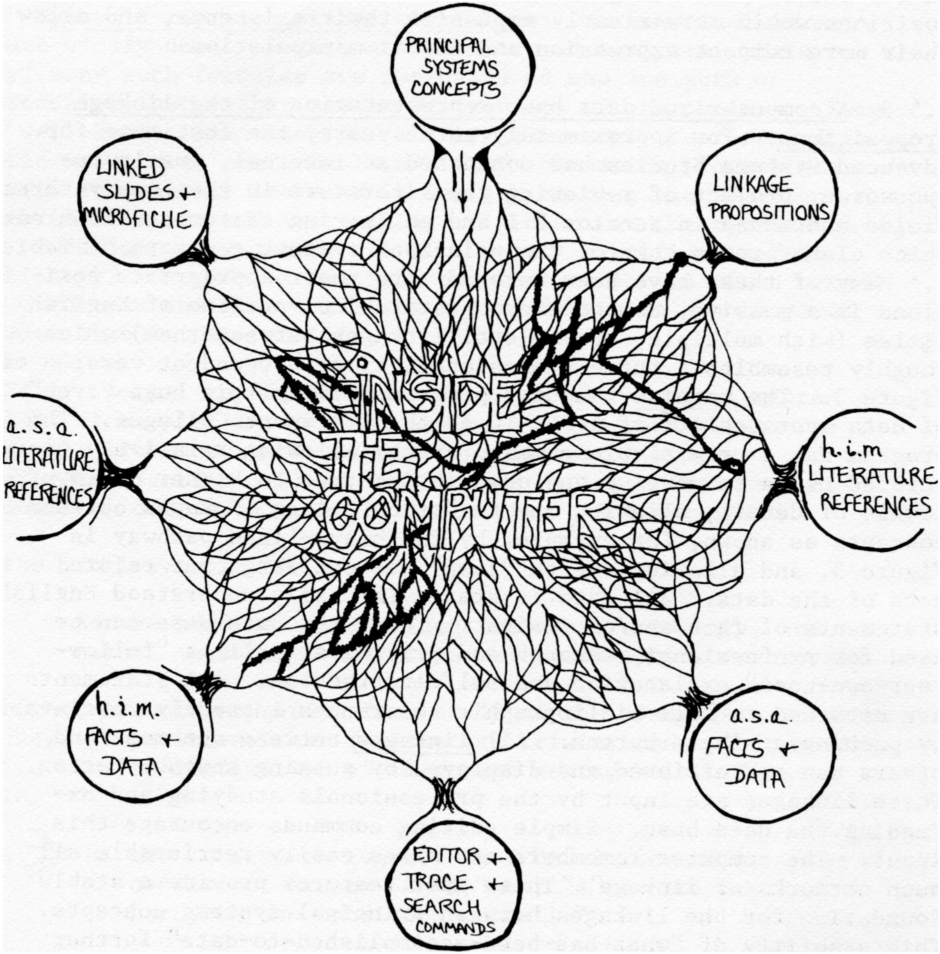


Figure 3 An image of the many "connections" between the quotation and data taken from the G.S.T. literature that have been input into, and can be recalled by, the computerized data base. The connections form a rich network of ideas. The bubbles represent the main categories of information in the model and also represent the entry points into the data base. The heavy line represents an example of one person's pathway through the information resulting from his/her "tracing" along connections.

deabstraction than 'those specific examples proposed by Darden and Maull. (The disturbing aspect of the "interfield" distinction is the arbitrary and humanocentric boundaries it uses for specific fields, terms and techniques. The P.S.C.'s organized into a linked system may help rationalize these distinctions and result in a more rigorous definition of "interfield theories." For example, the P.S.C. 's that guide setting of boundary conditions, hierarchical levels, equifinality, emergence, and exclusion principle all might be used as operating tools or at least criteria for distinguishing between fields and, therefore, the functional relations of their concepts.)

This "linked system of systems concepts" could also be used for the following important functions in general systems theory:

- (i) enriching the meaning and understanding of each principle systems concept,
- (ii) enriching the conceptualization of the origins of the phenomenon each concept names,
- (iii) enriching the awareness of dynamic-pro cess-orientation of systems,
- (iv) enhancing the search for isomorphies,
- (v) providing for better analytical/empirical testing of each individual "link" without losing sight of its contribution and position in the holistic nature of the full set,
- (vi) enhancing the power of the general systems models for explanation leading to generalized predictions,
- (vii) describing areas needing more work,
- (viii) providing a framework for a group paradigm,
- (ix) providing a framework to help assess the rigor and "completeness" of the many models and simulations being proposed for specific real systems,
- (x) for efficient education of students in the subject.

The systems concepts without the linkage propositions possess what philosophers of science call "antecedent theoretical meaning," (see [27] and [31]), which in this case refers operationally to the systems concepts' current literature meaning, relatively isolated and devoid of all possible connections. This comon perception of a concept divorced from its uses is our inheritance from the reductionist worldview that permeates almost all of our experiences in the West. The "isolated" meaning is much less fulsome and accurate than the meaning supplied by the set of connections taken together with, and as an intimate part of, the meaning of each concept. To achieve the more accurate "sense" of each P.S.C. 's real meaning we must shift our worldview. Expansion of our "unit" awareness to the word-cum-connections (including all impacts on it and influences proceeding from it) greatly widens our understanding of the functions of the concept and in itself will contribute to greater attention to holism.

Since many of these connections are process-oriented and involve probability and change over time, our emphasis on "connection awareness" will also result in a less *static* view of each P.S.C. and the set as a whole. Dynamics of systems will be easier to recognize. Further, the connections for each P.S.C. describe the multiple influences that give rise to the phenomenon so named. Attention to these generative linkages gives us a detailed reductionist pathway for the dynamic origins of each concept as well as the origins of systems organization and evolution--especially when we become conscious of the whole set of origins. This detailed but intermeshed explanation of time-variable, developmental schema that describe origins, might also become the foundation for making general systems theory a predictive science. For GST prediction to become a reality, many future years of effort are required *in* establishing rigorous rules for deabstraction, in coupling the general theory to the specific phenomena in each target field, and in applying long chains of correspondence rules. Even then, predictions will be more "holistic" in nature than those found today in reductionist science. In some cases, though, these holistic insights and predictions will be more valuable to man's evolving self-reference, values evolution, and future survival, than reductionist predictions of this century. I believe they will lead to more adaptative behavior for man.

The more complete view of systems provided by a linked system of systems concepts may help accomplish for systems what the "complete" view of the chemical elements in the periodic table of Mendeleev did for chemistry. It may point out dramatic gaps in our knowledge needing more work. It may help establish the "significance" of the needed information, thus attracting resources. A further important derivative of a more linked and so more complete general theory would be *its* usage to critique the large number of models of specific real systems available since the publication of The Limits to Growth [37, 38, 39]. These models are now influencing policy formation and decision making yet none of them contains data from the real systems on all of the P.S.C. 's and their complete linkages. Clearly, they are not yet true models of real operating systems. Therefore, they do not even model a general system, much less the real systems they claim to model. My wholehearted support goes to those who make such attempts, however, because we must begin somewhere. Still, conclusions from such incomplete models should be *given* with precautionary notes, and each such "real" systems analytical model should be contrasted with general linkage models to be sure all major areas of concern are covered by the data. Systems analytical modeling needs the help of a rigorous GST paradigm to be successful!

When more complete general linkage models than this are available in the literature, the consensus of the field on the best of them will finally provide GST with its much needed paradigm in the sense Kuhn uses the word [2]. The paradigm will make the field more acceptable as a metascientific discipline, more recognizable, more fundable, and will greatly help systems educators teach their students about the field. The new workers provided by these systems education programs can then select for intensive scrutiny and improvement anyone of the many specific linkages cited in the general, without losing sight of the total picture. I do not sympathize in the least with Emery [40] and others who fear that a "common conceptual framework" will lead to disputation and less progress. The history of science is eloquent testimony for the opposite case. Comon frameworks promote more orderly and rigorous investigations (see Odum, [41], for well-stated examples of this). Rather than new ideas being kept out, only the best literally force their way in, over time, and eventually restructure the paradigm [2]. The result is a healthier, less fuzzy field of knowledge.

In fact, it can be argued that the existence of a "common conceptual framework" in the form of a linked system of systems concepts will speed recognition and testing of isomorphies. Men must build their ideas on those of others. The anasynthetic nature of the linked model will provide a sufficiently detailed and documented "picture" of holism for new workers to explore and detect trends and patterns that are obscured today by our rather amorphous views. Man can hold only a few concepts and linkages at one time in his consciousness, and so a documented picture of the linkages "on hold" so-to-speak will be necessary if he is to detect new patterns and trends. (I do not intend this as a criticism, however, of those others who are exploring exciting new attempts to perceive holism on a metaconsciousness level.)

5.0 POSSIBLE APPLICATIONS OF THIS MODEL IN DEVELOPING COUNTRIES

Several applications of the linkage model have been explained in the text. Some are of special practical interest to NATO countries, such as:

(i) NATO countries, because of telescoping of the time necessary for their "industrial revolutions" have more control over the process. They are increasingly aware of and actively using the systems analytical models available in the literature. Are these models complete? As described above, a complete GST linkage model would help detect where such models are defective in analysis and prediction because they leave out one or another of the complete sets of principal systems concepts and their interrelationships. Implementation of defective models and promotions of decisions based on them could lead to NATO countries experiencing many of the problems now all too comon in the "overdeveloped" countries. NATO countries might avoid these problems by judicious use of GST overview models such as this one in addition to systems analytical models.

(ii) Exposing specialists to a linkage paradigm sumarizing GST literature would be the most rapid and efficient means of educating them in the anasynthetic domain to balance their learning in the purely reductionist analytical domain. The "linked system of systems concepts" provides a first-cut version of such a paradigm.

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