A SYSTEM VIEW TO URBAN PLANNING: AN INTRODUCTION

Research Seminar “Urban Systems”
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SYSTEM THEORY
DEFINITIONS OF SYSTEM

“A system can be defined as a complex of interacting elements”

Ludwig von Bertalanffy, General System Theory, 1968

“A system is a set of interrelated elements. A system is an entity which is composed of at least two elements and a relation. Each of a system’s elements is connected to every other element, directly or indirectly.”

Ackoff, Towards a System of Systems Concepts, 1971

“1. Each element has an effect on the functioning of the whole. 2. Each element is affected by at least one other element in the system. 3. All possible subgroups of elements also have the first two properties.”

Ackoff, Towards a System of Systems Concepts, 1971
In its broadest conception, a “system” may be described as a complex of interacting components together with the relationships among them that permit the identification of a boundary-maintaining entity or process.”


“A system is a set of interrelated elements that make a unified whole. Individual things—like plants, people, schools, watersheds, or economies—are themselves systems and at the same time cannot be fully understood apart from the larger systems in which they exist.”

http://www.ecoliteracy.org/essays/systems-thinking
PROPERTIES OF SYSTEMS

• A system is a set of interrelated elements. A system is an entity which is composed of at least two elements and relation. Each of a system’s elements is connected to every other element, directly or indirectly.

• An abstract system is one all of whose elements are concepts. Languages, philosophic systems, and number systems are examples. The elements are created by assumptions (axioms or postulates) and defining the relationships between them.

• A concrete system is one at least two of whose elements are objects. The establishment of properties and elements requires empirical research.

PROPERTIES OF SYSTEMS

• The environment of a system is a set of elements and their relevant properties which are not part of the system but a change in any of which can produce a change in the state of the system.

• The state of system’s environment is the set of its relevant properties at a moment of time is the set of its relevant properties at the time.

• A closed system is one that has no environment. An open system is one that does. Thus a closed system is one which is conceptualized so that it has not interaction with any element not contained within it; it is completely self-contained. Openness and closedness are simultaneously properties of systems.

• A system event is a change in one or more structural properties of the system over a period of time.

PROPERTIES OF SYSTEMS

• A **static system** is one to which no events occur. A table, for example, can be conceptualized as a static concrete system consisting of four legs, top, screws, glue and so on. Relative to most research purposes it displays no change of structural properties, no change of state.

• A **dynamic system** is one to which events occur, whose state changes over time.

• A **homeostatic system** is a static system whose elements and environment are dynamic. Thus a homeostatic system is one that retains its state in a changing environment by internal adjustments. A house that maintains a constant temperature during changing external temperatures is homeostatic.

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PROPERTIES OF SYSTEMS

• A **state-maintaining system** is one that can react in only one way to any one external or internal event but it reacts different to different external or internal events, and these different reactions produce the same outcome.

• A **goal-seeking system** is one that can respond differently to one or more different external or internal events … and can respond differently to a particular event in an unchanging environment.

• A **purposive system** is a multi-goal-seeking system the different goals of which have a common property. Production of that common property is the system’s purpose.

**Ackoff, R. L. (1971). Towards a system of systems concepts. Management science, 17(11), 661-671.**
“The system therefore consists of all the interactive sets of variables that could be controlled by the participating actors. Meanwhile, the environment consists of all those variables that, although affecting the system’s behaviour could not be controlled by it. The system boundary thus becomes an arbitrary subjective construct defined by the interest and the level of the ability and/or authority of the participating actors.”

Jamshid Gharajedaghi, Systems Thinking. Managing Chaos and Complexity, 1999
EMERGING PROPERTIES

“Emerging properties are the property of the whole, not the property of the parts, and cannot be deduced from properties of the parts. However, they are the product of the interactions, not a sum of the actions of the parts, ….Emerging properties, by their nature, cannot be analyzed, they cannot be manipulated by analytical tools, and they do not yield to causal explanations.”

Jamshid Gharajedaghi, Systems Thinking. Managing Chaos and Complexity, 1999

A flock of birds
“Methodologically, it is important to set apart a theoretical system from an empirical system. The former is a complex of concepts, suppositions, and propositions having both logical integration and empirical reference, while the later is a set of phenomena in the observable world that is amenable to description and analysis by means of a theoretical system.”

“Understanding interdependency requires a way of thinking different from analysis; it requires systems thinking. And analytical thinking and systems thinking are quite distinct. Analysis is a three-step thought process. First, it takes apart that which it seeks to understand. Then it attempts to explain the behavior of the parts taken separately. Finally, it tries to aggregate understanding of the parts into an explanation of the whole. Systems thinking uses a different process. It puts the system in the context of the larger environment of which it is a part and studies the role it plays in the larger whole”

Jamshid Gharajedaghi, Systems Thinking. Managing Chaos and Complexity, 1999
“The organism is considered to be an aggregate of cells as elementary life-units, its activities are resolved into functions of isolated organs and finally physico-chemical processes, its behaviour into reflexes, the material substratum of heredity into genes, acting independently of each other, phylogenetic evolution into single fortuitous mutations, and so on. As opposed to the analytical, summative and machine theoretical viewpoints, organismic conceptions have evolved in all branches of modern biology which assert the necessity of investigating not only parts but also relations of organisation resulting from a dynamic interaction and manifesting themselves by the difference in behaviour of parts in isolation and in the whole organism.”

“[...] emergence of a bundle of new disciplines such as cybernetics, information theory, general system theory, theories of games, of decisions, of queuing and others; in practical applications, systems analysis, systems engineering, operations research, etc. They are different in basic assumptions, mathematical techniques and aims, and they are often unsatisfactory and sometimes contradictory. They agree, however, in being concerned, in one way or another, with "systems," "wholes" or "organizations"; and in their totality, they herald a new approach.”

Ludwig von Bertalanffy, General System Theory, 1969
“Observed phenomena in the natural and human-made universe do not come in neat disciplinary packages labeled scientific, humanistic, and transcendental: they invariably involve complex combinations of fields, and the multifaceted situations to which they give rise require an holistic approach for their solution. Systems theory provides such an approach and can consequently be considered a field of inquiry rather than a collection of specific disciplines”.

“Systems Theory: the transdisciplinary study of the abstract organization of phenomena, independent of their substance, type, or spatial or temporal scale of existence. It investigates both the principles common to all complex entities, and the (usually mathematical) models which can be used to describe them.”

http://pespmc1.vub.ac.be/systheor.html
SYSTEM’S VIEW OF PLANNING
Planning is a process of human thought and action; spatial patterns are not the object of planning, they are the objects of a process independent from them. Planning has been too much concerned with the content of plans rather than with the process of planning.
Planning is a human activity related to human beings, their behaviour, their abilities. The systems view of planning is concerned with making the most and best use of human abilities; it seeks human decision and participation.
The word “system” has been used a number of times in the two preceding chapters in ways in which it is hoped that its meaning is implicit in its usage; now, however, a formal definition is required. The *Oxford English Dictionary* defines a system as: a complex whole, a set of connected things or parts, a department of knowledge or belief considered as an organised whole. Whilst this is useful, it is better to attempt more precision, and the definition put forward by Hall and Fagen (1956) is preferred:

“A system is a set of objects together with relationships between the objects and between their attributes.”

They go on to define “objects”, “attributes”, and “relationships”:

“Objects are the parts or components of a system, which are unlimited in variety ... admitted are abstract objects such as mathematical variables, equations, rules and laws, processes.”

“Attributes are properties of objects.”

“Relationships are those that ‘tie the system together’.”

In fact (as they say) it is these relationships which make the idea of a system useful, which are its central feature. A system has wholeness; although complex it has parts that are connected to each other in some way; thus smaller parts of systems can be identified, but it is these connections between the parts which make it a system. It is noteworthy that A. Angyal (1941) insists that “the structure of wholes cannot be described in terms of relationships. In aggregates, it is significant that the parts are added; in a system it is significant that the parts are *arranged*”. (My italics.)
Stanford Optner (1965) has elaborated the above definition somewhat, and filled out some of its apparent vagueness:

"Objects are the parameters of systems: the parameters of systems are input, process, output, feedback control, and a restriction. Each system parameter may take a variety of values to describe a system state.

"Attributes are the properties of object parameters. A property is an external manifestation of the way in which an object is known, observed, or introduced in a process. Attributes characterise the parameters of systems, making possible the assignment of a value and a dimensional description. The attributes of objects may be altered as a result of system operation.

"Relationships are the bonds that link objects and attributes in the system process. Relationships are postulated among all system elements, among systems and sub-systems, and between two or more sub-systems."
At first, a system is a way to see/understand the world; it has a subjective character. But a systematic analysis can be performed upon the identified system. Depending on our purpose, the system view of the “same reality” can change.
A NOTE ON THE MATHEMATICS OF SYSTEMS

We may describe a system also as a relation between an input to a process and its output, that is, there is a flow through a system—of information, energy, or matter—which can be described as an input–output relationship:

Fig. 3.1. System characteristics.

Fig. 3.2. A simple system with input $a$ and output $b$.

Fig. 3.3. A system with feedback loops.


Elements of a system can be seen as “black boxes”; in urban planning, individual buildings can be considered as such: they receive and input and produce and output. The planner does not need to know what happens inside the black box (e.g. the building).
The boundary of the system is defined by the interactions between elements; the elements that are not interacting are outside the system. Those that are interacting (giving inputs, receiving outputs) are the environment of the system.


Fig. 3.4. The definition of a system. The circles represent a large set of elements (which may be regarded as black boxes). From this set of elements a smaller set, within the bounding line, is selected because of the relevant connections between the elements indicated. The arrows crossing the boundary are inputs to or outputs from the system. The broken arrows are further possible connections of interest but which are not included within the present definition of the system. (after Van Court Hare, 1962).
The idea of process is inherent in all systems. Process at different levels. A system exists in relation to an environment, and the system may be “open” or “closed” in relation to that environment; that is, an open system is not isolated from its environment and its materials or energies or information are exchanged with the environment in a regular manner. A system is closed if it operates without such interchange.† Again referring to Klir and Valach’s set theoretic treatment, if \( r_{0i} = 0 \) and simultaneously \( r_{i0} = 0 \) for all values of \( i = 1, 2, \ldots, n \), we are concerned with an absolutely closed system. If a system is relatively closed and has \( n \) elements we can regard it as an absolutely closed system of \( n + 1 \) elements. This tactic is of considerable value in many practical situations, where a system is regarded as relatively closed: we can choose to treat it as closed by regarding the environment as an additional element of a now completely closed system, or we can regard it as relatively closed with a restricted set of inputs and outputs that we can manipulate successfully.

A system has its own structure (it is a *being*); it undergoes changes over time as a result of its functioning (it is *behaving* in a context); and it is transformed as a result (it is *becoming*).
A town – as physical artifact – cannot be regarded as a system. Only when it is filled with flows of people, information, goods ... becomes a system.

(Dice, 1955). The real world is, in fact, a complex system of both natural and man-made things; it can be discerned to have a morphology; it has a characteristic and complex endogenous behaviour; it is also undergoing irreversible change through the passing of time. It should be clear, though, that a town as a physical artefact cannot be regarded meaningfully as a system (except as a perceptual system); it is only when the buildings are occupied by people’s activities; when the spaces and channels are filled with flows and movements of people and goods and information; when there is daily and weekly and seasonal change in these activities and flows; when the whole situation ages or changes in longer periods of time – only then is a town usefully to be seen as a system. Likewise for the planner a bridge or a building as such is not a system (unless we see it as a molecular system, and this is without meaning for our resolution level): man’s activities and flows and the hand of time must be involved before we can see these things as a system. Thus the “built environment”,
we can see these things as a system. Thus the “built environment”, a concept advanced at the present time, does not exist as an entity. The environment is not built, it is largely adapted: adapted, that is, from natural features and circumstances; and any concern with the qualities of buildings only—for our purposes—is a shallow thing. The richness and complexity of that intricate combination of nature and man’s adaptation of natural space that is man’s habitat defies all attempts to cut out parts for study that are not

The “built environment” does not exist as an entity; it is not built, it is adapted.
All systems are flow systems, for flows of information and/or energy and/or matter make up the relationships which are the heart of any system. Even a perceptual system, for example a group of people walking through and seeing a landscape, has as its basis a set of flows of information which relate to the flows of matter (people) and to the flows of energy which they and the vegetation around them produce and consume. A set of ideas may be a conceptual system, related by flows of information again, and using flows of energy in the person producing them. The whole Man–Nature system that was discussed earlier in these pages can be seen also as a
Techniques to represent the dynamic character of a system
The size of a system is a measure of its complexity rather than a physical measure.
REFERENCES


THE WHOLE AND THE PARTS

“Implied the notion of a whole which was completely equal to the sum of its parts; which could be run in reverse; and which would behave in exactly identical fashion no matter how often these parts were disassembled and put together again, and irrespective of the sequence in which the disassembling or reassembling would take place. It implied consequently that the parts were never significantly modified by each other, nor by their own past, and that each part once placed in its appropriate position with its appropriate momentum, would stay exactly there and continue to fulfill its completely and uniquely determined function.”

Karl Deutsch, Mechanism, Organism and Society, 1951