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Report R22:1987

# THE SYSTEM-MAN BUILDING

An ontological perspective

Anders Ekholm

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ABSTRACT

Scientifically based concepts and general theories of the object of knowledge are necessary starting-points for research, education, and practical application in a field of knowledge. In the field of architecture such concepts and theories are lacking. Architecture deals with questions of buildings and man's use and experience of buildings. The hypothesis of the thesis is that with man's use and experience buildings emerges the system man-building. This system is the object of architectural knowledge.

The starting-points of the thesis are ontological theories (especially systems theory), architectural theories, and empirical observations. The thesis includes an account of basic concepts in ontology and systems theory. These are applied to describe certain properties of man, social systems, artifacts, socio-technical systems, and society. In the light of this, basic concepts and general theories of buildings and the system man-building are developed.

Key words

Architecture, artifact, building, hierarchy, level, ontology, system man-building, society, socio-technical system, systems theory.

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PREFACE

The aim of the thesis is to contribute to increased clarity about the theoretical foundations for research and design in the field of architecture. There are those who question the possibility of a particular architectural research. By implication, it is believed that architecture is a field of activity for practical action where different special knowledge is applied rather than developed. Architectural knowledge includes the ability to create and assess good architecture. A large part of this knowledge is so-called ”tacit knowledge” which is not conceptually formulated but based on practical knowledge and experience. However, in interdisciplinary research, in theoretical teaching and together with other professional groups in practical design, a conceptual knowledge of architecture is required.

Architectural research can be said to be research that develops the specific architectural knowledge. The field of architecture deals with issues of buildings and human use and experience of buildings. The field today lacks on a scientific basis elaborated general concepts and theories about its object of knowledge. The thesis assumes that the object of architectural knowledge is the man-building system. The thesis is based on ontological theories (especially systems theory), architectural theories and empirical observations. These are used to describe properties of the human being, sociosystems, artifacts, sociotechnical systems, and society. Against this background, basic concepts and general theories regarding buildings and the human-construction system have since been developed.

The outline of the thesis is stated in the table of contents. In chapter 1, Introduction, the background and problems of the work, the architectural theoretical and philosophical starting points and the method of the thesis work are presented. The conclusion of chapter 1 is a brief account of how general systems theory evolved in relation to philosophy, science, and technology.

In Chapter 2, Ontology, Chapter 3, General Systems Theory, and Chapter 4, Sociosystems and Artifacts, basic theories and concepts in these areas are presented. The definitions of concepts are supplemented by examples of descriptions of properties of buildings, man and sociosystems. In the case of quotations and the text based on other authors, I have made references to these.

In Chapter 5, The Man-building System, a description scheme developed in Chapters 2, 3, and 4 is applied. The results of the thesis are primarily this application, which has led to definitions of basic concepts and basic theories regarding buildings and the human-construction system.

Work on the thesis began in 1983 at the Foundation for Industrial and Ecological Construction, The Landscrona Group, with a grant from the Swedish Council for Building Research. In the summer of 1985, I got a PhD position at the Division of Architecture II b at Lund University, LTH. The PhD position has enabled the final work on the thesis. The teaching part of the service has meant a stimulating contact with students in the atelier teaching at the school of architecture. Help with financing of the work has also been obtained from the Helgo Zettervall Fund.

I would like to thank those who in various ways have been important for the thesis work. I thank PhD. Peter Broberg at the Landscrona Group. During my years there, 1975-85, his own work was a constant source of inspiration while encouraging and actively contributing to my research interest. I also thank the employees at the Landscrona Group who over the years have given me many stimulating impulses and ideas.

I thank Professor John Habraken of the Massachussetts Institute of Technology, MIT, for stimulating input to my work. His research has inspired my choice of thesis topic. A thank you is also addressed to Professor Eric Dluhosch, MIT for fruitful conversations and consideration.

I was accepted as a PhD student at architecture II b, LTH by Professor Bengt Edman who has followed my work with interest. Since the summer of 1985, Professor Jan Henriksson at Architecture I has been my supervisor in a committed and accommodating way. In the initial stages of the thesis work, Associate Professor Jerker Lundequist at Design Methodology, KTH gave valuable advice.

I would also like to thank the following people who have read the manuscript of the thesis at different stages and provided valuable advice: Professor Olle Eriksson at the Research Council Board and Professor Lars Löfgren at the Department of Computer Science and Engineering, LNTH. Architect Thomas Hellquist, Ph.D. Jonas af Klercker, Professor Birgit Krantz, architect Samuli Mustajärvi and Assistant Professor Mona Åhlund at the Architecture Department, LNTH and Associate Professor Erik Wallin at the Department of Human Geography, Lund University.

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Finally, I would like to thank my family. My children Karin, Jenny and Jens and their grandmothers have made the thesis work possible and meaningful. My dear wife Anki, with her encouragement and ability to listen and give advice, has helped me throughout the thesis work.

Anders Ekholm

## PREFACETO THE ENGLISH TRANSLATION

My original ambition was to direct my thesis to a Swedish audience of academics and other interested actors especially in the Architecture and Construction fields. To increase its availability, I therefore decided to write in Swedish. In 1987 it was still customary in the field of Architecture to write the thesis as a monography, and not as today as a collection of scientific articles earlier published in scientific journals. This has changed and most research is written as articles in English for an international audience. In my case this means that my thesis work has not been accessible outside the Swedish speaking community. On the other hand, my later work, directed towards more delimited problems of interest, is to a large extent based on literature, theories and ideas presented in this thesis. The reason for making this translation available is to fill a gap if by chance someone would be interested in this work. Having returned to the text now many years later I see that it represents a level of knowledge that I now in different project and contacts with co-workers been developed and hopefully refined. Therefore, this work is now mostly of historical interest, but perhaps also as a source of ideas for continued work.

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# 1 INTRODUCTION

## 1.1 About the thesis

### 1.1.1 Need for theory in the field of architecture

The thesis has drawn up definitions of basic concepts as well as general theories regarding the buildings and the man- building system. The background is the ambiguity that prevails about the theoretical foundations of architectural research and design. Scientific research takes place partly in relation to background knowledge in the form of existing hypotheses and theories, and partly in relation to empirical data. The thesis is based on ontological theories, especially systems theory, and architectural theories as well as empirical observations.

Before a general theory can be worked out, the object of knowledge must be determined. The thesis assumes that the object of knowledge of the subject of architecture is the system man-building. This system arises from human use and experience of buildings. What particularly characterizes the field of architecture is the knowledge of the relation between man and buildings and of the whole that arises from human use and experience of buildings. See Figure 1.1. The question that can be said to summarize the problems of the thesis is: ”What are the properties of the whole that is formed during human use and experience of the built environment?”.

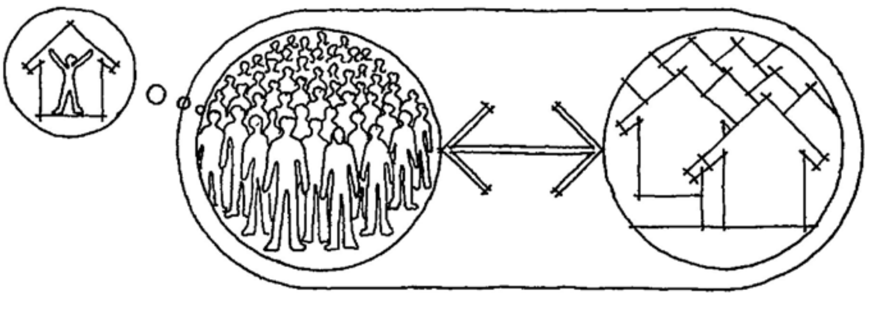


Figure 1.1. The domain of architectural knowledge relates to the relation between man and buildings.

The field of architecture also includes knowledge of the design of the man - building system. Development of design methods is an important research area in architecture. However, the development of design methods must be preceded by the knowledge of the object to be designed. The present work has been limited to dealing with the most general properties of buildings and of the Man-building system and does not deal with the design of these systems. However, the foundations have been laid for the development of a general methodology for design in the field of architecture.

### 1.1.2 The whole man-building

Buildings are designed and produced by man to be used for a variety of purposes. Activities that require protection from the climate and from invaders, or an aesthetic and symbolic expression, are thus made possible through the use and experience of buildings. Buildings provides both opportunities and limitations. It can be designed to facilitate contact between people, and it can also provide rich experiences. Joint use and management, for example, of residential buildings provides opportunities for collaboration between users. However, buildings are resource-intensive to produce and change, they both bind and limit the possible activities for a long time.

When people use and experience the buildings, they are also affected in different ways. Åke Daun has drawn attention to man’s dependence on the design of buildings in relation to the expansion of the modern metropolis: ”The geographically dispersed pattern of life, which is a consequence of industrialism and urban growth, has had an impact on human culture, on mindsets and attitudes towards other people. Man does not remain unaffected by the external changes that he produces, but rather becomes the object of his own actions” (Daun 1980:261).

Thus, the design of buildings also implies an influence on man, his actions, and experiences. This means that those who are engaged in the design of buildings also work on the design of properties of man. It is therefore not possible to treat the two objects separately from each other, the properties of one have an impact on the properties of the other, man and building are parts of a common whole. The activities made possible by the human use and experience of buildings can be considered as properties of this common whole.

The traditional view of the work of the architect is that it involves the design of buildings in terms of various technical, functional, and aesthetic properties. This view is already found in the Roman architect Vitruvius, who was active in the early decades BC. In his major work ”De architectura libri decem” (Ten books on architecture), he refers to the properties of the building ”commoditas”, ”firmitas” and ”venustas”. Palladio, who bases his presentation on Vitruvius, also distinguishes between the three aspects of buildings, ”utility or convenience, duration, and beauty” (Palladio 1983:6).

However, in line with the observations made above, it must be noted that architects not only work on the design of buildings, but also influence the properties of the person who uses and experiences buildings. The design includes determining the properties of these parts so that they can be included together in a common whole with the intended properties.

The properties of buildings must be determined in relation to both the requirements of the producing systems and the requirements of the users, see Figure 1.2. Among the problems that arise in determining the properties of buildings is the conflict that may exist between those properties that are desirable from the point of view of production, and those that are desirable from the point of view of users. For construction reasons, it can be advantageous for an inner wall to be load-bearing and of cast-in-place concrete, while for the users it may be desirable that the wall is possible to move when the needs change.

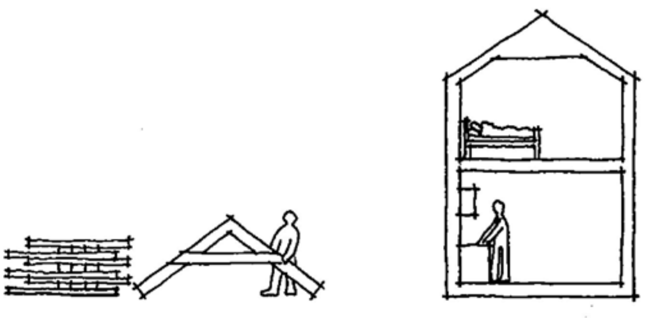


Figure 1.2. The properties of buildings are determined considering both production and use.

Another but similar problem is the contradiction that may exist between, on the one hand, the economic requirements for cheap buildings, which can be met, among other things, by mass production of building parts and even entire buildings, and, on the other hand, the users’ demands for a varied and individually adaptable environment. The parts produced by the construction industry must not make the desired use and experience of the building impossible.

The type of problem discussed above can be summarized in a number of typical questions concerning the relation man-building: ”In what way are users dependent on buildings for their activities?”, ”How are buildings used and controlled?”, ”In what way are the properties of buildings dependent on the producing systems?”, ”What does industrial construction with mass production, pre-manufacturing, standardization, etc. mean for the users’ use and experience of buildings?”.

### 1.1.3 Architecture as a field of knowledge

Architecture as a field of knowledge covers a variety of subjects with technological, social, humanistic, and artistic focus. It can be argued that architecture does not have its own object of knowledge, but that architects should only apply knowledge of man and building taken from other disciplines. The architects would thus not have to conduct any research of their own, but only apply other people's knowledge in building technology, psychology, sociology, aesthetics, etc. Thus, a question that belongs to the thesis' problem is whether the subject of architecture can constitute a scientific discipline with a domain (object of knowledge) that distinguishes it from other scientific disciplines.

Separate knowledge of man and building is necessary in architecture but cannot be said to particularly distinguish this area of knowledge as these are studied in a variety of different disciplines. Above was presented the hypothesis that during man's use and experience of buildings, a whole with new properties arises. One consequence of this is that man and buildings are to be studied not only separately, but also together. Thus, *the field of architecture is characterized by the study of the man-building system in connection with human use and experience of buildings.*

To achieve a whole with the desired properties, the architect must have knowledge both of buildings and sociosystems and of the relations between them. The knowledge the architect must have in his work can be developed both through the utilization of practical experience and through scientific research. Scientific knowledge is developed in relation to theories and empirical observations. A scientific description of the man-building relation must be based on a theory that makes it possible to consider man and the built as parts of a common whole.

Such a holistic approach is made more difficult by the fact that the development of scientific knowledge is divided into different areas of knowledge that have different scientific traditions. Research on buildings belongs to the technological and scientific fields, while research on man and sociosystems belongs to the social sciences and humanities. Since architects work with the design of wholes that include both people and buildings, knowledge from all these areas must be combined.

This breadth complicates the development of a comprehensive theory in the field of architecture. It also means that communication and collaboration between researchers and practitioners with different specializations is made more difficult. The lack of a general comprehensive theory also complicates the development of a holistic view of the man-building relation. A holistic approach is necessary in both research and design to formulate relevant and well-defined problems and avoid reductionist traps.

Within the design process, the architect can work with different conditions and problems. Sometimes the determination of properties can refer to entire buildings from detail to whole. Another time the task may be to change the floor plan of a building and a third time the problem may be to find a suitable user for a given building. In each of these tasks, the architect affects the properties of the whole. The parts affected may be different as well as the extent of the impact may vary. The effect of the impact depends on which parts you control, some are more significant than others.

Questions about the relations of the parts to the whole and which are the ”right” parts for a given whole, cannot only apply to buildings, but must apply to all artifacts. One should thus be able to discern some general principles of how things are composed and how they can be described, which could form the basis for the elaboration of descriptions of the things one is particularly interested in. In the above example, the term ”part” has been used, it would be desirable for this to refer to the same general characteristic of the object regardless of whether this is a building, the city or some other thing.

These questions are related to the concepts of system and level. When determining the properties of a building e.g., a building, one speaks of ”decision-making levels”, ”complexity levels” and ”compositional levels”. Sometimes the level concept refers to the scale of a geographical area. Other times, the rank of different decision-makers in a decision-making organization is meant. Still other times, the level concept refers to a class of things, e.g., the division of the parts of which a building is composed into different classes based on the complexity of the parts. In a level order of the latter kind, it can often be difficult to remain consistent, so that what is put together is addable. It is easy to understand that bricks can be assembled into one wall, but can people and the structure be correspondingly combined into a higher-level whole?

Among the problems that arise in interdisciplinary work in research and design is not only the absence of concepts for the most general properties of the object of knowledge. The problem is also that you do not have common designations for concepts with the same reference, i.e., you do not speak the same language. Thus, the motive for the development of very general theories in, for example, architecture is not only the need for conceptual knowledge, but also the need for common designations for the general properties of the object of knowledge, a common language.

Most often, however, the need for common designations coincides with the need for conceptual clarity. When we talk about architecture and ”buildings”, we use designations such as system, structure, unit, part, whole, level, scale, relation, flow, space, etc. For example, we can call a building a built structure, a system of rooms, a part of the city, a system of building parts. In design, for example, we talk about different levels of decision-making. When we use these designations, we cannot be sure that we are being understood unambiguously. One of the questions that forms the background for the discussion is therefore also: ”Can the architect’s language in research and design be given meaning in relation to a scientific theory of the man-building relation?”.

### 1.1.4 Architecture-theoretical starting points

In the studies that preceded the thesis work, there are some directions and traditions of ideas that I have been particularly interested in. These include the direction of architecture that goes by the term ”Structuralism”. My interest in this direction is based on not only paying attention to the importance of spatial organization for the use and experience of the building, but also being interested in how the building as a technical system affects its functional and aesthetic properties.

Within ”Structuralism” there are examples of both ideologically and scientifically characterized descriptions of the relations between man and building. Common to these architects and researchers is that attention is paid to change of human activities and that this is important for the organization and composition of parts of buildings. In connection with this, the ”structuralists” emphasize that man and building are in an interaction with mutual influence. Furthermore, humans and structures are regarded as both wholes and parts organized at levels of increasing complexity (Ekholm 1980b:9-14).

”Structuralism” within architecture developed during the 1950’s and 60’s in reaction to ”functionalism’s” static view of the building-activity relation. As a design ideology, functionalism argued that each part of the building should be designed to suit a specific use. The building would reflect its use. Instead, the ”structuralists” argued that the building’s use changes over time and that it should be designed to facilitate this. However, the ”structuralists” had in common with the ”functionalists” to view the man-building relation from an essentially constructional and functional perspective.

During the 1970s, the so-called ”post-modernism” has developed a complementary approach where the main emphasis is placed on the consideration of buildings from a historical-cultural and aesthetic perspective (Robertsson 1984: 7-8). However, the ”post-modernists” do not seem to have dealt with the significance of the change in the structure for its experiential properties.

Common to all these ideologically characterized attempts at a holistic view from different perspectives is that they developed from the practice of design and not within the various special disciplines that conduct scientific studies in their subject areas.

Among the scientifically characterized efforts made with a ”structuralist” orientation is the development of the Swedish Board for Public Building’s ”structuralist philosophy”. The purpose of this was to develop, from a ”structuralist” approach, such knowledge of the general and specific properties of buildings as is necessary for the design of adaptable buildings in the design (Ahrbom 1983: 182). According to information from Nils Ahrbom, Bo Kjessel was the first to come up with these ideas within the Swedish Board for Public Building. Of certain significance also was the Danish report ”Measurement typization” prepared by a development group for public construction (Ahrbom 1980:167). The structuralist philosophy of the Swedish Board for Public Building contains concepts for the general properties of buildings, the more general theoretical background of which I am trying to develop in the thesis. The structuralist philosophy has been developed for the Building Board’s need for knowledge about, among other things, offices, laboratories, and schools, and the general architectural theoretical or system-theoretical consequences of the approach have not been further developed.

Among other works that belong to and that have drawn attention to the structuralist tradition of ideas, is Peter Broberg’s theory of ”regional urbanisms” (Broberg 1974). In his work, Broberg has drawn attention to the relevance of general systems theory as a background for theory development in the field of architecture. He develops a theory of ”regional urbanisms”, cities that have been linked to an urban area within a geographically and culturally defined area. Broberg assumes that the ”urbanisms” are ”technological-human” systems, and that they have certain general properties in common with the biological organisms. His hypothesis is that a theory of the properties of urbanism, its growth and its physical structure, can be worked out by analogy, through the use of a theory describing the structure of biological organisms (ibid:20). Broberg compares the composition of ”urbanisms” with that of the organism organized in a ”hierarchy” of levels with elements of different complexity. Broberg’s work is an analogy study and has not led to the elaboration of a more general architectural or social theory. In a later work, however, Broberg has discussed the construction of such a more comprehensive theory. The basis for this should be general systems theory and ”speculative urbanology” should constitute a superior field of study (Broberg 1980: 199).

John Habraken has developed theories on how buildings can be organized with regard to changes in user activities. He has also shown how social relations depend on the control of structures. His most significant theoretical works are ”Supports, an alternative to mass-housing” (Habraken 1961 and 1972) and ”Transformations of the site” (Habraken 1982). In the former work, he discusses the problems of ”mass housing construction” based on people’s demands to be able to influence the design of the dwelling. He shows how apartment buildings can be organized into parts that are controlled jointly, ”support”, and parts that are controlled by individual apartment owners, ”infill”. With the terms ”support-infill”, Habraken precedes the Swedish Board for Public Building’s introduction of the concepts ”community-related”, ”building-related” and ”activity-related” parts (Byggnadsstyrelsen 1969).

Habraken’s theory of ”Supports” formed the background for the formation of Stichting Architecten Research, SAR. The purpose of this organization was to develop design methods based on the ”support” idea. The so-called ”Support method” means that the design of the building’s ”infill” parts can take place freely within the framework specified by its ”support” parts. The design thus involves examining the possible apartment plans within a given ”support” (Habraken et al. 1976 and Ekholm 1982). What I have been particularly interested in is the underlying principle of distinguishing between those parts of the building that are decided on at a superior level and those parts that are decided on in a subordinate level. The principle of level division is important for the organization of buildings and structures and is of the utmost importance for understanding the course of design.

The view of the division of the building into parts depending on both technical and social factors that Habraken introduces in ”Supports”, is further developed in ”Transformations” into a more general theory of buildings and how they are controlled. In doing so, he particularly highlights how control of buildings and sites is related to relations in the sociosystem. The ontological starting points of the theory in ”Transformations” can be said to be inductively derived and are not grounded in any explicitly stated philosophical tradition or schooling like Systems theory.

Christopher Alexander has developed a theory of architecture that, unlike the former, is essentially an expression of an idealistic ontology. According to Alexander, the knowledge of man-building relations is not the knowledge of concrete things and their properties, but instead the knowledge of so-called “patterns” (Alexander 1979). A “pattern”, according to Alexander, has an of material things independent existence and the knowledge of a “pattern” is obtained through introspection (ibid:255). The examples of “patterns” that Alexander presents in his publications are nothing more than representations of requirements for both general and specific functions and experiential properties of buildings and their parts. Knowledge of these qualities cannot be obtained only through introspection or one’s own subjective experience, but, contrary to what Alexander advocates, must be based on practical experience and scientific research on man and building.

The above works are not the only ones that have had an impact on my work on the thesis. Other works are mentioned in the references and bibliography. However, the above-mentioned have been particularly important for the thesis’s focus on Ontology and Systems theory.

### 1.1.5 Philosophical starting points

Common to the theoretical works presented above is that they draw attention to the fact that man is dependent on buildings, both for the social relations and for the properties of society. They also deal with issues that are fundamental to the design process, for example about decision-making levels in relation to the structure of buildings and society and about the relations between part and whole.

However, to deal with the problems, I have outlined in the introduction, it is necessary to start from more general theories than those mentioned above. The need for clarity regarding such concepts as part, whole, level, function, structure, etc. does not exist only in the field of architecture. This need is common, among other things, to all areas of technological knowledge, i.e., areas that relate to the knowledge and design of artifacts.

The need in technology for very general theories of composite things is one of the motives for the development of General Systems Theory. Even the basic and applied sciences have contributed to this development, as a response to the need for interdisciplinary theories. Systems theories are examples of interdisciplinary theories. They describe properties common to things of various kinds and are very general theories of an ontological nature.

To be able to describe the composition of parts of buildings and to be able to describe the whole that arises from human use and experience of buildings, I have wanted to try to take as a starting point the General Theory of Systems. One should, however, ask whether it is possible to develop a basic theory common to both man and material things. Among those who are skeptical of the possibility of finding such common theories is Nils Ahrbom when he points out that ”Architecture in my opinion is too complicated a whole to be made the subject of research using the methods taken from the natural sciences, which have been applied so far. Architecture is not only reason and calculation but also intuition, feeling and valuation” (Ahrbom 1983:12).

Systems theory has gained ground in technology and the natural sciences as well as sociology and social sciences. Thus, there is evidence to suggest that it might be applicable to my purpose. However, it is essential to recall Ahrbom's objection.

One can also, as Israel does in the book ”On relational social psychology”, question the possibility of reaching knowledge about the sociosystems via a theory that has a scientific conceptual world as a background. This approach is traditionally associated with ”hard” knowledge of a physicochemical nature and not with ”soft” knowledge of an emotional or linguistic nature. Israel asks why the social sciences ”should follow the rules of method of physics and treat their fields as if they were things or objects. Perhaps man and society, i.e., the ”objects” that the social sciences examine are by no means mere physical objects.” (Israel 1979:14).

What distinguishes man from other things, according to Israel, is that he has a language that enables communication, the transfer of meaning between individuals. This distinction is essential and is also reflected in the division of philosophy into, on the one hand, ontology, the field of knowledge relating to the properties of concrete things, and, on the other hand, the areas that deal with the abstract systems and their relations to the concrete systems: semantics, epistemology, and ethics.

For an architectural theory that involves the knowledge of people and buildings, it is necessary to consider all the main aspects of the object of knowledge represented by the various main areas of philosophy. A single research effort can hardly fully address all aspects but is usually forced to concentrate attention on only one or a couple of the aspects.

The aim of this thesis is to investigate the ontological foundations of architecture, i.e., to describe people and structures as concrete things. Such work cannot be done entirely without links to semantics, epistemology, or value theory, but must also touch on these aspects. Research work itself always touches on these issues, and when you touch on design, which is a problem-solving process, the epistemological aspects are doubly necessary. Furthermore, man's relations with the built structures cannot be described without the human interpretation of his environment. The questions of interpretation are of a semantic or semiotic as well as epistemological and value-theoretical nature.

Thus, one cannot make a complete description of the man-building relation from systems-theoretical or ontological points of view without touching on all the main areas of knowledge. It is a very extensive task to obtain an overview that allows for a coherent presentation from such diverse main aspects as those mentioned here. The work must be delimited to be possible to carry out. The knowledge of the man-building relation must precede the knowledge of the design of this system. The thesis has therefore been limited to mainly describing the man-building relation and is not about the design as an activity.

### 1.1.6 Mario Bunge, philosopher of science

The philosophical foundations on which I built this account are essentially Mario Bunge's major work ”Treatise on Basic Philosophy”. This work currently comprising 9 volumes is described by the publisher Reidel as ”the first philosophical synthesis to be authored after the completion of the period known as the Age of Analysis”. Bunge's ”Treatise” has been prepared in accordance with current scientific knowledge and, according to Bunge himself, aims to form a philosophical system of concepts that includes the four main areas of philosophy ”semantics, epistemology, metaphysics and ethics”. Once we have a system, Bunge says, we can start picking it apart, ”first the tree, then the sawdust” (Bunge 1974a:v).

Mario Bunge was born in 1919 in Argentina. He has been a professor of Physics but is now known primarily as a leading scientific theorist and philosopher, working as a professor at McGill University in

Montreal, Canada. In addition to the aforementioned ”Treatise”, Bunge’s extensive scientific theoretical and philosophical output includes the great work ”Scientific Research”.

Bunge is not usually attributed to any of the established school formations within the philosophy of the 1900’s such as positivism or structuralism. Prior to the elaboration of his ”Treatise”, Bunge was best known as a critic in philosophy as well as for his contributions as a theorist of science. ”Scientific Research” is an in-depth description of what science is and what the scientific method implies. The work is also a philosophy of science in that Bunge examines the philosophical premises of Science and its implications for Philosophy.

In his ”Treatise”, Bunge expands and passes on the reasoning of previous works, including ”Scientific Research”. Here he deals with the relation Science-Philosophy in the main areas of Philosophy, Semantics, Ontology, Epistemology and Ethics. As a philosopher, Bunge argues the interdependence of Science and Philosophy: Philosophy must be consistent with current scientific knowledge, while Science, in turn, presupposes basic philosophical assumptions. Bunge’s thesis is that ”all science presupposes some metaphysics” (Bunge 1977a:17).

This thesis is in contradiction to the main current of Anglo-Saxon philosophy in the 1900s. For example, logical positivism argues that the theorems of metaphysics cannot be tested therefore they are meaningless (Ahlberg and Regnell 1974:87). Popper argues that there must be a sharp boundary, a line of demarcation, between metaphysics and science. However, Bunge believes that no sharp line can be drawn between these fields. Bunge’s view is that a distinction should rather be made between, on the one hand, more and less general scientific theories, and on the other hand, scientific and non-scientific knowledge.

Bunge also opposes the idealistic trait of positivism, asserting a critical knowledge realism: there is a world outside of ourselves about which we can gain knowledge. Whether we have knowledge of this world cannot be judged in philosophy alone but is determined by scientific and technological activity. An analysis of the idealistic features of positivism can be found in Juul-Jensen (1973:71ff).

Bunge is a materialist in an ontological sense. His answer to the question of what the world consists of is: ”The world is the aggregation of its component parts which are things” (Bunge 1977a:152).

Bunge’s ontology describes a world that is organized into levels from the simpler to the more complex things. Bunge distinguishes five main levels of things: physical, chemical, biological, social, and technical. Things in the lower levels precede things in the higher levels. Such a tiered ontology is consistent with the theory of evolution.

In his ”Treatise”, Bunge shows that systems theory is part of ontology. Systems theory describes very general properties of composite things. A system is composed of parts in different levels. The system is in an environment and has emergent properties that are not found in the parts separately. Systems theory thus enables a description of how parts can form wholes with new properties. I have therefore chosen to take Bunge’s ontology and the other parts of his ”Treatise” as a philosophical starting point for the thesis work.

### 1.1.7 Thesis methodology

To describe the method, I have used in the thesis work, I must first define some of the concepts used in the description. These are discussed in more detail in the ontology section of the thesis.

In Theory of Science, a distinction is made between factual sciences and formal sciences. Factual sciences such as physics and psychology describe the factual properties of things. Formal sciences such as mathematics and logic deal with conceptual systems.

Among the factual properties of a variety of things, a distinction is made between the general and the specific. The more things that possess a property, the more general the property is said to be, and the fewer things that own the property, the more specific it is. Every human has unique qualities, but also has certain qualities in common with his/her race, and other qualities in common with all mankind. Still other properties are common to all organisms and finally he/she has the concrete existence in common with all other concrete things.

The results of research can be anything from well-founded hypotheses to fully developed theories. Hypotheses and theories consist of propositions that represent the actual properties of things. Theories are more complex and consist of logically related propositions. The more general properties a theory represents, the larger the reference class, i.e., the more kinds of things it can represent.

A general theory can be made more specific by supplementing it with additional data or hypotheses. For example, a theory of artifacts can be supplemented with assumptions about buildings to become a theory of buildings. This theory can be supplemented with additional assumptions to become a theory of houses, unlike, for example, bridges or canals. With each addition to a general theory of additional assumptions, the theory becomes increasingly specific. Its reference class is getting smaller and smaller (Bunge 1983a:336). See Figure 1.3.

A theory of a class of things is developed by the researcher starting from existing knowledge and carrying out empirical tests of new theories and new hypotheses formulated in the light of the existing knowledge. The existing knowledge can be of different scope, ranging from a multitude of hypotheses to a coherent specific theory of the object of knowledge. The background knowledge can consist of a more general theory that through the research work is supplemented with knowledge of the specific properties of the object of investigation, whereby a specific theory can be formulated. Specific theories developed with the support of more general theories are called *bound models* while such theories developed solely from the study of the specific object of knowledge are called *free models* (ibid:336).

In the field of architecture, there is a lack of general theories both about buildings and the relations between people and buildings, as well as about the city and society. One reason for this deficiency may be the theoretical difficulties shared by the subject of architecture with all the disciplines that deal with the human-artifact and human-environment relation.

Each theory of the man-building relation must thus have as its starting point a more general theory of concrete things and their properties and, among other things, deal with the relation between part and whole and the concept of level. It is against this background that my thesis work has started from very general theories in Ontology and Systems theory. These theories I have since supplemented with assumptions about artifacts and sociosystems into a very general theory of the human-artifact and sociotechnical system relations. Only then have I been able to develop the somewhat more specific but still general theory of the man-building system and its emergent properties.

The theory should also be scientific. According to Bunge (ibid:251), characteristic of the development of scientific knowledge is that the working method should

1. be intersubjective and give approximately the same results for different users,
2. be able to be controlled with alternative methods, and
3. be based on well-confirmed theories or hypotheses that help explain, at least in outline, how it works.

In simple terms, the so-called scientific method according to Bunge (ibid:252,254) means to

1. identify a problem in the light of existing knowledge in an area,
2. develop hypotheses in the form of proposals for the solution of the problem,
3. test the consequences of the solution proposal empirically or theoretically with trial technique,

4. evaluate the hypotheses against the test results and
5. formulate the new knowledge and any new problems.

Theory development includes testing the consequences of the theory both theoretically and empirically. Whether the emphasis should be placed on the empirical or theoretical test depends on the nature of the research work. If the result is a specific theory, it should be evaluated partly against other specific theories and partly against empirical observations. If the work concerns the development of a general theory, it shall be tested against other general theories, its implications for various specific theories shall be investigated and shall be consistent with empirical data.

The disposition of my work can be related to these principles. In the thesis, theory development and conceptual definitions are made partly in relation to specific theories about the man-building relation and partly in relation to other more general theories. I gradually describe more and more specific properties of the object of knowledge. For each step, the method sections described above are reviewed. As background and support for the theory work and as a help for the evaluation of the empirical consequences of the theory, there is always my own, through practical design and research activities acquired, empirical knowledge of the object of knowledge.

## 1.2 About systems theory

### 1.2.1 The emergence of systems theory

The emergence of systems theory as a special area of knowledge has occurred during the 1900s, especially in the latter half. Overviews describing the development have been made by, among others. Lilienfeld (1978), Cavallo (1979), Checkland (1981) and Mattessich (1982).

Mattessich (1982) distinguishes between four main directions in systems thinking,

1. systems philosophy; ontology, epistemology, and methodology,
2. systems analysis; mathematical systems theories, design of systems models,
3. empirical systems research; studies of systems behaviors, testing of systems laws, fitting of systems models and simulation studies and
4. systems engineering; constructing artificial systems.

Mattessich notes that *systems philosophy* has gone through an ”ethical and introductory phase” with the initial work done by scholars such as Bogdanov (1926), Bertallanffy (1968), Churchman (1968), Ackoff & Emery (1972), and Lazlo (1972). The current phase is characterized by the emergence of a particular ”methodology, epistemology and ontology emerging from the systems approach”. As an example of work in this phase, he mentions Bunge’s work (1979).

According to Mattessich, *systems analysis* is an essentially mathematical focus in systems thinking, which includes efforts from many different disciplines. The mathematical systems analysis develops mathematical models for complex systems. This orientation grew out of cybernetics and control theory whose founders were Wiener (1948), and Shannon and Weaver (1949). Two main areas can be distinguished today a) linear and non-linear systems theories and control theory, as well as b) automata theory.

*Empirical systems research* refers to the application of the concept of systems in various scientific disciplines. Mattessich gives a wide range of examples in both the social and natural sciences.

*Systems Engineering* are methods of problem solving developed broadly sensed in the engineering disciplines that are directly engaged in planning or construction of complex large-scale human/machine systems. Mattessich mentions here systems models developed by engineers and business economists in industry and industrial research to produce technologically advanced systems such as robots and weapons systems, as well as large-scale structures and facilities. Systems Engineering Methods have been applied in a wide range of areas normally associated with the term technology, but also in community planning and social organization.

There are different views on the designations and classification of the different directions of systems thinking. Molander (1981:16), for example, has presented three different interpretations of the concept of systems analysis: 1) descriptive, corresponding to Mattessich's category of ”empirical systems research”, 2) prescriptive, corresponding to ”systems engineering” in its broadest sense, and finally 3) algorithmic, corresponding to Mattessich's ”system analysis”.

Bunge distinguishes two main motives behind the development of the concept of systems, one cognitive or theoretical, and one practical. The cognitive-theoretical motive arises from ”the wish to discover similarities among systems of all kinds despite their specific differences – e.g. between body temperature control systems and furnace thermostats”. The practical motive stems from ”the need to cope with the huge and many-sided systems characteristic of industrial societies - such as communications networks, factories, hospitals and armies” (Bunge 1979:1).

Systems theory has developed simultaneously in science and technology. Systems philosophy and mathematical systems analysis refer to the treatment of the concept of systems in philosophy and mathematics, respectively, and have been influenced by the efforts of both science and technology. Empirical systems research refers to the application of systems thinking in science, and systems engineering refers to the application of systems thinking in technology.

In summary, systems theory can be said to have been developed for both theoretical-cognitive and practical reasons in both science and technology. There are mainly three main types of problems that systems theory has been developed to solve

1. interdisciplinary theories,
2. theories of complex systems and
3. design methods in technology.

With regard to the often-recurring concept of ”general systems theory”, it must be pointed out that it does not refer to general systems in contrast to specific systems. No such distinction can be made. However, concrete systems can have both general and specific properties. Thus, general systems theory refers to theories of general properties of concrete systems.

### 1.2.2 Systems theory and interdisciplinarity

In science, the observation is made that in nature and society there are systems with completely different compositions that nevertheless exhibit similar behaviors and organization. Mattessich draws attention to the Russian scientist Alexander Bogdanov, who already in 1912 in his work ”Tektologia” presented a general theory of systems. This theory was based on the study of similarity in organization of things ”from atomic, chemical, and biological 'complexes' to man and human organizations” (Matessich 1982).

Thus, in science, a need arises for concepts and terminology that describe these properties common to different systems. The interdisciplinary value of systems theory, both for common conceptualization and terminology in different disciplines, has attracted the attention of, among others, Norbert Wiener, who is one of the founders of cybernetics. He justifies the need for interdisciplinary conceptualization and terminology by stating that ”there are fields of scientific work, … which have been explored from the different sides of pure mathematics, statistics, electrical engineering and neurophysiology; in which every single notion receives a separate name from each group, and in which important work has been triplicated or quadruplicated, while still other important work is delayed by the unavailability in one field of results that may have already become classical in the next field ” (Wiener 1948:2).

The interdisciplinary value of systems theory has also been noted by Boulding (1956). He points out as a problem in many of the new interdisciplinary areas of knowledge that the lack of theoretical models makes it difficult to anchor empirical studies in one’s own area of knowledge. Often the theory formation may be borrowed from adjacent areas. Boulding’s observation is also valid for the typically interdisciplinary research in the field of architecture. Boulding believes that new areas of knowledge without their own theoretical background risk becoming unscientific. The task of general systems theory, according to Boulding, is to form a ”framework” for the ”interdisciplinary movement”. However, he warns that a general systems theory develops into a theory of ”practically everything”, since such a theory would become almost meaningless: ”we pay for universality by sacrificing content”.

Interdisciplinarity involves the integration of knowledge between different disciplines. Wallén (1981:24) defines knowledge integration between different scientific disciplines as a ”process that should lead to an comprehensive theory of relevant phenomena in what is being investigated”. Cybernetics, which deals with governance and control mechanisms in all kinds of concrete systems, is cited by Törnebohm (1978:129) as an example of a so-called integrative science that can enrich adjacent research fields.

Among the most far-reaching aspirations to such a knowledge integration lies the idea of the union of sciences into a unitary science. The epistemological direction denoted by logical positivism, with representatives such as Rudolf Carnap, among others, pursued this ideal by arguing that all scientific problems can be explained by the conceptual apparatus of physics (Juul-Jensen 1973:80).

The ideal of the unity of the sciences can be discerned even in groups within the so-called system movement. Von Bertallanffy who was one of the founders of the Society for General Systems Research, mentions as one of the goals of the general systems theory to approach the ”unity of science” (Bertallanffy 1968:37). Such a unity cannot, in my view, be achieved using the conceptual apparatus of physics on, for example, the problems of the social sciences. The basic concepts Boulding has noticed that may be common in different scientific disciplines, belong to philosophy, more precisely ontology, and it is here that the possibilities of a common basic conceptual apparatus for different scientific disciplines exist.

### 1.2.3 Systems theory and complexity

In addition to the interdisciplinary motive for the development of a general systems theory, there is also a need within each individual discipline not only to describe the parts in which a phenomenon is composed, but also to describe the properties of the phenomenon as a whole. Especially in the case of complex systems, there is a difficulty in obtaining such knowledge of the properties of the parts, that one can describe how they interact and give rise to the properties of the whole.

Checkland cites as an example that in chemistry in the mid-1800s, it was assumed that so-called organic molecules, due to their great complexity, could not be produced in laboratories. It was believed that these were created with the help of some kind of ”life force” that all living organisms possessed. After Wöhler’s synthesis of urea acid, this so-called vitalist explanatory model could be written off in chemistry (Checkland 1981:62).

A similar conflict recurred a few decades later in biology. In experiments with very young embryos of water lizards, it was found that when surgical procedures changed places between a part that would develop into a tail and a part that would develop into legs, the former future tail developed into legs and vice versa. If, on the other hand, parts were transplanted from slightly older embryos, the future tail developed into tail regardless of where it was placed on the embryo. Some scientists concluded that there could be no physicochemical explanation for these phenomena. Instead, it was assumed that there must be a kind of life force or comprehensive idea that guided the development of the organism which could not be explained by scientific methods (ibid:63).

Bertallanffy strove for a synthesis of the conflicting theories in biology (Mattessich 1982). Without being able to explain the experiments, he argued that living organisms have specifically biological laws, which one can describe without knowing in detail the properties of the parts. This view contrasted with, on the one hand, the atomistic view that could only recognize physicochemical laws, and on the other hand, the vitalists who, through the introduction of the idea of the principle of life, Aristotle's ”enteleki”, could not maintain a strictly scientific approach.

Thus, systems thinking implies the perception that the parts and the whole have different laws and that the properties of the whole cannot be fully explained by the laws that apply to the individual parts. But at the same time, this does not imply a rejection of the reductionist program of the scientific method, which assumes that the properties of the parts are fundamental to the properties of the whole. This insight is of course not new but goes back at least to Aristotle who stated that the whole is more than the sum of its parts. What is new is that modern science and technology are beginning to tackle problems of such high complexity that it is not possible to reduce the relations between the parts to simple cause-and-effect relations without much more complex relations. However, the complexity is not of the same nature as, for example, in a gas that can be described with statistical models, but the problems relate to so-called *organized complexity* as in biological systems (Weaver 1948).

Another thing that systems theory draws attention to is that the parts and internal relations of the system are dependent on the system's environment. Thus, it is not without problems to delimit a system from its environment (Bunge 1979:10). A characteristic of systems thinking is therefore that a system must always be considered as part of a larger whole before one can begin to describe the parts of the system. Thus, a system can never be understood in isolation because its properties are always dependent on the concrete environment in which it is viewed. This is the cognitive and methodological ”morality” of systems thinking. From this point of view, Ackoff has postulated that ”ultimate understanding of anything is an ideal that can never be attained but can be continuously approached” (Ackoff 1979:244).

According to Ackoff, systems thinking is a *synthetic thinking* in which the understanding of the properties of the whole precedes the knowledge of the properties of parts. Synthetic thinking differs in this respect from *analytical thinking*, which begins by trying to understand the parts, after which this understanding is brought together into an understanding of the whole. Ackoff believes that systems thinking characterizes the present in such a crucial way that one can speak of a particular ”System Age”. This era began at the time of the end of the Second World War and succeeded the ”Machine Age” which began already with the Renaissance.

### 1.2.4 Systems theory and technology

The need for systems thinking is particularly great in technology where the problem is to achieve systems with desired properties in a certain environment. The composition of the system is then usually not of decisive importance since systems with different compositions may have certain external properties in common. What matters is the whole's relations with the environment.

During the 1900s, an increasing need for scientific knowledge in technology arose. Technology requires the same interdisciplinary conceptualization and terminology as science. Especially, this applies to the design of the complex man-machine systems. Such projects can only be managed by multidisciplinary working groups where each special discipline adds its knowledge of the whole it intends to design. The application of systems thinking together with the interdisciplinary approach characterizes the previously mentioned system methods developed for the management of these complex problems. The analysis of operations is one such system method. It was developed in England during World War II. The aim was to contribute scientific knowledge from a variety of disciplines to the solution of important strategic and tactical military problems, for example on troop organization and weapons operations (Weaver 1948: 541).

In the postwar period, several new system methods were added, such as the form of system analysis developed within the American consulting organization RAND. This organization had its roots in the American military operations research. RAND's methods included developing project proposals and carrying out studies of costs for different project options (Checkland 1981:134ff).

The focus of operations research and the systems analysis characterized by the methodology at RAND has been towards social science and business administration problems. These methods also tend to go by the common name ”Management science” (Jenkins 1983:20).

The system methods also include the more scientifically and mechanically oriented methods that are known as Systems Engineering. These methods have focused on the problems of traditional engineering: analysis and construction of large-scale, complex man-machine systems such as communication systems, computer systems, energy, or power systems, etc. (Wymore 1976:1). Systems Engineering in this sense is based on the tradition of thought behind the development of the assembly line in the Ford factories, Taylor's time study methods and the so-called scientific management movement (Checkland 1981:128ff.)

The application of system methods, for example in urban and regional planning, has not always been considered successful and has been met with very strong criticism both from outside researchers such as Lilienfeld (1978), and from original initiators of the methods such as Ackoff (1979). The latter has been highly critical of the development of operations research, which he accuses of both forgetting the original systems thinking and interdisciplinarity and being overly preoccupied with advanced mathematical formalizations of type problems (ibid:243 and 246).

One of the main problems with system methods is that it is sometimes attempted to apply so-called scientific problem-solving methods to problems that are not scientifically mapped. This means that part of the method must be developed to allow for a kind of standardized scientific descriptions before the method can be applied. This kind of application of system methods poses great dangers for reductionist problem simplifications, since it is the system analysts who are responsible for the description and not the researchers in the discipline(s) who have first-hand knowledge of the problems.

The field of architecture has not been unaffected by the interest in the system methods. Broadbent (1973), Jones (1973) and Ferguson (1975) have outlined possible applications of such methods in architectural design. Chadwick (1971) has developed a theory of urban and regional planning based on the general theory of systems.

### 1.2.5 Systems theory, ontology, and science

The sciences that study concrete things, the factual sciences, are based on general concepts such as population, individual, behavior, and change. These concepts are not questioned in the respective sciences but are treated in philosophy, more specifically ontology. Bunge notes that the special sciences can be seen as ”regional ontologies” while ontology can be seen as ”general science” (Bunge 1977a:xiii).

A cross-disciplinary science must necessarily approach ontology by its placement ”above” the specific sciences, see Figure 1.4. A sufficiently general interdisciplinarity such as the general theory of systems is part of ontology. The general systems theories differ from the very general scientific theories for example the biological theory of evolution in that they are so-called mechanism-free theories. This means that they represent very general properties of things and that they can be applied in a variety of scientific disciplines. An example is the law of allometric growth which, applied to organisms in biology, states that the relative growth of an organ is a constant part of the relative growth of the whole organism. This law belongs to the general systems theories and has been shown by Nordbeck (1965) to be valid for the growth of a wide range of different systems such as cities, river systems and volcanoes.

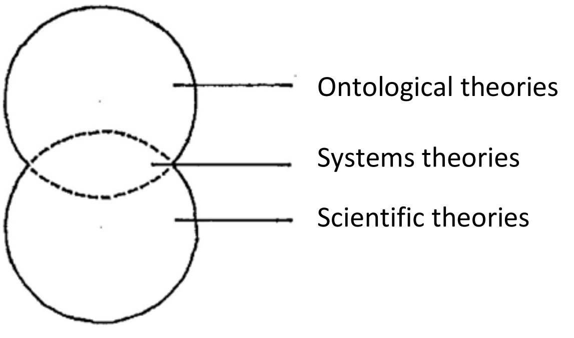



Figure 1.4. The relation ontology - systems theory - science.

General systems theories are hyper general theories. They have a very large reference class comprising several different genera of things. Such theories are not directly empirically testable but must first be supplemented with assumptions that the concepts of the theory represent properties of some species of concrete systems, after which the consequences of the theory can be tested through experiments and observations (Bunge 1977b:35). According to Bunge, the general systems theories thus pose a challenge to the traditional view that a scientific theory should be empirically testable. He argues that there is no sharp boundary between metaphysics or ontology on the one hand and science on the other, noting that the general systems theories are both ontological and scientific.

Systems theory thus bridges the gap between ontology and science. Bunge (1977a:19) notes that ontology forms part of science in

1. some of the problems handled by research, for example, the question of the emergence of new properties in the assembly of parts into a whole, and
2. in the axiomatic reconstruction of scientific theories, i.e. in the basic definitions of concepts, and
3. among extremely general theories in both basic and applied sciences, i.e. within the general systems theories such as the statistical information theory, game theory, control theory, automata theory, etc.

In this thesis about the system whole man-building, the first two of the three applications that Bunge has indicated have been used. The first application has concerned the theory of the relation of part-whole and emergent properties, and the second application has been in the definition of the basic concepts of the theory of the thesis.

# 2 ONTOLOGY

## 2.1 Composition

### 2.1.1 Concrete and abstract entities

The set of all objects can be divided into concrete and abstract. The concrete units consist of physical matter while the abstract units are mental constructs, see, e.g., Ackoff (1971). In the following, the composition of concrete units is considered. Mental constructs in the form of representations of concrete entities are treated in connection with the concept of thing.

### 2.1.2 Association

Concrete devices can be connected to each other. In association theory, the most general aspects of the *association* or *unification* of units are dealt with (Bunge 1977a:27).

The *composition* of a concrete unit is the amount of its parts (ibid:31). The composition of a concrete unit can consist of various combinations of parts. Combinatorics is the branch of mathematics that deals with the composition of units in various combinations. The number of possible combinations is determined by the number of parts n and is n! (n-faculty). For example, for units a, b and c, the number of possible combinations is 3!, i.e., the 6 different compositions abc, bca, cab, bac, acb, and cba (ibid:38).

When it comes to concrete things, there are different types of obstacles (restrictions) that limit the factually possible number of combinations.

Association is a particularly general characteristic. The term says little about the nature of the association. In assembly theory, which is a branch of association theory, two specific kinds of association between units are distinguished: *juxtaposition*, ∔, which can be said to be a kind of joining side by side, and *superposition*, ẋ, which is rather a kind of mixture. (ibid:39).

Juxtaposition means that concrete units are connected to each other side by side. The resulting unit is the sum of the coupled devices which are said to be additively composed. Superposition also means that concrete devices are connected to each other. The resulting device is a mixture of the coupled devices. These are said to be *multiplicatively* composed. A building is *additively* composed of the building parts. A concrete mix is *multiplicatively* composed of cement, gravel, and water.

A concrete unit can be said to be *composed* (*complex*) if it is additively composed of units other than itself. Otherwise, it is *simple* (ibid:42).

### 2.1.3 The part-whole relation

The relation between part and whole, according to Bunge, is a precedence relation; i.e., a part is included in the composition of the whole and the existence of the part precedes the existence of the whole. See section 2.2.8. According to Bunge, the fact that a whole is composed of parts means that *if x and y are substantial individuals, x is part of y if the juxtaposition of x with y does not add anything to y* i.e.: $x \sqsubset y = x \dotplus y = y$ (ibid:29-30 and 43).

One must distinguish between the relation part-whole, ⊏, which is a relation between substantial individuals, and the subset-set relation, ⊂, which refers to relations between concepts. The part-whole relation has here only been defined for substantial individuals and not for concepts. This means that only substantial individuals are wholes in the sense defined. However, it is necessary to have a corresponding concept of ”wholes” of an abstract nature. A concept is such a ”whole”, the concepts are properties of thinking things. See further in section 4.3.2.

### 2.1.4 Atomic composition

The composition of a substantial individual can refer to different kinds of parts. A structure can be composed of more complex individuals such as a frame, freshwater system, sewage system, and electrical system. A unit such as the frame, in turn, consists of less complex units such as joists, walls, pillars and beams. A wall, in turn, is composed of smaller units such as bricks, mortar, nails and plasterboard.

The set of all concrete units can be divided into several separate sets, *levels*, in such a way that each individual is composed of individuals from the next lower level (ibid:49). The individuals of the next lower level that are included in the composition of an individual of the next higher level, are called the *atomic composition* of the unit (ibid:47). See also section 3.2.2.

The level concept will be further elucidated in connection with the system concept. See section 3.2.10.

Substantial individuals with all their properties are things and systems (ibid:26). To allow a complete description of these, an illumination of the concept of property is required.

## 2.2 Property

### 2.2.1 Concrete and abstract properties

Properties characterize objects. The concept of property is one of the most central in both science and technology. In simple terms, it can be said that science aims at knowledge of the properties of objects, while the meaning of technology is to produce objects with desired properties. See for example, Bunge (1983b:214). Common to both science and technology are the objects with their properties.

In the epistemological sense, there is no difference between the scientific and the technological activity i.e., between research and design since both must apply an analytical-synthetic and hypothetical-deductive methodology in determining properties.

A distinction is made between properties of concrete and of abstract objects. The former are called *concrete properties* or mere properties while the latter are denoted *formal properties*, attributes, or predicates (Bunge 1977a:58).

### 2.2.2 Propositions

To describe the properties of objects, it is necessary to first draw up conceptual representations of the property in question. Properties are represented by a so-called prepositional function that maps objects on propositions with the form ”object X has attribute A” (ibid:62), e.g., ”the house is red”. The propositional function is also called *predicate*, while the concept of property, ”red” in the example, is called *attribute*.

Attributes can represent concrete properties. Theories of concrete things are built from attributes that represent concrete properties of things. However, the attributes may also lack concrete reference as, for example, in fairy tales where there are geese laying golden eggs and cats walking in seven-mile boots.

### 2.2.3 General and individual properties

One must distinguish between the properties that are common to a set of objects and the properties that distinguish the objects in the set from each other. The former properties are called *general* while the latter are called *individual* or *specific*. The general properties of a collection of brick houses of different colours include that they are constructed of brick, while the individual properties of the houses are their colour . See figure 2.1.

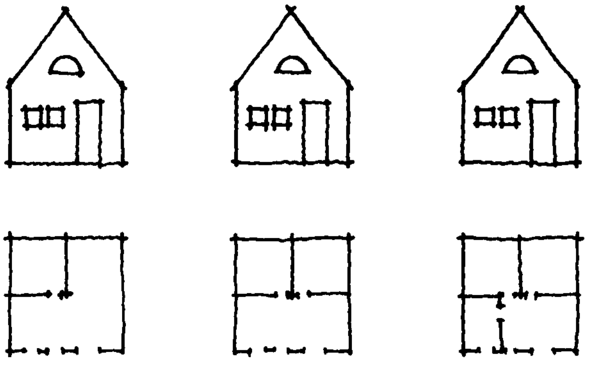


Figure 2.1. A set of houses with the general characteristic of brick but with individual floor plans.

Given the number of frames of reference and timings, the number of specific properties of an object is infinite while the number of general properties is limited (Bunge 1977a:72).

Properties of concrete objects must always be represented in the form of a propositional function from the amount of concrete objects X to various propositions. The propositional function, the predicate, represents the *general* properties of the objects in the amount e.g. that they are colored houses, while the *individual* property of an object is represented by the value of the attribute in the proposition e.g. that the house is red, cf. Bunge (ibid:62-63).

Properties are not considered in this representation as independently existing Platonic units such as ”round” or ”cubic”. Ackoff & Emery has defined an object as ”a set of properties” (1972:253). Bunge is careful to point out that it is the object that owns the properties and not vice versa. Properties have no independent existence from things (Bunge 1977a:64).

### 2.2.4 Primary and secondary properties

Properties are of different types, Bunge distinguishes between primary and secondary as well as between internal and mutual properties (ibid:65). See Figure 2.2.

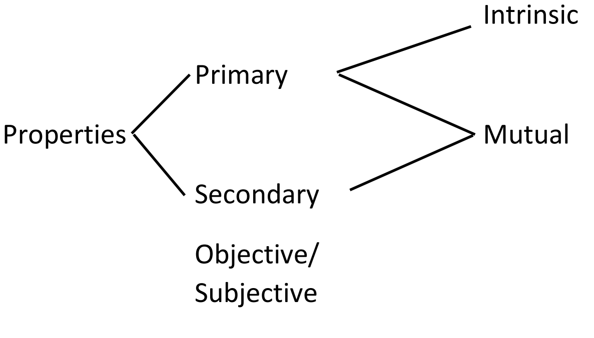



Figure 2.2. Classification of properties.

The *primary properties* are those that exist independently of an experiencing subject. The secondary properties arise in the relation between object and subject. The secondary or subjectively perceived properties of an object are neither entirely objective nor entirely subjective. However, they are relations between concrete objects, the experiencing subject, and the perceived object (ibid:67).

### 2.2.5 Intrinsic and mutual properties

*Intrinsic properties* are owned by the object alone while *mutual properties* arise in the union of two and several concrete objects. Intrinsic properties are only primary while mutual properties can be primary and/or secondary (ibid:65).

The composition of a concrete object is an example of an intrinsic property. The composition of parts of a building is an intrinsic property, while its function as a dwelling is a mutual property between the building and its residents.

Bunge (ibid:66) distinguishes between three kinds of mutual properties i.e., those arising in the relations

1. object - reference frame,
2. object -environment and
3. object -subject.

Some mutual properties arise in the relation between an object and a reference frame, such as speed, position, and temperature. Position of a building part is a primary mutual characteristic of the building and a spatial reference frame.

Other mutual properties of a pair of objects or group of objects depend on the influence of their environment. The property of weight, for example, is dependent on the object's mass in a gravitational field or the density of a surrounding medium. The child's behavior can be seen as a mutual property of the child-parent couple.

What distinguishes frame dependent, and environment dependent properties is the type of relations between the objects involved. The former are non-binding relations i.e. of the comparison type, while the latter are relations that affect the objects in question (ibid:l02).

The relation between object and subject is also not a binding relation but is dependent on the subject's experience and interpretation. See section 2.2.7.

### 2.2.6 Objective and subjective properties

A third form of properties consists of the secondary mutual properties of an object i.e., those that depend on the experience of a subject. These include properties such as colour, loudness, hardness, and smell. The subject here is both reference frame and environment of the object.

The objective properties are more independent of the experiencing subject than the subjective ones. The latter do not even have to be grounded in the actual properties of the object.

A house can be perceived as tall and be built on 50 floors. That it is high is an objective property that can be based on mutually primary properties of the house and an experiencing subject, seen as reference frame. However, the house can also be claimed to have other properties such as menacing or stately. These are subjective by being more grounded in the feelings of the subject than in the primary nature of the house.

Thus, objective properties reflect primary properties of an object, while subjective properties not necessarily reflect primary properties. A property does not become more objective because it is perceived by most subjects. The objectivity lies in the compliance of the secondary property with the primary property. The little lad who alone discovered that the emperor was naked in H.C. Andersen's fairy tale ”The Emperor's New Clothes” represented a more objective view than most court people who were all led to believe that the emperor was dressed in the finest silk.

That red is the color of revolution, love and stop signals is not due to the actual properties of the light-refracting surface layer to influence human behavior. Possibly this is because the concepts collectively refer to the red blood in different ways. This meaning of red things is essentially subjective even though it has been learned by all members of a cultural circle.

That an old half-timbered magazine can be suitable as an art gallery is both subjectively and objectively grounded. The objective lies in the actual properties of the magazine such as width of beams, strength, free wall surfaces, etc. The subjective lies in the culturally determined sense of the right environment for art and aesthetic experiences.

The subjective or secondary properties of an object can be based on non-subjective, primary properties. The purpose of science can be said to be to try to find the primary properties of things, among other things, to be able to explain the secondary properties.

In environmental psychology, research is ongoing with the aim of mapping subjective experiences of the built environment. The purpose can be twofold, partly towards better understanding the primary properties of man and partly towards being able to make demands on the properties of the environment based on human properties.

### 2.2.7 Interpretation properties

The secondary properties of an object-subject relation also include the ability to interpret the object. To *understand* an object is to possess knowledge of its properties both primary and secondary. Bunge distinguishes between two different kinds of interpretation: epistemic and semiotic (Bunge 1974b:1).

*Epistemic interpretation* means that the subject, via the secondary properties i.e., its experience of the object, seeks to obtain knowledge about its primary properties. *Semiotic interpretation* means that the subject, when experiencing the object, tries to reach knowledge about its importance as a sign in a communication system.

The scientific understanding is directed towards the primary properties of the objects, while in the humanistic sciences, literature, art and music, interest is directed towards the secondary properties of the objects, i.e., the understanding of the subject's experiences in the epistemic and semiotic interpretation.

The object considered as a symbol (meaningful sign) for example in a language is dependent on parsing rules. These issues are discussed in more detail in section 4.3.2.

### 2.2.8 Relations between properties

*Laws* are relations between concrete properties and, as such, also properties themselves (Bunge 1977a:78). Laws are relations that are constant or vary in a constant way. The relation between the mass of the load and the height of the beam is lawful, as is the relation between the house's energy consumption, heated air volume and thermal resistance in enclosing materials.

Some properties assume that the object already has other properties. Being able to write presupposes being able to think. Being carried presupposes that something is carrying. A property is said to *precede* another if it is more generic, or if it necessary for another property (ibid:80). The property load-bearing precedes the property of being carried as well as ”to think” precedes ”to write”. See Figure 2.3.

The *scope* of a property is the objects that have it. Properties are said to *accompany* each other if they have the same scope. If P and Q accompany each other, this means that if x owns the property P, then x also owns the property Q (ibid:81).

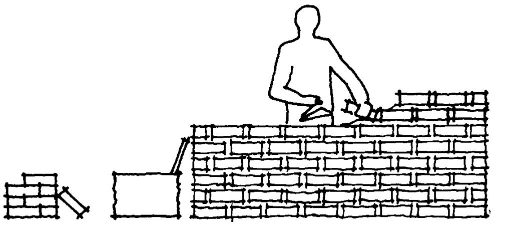


Figure 2.3. The brick property precedes the property brick wall.

A famous example of accompanying properties is in Decarte's thesis: ”I think, thus I exist”. To think and to exist accompany each other. However, the latter characteristic precedes the former which can also be said to be a law of thinking beings: ”I must first exist before I think”.

### 2.2.9 Basic and derived properties

Properties can be *simple (basic)* and *complex (derived)* (ibid:83).

The properties of load-bearing, delimiting, and connecting are simple (basic) properties of building parts, while the property climate protecting is composed, complex and can be derived from the former. Home is a complex property which can be derived from the simpler properties house and habitant.

### 2.2.10 Resultant and emergent properties

Properties of a thing as a whole can be called *comprehensive* . The *comprehensive* properties are of two types, *resultant (inherited)* and *emergent (emergent* or *gestalt* properties) (ibid:97).

The resultant properties of a whole are those that already exist of its parts. The mass of a building results from the mass of the building parts and the building area results from the floor area plus the cross-sectional area of the walls.

Emergent properties can be derived from the properties of the parts but are not found in these. A building has the emergent property of being climate protecting and enclosing of a heated amount of air. Something that the building parts individually do not have or do. Emergent properties cannot be explained as the sum of the properties of the parts. However, they are grounded in the properties of the parts. Buckminster Fuller has illustrated the concept of emergent property which he has called ”synergy effect” by uniting two statically indeterminate things into a third statically determined ”tetrahedron” (Fuller, 1979:316). See Figure 2.4.

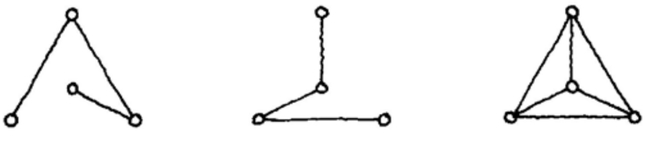


Figure 2.4. Stability as a emergent property of a tetrahedron.

The property of the tetrahedron to be a stable pyramid capable of carrying load, can be derived from the properties of the parts to have a certain strength, and when united in a certain way. This is not to say that the tetrahedron is nothing new. A new phenomenon, an ontological novelty, is not explained away by clarifying its composition (Bunge 1977a:98).

### 2.2.11 Epistemological implications

Reductionism as a theoretical direction of knowledge strives to explain emergent properties by properties of the parts (Checkland 1981:80). A famous example of a reductionist program has been formulated by Francis Crick who, together with James Watson, revealed the structure of the DNA molecule. Crick (1966) has stated as a goal of biological research to explain ”the whole biology of the terminology of physics and chemistry”.

An opposing view is found in the holistic program, whose view is that emergent properties are not founded in the properties of the parts. Here too, the basic issue is the property of life. As an example, we can mention the debate about the dualism brain-soul in which some scientists see the soul as one of the brain’s independent objects; the soul is thus not considered an emergent property of the brain (Eccles in Popper&Eccles 1981:361ff).

However, the materialist philosophy of which Bunge is a representative postulate that properties have no independent existence from things, and that there are no things without properties, as well as that new properties that are not found in the parts can emerge in a composite whole.

The view of the concept of property presented here differs from, for example, Plato’s, who argues that pure forms exist independently of things which are ”shadows” of pure ideas. This approach is neither compatible with the frequent idea of preformation in biology, i.e. that an organism develops towards a perfect form given as an idea.

In architecture, there is the notion that design contains the search for the idea of the building. A purely Platonic performance represented, for example, by Louis Kahn (1961) and the neoclassicists of the 1800s such as Ledoux. However, the designer can search for a way to transfer or awaken an idea in the viewer through the building.

## 2.3 Thing

### 2.3.1 Definition of thing

A *thing* is a concrete individual with all its properties (Bunge 1977a:110). Things without properties do not exist. Robert Musil’s famous novel character ”The Man Without Properties” is an abstract phenomenon about which everything and nothing can be said.

Things have concrete properties, primary and secondary, as well as internal and mutual. When two things are brought together additively, the properties of the new thing are both resulting and emergent. Some properties such as energy and mass are resulting. Others, for example, the structure of the composition is emergent. However, the new thing does not have all the properties of the parts. Some properties are lost in the composition of two things, for example, when the clay is burned, the brick becomes hard.

### 2.3.2 Things and concepts

To proceed further in the description of a thing and then especially of its state, it is necessary to touch very briefly on abstract entities, i.e., mental constructs. These are treated in logic, semantics and mathematics (ibid:116).

According to Bunge (ibid:116f), there are four kinds of mental constructs: concepts, propositions, contexts, and theories. Concepts build up propositions that form the components of contexts and theories. A concept can represent concrete or abstract objects or relations between objects. A function here is a conceptual relation between abstract objects. This concept of function must be distinguished from the concept of function which refers to concrete connections between things. The former may represent the latter. Functions can be propositional i.e., functions map objects on a variety of propositions. They can also be non-propositional i.e., the function maps objects on other sets e.g., numerical integers. The relation between the different units is shown in Figure 2.5.

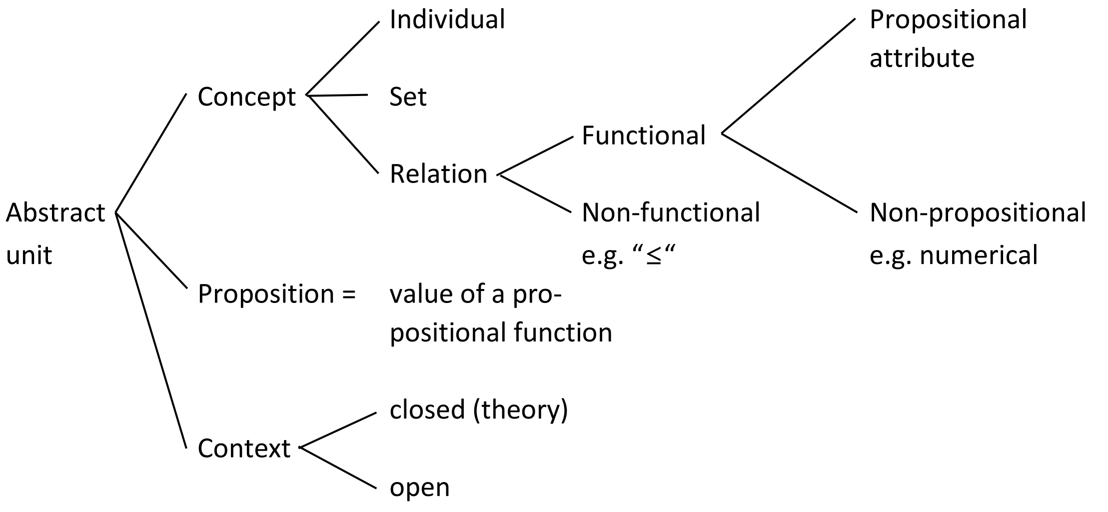



Figure 2.5. Abstract entities according to Bunge.

### 2.3.3 Abstract and concrete functions

A house can be used in different ways. The use is a concrete relation between house and user and can be represented by a propositional function. For example, the statement ”kitchen” could be one such propositional function whose domain is made up of building parts R and user a B. In the representation, these are mapped on a multitude of propositions containing the attribute ”kitchen”. See Figure 2.6.

The user properties are mutual relations between the used thing and the user. They can be represented through propositional functions that depict a domain of objects and users on statements about the object’s use.

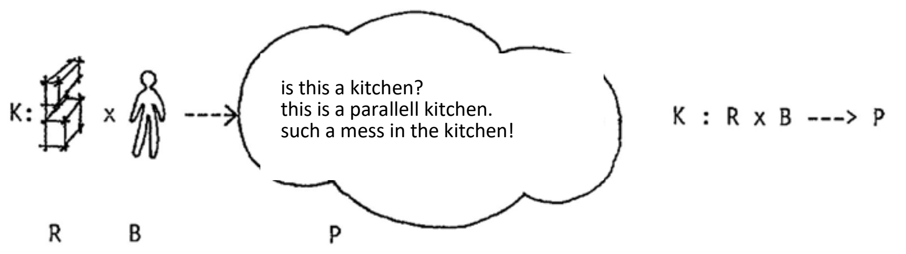



Figure 2.6. ”Kitchen” as a propositional function.

Concerning its use, the same object, of course, can be given different attributes. A ”kitchen” can also be said to be a ”family room” or a ”bathroom” depending on its use. The question of whether the propositional function represents actual functions or free fantasies is a question of the objectivity of representation.

An attribute should not be confused with the concrete thing and its factual properties. The term attribute is wrongly also used for concrete things. This is common in the construction literature. See, for example, ”Proposal for Good Housing” (Bostadsstyrelsen 1970). The concept of ”subsystem” is conceivable as a substitute (Cronberg 1973:63). The attribute as a propositional function then represents the properties of the part system. ”Lighting”, for example, is not an attribute of a house, but one of its subsystems.

### 2.3.4 Context and theory

A *context* is a set of propositions with a common reference class, such as a number of propositions regarding the user-construction relation. A *theory* is a context concluded during a deduction operation i.e., the theory is an abstract system of logically related propositions (Bunge 1977a:116).

## 2.4 Representation of things

### 2.4.1 Functional diagram or model thing

A thing was previously characterized as a concrete unit with the set of all its properties. Bunge also shows how a thing can be given a more detailed representation by a functional schema or a model thing. A functional schema for a thing Xm consists of an object set M and a set F of non-propositional, numerical functions Fi, each of which represents a general property of the thing, Xm=<M,F>. The values of M each represent specific properties of X (ibid:119).

The represented thing X can be a house and M a spatial frame of reference. The functions Fi can, for example, relate to specific values of position, area, and volume of the house.

### 2.4.2 State

Every thing can be said to be in some state dependent on, among other things, timing or other frame of reference. Bunge points out that it is the specific task of the exact ontology, more specifically the theory of systems, to elucidate the general meaning of the concept of state. In his presentation, Bunge provides a precise elucidation of the concept of state, something that, according to him, systems theory has hitherto failed to do (ibid:123).

The previously mentioned functions Fi in the functional schema Xm=<M,F> represent properties of the thing X and are called *state functions* or *state variables*. The state functions in the set F relate the objects in the set M to a set V of values, F:M--->V. V is a set in which the values of the state functions for different states of the represented thing can be given, e.g. the numbers 1,….,n. Each Fi represents a general property of the thing X, while the values the function assumes in V represent specific properties of X (ibid:125).

For example, the represented thing can be a village X with several houses. The state function for the number of houses in the village at any given time is X(m)=<M,F>. The number of houses is given by the function F and the years in the set M, where m is an individual year, m∊M. At a given time, e.g., m=1986, the number of houses in the village can be e.g., X(1986)=75.

### 2.4.3 Law statement

In section 2.2.8, a law was defined as relations between properties of concrete entities and thus also as properties of these entities. Bunge notes that the very concept of law is a condition on certain state variables of a thing (ibid:128).

In a functional schema for a thing, any restriction on the possible values of the state variables and any relation between these variables is called a *law statement* if

1. it belongs to a theory of things and
2. it has been empirically confirmed to a satisfactory extent.

### 2.4.4 State space

The set of states that the state variables in the functional schema can theoretically assume, is called *the conceivable state space* (ibid:133). In sociology, the term *property space* is used for the same concept. See, for example, Asplund (197l:20).

If the represented thing cannot have all the properties that the total state space represents, it may be because it has laws that limit the factually possible states. The lawful restrictions are said to reduce the possible state space to the lawful state space (Bunge 1977a:133).

A state space is not a physical space but refers to the different values the state variables can assume. A door can be said to have different states between open and closed, from O to 180 degrees. Other opening states are not possible due to the laws of the door. A house can be new or old related to a lifespan from O to 100 years.

In a functional schema, even the spatial properties of the house can be represented. In this context, the location of the loadbearing structure or frame limits the possible placement of the interior walls. The relation between the frame and the inner walls is lawful. There may be additional factors that limit the location of the inner walls, e.g., that they may only be placed centrically over a modular line in a modular mesh with the mesh width 3M. The possible state space of the inner walls in the house is thus reduced by various lawful restrictions to the legal state space.

In spatial planning of an activity, the restrictions in the state space can be determined by the space the activity has available in a room. The walls of the room limit the space of the activity. Conversely, the activity's space requirements can impose restrictions on the state space of the walls in a representation.

### 2.4.5 Reference frame

A state function specifies properties of a thing relative to the state of a reference frame. A *reference frame* can also be a standardized thing (ibid:232). Standardization means that the properties of things are determined by a convention, an agreement.

In construction, reference frames are utilized, for example, in connection with the dimensioning of the construction site. This always takes place in relation to one or more reference points. The state of each building part with respect to its position can then be indicated independently of other building parts and in relation to reference points whose position has been standardized.

There are also experiential reference frames. In the NCS system, colours are determined in relation to a reference frame consisting of six standardized colours blue, red, green, yellow, black and white.

### 2.4.6 Modular grids

A *modular grid* is a reference frame against which the position of a thing can be indicated. Modular grids are used, for example, in the determination of spatial properties of buildings. The state of the thing with respect to spatial extent can be specified relative to the selected module in the modular grid, e.g. 3M, (=3x10 cm). Likewise, its position can be indicated, for example, ”frame components centrically on the blue line”.

A reference frame must not affect the referenced thing. The respective states must be separated. Each state in the representation of a thing must be related to at least one reference state. For the mathematical formalization see Bunge (ibid: 232ff*).*

### 2.4.7 Similarity of things

Two things can be represented by the same functional schema, although in many respects they are different. A concrete house and a floor plan drawing have certain common spatial properties that allow them to be represented by the same functional schema. It is this similarity that allows the design of buildings in drawings, computer graphics and scale models.

The figure in the drawing and the screen, as well as the scale model, have, like the building, an area or volume and a position in a reference grid. What differs is the size, but this can be recalculated using a scale so that the position and dimension measurements give the same values for both things.

A general principle states that if two things can be given the same representation, one can study the properties of one thing with the help of the other thing if the study relates only to the properties represented in the common conceptual schema. There is always a danger that such a model or analogy study will lead to false conclusions about the properties of analog things. It can be very difficult to draw conclusions based on a floor plan about the room experience in the finished building.

### 2.4.8 The concept of model

Unfortunately, there is a significant confusion of language through the different meanings of the term model. On the one hand, it refers to a concrete object, the scale model, and on the other hand, it refers to an abstract object, the functional diagram, or representation.

The concept of model can be derived from the Latin modulus meaning small measure. Thus, model originally refers to one thing that on a smaller scale depicts another. For this reason, one would like to see a different designation of the theoretical model such as representation or functional schema. See Figure 2.7.

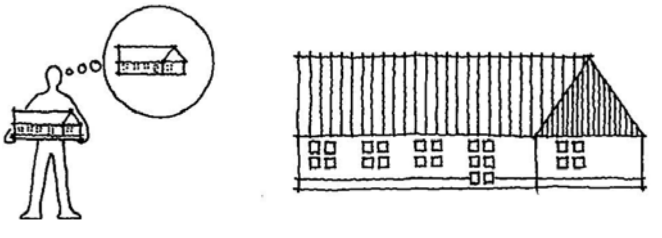


Figure 2.7. A house, a concrete model of the house and an abstract representation of the house.

The conceptual confusion has led to difficulties in understanding what scientists mean, e.g., Ackoff (1962) talks about three main types of models, iconic, analogous, and symbolic. The iconic and the analogous can be understood as concrete things with certain properties in common with the thing they are intended to depict. However, the symbolic models should be representations because they are composed of concepts, symbols.

### 2.4.9 Analogous similarity

Things can show similarities of different kinds. A photograph is like its subject as well as the architect's drawings resemble the plans and facades of the house. These similarities are analog similarities (Bunge 1983a:210-13). By *analogous* similarity is meant that things have the same concrete properties in some respect. The analogous similarity may refer to composition, environment, or structure.

When designing, the properties of a real possible thing, for example, a house, are determined. In doing so, models of the house are processed in the form of drawings and scale models in small, and sometimes even full-scale.

Models are like the construction object in different ways. *Similarity in composition* exists, for example, when testing wave formation in a model of a port basin. The water in the model has the same composition as the water that occurs in the real port. The properties of the water in the model are the same as those of the water in the real port after various approximations.

*Similarity in environment* exists, for example, when testing building components and building parts in so-called full-scale tests. A window's aging properties and climate resistance are tested in an air conditioning system where it is exposed to rain, sun and cold that simulates the natural climate when the window is placed in a building's façade.

*Similarity in structure* prevails between the drawing and the building with respect to the spatial structure. Dimensions and relative positions of building parts and the lines in the drawing are proportionally equal.

*Iconic similarity* belongs to the analogous similarity and is the same as similarity in spatial structure, configuration. The biological phenomenon of ”mimicry” means that one species resembles another by resembling in external form.

In the dictionaries there are a variety of words that begin with iso. All of these relate to similarities between things. Isomorphism is similarity in spatial structure, isobar is similarity in air pressure, isogenic is genetic similarity, etc.

In architecture, it is common for analogies to be used to describe the properties of the city. This is primarily intended to refer to structural similarity. The city is likened to an organism where the transport network corresponds to the bloodstream, the turnover of goods is likened to the metabolism and the parks are said to be the lungs of the city. In this context, the machine analogy has also occurred. The house is likened by le Corbusier to a machine to live in.

For a detailed account of the organic analogy of architecture, see P Steadman's ”The evolution of designs” (Steadman 1979).

In scientific contexts, a word of warning is usually directed at the use of analogies. The only way to scientific knowledge lies in the study of the things to which knowledge is to relate. The danger lies in the fact that the knowledge of the analog thing is confused with knowledge of the unknown thing. Aware of this, however, the researcher can use the analogy as a catalyst of thinking. It sets the imagination in motion without being involved in the process itself.

### 2.4.10 Symbol similarity or semiotic similarity

In addition to talking about analogous similarity that relates to the concrete and primary properties of things, one can speak of symbol-similarity or semiotic similarity and refer to similarity in abstract and secondary properties. See Figure 2.8.

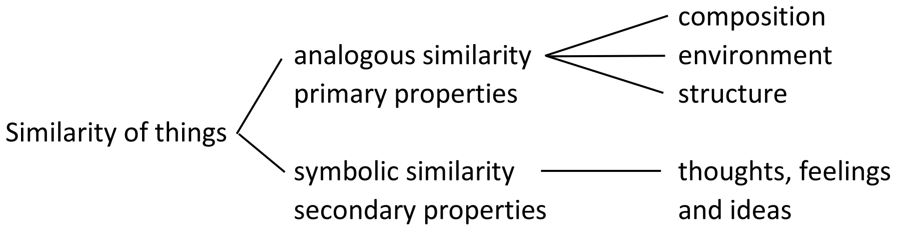



Figure 2.8. Different kinds of similarity between things.

According to semantic theory, a symbol designates a concept. The term refers to a concrete thing and the symbol is said to denote this thing (Bunge 1974a:43 and 91). See Figure 2.9.

Two symbols that designate the same concept can be said to be *symbol-like* as the image of a heart and the word heart. The similarity between these consists in the thoughts, feelings, and ideas that the two things evoke. ”My darling, you are like a rose” indicates a symbolic similarity between the rose and the beloved. The rose becomes a symbol of the beloved and gives rise to similar emotions, for example, the experience of beauty or fascination.

The designation is conventionally determined, i.e., based on agreements between the members of a communication system. A building drawing consists of signs (symbols) that have both symbol similarity and analog similarity to the depicted building.

The iconic similarity has previously been mentioned and consists in a similarity in configuration between the signs of the drawing and the parts of the building. The symbol similarity consists in the fact that the signs of the drawing designate concepts of the type ”wall”, ”window” and ”door” which refer to the concrete things with these designations.

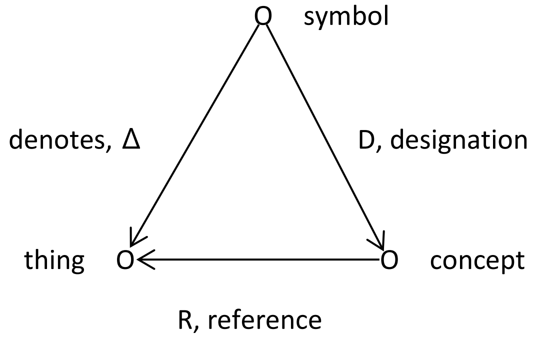



Figure 2.9. The relation symbol-concept-ting.

The symbols of the drawing also include the linguistic signs that describe (designate) material properties such as ”wood, concrete, linoleum”. These material properties are difficult to depict in the drawing in analogous form, although cut surfaces made of materials can be given symbols like concrete, wood, etc.

## 2.5 Classification of things

### 2.5.1 Class, kind, and species

The scope of a concrete property is the things that possess it. This set of things constitutes a class (Bunge 1977a:140). While a single property determines a *class*, a set of properties determine a *kind* and a set of law-related properties a ”natural” kind, a *species* (ibid:143).

Things with only a single property defined are for example wall, foundation, and building, while a certain kind of wall is determined by several properties such as a house wall, an external wall or a partition wall. Walls of a particular species are those in which the properties are lawfully related, for example, brick wall, wooden stud wall with cladding of plasterboard and reinforced concrete wall.

The principle behind the classification of things into individuals, species, genera, families, orders, etc. is to divide things into *equivalence classes* of different degrees of fineness. An equivalence class is a class of things equal to a particular property that can be either simple or complex. By degree of fineness is meant the number of specific properties so that the degree of fineness of a species is greater than that of a genus. The species has more properties specified than the genus (ibid:145). Half-timbered houses of the Bornholmer type constitute a class with a greater degree of fineness than the class of Scanian-Zealand half-timbered houses.

When classifying things, it can be done in different ways. One is the simple ”pre-theoretical” taxonomy that notes and compares all observable properties regardless of their significance. This can be misleading as some similarities can be unimportant while small differences can be fundamental (ibid:145).

Another method of classifying is according to the lawful properties i.e. the laws of things. This results in the most natural grouping and produces a set of ”natural kinds” or species (ibid:145).

Linnaeus’ sexual system for the classification of plants can be said to be ”pre-theoretical” in the sense that it is based on external differences in certain organs. Linnaeus was aware of this, and he himself worked on finding a natural classification system. The later developed ”natural” system is based on the genetic kinship of plants (Ursing 1956:5).

The similarities, as mentioned earlier, can be analogous or symbolic. However, it is similarities in lawful properties that result in ”natural” divisions, i.e. the similarity should include both composition and structure.

Speciation consists in the emergence of a collection of things who obey the same laws, i.e., a natural kind or species (Bunge 1977a:147).

The question of how a classification of buildings could be made is not the subject of this account. However, the following examples may illustrate some of the problems in choosing the, in my opinion, most fruitful basis for subdivision.

The English panel houses outwardly bear great similarities with the half-timbered houses, while the post-and-plank houses are more reminiscent of timber log buildings. However, a closer analysis reveals that the constructive principle of the panel system consists in the joining of small units, boards and narrow panels into a plate effect without a distinct skeleton. This is the same principle as for the log wall. The difference here is that the panel system is vertical like a palisade while log timber is horizontal. However, the post-and-plank house rests on the same constructive principle as the half-timbered house with its supporting skeleton and fillings of in the former case boards and in the latter case ”clay and straw” (Lundberg 1971:295-307).

In the above example, half-timbered houses and post-and-plank houses obey the same laws with respect to the interrelations of the supporting parts. However, panel houses and timber log houses do not share any corresponding laws either with each other or with the half-timbered species. The half-timbered and post-and-plank houses can be said to belong to the same species in terms of their constructive structure.

The formation of the structures can be based on different classification principles, e.g., constructive regarding the load-bearing system or functional regarding the relations with the users, e.g. homes, offices, industrial buildings, etc.

Classification can be based on similarity with respect to the previously mentioned properties environment, composition and structure. Similarity in structure and environment exists between two things with the same function as, for example, birds and bats, both of which can fly. However, this similarity is not fine enough to distinguish the two species. Such a classification must also consider the composition of animals.

### 2.5.2 Variety, population, and genus

Variety or difference in a limited set of things can be measured in different ways and relate to different properties (Bunge 1977a:150).

However, in connection with this presentation concerning the classification of things, it is qualitative similarities and differences between things that are interesting, and not the quantitative aspect.

*Qualitative* variation refers to differences with respect to general properties and *quantitative* variation refers to differences with respect to specific properties. When classifying, one must disregard peculiarities and concentrate work on the formulation of general and specific laws.

However, in connection with classification of things, we must disregard circumstances and peculiarities and focus on generic or basic laws. The set of all things that share a *basic law* is called a *natural genus* while the things that share a *specific law* are called a *natural variety* or *species* (ibid:151). Since the number of general laws is limited, there are a limited number of natural genera, but there are an unlimited number of natural varieties (species) because the number of specific laws is basically infinite (ibid:151).

Building is a natural genus. The class of buildings consists of the set of things with building properties. Buildings share certain general laws such as being artifacts whose parts are connected to the ground and form spaces for people in their activities.

The number of species of buildings is in principle infinite, while the number of individual buildings is limited. Even the things that belong to a species share laws. However, these laws are not general but specific laws. The half-timbered buildings are a species that shares the specific laws that apply, among other things, to the construction of the frame.

Science distinguishes between a species and local variations within the species. In particular, three levels of concrete things are distinguished: an individual, an aggregate of individuals of a given kind, e.g., a population, and the aggregate of individuals of different kinds, e.g., a mixture of populations as in an ecosystem (ibid:153).

In architecture, the corresponding object of study can be the individual house, a set of houses belonging to a certain technical kind or a part of the urban agglomeration within an area. However, a more complete study of buildings requires that human use and experience of the building is also studied.

A *population* is a concrete aggregate of units belonging to one or more species. Biological populations are often systems. The members interact and sometimes have a common gene pool (ibid:153).

The variations of human races are an indication that the population is an evolutionary unit. Within the relative isolation of populations, cultural habits also develop that separate populations, which is reflected in construction cultures. Amos Rapoport has stated that crucial to the shape of a building in otherwise similar circumstances such as climate, materials, technology, etc. are sociocultural factors in the form of "the vision people have of the ideal life" (Rapoport 1969:47). Over the years, Scanian and Danish construction culture have come to differ in terms of building types, materials and colour scheme. On the other hand, interesting similarities can arise between completely different human populations such as the Danish half-timber tradition and similar Japanese building types.

When describing a thing, such as a building or a person, it is not enough simply to talk about what these are. It is also important to understand the possibilities of things.

## 2.6 Possibility

### 2.6.1 Actual and possible properties

Each thing has properties, some of which are *actual* while others are *possible* (Bunge 1977a:164).

An actual characteristic is also said to be *manifest*. A versatile useful structure already has several different pre-existing properties, while a changeable construction has possible properties that can be actualized, for example, by changing the room organization.

Bunge makes a distinction between a *conceptual possibility*, and a *real possibility*. Conceptual possibilities refer to propositions and relate to relations between concepts. Real possibilities refer to concrete things and events (facts) (ibid:168).

### 2.6.2 Fact

A *fact* is defined as a state of a thing or as a change of state of a thing (ibid:169).

Thus, a fact is a concrete property of a thing. Secondary properties of things such as thoughts, feelings, and ideas of an experiencing subject are mental constructs and do not belong to the class of facts. Concepts and propositions are not facts. They may possibly represent the facts of things (ibid:267).

There is an order of magnitude in the set of facts that distinguishes between conceptually possible facts, really possible facts, and actual facts (ibid:171).

A fact is *really possible* if there is no prior fact to prevent it. A real possible fact is free to occur. Freedom of action can thus be said to depend on the existence of real possibility (ibid:172).

Conceptually possible facts can be prevented from becoming genuinely possible facts by existing facts (ibid:172). During design, existing facts such as available resources, decisions already made, and the properties of the site constitute limitations for the really possible facts.

The freedom of living, the real possibilities for determining the design of one's own dwelling, can be construed as the conceptually possible designs minus the existing restrictions on the design.

What really happens is said to be *necessary*. This means that a fact x, is necessary if there exists a *circumstance* y, which *accompanies* x so that the occurrence of y entails the occurrence of x. Otherwise, x is *uncertain* (ibid:175).

In conclusion, Bunge notes that laws along with circumstances result in facts. He identifies four kinds of facts according to Figure 2.10 (ibid:176).

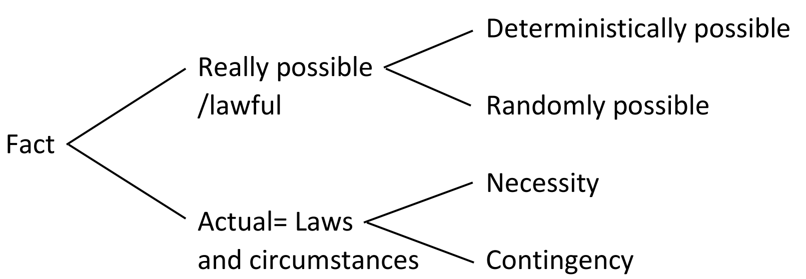



Figure 2.10. Classification of facts according to Bunge.

Deterministically possible facts are those that follow the deterministic laws, and randomly possible facts are those that follow the random or stochastic laws of things.

When designing a building, the real possibilities of the design are examined, the process results in an actual fact, the finished project.

In science, both actual facts and really possible (lawful) facts are studied (ibid:177). Architectural science can therefore be said to study actual and really possible buildings as well as man's actual and really possible use and experience of buildings.

In design, knowledge of really possible buildings and man's really possible use and experience of construction during elaboration of the things to be actualized taking into account given circumstances according to the principal laws plus circumstances give facts. This also applies when facts are randomly possible, e.g., when things follow stochastic laws.

### 2.6.3 Disposition

*Disposition* or *causal propensity* as well as *chance propensity* are two aspects of the concept of real possibility (ibid:179).

A causal propensity is always actualized when suitable circumstances exist according to the scheme: disposition & circumstance = actuality (ibid:180).

A disposition of a thing x is a necessary but not sufficient condition for a property to emerge. This requires certain circumstances in the environment of the thing. A ting y separate from x. Y is called the complement of x and must have a disposition to fit x for the new property to be actual. What exhibits the new property is the composition of x (with the causal propensity P) and y (with the causal propensity Q) to the thing z=x∔y (with the manifest property R) (ibid:181).

Artifacts are designed with dispositions to exhibit, together with other things, new desired properties. A pencil should always leave a thin graphite layer on a piece of paper when writing. However, it is not possible to write on a water surface. The new thing here becomes human-pen-paper which together has the manifest property of producing strokes, a property not possessed by the human-pen-water thing.

A heating system and a house with enclosed air together have the causal propensity to heat the air to a given temperature. A transport system consisting of roads, cars and people has manifest properties such as transport capacity and accident rate. A characteristic feature of buildings is that they have been provided with causal dispositions to present, together with sociosystems of various kinds, emergent, new manifest properties.

The set of all dispositions or causal propensities of a thing is called the *causal potentiality* of the thing (ibid:182).

The causal potentiality of a building in terms of its use properties is the amount of its possible functions. A versatile building can thus be said to have a high causal potentiality.

### 2.6.4 Probability

By *probability* is meant the propensity for each individual fact to occur (ibid:191).

The probability of being manifest is greater for some of the functions of the building and less for others. This is considered when designing a building. The less likely can be treated as an exception. The dimensioning of the heating system may be able to withstand a shorter period of severe cold. For an extended period, supplementary energy must be supplied. It is perfectly possible to design a building so that it has a given causal potential. However, one cannot similarly prescribe its manifest properties because they depend on different users.

Of the causal dispositions of a sociosystem, only a limited amount are manifested along with a building. These include the documents necessary to enable the building to be used as a tool for various activities.

A thing can also be said to have a *chance (stochastic) propensity* to acquire certain properties in each environment. Chance propensities of a thing are wholly or partly independent of the environment of the thing. If x can obtain a property completely without the presence of y, it implies that the new property is not a mutual property of x and y but only intrinsic of x that with a certain probability occurs in the presence of y (ibid:197).

In summary, Bunge (ibid:198) divides the actual and possible properties of a thing into three groups

1. manifest properties i.e., those owned by the thing in all circumstances as long as the thing exists and belongs to the same natural kind,
2. causal dispositions or propensities to acquire certain properties in certain circumstances and
3. chance propensities or dispositions to acquire with probability certain manifest properties depending on or regardless of the circumstances.

## 2.7 Change

### 2.7.1 Change of state

One of architecture's most central concepts is "change" partly in terms of how the users' and society's demands on the buildings change, and partly in terms of how the properties of the buildings can change to meet new requirements.

A change is an event or process that consists in variation of the state of a thing. A of a thing is a description of its properties, each represented by a value of a state variable (ibid:215). States are relative, i.e., dependent on the frame of reference or form of representation chosen in the representation. The present state of a thing is represented by the value of the state functions.

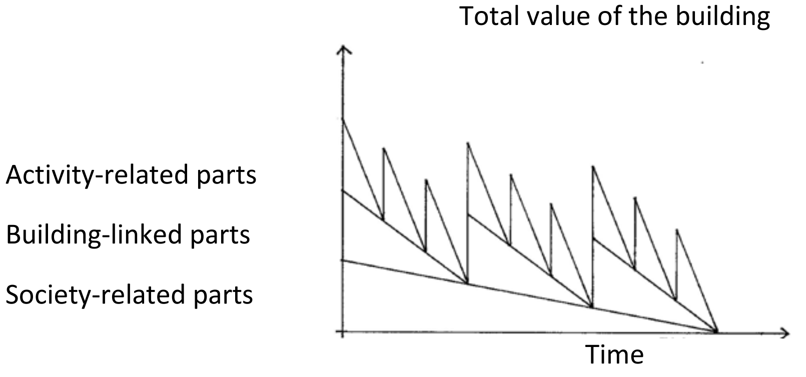



Figure 2.11. The variation of the total value of the building throughout its service life as a function of the value of its parts.

The economic value of a building is a state that can be represented graphically in relation to a time axis. Kjessel has prepared a diagram illustrating how investments in reconstructions of different types of parts over the total life cycle of the building affect the total value of the building (Ahrbom 1980). See Figure 2.11. Different parts of the building may have different service life, which is why their value decreases differently hastily. The value of, for example, the activity-related parts during a time course is represented by the movement of a point along the curve in the figure. The value of the entire building is indicated by the height of the point above the x-axis.

### 2.7.2 Action

Changes make up a thing's history. The *history* of a thing can be represented by the sequence of its states, its *trajectory* in state space. Different things have different histories (Bunge 1977a:256).

Changes in the state of a thing are brought about by action. One thing x *acts* upon another thing y if y's history in the presence of x is different from y's history without the presence of x. Two different things *interact* if they act on each other (ibid:259). Two things are *bonded* if at least one acts on the other (ibid:261).

Bunge further postulates that each thing acts on or is acted on by other things. This postulate forms the basis of Bunge's criterion of concrete existence: concrete existence has only that thing that acts on or is acted on by some other thing (ibid:271). This criterion is different from Descartes': "I think thus I exist". Bunge would have said, "I'm acted on, thus I exist."

In addition to bonds, there are also non-bonding relations between things. The *structure* of a thing is the aggregate set of all relations bonding and non-bonding. The structure is a property and has no independent existence. There are no bonds without things (ibid:275). This further leads to the definition of the concepts of aggregate and system. A closer treatment of the concept of systems is made in the section on the general theory of systems.

### 2.7.3 Qualitative and quantitative change

Changes can be of different kind. The qualitative ones can be said to be deep while the quantitative ones can be called superficial. Both qualitative and quantitative changes can be large or small (ibid:219).

A *profound* (*qualitative*) *change* implies the creation or loss of a state variable in the state space. A *quantitative* change, on the other hand, is represented as a change within a given state function (ibid:220).

The different types of change can also be illustrated as in Figure 2.12 where a new dimensional axis (F3) is established at point s and the space in which the trajectory is drawn is expanded with a new dimension.

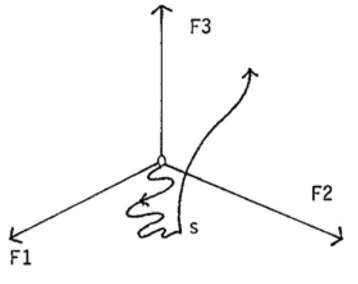



Figure 2.12. The represented thing undergoes a quantitative change from 0 to S with respect to the general properties F1 and F2. At S, a qualitative change occurs with the advent of the general characteristic F3. After that, the change is again quantitative.

If the change refers to general properties of a thing, it is *qualitative* (*profound*) as when a building's frame changes from load-bearing wall panels to a column-beam system. On the other hand, if the change relates to individual properties of the thing, it is *quantitative* (*superficial*) as when the floor plan changes in a building whose frame is left unaffected.

The division of properties into general and individual is dependent on the degree of fineness of the classification. The question is what qualities one is interested in studying in a representation. The degree of change is therefore dependent on the classification. If you want to study the floor plan properties of a building, it is advisable to investigate the possibilities of varying the location of the non-load-bearing walls in the building. In the set of really possible buildings under study, the frame determines the general spatial properties, while the individual spatial properties of the buildings in the set emerge from variation in the location of the non-load-bearing walls.

| Change | Large | Small |
|---|---|---|
| Profound | a | b |
| Superficial | c | d |

Figur 2.13. Matrix depicting different kinds of change.

Both profound and superficial changes can be large or small. If a hall building is provided with a number of floors on different levels, the change is both profound and large (a in Figure 2.13). The change is profound because the general properties of the building change and the change is large because the work to restore the building to hall building is extensive. If an office building is changed into a residential building and the room height changes from 2.70 m to 2.40 m by mounting a suspended ceiling, the change is profound but small (b in Figure 2.13). The change is profound because the general properties of the building change. It is also small because the work to restore the building is relatively insignificant.

If the hall building is changed from car showroom to market hall, the change can be said to be superficial but also large because the work on the redevelopment can be relatively extensive. The change belongs to variant c in Figure 2.13.

If the inner walls of the office building are moved, for example, during a reorganization of the business, the change is both superficial and small, i.e., of type d in Figure 2.13.

### 2.7.4 Dialectical change

One type of change that is often mentioned is the dialectical one. The notion that things change according to particular dialectical laws characterizes traditional Marxist philosophy, dialectical materialism. As an example of dialectical change, it is usually emphasized that quantitative change turns into qualitative, that history is a struggle between opposites and that all development eventually turns into its opposite.

While in the sciences one generally recognizes materialism, i.e., that properties are in things and not independently existing ideas, dialectics as ontology has been subject to strong criticism. Bunge notes, for example, that no particular dialectical ontology exists, and that dialectical concepts either lack concrete reference or are better subsumed into modern scientific ontology and systems theory (Bunge 1975).

### 2.7.5 Event

An event can be represented as a change from one state to another in state space. Although all states in a state space are lawful, not all events are possible. Some events are non-reversible such as aging or plastering a wall. Other events must take place in a certain order to occur. The foundation must be laid before the walls can be built.

Events can be arranged with respect to the *precedence* relation so that some events must precede others to occur (ibid:225).

Construction is a series of events in which certain events must occur in a given sequence. In construction, one can distinguish three types of connections between building parts that determine the order of events in the building. These relations are

1. load-bearing - borne, the foundation must be erected before the walls,
2. connecting-connected, a flow must first be able to pass in a preceding, or main, pipe before it can pass in the following, or collateral, pipe, and
3. enclosing-enclosed, the insulation must be mounted between the wall joists before a covering wall board is mounted.

Thus, the event assembly of foundation must occur before the event assembly of wall. The event opening of the main pipe must occur before the event flow in the collateral line. The event mounting of insulation must occur before the event installation of wall board. The event space when assembling the parts of the building is arranged according to the precedence relation. The theory of event spaces underlies methods in process control such as network planning and scheduling.

### 2.7.6 Process

Complex events joined together by several elementary events are referred to as a *process*. Two processes are called equivalent if they have the same result (ibid:225).

According to Bunge (ibid:243), a set of events is a serial change or process if it satisfies the conditions that

1. the events must involve or concern just one thing, however complex, and
2. the events must be ordered intrinsically.

There are several different process types: chain processes, continuous processes, path-independent processes, hereditary processes, reversible and irreversible processes, random processes, and stable processes (ibid:243-255).

A *chain process* is discontinuous, its state function can be depicted on a sequence of natural numbers. Example: digital time indication.

A *continuous process* is characterized by the state being a continuous function of a variable e.g., time. Example: analog timing (clock with hands).

*Equifinal processes* are path-independent in the sense that the thing from different starting positions reaches the same final state.

If the state of a thing depends not only on a given stage in a process but also on previous states, the thing is said to own a *memory*, i.e., the process is a *hereditary process*. For a hereditary process in a thing, each state of the thing is determined by previous states.

Some processes are *reversible* i.e., the thing can after being changed be returned to the original state. However, in practice, most processes are *irreversible*, for example, due to loss of energy or energy quality.

In a *random process* a thing assumes different states with certain probability. Queue theory has been developed for such processes.

A thing is said to be *stable* if its representative point in a state space stays within a ”small” region. A state of *dynamic equilibrium* means that after all changes, the state of the thing returns to a definite subset of its state space. If this subset is a point, the thing is said to be in a state of *static equilibrium*.

One speaks of three different process types with respect to beginning and end namely linear, converging and divergent processes.

In construction, there are examples of all these types of processes. The construction process is a series of events that involve the design, construction and use of buildings. This process can be continuous or discontinuous with respect to the participating parties and the production of various products.

The construction process is a chain process with respect to decisions. It is equifinal because with different methods you can achieve the same end result with respect to the finished building. The process is hereditary insofar as it is based on experience feedback. Some sub-processes are more reversible than others. Prefabricated buildings are easier to dismantle and reuse than on-site buildings.

The construction process is random, for example regarding the weather during the construction period. The finished building is in a state of dynamic equilibrium in terms of moisture content in the walls, the number of residents and heat consumption.

## 2.8 Spacetime

### 2.8.1 Relational spacetime

Bunge states that without tings there are should be no spatial relations, and without change there should be no temporal relations (ibid: 276). He describes three main views of the concepts of space and time (ibid:278-81). From these aspects, space and time are

1. *containers*, i.e., physical objects exist in space and time which in turn are not physical objects but have some kind of absolute existence, this approach is characteristic of everyday thinking,
2. *prime stuff* view, i.e., spacetime is the elementary substance of which each physical object is made, things are a kind of concretization of spacetime and
3. *relational* view, i.e., space and time have no independent existence, they are a network of relations among things and their changes, this view is not new but is already represented by Aristotle.

Bunge has developed a complete relational theory of spacetime that is only very briefly set out below. Space and time, according to the relational approach, are relations between actual things and events. Space is a specific relation between things while time is a specific relation between events. The meaning of the relational approach is that “spacetime is the basic structure of the totality of possible facts” (ibid:281).

### 2.8.2 Space

Space is a set of things together with their separation relation (ibid:286). Space is a primary, mutual property of separated things. Thus, a room is not a thing and cannot influence anything. The spatial relations are non-bonding rather than bonds or couplings (ibid:296). See Figure 2.14.

The concept of space is central to architecture. In everyday use of the concept of space in architecture, one can find examples of all the three previously mentioned aspects 1) space as a container, 2) space as prime stuff and 3) space as relations.

A ”territory” is a relational space. It is defined by things related to each other marking the boundaries of the territory. The Baroque space is a prime stuff that can be ”kneaded”. In the container room of the normal designer, walls are placed, and distances are measured.

The *spatial extent* (*bulk*) of a thing is an intrinsic property that the thing it possesses independently of reference frames or observations. *Position*, on the other hand, is a spatial relation between a thing and a reference frame. Likewise, *shape*, is a property of a thing in relation to a reference frame. A shape is a sharply delineated. Small micro-objects such as electrons have no shape. It is first macro-bodies that have a shape of their own. Gases and liquids also do not have their own sharp external shape. The shape arises because of an interaction between internal and external forces (ibid:294).

Sociosystems can have a spatial extent but have no shape. Although sociosystems have no shape, their spatial extent is of the utmost importance for the ability to maintain the connections in the systems.

The relational concept of space is the one that will be used in connection with the later description of buildings. In doing so, I have deliberately tried to avoid treating rooms as things, which architects often do. During design, for example, designers talk about rooms of different sizes or about the functions of the rooms when they really mean the distance between space-delimiting building parts and the relation of the building parts to their users. Designers speak of connections between spaces and refer to the interrelations between activities of the sociosystem that uses e.g., a building.

During design, designers also talk of shaping spaces. What they actually do is partly to determine the spatial properties of the building and partly to determine the spatial properties of the user system. Since the room is not a thing, it can also have no properties. It cannot have ”form”. If you want to ”shape” the room, you must shape things and their spatial properties. One can also put it that the knowledge of space is the knowledge of the spatial relations of things. Realizing this is important. The traditional use of language seems to stand in the way of a deeper theoretical understanding that it is things and not spaces that are the objects of knowledge of architecture.

Space is a concrete relation of separate things. It is a primary characteristic of these in the sense that it is there independently of an observing subject. By changing things and their separation, the space is changed and shaped. The architectural design of the space, i.e., the spatial relations, takes place not only with functional purpose but also with the human spatial experience as the goal. Thus, man belongs to the object of knowledge of architecture, not space itself.

Spatial experience is based on secondary mutual relations between building and man. These properties are both subjective and objective. It is the task of spatial designers to anchor these secondary properties of things in primary properties. By understanding human experiences of spatial properties of buildings, architects can consciously evoke desired spatial experiences.

### 2.8.3 Time

Space is a concept that represents the properties of things namely their separation into three-dimensional physical space. The time relation is constructed in the same way but as a distinction between different states (ibid:297). The time relation known as a day can be said to be the separation between the successive states in which the sun rises and sets on the horizon. See Figure 2.14.

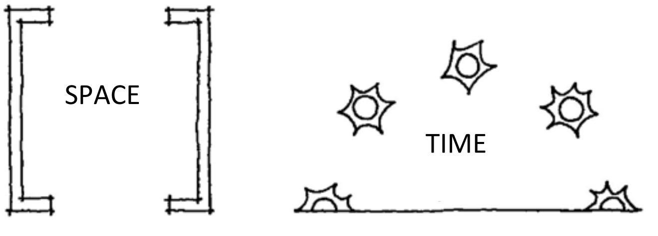



Figure 2.14. Space is a separation relation between things. Time is a separation relation between events.

An event involves a change in a state of a thing. The concept of duration refers to the temporal extent of an event relative to a frame of reference, e.g., a clock. A clock is defined by Bunge as a thing whose lawful state space is arranged with a before-after relation (ibid:300).

Without having to go into the underlying theory, it can be stated that the concept of time itself is based on concrete things and their change. Bunge thus notes that ”there is no time where there are no changing things” (ibid:303).

In architecture, the concept of time has significance because events, changes of things from one state to another, must be coordinated. Such a coordination is the division of a house into parts with different service life. The National Board of Public Building distinguishes between building-related and activity-related parts, among other things. These are arranged among themselves so that the building-related ones change at a longer time interval than the activity-related ones. The former parts can be said to have a longer duration than the latter.

# 3 GENERAL SYSTEMS THEORY

## 3.1 System

### 3.1.1 Examples of definitions of systems

The concept of system has been defined in a variety of ways during the relatively short development time of general systems theory. Below is a selection of definitions from the literature.

”A system is any arbitrarily selected set of variables” (Ashby 1954:15).

”By system now means not a thing but a list of variables” (Ashby 1956:40).

”System: a model of a whole” (Checkland 1981:317).

”Systems are complexes that can be designed and evaluated” (Churchman in Mesarovic, 1964:173).

”System: a set of interrelated elements...” (Ackoff & Emery 1972: 18).

”Systems, a regularly interacting or interdependent group of items forming a unified whole” (Webster’s New Collegiate Dictionary 1979).

A system is ”(1) something consisting of a (finite or unlimited) set of entities, (2) between which a set of relations is specified so that (3) conclusions can be drawn from some relations to others, or from relations between the entities to the behavior or history of the system” (Rapoport 1965:453).

”A complex thing with coupled components will be termed a system” (Bunge 1977a:26).

Common to these different definitions of system is that systems have a) *parts* between which there are b) *relations* that lead to the emergence of a c) *whole*.

### 3.1.2 Theoretically defined system concept

The purpose of this text is not to explain different definitions of the concept of system. The intention is to study a well-defined concept of systems and apply it in the preparation of a description of buildings and sociosystems and their interrelations.

For this purpose, a system concept is needed that is rooted in a coherent theory formation. Such theories have been developed by various researchers including Ackoff and Emery in ”On purposeful Systems” (Ackoff & Emery 1972), Laszlo in ”Introduction to Systems Philosophy” (Laszlo 1972), Miller in ”Living Systems”, (Miller 1978) and by Bunge in his ”Treatise on Basic Philosophy”, volumes 3 and 4 with the titles ”Ontology I : The Furniture of the world” and ”Ontology II: A World of Systems”.

Bunge’s presentation is characterized by depth and breadth in both philosophical and scientific terms. It therefore best suits my purpose and forms the basis for the account of the concept of the system that follows below.

Bunge treats the concept of systems as part of ontology, which he regards as the doctrine of the most general properties of things. Bunge’s ontology is a complete so-called hypothetico-deductive system i.e. an abstract system of logically connected propositions with actual reference. Bunge’s ontology is also exact in the sense that the conceptual definitions are logically coherent and formulated in mathematical terms. Furthermore, it is consistent with scientific knowledge in a very wide field from physics through chemistry and biology to sociology.

In this presentation, however, I have chosen to avoid mathematical formulations as far as possible and instead try to be as precise as possible in natural language.

### 3.1.3 Concrete and abstract systems

One must distinguish between two main types of system: *concrete* and *abstract*, depending on whether the parts are concrete entities (things) or abstract entities (concepts).

In *systems theory*, the concrete systems and their general properties are treated. The individual properties of different systems are treated in *special sciences* such as physics and sociology. Architectural science studies buildings and the built environment as well as sociosystems with a special focus on human use and experience of the built environment.

One can divide the concrete systems into three main groups: *natural*, *social*, and *artificial* systems (Bunge 1979:209). See Figure 3.1. Natural systems include physical, chemical, and biological systems. Sociosystems include families, organizations, and nations. Artificial systems include man-made things (artifacts). Concrete systems and their properties will be discussed in more detail in section 3.2.

The abstract systems consist of mental constructs, *concepts*. The knowledge of conceptual systems is not treated in systems theory but in *semantics*, *mathematics*, and *logic* (Bunge 1977a:116).

Abstract systems can *represent* concrete systems, for example in theories and models. For theoretical activities such as research or design, knowledge of, for example, representations in the form of theories and models is required. Such knowledge is also necessary if one wants to try to understand and influence the human experience of the built environment. These aspects of the abstract systems are treated, in addition to the above-mentioned areas, also in epistemology.

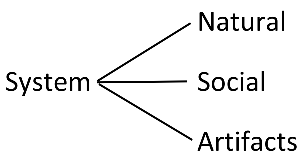



Figure 3.1. The three main groups of concrete systems.

## 3.2 System properties

### 3.2.1 Definition of system

In the ontology section, a *thing* was described as a concrete entity with all its properties. A complex thing with bonded parts is called a *system* (Bunge 1977a:263).

A fundamental feature of a concrete system at a given time is that it is composed of parts with intrinsic relations. However, the parts are also related to things other than those of the system. These other things are called the *environment* of the system. The set of elements of the system is called *composition*. The relations between the parts and between them and the environment are called *structure*.

A concrete system is thus characterized by the properties of *composition*, *environment*, and *structure* (Bunge 1979:4).

A concrete system is composed of concrete parts. Systems consisting of a mixture of concrete and abstract units do not exist. It is not possible to physically add a thing and a concept. ”Sesame Open Up” is a formula that works only in the world of fairy tales.

The above note excludes non-material explanatory grounds for such phenomena as thought transfer and psychokinesis. As an example of concepts that suggest such non-material connections between mental and physical events, is Jung’s concept of ”syncronicity”. This is defined as ”the meaningful coincidence or equivalence of mental and physical conditions which have no causal relation to each other” (Jung 1972:138).

### 3.2.2 Composition

A system is composed of parts. The *composition* of a system refers to the entire set of system parts (Bunge 1979:5).

The parts that have the basic properties that give rise to the properties of the system as a whole in a given respect are called *atomic* parts. They make up the *atomic composition* of the system (ibid:5). See Figure 3.2.

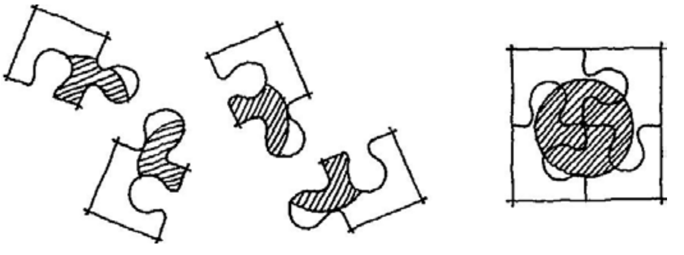


Figure 3.2. The pieces of the puzzle are the atomic composition of the puzzle.

When describing a building, one can account for its composition. In doing so, you choose the parts that are perceived as characteristic of a building, for example that it has a roof, walls, floor, and foundation. Admittedly, the building is also composed of other parts such as bricks, gravel, wooden studs and sheet metal pipes, but these are not interesting for the understanding of what distinguishes a building from other structures such as chimneys, swimming pools or garbage dumps. The difference is, among other things, that walls, floor, and ceiling have such spatial relations that are basic to the spatial properties the building. Bricks, gravel, and wooden studs do not independently have these spatial properties.

### 3.2.3 Environment

Bunge makes a distinction between mere relations such as being older and couplings that imply actions among things. An *action* refers to a relation between things that entails a change in or has a bearing on, the ”behavior line, trajectory, or history” of a thing. *Interaction* is mutual action (ibid:6).

The environment of a system consists of the amount of all things other than those included in the composition of the system that affect or are affected by the system and its parts (ibid:6). See Figure 3.3.

A building's *environment* consist of, among other things, the earth with its gravitational force, of the ground where it is erected, of the people who use it and of climatic factors such as precipitation, air and wind. All of these are concrete things that affect or are affected by the building and its parts.

Thus, interaction may exist between the system as a whole and the environment. This is obvious because the whole exhibits emergent properties that are not found in any of the parts themselves.

### 3.2.4 Structure

A system consists of parts with relations to each other and to the environment of the system. The set of all the system's relations is called the *structure* of the system (ibid:6).

The structure can be divided into *connection relations* and *comparison relations*. Connections are relations that between things that act on each other, unilaterally or mutually. Comparisons are relations that do not have any impact, e.g., larger, faster, older, etc.

The structure can also be divided into *internal relations* and *external relations*. The internal relations exist between the parts of the system and the external relations are between the system and its environment. See Figure 3.3.

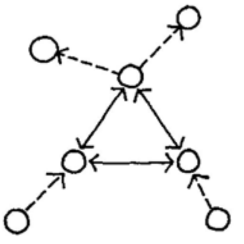


Figure 3.3. A system with composition, environment, and structure. The relations between the parts of the system are marked by solid lines. The relations between the system and the environment are marked by dashed lines.

Connections in a system can expose different types of action, namely permanent, temporary, static and dynamic (ibid:91). In construction there are examples of all these connections. See Figure 3.4.

| | Permanent | Temporary |
|---|---|---|
| Static | Position of joist on walls | Position of furniture on floor |
| Dynamic | Flow of energy environment-building | Flow in a sewer |

Figure 3.4 Examples of different action connections

In construction, the term ‘structure’ is usually used in many different ways, e.g. in ‘composite structures’, ‘load-bearing structure’, ‘surface structure’ ‘façade structure’ and ‘building structure’. With the above meaning of the concept of structure, its use should be reduced to referring to the ”invisible parts” i.e., the relations in a system.

The same set of parts can be compiled in different combinations into systems with different structure. Systems with the same composition, but with different structure are called *isomeric*. See Figure 3.5. This is the principle behind the Lego toys, the basic parts of which can be combined in many

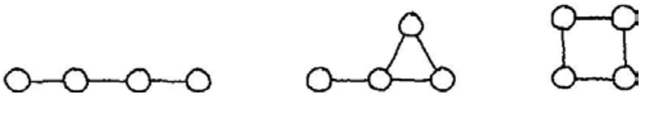


Figure 3.5. Isomeric systems.

different ways to many different systems. The same principle underlies the idea of ”building boxes”, the purpose of which is to make it possible to design different buildings with a limited number of parts (Ahrbom 1983:162).

The *spatial structure* of a system is a subset of the total structure. The spatial structure or *configuration* are not connections but *separation relations* between the elements of the system.

The concept of connection clarifies the difference between a system and an *aggregate*. An aggregate is a collection of concrete things without connection relations (Bunge 1979:4). However, an aggregate may have relations between its parts. They can be arranged from larger to smaller, sorted into blue and yellow, etc. The spatial relations, the configuration, belong to this type of non-binding relations that can exist in aggregates.

The furnishing in a room is an aggregate. When the furniture, such as a table, chair and lamp is used, it is included together with the users in a system. The relations between furniture and users in the user-furniture system are temporary, both static and dynamic. The connection between the parts takes place via the user, e.g., in a work activity. When the furniture is not in use, it forms an aggregate without interaction between the parts. However, the spatial relation that is admittedly static remains between the parts of the aggregate.

### 3.2.5 Open and closed systems

The environment of a system exerts a *selective impact* that may reduce an initial set of systems to a smaller selection of systems. Among all possible systems, only a certain selection can exist in a particular environment. Each environment directs a certain *selection pressure* towards a system (ibid:34). This ”system law” applies to buildings that are produced, used and demolished as well as to social organizations such as marriages that are subjected to selection pressures, of different strength in different cultures.

A system that neither affects nor is affected by another thing is said to be *closed*. Such a system has no environment. No systems except the universe are completely closed. A system is *open* with respect to a certain property if this can be related to a property in the environment (ibid:10).

In the classical natural sciences such as physics and chemistry, mainly closed systems are studied, here the influence of the environment on the properties of the system can be neglected or kept constant. For complex phenomena, the delimitation may be too complicated to do. Examples of such complex open systems are the sociosystems that can stand in interaction with the investigator. However, it must also be possible to make open systems the subject of scientific studies. Systems theory has been developed with this purpose as one of the fundamental motives.

In construction, the concepts of open and closed systems are often used without a proper theoretical background. In construction, open systems have traditionally been used to refer to buildings whose parts have been arranged in a general dimensional coordinate system, primarily through standardization of dimensions. However, such a system may be open with respect to certain properties such as floor plan design or building size, and closed with respect to other e.g., façade design or the variety of building parts.

### 3.2.6 Subsystems

A system can be composed of parts which in turn are systems. Such a part is called a *subsystem*. According to Bunge, a more precise definition must also include the concepts of environment and structure (ibid:11). Such a definition may read as follows (free after Bunge):

A system B is a subsystem of another system A if B’s composition and structure are subsets of A’s composition and structure, and if B’s environment are other subsystems in A and A’s environment. See Figure 3.6.

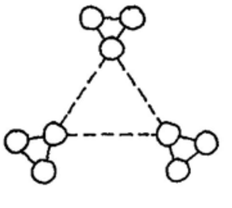


Figure 3.6. System with subsystems. The relations in the subsystems are marked with solid lines. The relations between the subsystems are marked with dashed lines.

The concept of subsystems can be limited to only the atomic parts of a system. See section 3.2.3. Bunge mentions as an example that factories, hospitals and schools are subsystems of society but that the persons included in the composition are not subsystems of society because they are not sociosystems but biosystems (ibid:191).

A biosystem is not an atomic part of a social system and thus should not be considered as a subsystem thereof. A subsystem of a hospital, viewed from the point of view of the activities that characterize the hospital, is, for example, an X-ray department comprising part of the hospital building, care workers, and the required X-ray equipment. A sociosystem has social properties e.g., that the structure is communication. The subsystems of a sociosystem, such as the board of an association, also have the social properties. A biosystem, e.g., a human, may work and communicate and can be seen as an atomic part of a sociosystem.

A building has construction properties, for example, to form spaces for human activities. The subsystems of a building also have such features that characterize the building as a whole. The subsystem house has the spatial properties and the subsystem va has the sanitary properties. Here it can be noted that the parts that in the section on buildings are termed building materials, building components and building parts in this sense are subsystems. Also, a wall has the basic spatial properties that characterize a building as a whole. However, so called raw materials e.g., water, gravel, or clay are not subsystems of a building.

This distinction can also be understood if one considers the difference in environment between the building parts and the building materials. The environment of the wall include other parts of the building and the users of the building. The brick's environment include the brick mortar and the other bricks that affect and are affected by it, as well as the walls that erect the brick wall.

### 3.2.7 Supersystem

Thus, if one ”looks downwards” in a system, one finds subsystems of different complexity. If you turn your gaze ”upwards”, you will instead find different supersystems, i.e., environment that are also systems.

The definition of the term *supersystem* is based here on Bunge's definition of subsystem as follows: A system C is a supersystem of a system A, if A is a subsystem of C. Thus, A's composition and structure must constitute a subset of C's composition and structure, and A's environment must consist of other subsystems in C and C's environment. See Figure 3.7.

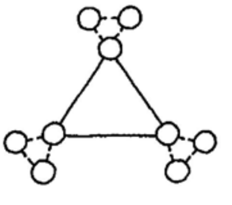


Figure 3.7. Systems with supersystems. The relations in the systems are marked with dashed lines. The relations between the systems of the supersystem are marked with solid lines.

Thus, the subsystem house, seen separate from the installation systems, in a building is a supersystem to the system wall, and the building is supersystem to the subsystem house. A house refers to the whole of load bearing and room-separating parts. Wall and floor are parts with such properties. The freshwater system is part of the same building as the house, but they can be each other's environment.

### 3.2.8 Level

One of the main purposes of this account is to apply the concept of level in the description of buildings and the system formed by human use and experience of buildings. Although the concept of level is necessary in design theory, there is no generally accepted and theoretically well-founded definition of the concept of level. One talks about different planning levels, such as the level of the building or the level of the block, and one talks about the existence of a hierarchy of superior and subordinate decision-making levels.

In scientific literature, no distinction is usually made between the concepts of level and hierarchy. Similarly, there is a lack of precise definitions of the terms. See, for example, Pattee (1973), Simon (1980) and Miller (1978). Bunge (1979:13) notes that ”this fuzziness must be blamed not only on scientists but also on philosophers - on the inexact philosophers who despise clarity and on the exact ones who are not aware of the problems raised by scientific research”.

Systems consisting of subsystems and supersystems in many levels are usually likened to Chinese boxes. These consist of a larger box enclosing a smaller one which in turn contains a smaller one etc. Such an organization of systems is usually referred to as a *level order* or *level structure*. Sometimes the term ‘hierarchy’ occurs, but this should be saved to refer to its original meaning of decision-making or influence order.

The relation part-whole, ⊏, applies between a thing that is a *whole* and the things that are its *parts*. ”Part” and ”whole” are concepts that refer to things belonging to two different levels of composition. Things belonging to a lower level can be included in the composition of a thing belonging to a higher level. Building parts such as walls, floors and ceilings are included in the composition of the building. The building parts belong to a lower level than the building.

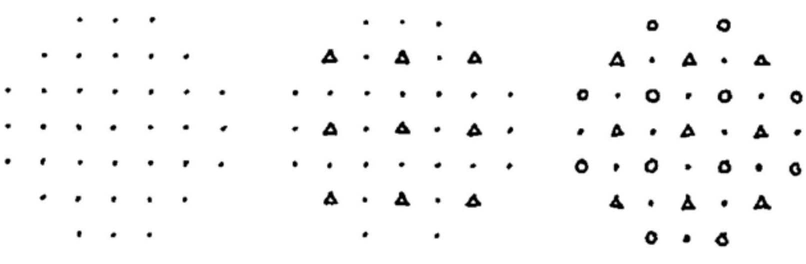
Buildings are composed of parts of different levels and are also included in supersystems of different levels. Buildings can be included together with sociosystems in a school, hospital, or residence. The structure itself is composed of so-called main technical systems composed of building parts, which in turn consist of building components produced from building materials and raw materials.

Bunge (ibid:13) has given a precise definition of the concept of composition level which is reproduced here in a somewhat simplified version. Let L be a family of concrete things arranged in levels. In this case,

1. a level Li *precedes* another level Lj if all things in the latter level are composed of things in at least one of the former levels,
2. a thing *belongs* to a given level only if it is composed of things in the preceding levels, for each system in Li the composition is a subset of the union of the previous levels and that
3. a family of sets arranged in levels is called a *level structure*.

A level is thus a *set*, classified according to certain properties, and therefore a concept and not a concrete thing (ibid:13). Concepts cannot, as things, have bonding relations and therefore cannot form hierarchies or orders of influence.

The relation between levels is a precedence relation which means that the things belonging to a lower level are composed of things belonging to a higher level (ibid:14). The class, i.e., the level, brick precedes the class wall in the sense that the wall is composed of bricks. See Figure 3.9.



Level L Levels L and L+1 Levels L, L+1 and L+2

Figure 3.9. The figure illustrates the emergence of the new levels L+1 and L+2 from the level L. L can be supercooled water vapor that condenses and forms ice (level L+1) that collects into snowflakes (level L+2).

The relation between levels is neither a part-whole relation nor a subset-set relation. One level cannot be part of another level because levels are concepts and the part-whole relation is defined only for concrete things. Nor can one level be a subset of another level; A set of building parts cannot be a subset of the set of buildings.

Characteristic of the relation between systems at different levels of a level order is that the systems in the next higher level are supersystems and the systems in the next lower level are part systems.

### 3.2.9 Assembly of systems

A system is composed of parts. The process by which a system is produced from its parts is called *assembly*. Bunge distinguishes between *self-assembly* and *self-organization*. By self-organization is meant a self-assembly that involves the formation of subsystems that did not exist before the start of the process (ibid:27).

Artificial systems depend to a greater or lesser extent on human intervention for their assembly. The natural systems are created through self-assembly, e.g., the whirl in the gushing bathtub water and self-organization, e.g. protein-oxygen synthesis in the cell.

Assembly of a system can be done by first forming an aggregate of parts that are brought to interact by external influence. An example of this is the setting up of dominoes at such a short distance, that if one tray falls, the next one is hit, etc. When a washer falls, the entire unit is simultaneously transformed into a system that goes through a chain process in which the position of the parts changes from standing to lying.

The assembly can also take place via the construction of subsystems, which are then merged into a single system. When dominoes are set up to form larger intricate patterns of tens of thousands of tiles, it is safest to divide the assembly into smaller units by allowing for interruptions in the chain reaction. A tray that accidentally falls over activates only one subsystem and not the entire system.

In nature, both types of system formation occur. Subcooled water can, through an external influence, be brought to freeze into ice through something reminiscent of a ”domino effect”. Biological systems, on the other hand, are characterized by being made up of pre-compiled subsystems in the form of amino acids, oxygen, water, etc.

In construction, the assembly of a concrete wall is an example of both an artificial and a natural assembly. The artificial consists in formwork and concrete mix. The natural is the chemical reaction that results in the hardening concrete.

### 3.2.10 Properties of parts and wholes

When assembling parts into a system, the whole acquires new properties that are not found in the parts separately. The parts of a self-assembled system are called the *precursors* of the system. The precursors to some extent retain their original properties but also give rise to emergent properties of the system (Bunge 1979:29).

*Emergent* properties are new properties that are not found in the parts. During assembly, some properties that the parts had may also be lost. The properties of the system that are already found in its parts are called *resultant* properties, e.g., spatial extent and mass.

Studs and plasterboard sheets can be put together and become a wall. Walls, floors, and ceilings can be put together and become a building. These new features emerge because of the assembly of the parts.

The properties of parts are *basic* to the properties of the whole. The latter can be *derived* from the former. For the relation between properties of systems in an upper and a lower level, the properties of the latter are basic to the properties of the former. Conversely, the properties of systems at higher levels can be derived from properties of systems at lower levels. See Figure 3.10.

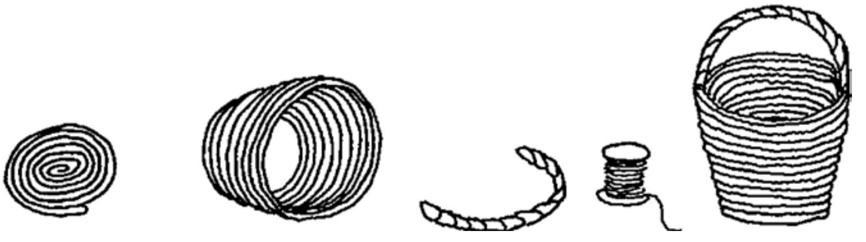


Figure 3.10. The properties of the whole can be derived from the basic properties of the parts

Moreover, for the properties of systems of a higher level, they are both resulting and emergent. The former are already present in the parts, e.g., the mass of the building, while the latter are new, for example of the building's climate-protective properties. Together, the resulting and emergent properties are the *comprehensive* properties of the system.

What justifies the construction of the concept of level is that things, through their intrinsic and extrinsic relations, sometimes give rise to a system with real news that differs in a decisive way from its parts. In the sciences, at least four main levels of systems are usually distinguished, which reflect major innovations of the natural systems, namely the physical, chemical, biological and social levels. Within each of these comprehensive system orders, in turn, there are several system levels of things with different emergent properties.

### 3.2.11 Integration

By the degree of *integration* of a system is meant the scope and strength of its connections. Some systems and system parts are looser connected than others, i.e., the integration varies between different systems (ibid:35). A family is more strongly integrated than the social network of a neighborhood.

The concept of integration is sometimes confused with the concept of variation. ”Integration of different building types” refers to a varied composite settlement. There is also talk of 'integration of functions', which can correctly refer to the interaction between different activities.

There is no universal unit of measurement for the degree of integration because couplings are of different nature in different systems. A system is said to be *stable* in a certain time interval if its integration is constant or varies very little around a fixed value (ibid:36).

Each system has a *critical* or *optimal size*, meaning the number of components that maximize the degree of integration into the system. As a natural consequence, there is also a minimal and a maximal size. The minimal size called *threshold size* indicates the minimal number of components that allow the system effect to occur. The *maximum size* indicates the largest number of components above which the system breaks down (ibid:36-37).

It is easy to make observations that support these postulates. In construction, there is an example of the maximum size of brick houses whose maximum height is limited by the lowest bricks being crushed by the above-ground bricks when these have reached a critical weight.

An important observation is that in a system organized in subsystems, there is a contradiction between the integration of the system and the integration of the subsystems (ibid:38). Different forms of management in residential areas reflect this ”law”. The social network between households in a house with a tenancy is usually looser integrated than if the form of management is condominium.

### 3.2.12 Coordination

The concept of integration should not be confused with *coordination*. Integration refers to the strength of the connections between the system parts. Coordination refers to properties and functions of the parts of the system that enable system or synergy effects, i.e., emergent properties. The fact that two things are coordinated means that together they contribute jointly to the integrity of the system (ibid:38).

The integrating couplings hold the system together as a nail holds two boards together or a weld joint two plates. The coordinating relations are those that are important for the functioning of the system. Strength and load must be coordinated, as well as the hole for windows in the façade board and inner wall board of a building. Integrating different types of activities in, for example, a residential area is important for the emergence of a comprehensive and varied environment. Coordination is also important, for example, by stores in a shopping center to get a comprehensive range of goods as well as by companies in a region to obtain a comprehensive production and service focus.

### 3.2.13 Complexity

The concept of *complexity* can be interpreted in different ways, there are examples of use of the concept of complexity that relate to both primary, intrinsic, and mutual properties as well as secondary properties of the object.

In the literature on systems theory, there are examples of all these meanings of the concept of complexity. According to Rosen (1977:229), complexity is not an internal property of the system. He defines a complex system as one with which we can interact in many ways, each requiring a different kind of system description. He cites as an example a rock which for a geologist can be considered an infinitely complex system.

Complexity, according to Rosen, is both a primary mutual property and secondary mutual property of an object and its users. Ashby (1972:1) believes that complexity is a mutual secondary property of a viewer and a system.

In this context, however, I am interested in complexity as an intrinsic primary property of the studied object. Such a view is represented by Beer (1974:21) who believes that the complexity of a system can be expressed in its variety. According to Beer *variety* is a measure of the complexity of a system defined as the number of possible states.

Bunge (1977a:43) sees as one of the dimensions of complexity its *number of parts*: ”The complexity of an individual can be defined as the numerosity of its composition”. As another dimension, he sees the manner of the part’s couplings.

Simon (1981:195) has a similar view: ”By a complex system, I mean one made up of a large number of parts that interact in a non-simple way”.

Like all systems, complex systems have emergent properties, i.e., the system as a whole has properties that are not found in any of the parts separately. Complex systems are composed of subsystems which in turn consist of subsystems i.e., they are organized into levels. Systems in each level have emergent properties.

Characteristic of complex systems in nature is partly that the number of elements is large and partly that they are organized into several levels. Herbert Simon (1981:201) has shown in the form of allegory that level organization is superior in an environment that can interfere with the construction of a system:

Hora and Tempus shall each build a clock with 1000 parts. Tempus builds his clock in such a way that all parts must be combined without interruption. If he is interrupted, the construction falls apart. However, Hora is wiser. She builds her clock by joining the parts into several stable subassemblies. If Hora is interrupted in her work, only a minor part of the comprehensive system is affected. Hora divides the clock into 111 subassemblies with 10 parts in each. If the probability is only 1/100 that they will be interrupted during the assembly of a part, it still takes about 4000 times longer for Tempus than for Hora to complete a clock.

The clocks in the example can advantageously be organized so that the different subassemblies have certain definite functions. This enables a subsystem with a certain function to be replaced and replaced with a more efficient subsystem or repaired without affecting other functions.

The principle of organization in subsystems is exploited in an infinite number of ways both in natural, social and artificial systems. Examples include the spinning of thin fibers into a thread and the forcing of strands into a rope. In doing so, the characteristic feature of the chain is avoided of not being stronger than its weakest link.

The level organization of a system assumes that the subsystems are reasonably stable. This means, among other things, that the integration between elements within each subsystem is greater than between elements belonging to different subsystems or the system’s environment.

Another feature of complex systems is that the same part of the system is included in several different subsystems, i.e., the part has several different connections to other parts of the system. A window is included in a building as part of the outer wall, as part of the lighting system and as part of the heating system. The design of a window must consider all these relations and not simply adapt the properties to one of the different subsystems of the building. Requirements for properties are often opposing, façade design, furnishing, light input and thermal resistance can place different demands on the properties of the window.

Figure 3.11 illustrates a complex system. In conclusion, it can be stated that a complex system is characterized by the properties of

1. a large number of parts (high numerosity),
2. connections between parts that imply that these interact in a non-simple way,
3. level organization,
4. emergent properties and
5. parts that are part of several different subsystems.

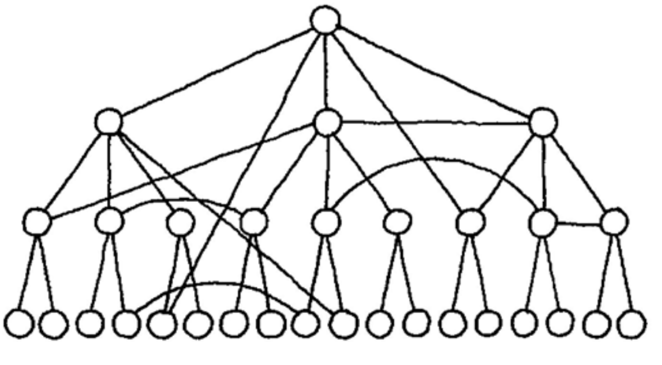


Figure 3.11. A complex system has many parts and many connections between the parts and is composed of subsystems in several levels.

### 3.2.14 Hierarchy

In the case of interaction between two things, the acting thing is called the *agent* and the affected thing is called the *patient*. One-sided influence is also referred to as *control* or *dominance* (Bunge 1979:6 and 225).

A *hierarchy* or order of *influence* is a structure in a system whose parts are arranged in one-sided influence relations. Feedback is a specific form of control characterized by a partially closed order of influence. An influencing thing has a higher *rank* in the hierarchy than the influenced thing. In hierarchical systems, influences give rise to chain reactions, for example, when dominoes set up within the range of action from each other are brought to fall, or when an order is passed on through a military hierarchy from command to private.

The spread of infectious diseases and rumors also takes place in a hierarchical manner. Sociosystems are often hierarchical with regard to the decision-making order, e.g., military organizations and political dictatorships. Technical systems are often hierarchies with respect to acting forces such as gravity. A building has a hierarchical structure in which the foundation affects the wall which in turn affects the roof so that it does not fall to the ground. The fact that the impact can be perceived to go in this direction is justified by the fact that the ceiling falls if the wall is removed.

The concept of hierarchy should not be confused with that level of order. In a system, the relations between the parts of a system within a given level can be of a hierarchical nature. This is the case with the load-bearing and borne parts of the building.

Figure 3.12 shows two systems S1 and S2. S1 consists of parts S2, B1 and B2. S2 consists of parts G, D1 and D2. S2 is a subsystem of S1 and S1 is a supersystem of S2. S1 belongs to a higher level than S2. In S1 there is an order of influence from B2 to B1 to S2 and in S2 there is an order of influence from G to D1 to D2. The structure of both S1 and S2 is hierarchical. However, there is no hierarchical relation between S1 and S2. S1 does not affect S2 because S2 is part of S1.

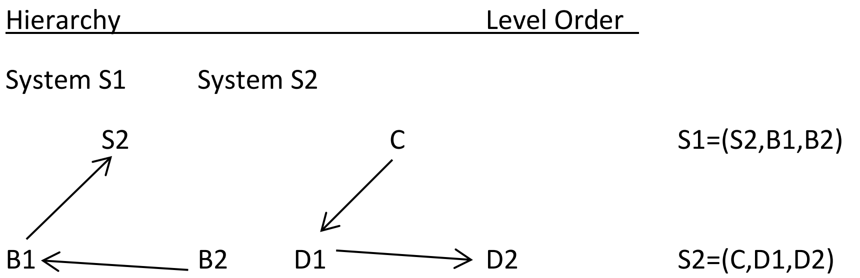



Figure 3.12. Hierarchy and level order of systems S1 and S2. In the example, S1 can be a building and S2 its foundation, B1 can be walls and B2 ceiling. In the building there is a hierarchy between the roof, walls, and foundation. Similarly, there may be a hierarchy between the parts of the foundation where G can be a sill, D1 can be a foundation wall and D2 can be the foundation beam. From the example the relation between the level of buildings and the level of foundation is a non-influencing so-called precedence-relation and not a hierarchical relation.

### 3.2.15 Rank and universality of the elements of the system

In a system, the properties of parts are basic to the properties of the whole. When classifying systems, a distinction is also made between general and individual properties. The general properties are those that are common to a set of systems while the individual properties are those that distinguish the systems in the set.

The fact that the structure of the system is a hierarchy means that the parts must be assembled in the order determined by their mutual rank. In this context, the system becomes increasingly complex.

The properties that emerge in the early stages of the assembly process are fundamental to the properties that emerge in the later stages of the process. As the assemblage progresses, the amount of genuinely possible systems decreases. When the foundation is laid, it is too late to discuss the length and width of the house.

In a variety of hierarchical systems, the general principle holds that *parts of higher rank are fundamental to the general properties of the systems in the set, while lower-rank parts are fundamental to the individual properties of the systems in the set.* See Figure 3.13.

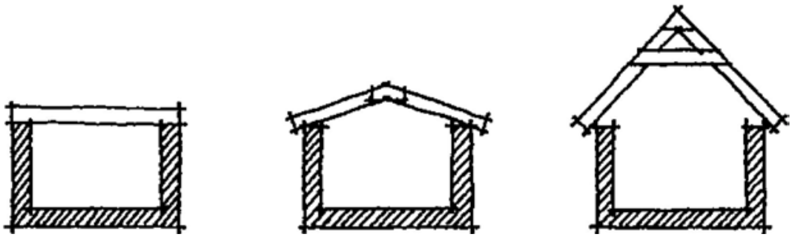


Figure 3.13. Walls and foundation are fundamental for the general properties of the houses in the figure. The roof trusses are fundamental to the individual properties of houses.

## 3.3 Representation of systems

### 3.3.1 System delimitation

Delimiting a system for the development of a representation of the system can be very difficult. There can be many things that affect the system and that are considered relevant to include among its parts. One way to draw the line is to include things whose mutual influence we want to study or describe in the system. The environment then includes things that exert an influence on the things in the system or that are affected by it without belonging to it themselves.

All concrete things can be considered as linked to a single large system, the world, see below sect. 3.3.2. A system delimitation must be made based on the properties one wants to study in the system and involves the choice between things with relevant relations and things with irrelevant relations taking into account the set criteria.

### 3.3.2 Analysis and synthesis of systems

Chapters 4 and 5 of this thesis describe systems about, among other things, composition, structure and environment. The composition of the systems consists of subsystems and parts in lower levels, while the systems environment consists of other systems and supersystems in higher levels. The structure consists of the relations between the parts of the system and of the relations with the environment.

A description of a system must therefore be made from two directions. Partly ”from below” as a compilation of subsystems and partly ”from above” as a subsystem of a supersystem. This is possible because all systems are composed of parts, and because all systems are parts of a larger whole called ”the world” (Bunge 1977a:114).

Description of a system from below is usually called ”bottom-up” while description from above is ”top-down” (Gustafsson, Lanshammar &Sandblad 1982:119).

When describing a system in the direction top-down, one starts from one’s knowledge of the system’s behavior (external structure) in its immediate environment, e.g., as a subsystem of a supersystem and makes assumptions about its composition and internal structure. A top-down description thus involves making assumptions about and testing which different types of composition and structure correspond to the known properties. This type of problem treatment is called *synthesis* (Bunge 1983a:274).

When describing a system in the direction bottom-up, one starts from a given composition and internal structure and makes assumptions about and tests the system's behavior in its environment, for example as a subsystem in a supersystem. This procedure is called *analysis* (ibid:274).

Analysis involves describing a system by indicating its properties in relation to the supersystem in which it is part. Synthesis means describing the subsystems of the system which contribute to the properties of the system and the supersystem. Both analysis and synthesis thus take place in relation to a level order comprising at least three compositional levels as in Figure 3.14.

Level L+1: Super system A

Analysis of B:
Given C and relations between C,
seek A and relations between B in A

Level L: System B

Synthesis of B:
Given A and relations between B in A
seek C and relations between C

Level L - l: Subsystem C

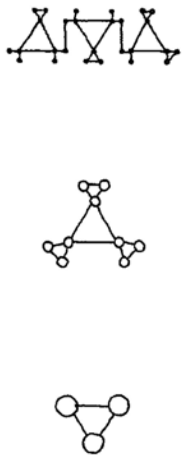


Figure 3.14 Analysis and synthesis of systems.

The system B in level L must have an external structure, purpose and behavior so that it can constitute a subsystem of system A in the next higher-level L+1. A is supersystem to B. Composition of system B consists of systems C belonging to the nearest lower-level L-l. C is subsystem of B and the external relations between different C are the internal structure of system B.

### 3.3.3 Parts of systems

It is not obvious what are the parts of a system. An organism like man is said to have body parts of the type arms, legs, head, and torso. However, these parts are not those of which man is composed. The body parts are not parts in the sense of the part-whole relation. The level body parts do not precede the level human. Rather, the body parts should be seen as emergent properties of the human being as a whole.

The composition of the organism consists of biomolecules, cells, and organs in different levels. These levels precede the level of organisms. Properties of the parts of these levels are fundamental for the properties of organisms. The human being is characterized by being a social and rational animal and the parts of man are those that are fundamental to these qualities. These include the brain, nervous system, skeleton, blood system, etc.

Man's conception of the composition of things is usually pre-theoretical, i.e., it is not based on the actual properties and laws of things but based on the apparent ”parts” of the form or external form of things. Such *gestalt* ”parts” are instead often emergent properties of the whole. What the ”right” parts of the natural systems are, is not obvious, but must be assessed in terms of their specific properties relative to other parts and the environment. The blood system, for example, was discovered as late as the 1800s.

The presence of compositional levels of the natural systems is evolutionarily determined. There is no particular purpose that hides behind the parts, but the starting point for every evolutionary process is the already existing things. These form connections and new systems. Some prevail in their environment others perish.

Thus, only those constructions of parts that prevail in their environment constitute a new level. Therefore, *to prevail in one's environment means to be able to be part of supersystems together with things in the environment*.

Likewise, it is far from a given which parts are the ”natural” ones of artificial systems. In a building, three main subsystems are usually identified, the load-bearing, the space-enclosing and the supplying. However, in the case of artificial systems, the fact is that only those constructions that fulfil any of man's purposes prevail in their environment. This environment is the sociosystems that use the artifacts.

The parts and compositional levels of the artifacts are determined in relation to a purpose. A doll's parts may well be arms, legs, head and torso, i.e., those that in man rather are emergent properties. It is crucial for the determination of parts of artifacts that they should be able to be included in different control systems. The parts must be capable of being manufactured and they must be useful. For the doll's arm to be mobile for the child, it must be made separately from the torso.

Decisive for the choice of properties of artifacts in different levels are conditions of their manufacture and use. Sometimes the wishes for properties can be contradictory, such as for a modern electrical cord consisting of a cast together wire and connector. From a production point of view, the design may be desirable, but from a utility point of view, the ability to repair the equipment is made more difficult when the cord breaks down because it does not have parts that can be replaced.

The same rationale applies to a building. From a production point of view, it may be desirable that all walls should be cast in place from concrete. But from a utility point of view, it is desirable that load-bearing and internal space-delimiting parts be separated to easily allow for plan changes.

### 3.3.4 Vector representation

In a *vector representation* of a system, each edge constitutes a special relation and each node a part of the system. An edge forming a circle at a node represents a reversal relation or feed-back within the subsystem that the node represents (Bunge 1979:17). See Figure 3.15.

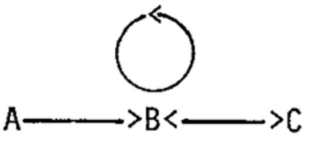



Figure 3.15. Vector representation of systems.

In the preparation of a floor plan, a vector representation may be illustrative of the relations in the sociosystem. An example is the so-called OK diagram, which shows the most common relations between activities in a home (Björkto 1969:5/3).

In his famous essay ”A city is not a tree”, Alexander uses a vector representation to show the possibilities of connection between different parts of a city. He shows that modern cities have connections whose vector representation is like trees. There are no lateral connections between the branches. Older so-called self-grown cities, on the other hand, have the character of a half-lattice in the vector representation, i.e., there are several different connections between the parts of the city (Alexander 1965).

In a vector representation, the environment can be represented by a node with an input edge to each affected element and an output edge from each influencing element.

### 3.3.5 Matrix representation

Figure 3.16. Matrix representation of a system.

A system can also be represented by a *matrix*. Each general characteristic of the system must be represented by a separate matrix. In the array, each element represents a relation in the system. The existence of a relation is marked with 1 and the absence of a relation is marked with 0. However, the element can also represent the strength of a relation by being greater or smaller in a given range e.g., between 1 and 10. A feedback relation is represented by a subsystem's relation with itself.

| | | |
|---|---|---|
| | | A B C |
| | A | 0 1 0 |
| S= | B | 0 1 1 |
| | C | 0 1 0 |

Figure 3.16. Matrix representation of the system I Fig. 3.15.

The matrix representation of the same system as in the example in Figure 3.15 looks like in Figure 3.16 (Bunge 1979:17).

The total coupling capacity of a matrix is m(m-1) if one disregards the identity relation of a part with oneself. The coupling capacity of a system of n matrices is nxm(m-1) (ibid:17).

### 3.3.6 State space

However, the graph and matrix representations cannot represent the dynamics of a system, its events and processes. For this purpose, a representation with state functions is needed. This form of representation has been presented in section 2.4.4.

In summary, Bunge (ibid:23) notes that in the case of a representation with till state functions,

1. a *general property* of systems of a certain kind is represented by a *state variable*,
2. a *particular property* of a particular system is represented by the value of a state variable,
3. the *combined state* of a certain system is represented by the values of *all state variables*,
4. the set of all *factually possible states* is called the *lawful state space*,
5. an *event* is a change from one state to another in the *state space* of a system,
6. the set of factually possible (lawful) events is the *event space* of the system,
7. the state variables are often *time-dependent*,
8. a *process* is a series of events in a system,
9. the *history* of a system is the events (its trajectory) in the event space, and
10. the total *action* of one system upon another is equal to the difference between the forced trajectory and the free trajectory of the patient (affected system).

## 3.4 System models

### 3.4.1 Black box models: control system

Systems can be organized with different complexity. The complexity of a system is dependent on, among other things, the absolute number of components and relations in the system. The simplest systems can be represented by a so-called *black box*. A black box has no internal structure, but only relations to the environment. See Figure 3.17.

Bunge (1979:254) presents five basic types of black box with rising complexity:

1. without contact with the environment,
2. an input connection to the environment,
3. an output connection to the environment,
4. a complete black box with an input and an output connection to the environment and
5. several input and output connections to the environment.

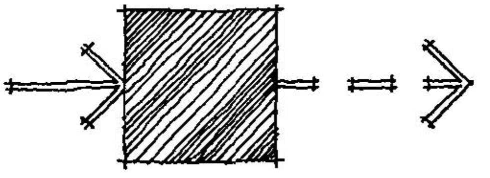


Figure 3.17. A black box with input and output.

The relation between input and output of a black box consists of the *transfer function* f, where f:u--->v. Here u is the amount of input and v the amount of output.

For example, a loudspeaker has a transfer function that converts electric currents into sound waves. A designer has been likened by Jones to a black box that converts program requirements into projects (Jones 1970:46).

The transfer function can have different structure. Output can be a direct function of current input. It can also be dependent on previous input, whereby the system has a memory function.

Black box models are of limited value if we want to know something about the composition or internal couplings of a system. Input and output are properties of the system-environment pair i.e. mutual properties. The mutual properties do not say anything unambiguous about the internal properties of a system, its composition, and its internal relations. Two systems with somehow the same mutual properties in relation to a third system can have completely different composition. For example, a bird and a bat, a fish and a whale, and a wooden house and a stone house.

Control systems can be represented by a black box. The study of control systems has developed into a special area of knowledge, cybernetics. Among the main representatives of this direction are Norbert Wiener (Wiener 1948) and W. Ross Ashby (Ashby 1956).

Characteristic of *control systems* is that they are provided with *feedback couplings*. The feedback coupling means that part of the system's output is returned as input to the system. The feedback connection is necessary in control systems of various types. However, the fact that a system has a feedback coupling is not sufficient for it to be a control system. A control system must have two subsystems, one *controlling* and one *controlled*. The controlled system is also usually referred to as *control object* (Norrbom 1973:71).

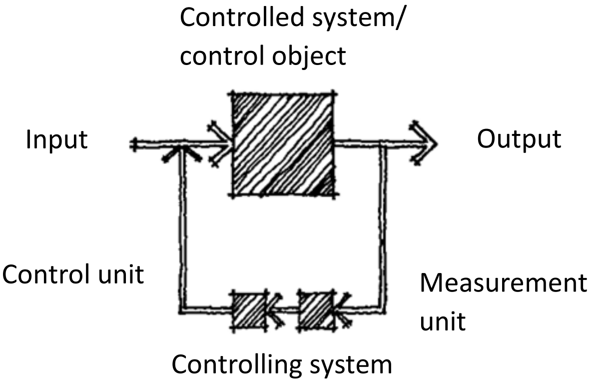



Figure 3.18. Scheme showing the construction of a control system.

The controlled system has two inputs. One from the controlling system and one from the rest of the environment. Output from the controlled system is linked through feedback to the controlling system. This is provided with a measurement unit, a control unit and a controller (ibid:71). See Figure 3.18.

The controlled and the controlling system together make up a supersystem whose state as a whole is indicated by the values assumed by its state variables. The state variables of the control system are also called control variables. These are determined according to Bunge (1979:258) by

1. *constraints* on the values of state variables,
2. *control or steering conditions* that specify the way in which the control variables affect the state variables, and
3. *optimization conditions* for certain state variables.

Among the classic examples of control systems are the thermostatically controlled heating systems (Wiener 1978:96). The optimization condition for a heating system is the required room temperature. The restrictions can be set as maximum and minimum values for room temperature. The control conditions imply that the control unit (thermostat) puts the boiler power on or off.

In the construction process, a building board can be considered a controlling system and a developer with his architect as the controlled system. The building committee has a measurement unit in the form of an examiner who records the condition of the architect's output, the proposed building in the project. The examiner is also control unit by comparing the building's various permit variables, such as floor number, function, and color scheme with the established norms for construction in the intended area. The building committee may also have an optimization condition, for example that the new building should be adapted in the best possible way to the existing buildings in the area.

The measuring unit notifies the control unit if the optimization conditions are met. In this case, the examiner notifies the building board whether or not planning permission can be granted. If input to the developer/architect is a negative message, they may try again. This can either mean that the architect adapts the project to prevailing standards or that he tries to change the permit restrictions for the building. In the latter case, however, it becomes a question of a much more complex system relation than controlling-controlled.

In a control system, feedback can be *positive* so that it enhances the effect of input. An example of this is so-called ”acoustic feedback” in the system microphone, amplifier, and speakers. Children who swing learn to use positive feedback to speed up the swing. Input in the form of the action of gravitational force on the rocking is amplified with appropriate center of gravity shifts and pulls in the ropes of the swing so that the swings of the swing are continuously increased to the desired amplitude.

In the case of *negative feedback*, the relation is the opposite, namely, it stabilizes the system. This is, in fact, the principle behind most control systems, both natural as homeostats (Wiener 1948:114), and artificial as the steam engine speed controller (”governor”).

Bunge (1979:262) distinguishes between two main types of control systems with negative feedback namely self-governed, self-controlling, autonomic, adaptive, or plastic systems.

The state of a *self-governed system* can vary within the lawful state space, for example in response to an external influence. If this impact increases above a certain limit, the system can break down, burst into the air, die or dissolve in its parts. This effect is referred to as Bunge *structural breakdown* (ibid:262).

A *self-governed system* of the plastic kind is self-stabilizing but can suffer a *functional breakdown* (ibid:262). But such a system might change its structure so that the state space is expanded through the expansion of existing state variables or the advent of new ones. In the latter case, it can be said that the system is undergoing a profound or qualitative change. Man and society are examples of self-governing systems with the ability to change their state through the development of new general properties, for example through technological development.

Most systems controlled by control mechanisms belong to the kind of self-stabilizing systems. The steam engine is an example of a self-stabilizing system. The machine can be kept at a specified speed through a steam regulator. The regulator is controlled by the speed of rotation of the machine by centrifugal force. As the steam decreases and the rpm drops, the regulator opens the supply. As the steam and rpm increase, the regulator reacts by reducing the supply of steam to the machine.

### 3.4.2 Grey box models: information system

A *grey box* is a system of input and output coordinated with each other through an unidentified mechanism. What distinguishes a grey box from a black box is that the former is observed to have or is assumed to have certain internal conditions. Bunge describes two main types of grey-box models, *automates* and *information systems* (ibid:263).

An *automaton* is a one-component system that is susceptible to a particular input, has a limited number of states, and can emit some kind of output. The state of an automaton is dependent on its recent input.

In a *deterministic automaton*, output is determined unambiguously by input and the state of the automaton at input. A typewriter and a computer are examples of deterministic automata. Most machines are designed according to the main principle of deterministic automata.

The state of a *probabilistic* or *probability-controlled* automaton· is not unambiguously determined by input and state of input. Such an automaton only with a certain probability assumes a given state carrying a given output.

Most natural systems have properties in common with probability-controlled automata. One can only with some probability predict the output of a system given a certain state and input.

Automata are by definition limited in terms of the number of possible states. This means that the usability of the automaton model is limited to things and systems with limited state spaces.

The living systems cannot be fully represented as automatons because qualitatively new states can emerge through evolutionary, cognitive and societal development processes.

*Information systems* are characterized by the fact that a certain input can affect the amount of qualitatively possible states of the system, i.e., reduce or expand the number of state variables in the state space of representation (ibid:270).

An information system consists of a source of information, a signal and a receiver. In an information system, a signal has *information effect* on the system. Information effect means that the impact changes the qualitative state of the system. The information power is not a characteristic of the signal itself, but of the system information source-signal-receiver.

Another concept of information is the *semantic concept* of information in which information is meaning-filled signals. By semantic information is meant the proposition that a statement designates (Bunge 1974a:136). It can be said that a statement is a signal in a semantic information system if it designates a proposition in the system.

Similarly, one could speak of an *epistemic concept* of information. Signals from the source of information are interpreted epistemically by the receiver. Epistemic information then refers to the concepts that represent the source of information as a concrete system. An example could be radio signals from distant sources in the universe. See further sections 4.2.2-4.

In *statistical information theory* there is another concept of information. Information here refers to a signal that reaches a receiver through a channel. The theory refers to the probability of a random binary signal reaching the receiver through a medium with certain disturbances (Bunge 1979:271). This is a kind of epistemic concept of information.

# 4 SOCIOSYSTEMS AND ARTIFACTS

## 4.1 Introduction

### 4.1.1 Purpose

The purpose of going through sociosystems and artifacts is to lay the foundation for a description of the properties of the buildings and of the properties of the systems formed during human use and experience of the buildings. By linking the description to a theory of the systemic properties of society, a study of how the properties of the building are related to the properties of society is made possible.

First, in brief, the human being, the sociosystems, and the artifacts are dealt with separately. After that, their interaction in sociotechnical systems and societies is highlighted. Society is considered here as a whole of sociosystems and artifacts in unison. Sociosystems and artifacts can be studied separately as separate things, but to understand them one must also consider them together as a whole. In collaboration, sociotechnical systems arise, which in turn through collaboration form entire societies.

### 4.1.2 Description scheme

The description scheme that will be used here is based on the definitions developed in the previous chapter of this thesis for, among other things, the concepts of thing, property, system, and level.

The most general properties of systems are to have composition, environment, and structure. Properties can be classified into primary and secondary, as well as internal and mutual. See Figure 4.1. The primary and internal properties of systems include their composition and internal structure. The primary and mutual properties of systems are their environment and external structure. The secondary and mutual properties of systems depend on an experiencing subject.

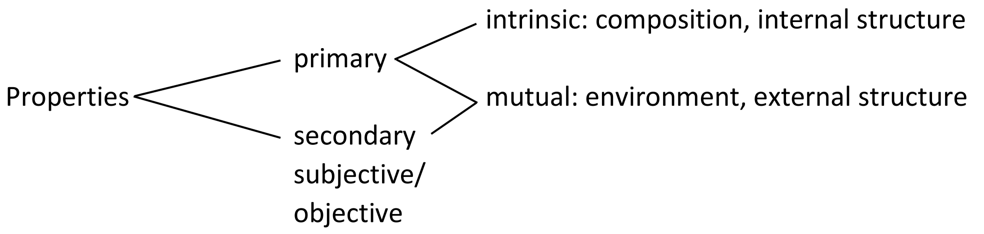



Figure 4.1. Classification of system properties.

The description scheme describes systems in relation to the upper and lower levels. The composition of the systems includes subsystems at lower levels. The environment of the systems include other systems and together these form supersystems at higher levels. See Figure 4.2.

| | |
|---|---|
| Level L + 1 | Supersystem/Ambient |
| Level L | System |
| Level L-I | Subsystem/Assembly |

Figure 4.2. Principle of level order of systems.

Using this description scheme, are described below:

1. sociosystems,
2. artifacts,
3. sociotechnical systems,
4. society,

5. buildings and building complexes, and
6. the system man-building.

## 4.2 Sociosystems

### 4.2.1 Behaviour

Sociosystems are formed by both humans and animals. To describe the sociosystems, it is necessary to touch briefly on some of the properties of man and animals that are fundamental to the properties of sociosystems.

Characteristic of humans and animals, according to Bunge, is their behavior. The *behavior* of an animal refers to all its motor movements. When the behavior is stable or recurrent, it is called the animal's *behavior pattern*. The *behavioral repertoire* is the sum of all the behavior patterns of an animal (Bunge 1979:157).

### 4.2.2 Thinking

The behavior of an animal is controlled by its nervous system. All animals have *nervous systems* that allow the reception of impressions from the environment and their own body. The nervous systems can be genetically determined or plastic (Bunge 1979:158). A *plastic nervous system* can form new connections between nerve cells. Only higher vertebrates have plastic nervous systems (ibid:133).

When it comes to the ability to receive and process impressions from the environment and one's own organism, according to Bunge (1983a:35f), a distinction is made between a) sensation, b) perception and c) thinking (ideation).

A *sensation* is a state of a nervous system (Bunge 1979:151). The sensation can be caused by both internal and external stimuli and is dependent on the state of the organism in general. The sensation can give rise to a *reflex*, an automatic reaction, in the body. Reflexes are controlled by the autonomic nervous system and do not presuppose any conscious action on the part of the individual. The patellar reflex that occurs during a slight blow to the knee tendon just below the kneecap is an example of such a reflex.

A sensation can lead to one or more *perceptions*. This is a feature of the plastic nervous system. It means that the individual develops a kind of maps of events in the body or environment. These maps are not to be compared to ”imprints”, but rather are correspondences between different sets (ibid:155). Perception is drawn up in the plastic parts of the central nervous system. It is not a passive effect of the sensation but depends both on previous conceptualization and other behaviors. The same stimulus can lead to different perceptions. Fantasies, dreams, and hallucinations are examples of such self-generated perceptions (ibid:152). The perception can be *undetermined* or *directed*, the latter as when looking for a needle in a haystack. In this case, perception is called *observation* (Bunge 1983a:139).

Perception is the basis for the possibility of being able to think. *Thinking* is an activity of the plastic nervous system that involves ”forming concepts, propositions, problems and directions” (Bunge 1979:164). To form *concepts* means to construct classes such as the class of houses or the class of architects (ibid:165). Thus, thinking can be said to involve sorting and organizing among the perceptions. Thinking also involves forming propositions. A *proposition* is a sequential association of concepts (ibid:166).

New concepts and propositions correspond to qualitatively new states of the plastic parts of the CNS. The impact on the central nervous system (CNS) is not the result of external stimuli alone but requires a special thought activity of the individual. Thus, thinking has an informational effect on the CNS.

Thinking includes establishing conceptual relations between objects as between things and concepts. This activity is called Bunge (1974b:xi) to *interpret*. He distinguishes between two different kinds of interpretation, epistemic and semiotic (ibid:1).

The purpose of *epistemic interpretation* is to develop concepts, propositions, contexts, and theories that represent things and their properties. If the representation refers to a concrete thing, it has an factual reference class. See Figure 4.3 A. This class includes the things that are interpreted. Bunge (1983a:222) has also called *conceptual analysis* the epistemic interpretation. The epistemic interpretation of a system involves describing the composition, environment, and structure of the system. Complete knowledge of a system also includes its laws and history (Bunge 1979:8). Scientific research can be described as a systematized epistemic interpretation that takes place according to certain agreed rules with, among other things, theory formation and hypothesis testing as cornerstones.

The purpose of semiotic interpretation is to understand a thing as a symbol of a communication system. A thing that denotes a class of objects is called a *signal*, *symbol*, *sign*, or *message*.

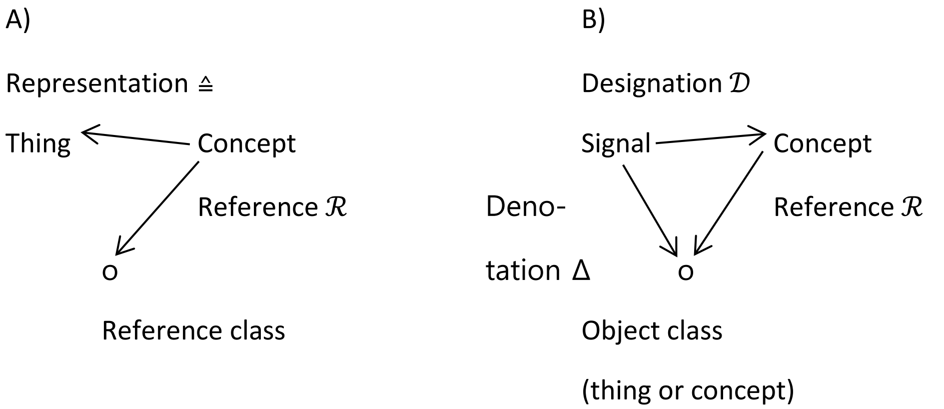



Figure 4.3 Epistemic interpretation (A) and semiotic interpretation (B).

Concepts *refer* to a class of objects (things or concepts). A symbol is said to *denote* the objects in the *reference class* (Bunge 1974a:43). See Figure 4.3B.

The *semiotic interpretation* of the relation between signal and concept occurs according to special designation rules. A *designation rule* is a conventionally defined relation between a signal and a concept. By following designation rules, it is possible to transmit a message in a communication system. In semiotic interpretation, the concepts do not refer to the actual properties of the signal, but to other objects, things, or concepts.

The epistemic and semiotic interpretations can support or contradict each other. A forest path can be marked with small signs, which means that the semiotic interpretation facilitates and verifies the epistemic interpretation that one is ”on the right track”. Contradictions also arise. For example, it happens that stairs in heavily trafficked spaces are ”one-way” with the help of signs indicating ”not up” and ”not down”, respectively.

All things can be interpreted both epistemically and semiotically. Natural configurations can serve as sea marks, forming lines of safe passage, so-called transits. When this occurs, the natural configuration is interpreted as a sign for a certain course to be held. More commonly, however, natural things are only interpreted epistemically. Artifacts are things made by man. In the broadest sense, to artifacts belong all things whose condition has been influenced in some respect by man. When the artifacts are interpreted semiotically, the transfer of concepts between people is made possible. Man himself is also interpreted semiotically, not only with language, but with body movements and clothing as messages.

The epistemic and semiotic interpretations interact in the practical ”reading” of the outside world. The value of the distinction between epistemic and semiotic interpretation and the relations between the modes of interpretation cannot be assessed in the context of this work, which is limited to the ontological problem.

### 4.2.3 Personality

An animal is distinguished by its behavior. If the animal has a CNS with plastic parts, it has opportunities for perception. The most highly developed animals also have the ability to think. These animals, to which man belongs, are distinguished not only by their behavior, but also by their thoughts, feelings and ideas, their mental qualities. A collective designation of the individual’s behavior and mental properties is *personality* (ibid:174).

### 4.2.4 Communication

Through the ability to develop mental constructs in the form of perceptions of the environment and to develop concepts that represent properties of the environment, an individual can develop factual knowledge (ibid:74). Such a knowledge-developing system is an *information system*; it could also be called an *epistemic* or *cognitive system*.

The development of knowledge can be made far more effective if several individuals can collaborate. This is done through communication. *Communication* is a social activity that involves the mediation of signals between animals (ibid:113). One might ask whether communication is not a prerequisite for the emergence of sociosystems.

A *communication system* consists of three components: *sender*, *channel* and *receiver* (Bunge 1979:101). In communication, *signals* are transmitted from one individual to another. The meaning of the signal is its *message*, i.e. the concepts and propositions that can be interpreted according to the *designation rules* agreed between transmitter and receiver. If the recipient learns something new, a qualitative change occurs in their CNS. In this respect, the signal has been interpreted as *information*.

The semiotic interpretation of a signal allows communication between the members of a sociosystem. With communication can be conveyed both factual knowledge and fantasies as when the signals in a language designate concepts with and without factual reference. Through communication, an individual can obtain factual knowledge without having to make the epistemic interpretation himself.

In addition, sociosystems have the property of being able to convey information from individual to individual and between generations of individuals. The latter characteristic has been further reinforced by the emergence of the sociotechnical systems with their libraries and databases.

### 4.2.5 Sociosystem: composition and environment

By sociosystems is meant not only the various organizations of man. Other animals can also form sociosystems. Sometimes animals and humans are part of sociosystems together, such as when dog and man interact in cattle raising, watchkeeping, tracking and hunting, or when they just make up each other’s company.

The environment of the sociosystem includes other animals whose behavior affects or is influenced by the members of the system. The environment also includes the natural systems and artifacts. Sociosystems can influence their environment so that they acquire the desired properties. The natural environment can be transformed into artifacts. Sociosystems can compete or interact.

According to Bunge (1977a:177), a sociosystem is a concrete system whose

1. composition is a set of animals of the same order, they do not have to belong to the same species,
2. environment is the set of things other than the components of the system that act on or are acted on by the latter, and
3. structure is the social behavior repertoire of the members.

Families, factories, and social networks are examples of sociosystems. A sociosystem is not the same as a society. Society is a self-sufficient sociosystem, see section 4.6.

### 4.2.6 Social structure

By *social behavior* is meant the behavior of the individual that makes up the structure of a sociosystem. The *social behavior repertoire* is the part of the total behavior pattern that belongs to the social behavior (Bunge 1979:176). To the comprehensive pattern of behavior of animals belongs reproduction. This is reserved for individuals of the same species. Reproduction can be said to belong to the properties of biosystems and does not have to be counted among the properties of sociosystems.

A distinction should be made between behavior and activity. Behavior includes the entire amount of motor movements of an animal, both external and internal. An *activity* is defined as a sequence of goal-oriented actions (ibid:197). The activities constitute the subset of the individual's behavior that takes place with a conscious purpose. An activity includes both motor movements and thinking. Examples of activities are speaking, cycling, cooking, playing, and working.

The concept of activity is central to the study of the human-artifact relation. See, for example, Agervold (Cronberg 1975:22). Cronberg cites a variety of examples of goal-oriented actions (ibid:26).

To carry out its activity, the system must be a control system, for example, a worker with his tool. Such a system is self-correcting so that the activity can be aimed at the achievement of a set goal. During an activity, the system affects itself and/or its environment. Some activities form the internal bonds of the sociosystem. Others form the external bonds between the system and the environment.

The bonding relations in a sociosystem are the influence between the members and between the system and its environment. The purpose of bonds in sociosystems may be the interaction of the members. Collaboration is defined as behavior that is valuable to participating parties. Collaboration regarding things is called *sharing*, e.g., sharing the use of a tool or sharing ownership of a house. If collaboration refers to activities, it is called *participation* e.g., in business deals, teaching or sports competitions (ibid:177).

What distinguishes sociosystems from natural and artificial systems (see section 3.1.3) is that the bonds are mainly maintained through communication. The view of communication as the fundamental property of sociosystems is consistent with the conception of modern sociology. See, for example, Israel (1979:15) or Habermas (1984:40).

The bonds between the members of a sociosystem can be said to consist in influence. When two members communicate, one exerts *influence* on the other with respect to a particular activity if this differs from a situation where the members do not communicate (ibid:225).

In building planning, a building committee can exert an influence on a developer, for example by determining the color scheme of a building. If the building board's influence on the developer is far greater than the other way around, the former is said to exercise *power* or *control* over the latter (Bunge 1979:225). Control is an influence with the aim that the affected thing should assume a definite state.

When the power of the building committee is not sufficient to influence the developer's choice of color of the building, the surrounding residents may be able to try to exert influence through group pressure. *Group pressure* refers to the influence on a member of a sociosystem from other members of the sociosystem (ibid:225).

If ”our” builder does not want to give in to peer pressure, there is a risk that he or she will be ”excluded” from the social community. He or she will then no longer be allowed to have any of the *optional* connections between the surrounding neighbors. The exercise of power can be facilitated if the bonds between the members of the sociosystem are made *coercive* through, for example, legislation or the construction of obstacles such as fences and locked doors.

In the context of the exercise of control in a sociosystem, the concept of freedom also acquires a special importance. Freedom can refer to different activities. Economic, cultural, and political freedom are not the same thing. Bunge notes that the *freedom* of a person to perform an activity is composed of several factors. The activity shall (a) be a possible alternative, (b) be carried out efficiently and (c) be valued. Moreover, the benefits of implementation should be greater than the cost (ibid:220).

This compilation of freedom criteria can be the starting point for a discussion of user freedom in the built environment. Freedom here can mean the possibility of exploiting a building for various purposes. Thus, freedom is not only dependent on financial resources, but is also a matter of values and real opportunities.

The purpose of the connections in the social systems may be the *collaboration* of the members. Collaboration is defined as behaviour that is valuable to participating parties. Collaboration regarding things is called *sharing*, e.g. sharing the use of a tool or sharing ownership of a house. When collaboration activities refer to activities, it is called *participation* e.g., in business deals, teaching or sports competitions (ibid:177).

The structure of sociosystems can be *hierarchical*, which means that the influence between the members of the system in some respect is predominantly one-sided. The relations in a hierarchy or *influence order* are power relations or control relations. The prototype of the hierarchically structured system is the military organization. Influence in the military system occurs by order from superior to subordinate.

Other organizations such as companies and government agencies may also have a hierarchical structure. These often base their order of influence on the importance of the decision-maker for the company’s production or for those affected by the exercise of public authority. The managing director has the highest rank in the company’s hierarchy while the cleaning staff has the lowest. The Supreme Court is the highest in the legal power hierarchy while the Court of Appeal and the District Court have a lower rank and the individual citizen has the lowest rank.

The sociosystems that use buildings are also often hierarchically organized. Housing management often takes place in large sociosystems where the residents are the lowest in the hierarchy while the municipality or private property owners are the highest in the hierarchy.

### 4.2.7 Work

*Work* is a special kind of activity. It is a sequence of goal-oriented actions whose purpose is to change the state of another thing and to be socially useful (ibid:197).

Work belongs to the bonding relations in a sociosystem and between this and its environment. The utility criterion distinguishes work from other activities. Bunge distinguishes three basic types of work: labor, cultural work and managing (ibid:198).

*Labor* refers to the production or alteration of things in the form of goods or services that are materially beneficial to the members of the sociosystem.

*Cultural work* has the purpose to influence people's thoughts, feelings, and ideas, for example through teaching or entertaining.

*Managerial work* refers to the control of the economic and/or cultural work through some form of planning or controlling activity. See Figure 4.4.

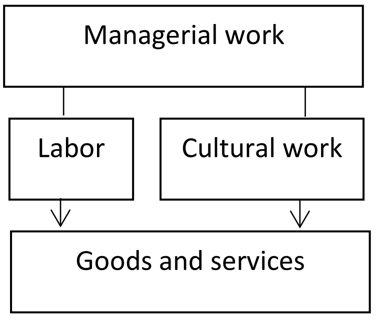



Figure 4.4. Managerial work controls labor and cultural work which result in goods and services.

Work requires control of both work tools and work activities. Work is carried out through the interaction of members of the sociosystem. The organization of this collaboration concerns questions about how the work tools are shared and how participation in the work activities takes place. The ownership of the means of production and the method of production are issues related to sharing and participation.

### 4.2.8 Role

The activities that an individual performs and the mental properties of the individual that depend on the activities can together be given the designation of *role*. The role is a subset of the individual's personality. In different sociosystems, individuals have different roles, for example in the family as father or mother, in the group as a leader or subordinate and in teaching as a teacher or student.

Thus, a role does not refer only to motor activities. Thoughts, feelings, and ideas must also be considered to belong to the role. Some mental activities are directly necessary for the performance of the role, e.g., the learning of conceptual knowledge such as theories and methods. Other mental activities appear as a result of the role. People's dreams, beliefs and worldviews depend on their roles in different social and societal systems.

Israel (1984:26) notes that when defining the concept of role, it is usually assumed that ”man has different positions within an organization or institution… All the expectations associated with a definite position are in this theory (the theory of roles) usually summarized under the term ”role”.

Bonding relations resulting from a social role differ from the more basic biosocial bonds such as friendship, love and hate. This distinction between the biosocial relations and the social relations that arise in organizations and societies is also found in Israel (1979:70).

### 4.2.9 Configuration in sociosystems

Sociosystems have no spatial shape. However, sociosystems have a spatial structure as do other concrete systems. The spatial relations between the members of the system provide various opportunities to maintain the relations in the system. Here are just a few aspects of the configuration of sociosystems which are of great importance for determining the spatial properties of buildings.

The bonds in the sociosystem are maintained via the social behavioral repertoire through various forms of communication. The signals between members of a sociosystem have different reach and thus determine the spatial extent of the system.

Hall (1966) and Gehl (1971) have studied the kinds of communication that are possible at different distances using only the social behavior repertoire without the help of special technical aids.

With different senses, different types of signals can be recorded. Hall classifies the senses into sensory, thermal receptors, sense of smell, sight, and hearing. These senses have different properties and allow communication at different distances between the people.

Hall (1966:116-129) talks about four different relations between people namely

1. intimate,
2. personal,
3. social and
4. public.

The different relations are characterized by the fact that the configuration of the system has different extents. For each relation, the distance can vary within a margin from near to far away.

The extent of the *intimate* distance is from 0-45 cm and is ”the distance of love-making and wrestling, comforting and protecting” (ibid:117). The *personal* distance ranges from 45 to 130 cm. Within the closer part, ”one can hold or grasp the other person” and at the longer distance ”subjects of personal interest and involvement can be discussed at this distance” (ibid:120).

The *social* distance is between 130 and 225 cm. ”Impersonal business” and sociable exchanges of a more formal nature take place at this distance.

Finally, there is something that Hall calls *official* distances that are between 3.75-8 meters and above. Within the closer range, ”an attentive human being can take to the run or perform a defensive act.” At 5 meters, the color of the eyes cannot be distinguished, ”only the white of the eyes is visible”. The longer range over 8 meters is, for example, the void that ”surrounds prominent public figures”. Hall points out that these distance rules apply to Westerners, especially in the United States.

Within the distances mentioned above, it is possible to maintain a direct contact between the members within a sociosystem. As soon as the distance becomes greater, communication is broken if it cannot be maintained by technical means. When the connections in the sociosystem are maintained with the help of artifacts, the system can be said to be a sociotechnical system. Examples of such means of liaison are mass media such as newspapers, radio, television, and telephones.

## 4.3 Artifacts

### 4.3.1 Tools

The artifacts belong to the larger group of tools. *Tools* are used to enable an activity. Tools have the disposition to produce, together with other things, the desired properties.

A stone may have the disposition of being able to be thrown and damage the hit. Some species of the so-called Darwin finches in the Galapagos Islands have learned to use sticks or cactus tags with the help of which they can poke insects out of narrow nooks and crannies in the trees and on the ground. Chimpanzees use canes and branches to scare intruders on the run. The use of tools is not uncommon among the animals.

Törnebohm (1983:160) has formulated several theses in which he establishes the meaning of instruments, the properties of tools. Instruments have *functions* whose purpose is to enable *intentional actions*. These can be part of *systematic complexes* of actions that are *governed* by a plan and are subject to *control*.

### 4.3.2 Manufactured tools

*Artifacts* are a special kind of tool. They differ from natural things by being made by rational beings with the help of some technique (Bunge 1979:209). Artifacts can be considered a whole new class of things that did not exist before the emergence of rational beings. Bunge refers to the class artifacts artiphysis. See Figure 4.5.

Rational beings also refer to other than humans. Rational beings are those who can make rational decisions. A decision is *rational* if it is based on a) relevant knowledge and correct valuations and b) foresight of the possible outcomes of the corresponding action (ibid:167). The degree of processing may vary between different artifacts. The criterion is that the state of the thing in some respect was determined for some purpose.

Whether the production and use of tools is genetically programmed or can be learned varies between animal species. Higher animals such as monkeys and humans have greater amount of plastic brain mass than lowly animal species such as ants and fish. It is the plastic brain mass that is the prerequisite for learning in that it can form new connections (synapses) between the brain cells (neurons) (ibid:133).

An important difference between tool use and artifact making is that the latter is a mentally more advanced activity (Dobzhansky 1962:194). To look at a thing from different aspects means, among other things, to imagine the thing in relation to different environment. A branch lying on the ground can easily be understood as a cane that can be held in your hand. To produce from the same branch a spear or a boomerang requires additional creative effort. In this regard, the thing is not considered given, but its parts and internal structure must be understood and represented conceptually.

The boundaries between the use and manufacture of tools can be perceived as difficult to draw. However, only man has developed into a prominent tool manufacturer. This has been possible through the mutual evolution of hand and brain. The manual processing of the natural environment is fundamental to all artifact making. The more advanced artifact production, on the other hand, takes place using other artifacts as tools.

From a developmental point of view, there is a mutual relation between the manufacturing and the manufactured tools in that the use of more advanced tools also enables the production of more advanced tools, which in turn can be included in the manufacture of further more advanced tools. This is also the principle behind all technological development.

One might ask whether it is the same principle that guided the evolution of the hand and brain? Is there a corresponding interplay between their development and the development of artifacts? Such questions arise naturally here but must be answered with knowledge in other sciences. An account of some of the answers to these questions is given in section 4.5 Man and the Artifacts.

### 4.3.3 The concept of artifact

Artifacts can be considered a whole new class of things that did not exist before the emergence of rational beings. Bunge {1979:209} refers to the class *artiphysis* or *technical systems*. See Figure 4.5.

The Latin ”arte” means art or skill. The ending ”physis” in artiphysis is Greek for ”growing” and ”nature”. Physis can be derived back to ”phyein” meaning ”to bring forth (do)” (Websters 1979).

Technical comes from the Greek ”techne”, which also means art or skill. A direct equivalent of the concepts of artificial and technical is ”artificial”. *Artiphysis* is thus the class of artifacts, ”artificial” things.

According to Bunge (1979:209), the artifacts can be classified based on their purpose of use and divided into non-living and living as well as economic and cultural. See Figure 4.5.

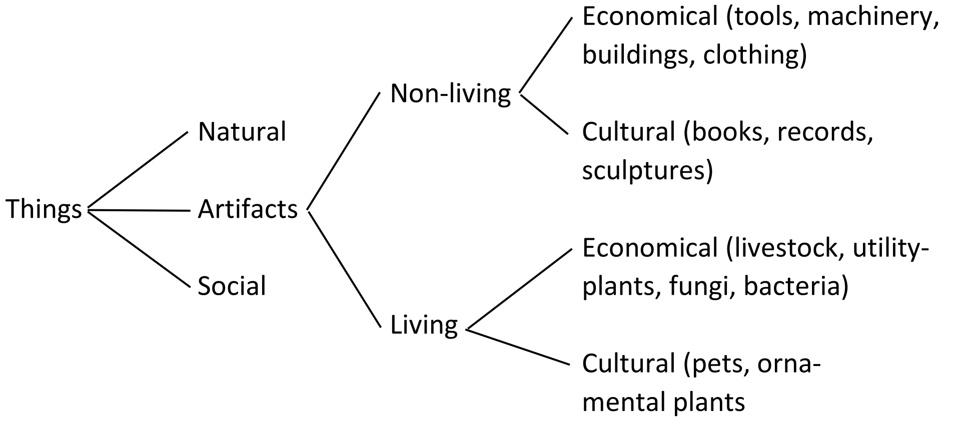



Figure 4.5. The class Artiphysis divided into subgroups.

The *economic* artifacts are those whose purpose is the material benefit. As tools, it is their mutually primary properties that are the most important. The economic non-living artifacts include tools, machinery, buildings, clothing, etc.

The *cultural* artifacts are those whose purpose is the cultural benefit. In doing so, it is the mutually secondary properties that are the most essential. These qualities emerge together with a thinking and sentient observer, a sensory user.

The purpose of cultural artifacts is to influence people so that they are stimulated to develop thoughts, feelings, ideas, and knowledge. Cultural non-living artifacts include all those things whose purpose is cultural: books, cassette tapes, newspapers, televisions and television programs, musical instruments, sheet music, speeches, and music, works of art, etc.

The things man has hitherto been able to produce belong to the non-living. However, it is reasonable that even some living things are assigned to the class artiphysis because their evolution was guided by the purpose of man. Such living things are, for example, animals, plants, fungi, bacteria, and genes. They are also usually given the designation domesticated. On the one hand, is meant those whose purpose is the material benefit. These include animals such as cattle and draft animals, beneficial plants such as cereals and vegetables, fungi and certain bacteria and genes. On the other hand, it refers to living artifacts whose purpose is cultural e.g., pets such as certain dogs, cats and caged birds or ornamental plants. See Figure 4.5.

Herbert Simon (1981:5) subscribes to this view when he notes that, ”his corn and his cattle - are artifacts” and ”a plowed field is no more part of nature than an asphalted street – and no less ”.

### 4.3.4 Artifacts as systems

The properties of artifacts (composition, environment, and structure, as well as laws and history) are characterized by the purpose of their use. Likewise, the natural and sociosystems are characterized by being shaped in their respective environment.

An artifact’s *environment* consists of things that have participated in its production, maintenance or destruction and of the things that the artifact affects or is affected by, for example, during its use as a tool.

The *composition* of an artifact consists of natural or artificial things, the latter processed in one or more stages. The properties of the composition, e.g., the presence of subsystems and levels, are determined by conditions of the production and use of the artifact.

The *structure* of an artifact is all relations (bonding relations and non-bonding relations) that exist between parts of the artifact and between the artifact and its environment.

Of the external relations of the artifact, two are of particular interest in this context. Bunge mentions transformation relations (1977:189), and here is added what could be named tool-relations.

*Tool relations* are bonding relations to the user during the use of the artifact. A hammer's tool relations consists of connection to the "hammerer" via the shank. Part of the typewriter's tool relations are the bonds with the user via the keyboard. The building's tool relations consist of, among other things, the user being carried by the floor and protected by the walls and ceiling. See Figure 4.6.

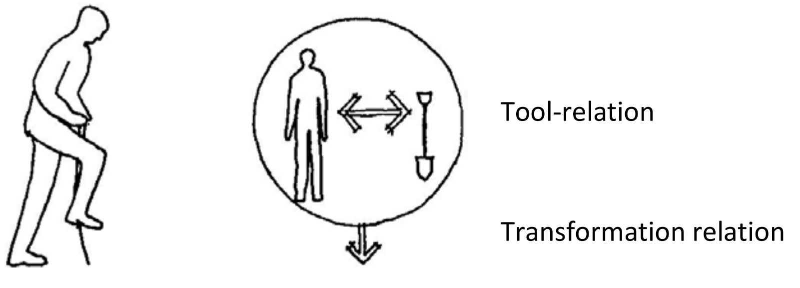



Figure 4.6. Tool relations and transformation relations.

In the somewhat lax computer user language, the tool-relation is called "user-interface". The study of the specific tool-relations that may be important for human physiology takes place within ergonomics. As an example, basic ergonomic studies of different types of stairs are conducted at the Architecture Department at Lund University.

The common designation for the tool-relations is *functions*, but the tool-relations can also be called *ergonomic relations*. A distinction must be made between use and control of tools and thus also between use relations and control relations. When the tool is controlled, it belongs to the system, if it is only used, it can belong to its environment.

*Transformation relations* exist between the artifact and the things it affects in an activity. The hammer's transformation relation consists of the head's impact on the environment in which the hammer blow is directed at, for example, the nail head. The transformation relations of the typewriter is the impact of the types on the paper. The transformational relations of the building consist in its impact on its environment in the form of subsoil, wind, precipitation, intruders, etc. See Figure 4.6.

The control relations to a tool are necessary to enable the transformation relations. You can't drive a car without steering and you can't live comfortably unless you can change the furniture and furnishings.

The transformation relations could be given the designation "product-interface" in the aforementioned parlance. Simon (1981:9) also speaks of "interface" as a designation of the artifact's external relations: "An artifact can be thought of as a meeting point - an "interface" in today's terms - between an "inner" environment, the substance and organization of the artifact itself and an "outer" environment, the environment in which it operates". In his presentation, however, Simon does not distinguish between "user-interface" and "product-interface".

The tool-relations and the transformation relations together are referred to as *functions* in traditional parlance. Here, then, I distinguish between the internal and external functions of systems.

## 4.4 Man and artifacts

### 4.4.1 Artifacts, sociotechnical systems and societies

One of the main hypotheses of this thesis is that man and his tools form a new family of systems, the sociotechnical systems. These systems have emergent properties such as activities and social roles and can fabricate complicated artifacts.

When the sociotechnical systems produce new artifacts in the form of goods and services, it does so through the interaction of a wide range of sociotechnical systems. From this collaboration grows another new kind of system, namely society.

The emergence of the sociotechnical systems should be seen in an evolutionary historical perspective. It is only through this that a real understanding can be gained of the fundamental importance of artifacts for man and society.

The purpose of the text in section 4.4 is to provide a background that demonstrates the importance of not trying to study man separately from his artificial environment. Both man himself and sociosystems and society have evolved in interaction with the artifacts. Man as a phenomenon can therefore only be understood in his interaction with the artifacts.

### 4.4.2 Evolutionary background

Artifacts play a central role for man and are intimately linked to his biological and cultural development. The emergence of complex social organizations and society are both the result of and the purpose of human production and the use of artifacts. Science and technology often tend to overlook this interaction. Scientific activity often refines problems by reducing their complexity, missing significant connections between seemingly distinct phenomena. Thus, during the 1800s and well into the 1900s the prevailing view among anthropologists were that it was the development of the brain that was the reason why man got upright gait, began to use tools and developed language (Gould 1977:174).

In evolutionary research, however, in recent years, more and more attention has been paid to the central role artifacts have played in the development of man as a new species. The earliest human-like creatures the Australopithecines that lived 1 - 2 million years ago had both upright gait and used tools (Wood 1978:53, Dobzhansky 1962:193).

The eminent evolutionary scientist Theodosius Dobzhansky (ibid:193) refers to the American anthropologist Sherwood Washburn who notes: ”Much of what we think of as human evolved long after the use of tools. It is probably more correct to think of much of our structure as the result of culture than it is to think of men anatomically like ourselves slowly developing culture”.

The modern view among anthropologists is that the brain can hardly have evolved without some primary causal relation. This, they say, consists in the fact that our ancestors are first for some reason forced to leave the trees to live on the ground. This frees up the hands with their gripping possibilities for increased use and manufacture of tools. ”The entire release of hands for tool use preceded most of the evolutionary magnification of our brain” (Gould 1977:175).

It may be interesting to note that the misconception about brain development as a driving force for the development of human properties underlies the difficulty of finding the ”missing link” between ape and human. This would be an early primate with a large brain but without the characteristic erect gait. On the basis of this assumption, a group of career-hungry anthropologists in England in the

1910s constructed a find that had the sought-after properties of large skull volume, ape-like jaws and ditto teeth, the so-called Piltdown man (Gould 1980:108 ff).

The recognition of the Piltdown man in scientific circles delayed the realization of the developmental importance of australopithecines. The African australopithecines discovered in the 1920s were first believed to belong to a species other than the one that was the forerunner of Homo Erectus and later to Homo Sapiens due to the fact that although they had upright gait, they had an overly small brain, about 450 ml. However, later findings of Australopithecus Africanus by Richard Leakey have strengthened the hypothesis of the australopithecines as Homo Sapiens' forerunners. Leakey's findings ER-1470 exhibited a brain volume of 800 ml (Gould 1977:155).

The hypothesis that the upright gait and tool use preceded the development of the larger brain led Bartholomew and Birdsell to assume that the Australopithecines were *tool users*. This was later confirmed by finds of stone tools at earlier sites (Dobzhansky 1962:193).

The question of whether the upright gait came before the use of tools is, according to Dobzhansky, the same as the question of whether it was the chicken or the egg that was developed first. However, he is careful to point out that there is a difference between using utensils and making them ”*Tool-making* is a performance on a psychologically higher level” (ibid:194).

As early as the 1800s, there were those who claimed the importance of artifacts for human life. Among others, Sigmund Freud and Ernst Haeckel, the champion of Darwinism in Germany. Friedrich Engels was also among those who opposed the theory that brain development precedes the upright gait and the use of tools.

Although Engels' main contribution, according to Gould, consists in his political analysis of why Western scientists were so inclined to emphasize the importance of the brain, his description of the causal relations in the evolution of the monkey into man is also valid. ”Upright posture freed the hands so that they could use tools; Increased intelligence and speech came later”. Thus, he concludes that ”the hand is not only the organ of labor, but also the product of labor” (Gould 1977:176).

Modern brain research has been able to support theories about the importance of artifact use for the development of the cerebral cortex, the part of the brain that has been responsible for the great growth during the development humans.

Canadian neurosurgeon Wilder Penfield has done a study of the functions of the cerebral cortex. From his investigation it appears that, relatively speaking, very large areas are occupied by sensory and motor centers of the hands, mouth, and speech organs. Carl Sagan (1979:45), who reported Penfield's studies, states that ”Our science and culture could never have developed without our language and technology and our buildings would never have come into being if we had not had our grappling hands”.

Here one can link to Dobzhansky's thesis that the *manufacture* of tools is an activity on a different psychic level than the *use* of tools. Innovative manufacturing requires the brain to be able to develop representations of an imagined object before it exists. In doing so, it is necessary to be able to freely form mental constructs and concepts without genetic binding. The emergence of the genetically ”decoupled” conceptualization allows the development of language and at the same time is a prerequisite for being able to manufacture artifacts. See Figure 4.7.

About the emergence of language is not yet known much. It is assumed that Homo Erectus had a language that enabled their relatively complex societal formations. Erectus is known, among other things, for its production of stone tools that were of such a magnitude that Mary Leakey has called it the ”Olduvai industry”. Erectus lived 1.5 to 0.5 million years ago (Wood 1978:93).

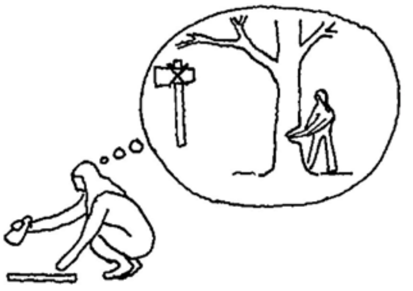


Figure 4.7. Creation requires the brain to be able to develop representations of an object before it exists.

Other researchers such as Ralph Molloway claim that the skull shape of Homo Habilis that lived about 2 million years ago shows the existence of a motor speech center. Sagan (1979:114) draws from this the conclusion that ”The development of language, manufacture and use of utensils, and the development of a culture may have taken place largely simultaneously”.

### 4.4.3 Technology as an environment or system component

The artifacts can be viewed from two main aspects namely a) as *enhancers* of man’s own senses and organs and b) as *environment* to man and his various sociosystems. The latter aspect gives the traditional notion in the sciences of the relations between man and technology as two separate phenomena which can and should be studied separately. The first aspect provides a parallel line but with weaker impact.

The aspect of the technical systems such as extenders, amplifiers, expansion etc of man’s own abilities has been developed by, among others, Samuel Butler (1872 & 1970) and Marshall McLuhan (1967).

In his book Erewhon (the title read backwards becomes nowherE), Butler had two professors each argue their own position on the nature of evolution. One argued the Darwinian principles of random variation and natural selection and the other preferred the Lamarckian notion of the gradual inheritance of acquired traits (Steadman 1979:131ff).

Butler himself was originally a Darwinist but later switched to the Lamarck view. His notion was that all evolution follows the same principles. The purpose of his presentation was to convince readers that not only cultural but also biological evolution followed the Lamarck principle.

The first professor explained his argument against the Darwinian principle by comparing machines with animals and plants. There is no decisive difference between these from a developmental point of view, according to the professor. If machine development were to follow Darwin’s principles, machines would soon take over man’s dominion on earth.

In a couple of thousand years, the machines had developed into very advanced designs. Within another couple of thousand years, therefore, they would not only be larger and stronger, but also much more intelligent than man. The humans would in the future be reduced to becoming the slave laborers of machines. The professor’s conclusion was therefore that it was necessary for humans to destroy the machines before they took dominion on Earth.

Butler considered Darwin’s theory of evolution to be mechanistic. By drawing out the consequences of Darwinian theory of evolution for the development of machines, Butler wanted to demonstrate the absurdity of this theory and that it could therefore not apply to the evolution of organisms.

Butler's second professor argued that evolution follows Lamarck's principles that involve the inheritance of acquired traits. As "proof" of this, the professor put forward the view that human evolution is now being passed on through the development of machines and that these were primarily to be regarded as an enhancement of the human body's resources. "A machine is merely a supplementary limb; this is the be all and end all of machinery. We do not use our own limbs other than as machines and a leg is only a much better wooden leg than anyone can manufacture" (Butler in Steadman 1979:133).

Butler argues in the first case that Darwin's theory must also apply to machines. Something that Darwin never claimed. By pointing out the absurd consequences of the theory for machines, Butler argues that it cannot apply to organisms either. In the second case, Butler argues that human evolution now takes place through machines, and since Lamarck's principles apply to machines, they must also apply to humans. The modern view, of course, is that biological evolution obeys Darwin's laws and that cultural evolution, the development of social organizations and artifacts is Lamarckian in nature.

In his book Evolution of Designs, Steadman shows how Butler's view of technology as an extension of human body organs has had an impact on the discussion of ideas in art and architecture. During the 1920s, Le Corbusier and Amadie Ozenfant developed the theories behind Purism, which were published in the journal L'Esprit Nouveau. This introduced, among other things, the notion that " files and copying machines extend the capacities of our memories" (Steadman 1979:136).

Buildings, like other artifacts, are tools for human activities. Sociosystems and buildings in interaction give rise to villages and cities. Lewis Mumford, in his book The City in History, describes how the village and the city can be regarded as a tools to facilitate human cooperation, communication and togetherness (Mumford 1961:26 and 115).

McLuhan has continued to develop Butler's view of the importance of technology to humans. He sees the new information-processing and information-transmitting machines as an expansion of the human nervous system and brain (McLuhan 1967:12).

McLuhan regards the artifacts as enlargements of man's own organs into technoorgans. However, he does not construct the *concept* of sociotechnical systems, but speaks of the fact that "each new technology gives rise to a new human environment" (ibid:6). This quote contains the traditional view of the artifacts as environmental. Another quote from McLuhan shows that his line of thinking, however, is consistent with this hypothesis of the sociotechnical systems: "The railroad did not introduce the movement, transport, wheel, or road into society but it gave greater speed and greater scale to the hitherto human functions, gave rise to entirely new types of cities, and to new forms of work and leisure… The aircraft, on the other hand, further accelerates the transport capability, and tends to dissolve the railway-shaped forms of cities, politics, and associations quite independently of what the aircraft are used for" (ibid:15).

McLuhan believes that technology provides an environment, an environment that changes human life patterns and "functions." This is true but the artifacts are not just environment. They also provide us with roles as people. Not the original social roles of mother, lover, or herd leader but the roles of sociotechnical systems as operators, cashiers, directors and administrators. These roles will be explained in the following presentation as emergent properties of the new sociotechnical systems formed by human use of the artifacts.

McLuhan says that "the personal and social consequences of each medium (in the sense of expansion of ourselves) are a function of the new scale introduced into our affairs by every expansion of ourselves through each new technology" (ibid:14). This can be understood as the social consequences of technology being a consequence of the properties of technical systems. This, according to McLuhan, applies not only to the specific properties of each individual technology's products ("cornflakes or

Cadillacs"), but also to the most general properties of the technology or the machines, their quintessence. For the machines, this would be the fragmented technology and for the automatons, according to McLuhan, the opposite tendency to seem integrative, forming unity (ibid:14).

Thus, the properties of the more primitive machines not only act for a specialization and fragmentation of man's manual labor, but also have corresponding consequences for his thinking. This effect, incidentally, has today's computers on intellectual work. According to McLuhan, however, automation and the new electronic media function in the opposite direction for integrated and comprehensive work. Whether McLuhan is right or wrong may not be so important as that these kinds of questions or hypotheses must be considered fruitful. They should be able to generate research in the field of human-artifact.

Butler's reasoning is of interest because it constitutes an early example of perceptions that constantly appear in the context of discussions about technology and its implications for man. Mumford's and McLuhan's work are examples of modern reports around the same themes.

Constantly recurring are the two opposing conceptions of the properties of technology as something positive or something negative for human development. For example, there is a fear that computers will develop to become more intelligent than humans and that they will completely take over the advanced decision-making processes in society. A fear that is substantiated by the fact that computers are declared to be the cause of many wrong decisions made by administrative bodies. One blames the computer and forgets that the responsibility for decisions lies with machine designers, programmers, operators, and administratively responsible people.

The fear of machines is also based on the fact that they replace humans at workplaces. A further view is that the machines and now especially the computers reduce the need for the personally acquired knowledge and judgment of the human being. Understandably, these attitudes often lead to a negative attitude towards technology at all. However, there is also a naivety in development of technology, the purpose of which consists only in replacing humans with machines.

One can agree with Butler's professor who wanted to stop the development of machines. If it is possible to produce machines that are more intelligent than humans and more capable in various ways and that 'take over', we should not do this. The reason is that we must consider the human being as the goal and technology as the means and not the other way around.

This account talks about the new system levels of sociotechnical systems and societies. These systems must not be allowed to have such rules of members' behaviors and such laws in human-machine relations that humans as individuals are reduced to robots. The design of regulatory systems and laws takes place with a large element of freedom of choice and should thus take into account the innate need of man for social interaction and talents for manual and intellectual work.

## 4.5 Sociotechnical systems

### 4.5.1 A new kind of system

One of the main hypotheses of this thesis is that the sociosystems in the use and experience of artifacts form a completely new kind of system, the sociotechnical systems. These are neither purely technical systems nor sociosystems. The importance of tools in the system can be very different from the situation when two people are talking and one takes the help of headphones, to the situation in modern automated industry.

A simple sociotechnical system can be illustrated by the things: human, hammer, nail and boards. The composition of the system can include man and hammer, and the environment includes nails and boards. The system's intrinsic couplings consists of the human grip on the hammer handle and the extrinsic couplings are hammer blows with an initial pinch of the nail. The system can be given the designation of hammering system where the human component is a hammerer. The system is a control system which allows the targeted activity to hit the nail and fasten the boards together. See Figure 4.8.

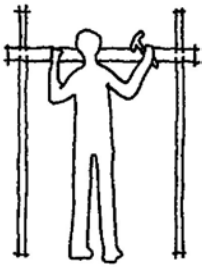


Figure 4.8. Hammering system and environment

Considering the human-hammer pair as a hammering system makes sense, for example, for a supervisor at a construction site. He must be able to distinguish between different hammering systems in terms of their nailing capacity. Carpenter Jacobsson and clerk Johnson can be assumed to be different good hammerers in such a system.

### 4.5.2 System delimitation

In the previously discussed hammering system, both hammers and humans constituted parts of the system. However, they are also systems themselves and from this perspective hammer and human can also be seen as each other's mutual environment. See Figure 4.9.

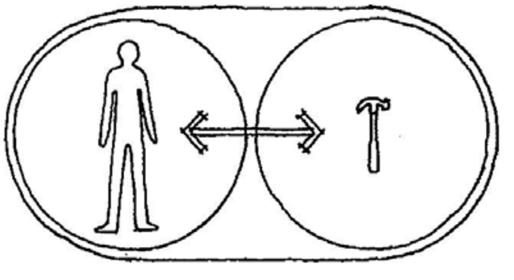


Figure 4.9. System or environment depending on the purpose of the representation.

A novice who does not know how the hammer can be used must learn to hammer. A novice is a system for which the hammer forms part of the environment. The novice must learn to hammer by adapting himself to the properties of the hammer. In this respect, the novice can be regarded as the system whose properties are to be designed.

The opposite is true when experienced ”hammerers” participate in the design of a hammer either directly during manufacture or by sharing their experiences with a designer. When designing a hammer, this is the system whose properties are to be determined, such as grip, weight distribution and appearance. The system's environment include the artifacts and people involved in its design as well as the future users and the things the hammer is designed to influence.

Another example of the problem of system delimitation is the question of where the line between company and product should go. This is regulated, among other things, by warranty commitments. During the warranty period, the product with certain conditions belongs to the corporate system. Of particular attention are the cases when a company ”recalls” a product deemed faulty to fix it. After the product has been perceived as part of the company's environment, it is now resumed in the system.

Whether a thing should belong to the system or not is not based on any real fact of the thing. On the contrary, all systems, except the universe, are subsystems of some other system (Bunge 1979:245). However, it would be unreasonable to include in a representation of a system all the different types of influence to which the system in question is subjected. When representing a sociosystem, there is usually no need to consider the influence of gravity on members.

A main hypothesis in this presentation is that if one considers humans and artifacts as parts of the same system, this leads to a better understanding of both man and the artifacts. A further reason is that modern society is more characterized by sociotechnical systems than by social organizations as subsystems of society.

The system boundary should be drawn considering on the one hand, the subsystems to be included in the system and, on the other hand, the supersystems of which the system is part. The subsystems to be included are those that are most fundamental to the properties of the system, and the system to be studied is the one whose properties are fundamental to the properties of the supersystem.

### 4.5.3 Properties of sociotechnical systems

The sociotechnical systems have *emergent properties* that their parts do not have separately. These emergent properties are the activities made possible by the artifact use. The spectacle man has sharp eyesight. The pen and paper man can hold together large organizations and has very extensive and detailed memory. The telephone person can maintain social connections without physical movement. The car person has greater physical range than the pedestrian. The rocket man can fly to the moon. The CT scanner can see into the human body much like the knife man but without harming the patient.

The sociotechnical systems are *control systems* that allow for targeted activities. Such a system consists of a controlled and a controlling part. The controlling part is mainly the sociosystem and its members and the controlled part is the technical system.

Company management is the controlling system in a factory while machines and workers belong to the controlled systems. At the machines, the worker is the controlling and the machine the controlled system. The cyclist on his bike is also a control system where the cyclist is the controlling and the bike the controlled system.

The designations people receive in the production of artifacts are often given by the properties of the sociotechnical system. Choppers, welders, turners, typists, and computer operators are examples of human roles in various sociotechnical systems.

The sociotechnical systems are also *information systems*. They can be developed and acquire new properties, which is done through the development of new artifacts and new roles in the systems. This course of development is ”Lamarckian” in nature. The knowledge of artifacts and roles acquired by one generation is passed on through learning to the next generation of people.

Furthermore, artifacts with both short and long lifespans occur relative to humans. The long-lived artifacts to which many built structures belong require large investments in both labor and capital and characterize the properties of sociotechnical systems and society for a long time.

The *composition* of the sociotechnical systems, as mentioned earlier, consists of artifacts and people or, in other words, of technical systems and sociosystems in collaboration.

The *environment* of sociotechnical systems is made up of all the things that affect or are affected by the system. Of particular interest are those things in the environment that the sociotechnical system intends to interact with during an activity. For the skater it is the ice, for the sailor the wind and the water, for the worker at the machine it is the raw materials and for the company it is also the clientele, for example in marketing.

4.5.4. The structure of sociotechnical systems

The *structure* of sociotechnical systems includes the relations between artifacts and sociosystems, as well as the relations in the sociosystems that arise from artifact use and artifact manufacturing.

The internal connections between the artifacts and their users belong to the previously mentioned *tool relations*. The external relations of sociotechnical systems include their couplings with the environment they were designed to affect during the system's activity. The extrinsic couplings are the activity of the system and can also be called transformation relations.

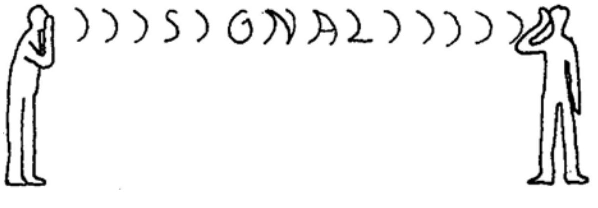
The tool relations and the transformation relations usually have the common designation *functions*. A *function* is a mutual property of two connected things. In the previous example of the hammering system, the hammer handle has the function "shank" i.e., to be the part that connects the hammer's head with the "hammerer". This function is a tool relation while the whole system's function of "hammering" is a transformation relation to the environment's nails and boards.

The transformation relations can be classified into

1. material actions that exert an influence on concrete things in the environment of the system into artifacts of various kinds and
2. cultural actions that exert an influence on people's thoughts, feelings, and ideas.

The intrinsic relations of sociotechnical systems also include the *interpretation relations*. They are the mental activity (thinking) of the human being in the system. They are mutually secondary properties of things and man and dependent on epistemic and semiotic knowledge of things as systems and of rules for interpreting things as symbols.

The sociotechnical system can be a communication system. The transmitter affects a signal with its transformation relations and the signal affects the receiver via the tool relations. The encoding is done through the transformation relations and decoding via the tool relations. See Figure 4.10.




Transmitter Receiver

Figure 4.10. Communication system with transmitter, signal and receiver.

Not only artifacts, but also persons can be made subject to interpretation. A train driver has the property of being able to drive a train. The epistemic interpretation of the person's role can be made through observations of his or her actions. In doing so, the study must relate to both the functions of the train driver in driving the locomotive and the mental state (thinking) of the train driver as formed by the professional role. The train driver is wearing a uniform. In this way, he or she can symbolize his or her role as a train driver and also the State Railways as an organization.

Knowledge development is not only a property of biosystems or sociosystems. It is also a feature of sociotechnical systems. Human knowledge of nature would be significantly less extensive without access to technical equipment such as binoculars, microscopes, and other instruments. The scope and depth of human knowledge depend on the technological level of development of the sociotechnical systems.

### 4.5.4 Instrumental work

The work of a sociotechnical system is instrumental, i.e., it is carried out using artifacts. Work is the transformation relations that exist between the system and its environment. Even in housing, the effect of the building on climatic factors could be considered instrumental work.

The work done in sociotechnical systems is more advanced than that which occurs in the simpler ”bio-social” systems. Bunge (1979:202) calls the most modern advanced production systems ”technosystems”. This is characterized by the fact that

1. the composition consists of rational beings and artifacts,
2. the environment consists of members of society, and
3. the structure consists of the production, maintenance, or use of artifacts.

The technosystems in Bunge's definition can be said to constitute a subset of the larger set of sociotechnical systems. Characteristic of technosystems is the simultaneous presence of advanced organizational work in combination with advanced productive forces such as labor, machines, and tools, for example in modern industries, hospitals and schools (ibid:202).

Technosystems are not the only sociotechnical systems that perform work. Less technologically advanced work occurs in most sociotechnical systems such as households, various forms of crafts, commerce, and health care. Even in entertainment, for example, theater and music, the level of technological development is usually low. However, there is also technologically advanced entertainment and art, such as computer games and computer art. Modern elite sport must also be considered technologically advanced.

The sociotechnical production systems can be classified with respect to the nature of the artifacts they produce. *Economic production systems* are characterized by the production of materially useful artifacts, while *cultural production systems* produce artefacts whose benefit is mainly cultural. In both types of producing systems, economic, cultural, and organizational work occurs simultaneously.

The more advanced artifact production requires specialization and coordination of the sociotechnical systems. This interaction gives rise to a completely new kind of system, namely societies. The further treatment of work and artifact making is therefore made in connection with the description of the concept of society.

### 4.5.5 Roles in sociotechnical systems

The term 'socio-technical systems' has been used by Emery and Trist (1960:87) as a designation for companies where humans and machines interact. They refer to a study of mining carried out by Trist and Bamforth in which it is noted that the social and technical conditions interact and that ”the relation between the various aspects that the social and psychological can be understood only in terms of the detailed engineering facts and the way the technological system as a whole behaves in the environment of the underground situation”.

Emery and Trist also pay attention to the social relations that arise because of the organization of labor. These relations are referred to as work roles (ibid:88). It shows how different technical solutions of production entail different roles for workers. At the same time, it is pointed out that with a given technology, the same production result can be achieved with different social organization. Thus, it is shown that there is a choice situation not only in the design of the technical subsystem, but also in the social organization of an enterprise (ibid:89).

Just as in sociosystems, also in sociotechnical systems different roles emerge which are determined by the purpose of the whole system. Characteristic of the sociotechnical systems are *user roles*, including *professional roles*.

The relations between artifacts and humans in sociotechnical systems have the character of *utility relations* with rationality and targeting as important properties. The role-relations that arise between the members of the sociotechnical systems are also utility relations.

The difference between the individual-artifact and individual-individual relations is that between the latter, the benefit can be mutual. The employer and the employee benefit mutually from each other. If this mutual benefit does not exist, for example if the work is harmful to the employee or is carried out under duress, it can be said that he is reduced to a thing, i.e., in this sense an object without consciousness. The phenomenon that man is regarded as a thing without consciousness is called ”reification” (Israel 1979:70).

Like activities, user roles and professional roles are emergent properties of sociotechnical systems. Thus, the study of the roles of man must form part of the study of the sociotechnical systems. similarly, the design of the sociotechnical systems (sociotechnology) involves a design of the roles of man (Emery and Trist 1960:88).

One consequence of this is that knowledge of the properties of sociotechnical systems must also include the study of the feelings, thoughts and ideas that emerge because of the role activities.

Since the human being is an information system, thinking and knowledge must be seen as emergent properties of sociotechnical systems. In learning a role, the CNS undergoes qualitative changes in which the human being and, consequently, the entire sociotechnical system change. *Thus, a sociotechnical system is not the passive sum of a technical and a sociosystem, but something fundamentally new.*

Man’s mental activities are not unambiguously determined, either by his interaction with the artifacts or by other environmental influences. As previously stated, perception and conceptualization are only partly dependent on external and internal stimuli. The individual is to some extent independent of the influence of the environment on thinking. According to Habermas (1984:22), man is equipped with an ”emancipatory” reason that makes change and critical stance possible.

The study of human mental activities can be done in different ways, for example through interviews. Due to the difficulties in asking about things that one does not already have knowledge of *empathy* must also be considered an adequate research methodology in this context. In doing so, reports from shop floors and residential areas, prepared by people who have or have held roles in such systems, are necessary sources of knowledge.

The West German writer Günther Wallraf has developed a special working method based on these insights. By assuming different roles and submitting to the conditions that apply to a role, for example in working life, Wallraf himself can obtain the thoughts, feelings and ideas that belong to the role, and convey these in his reports. ”He submits to a situation and portrays it from the perspective of the submissive. He is always a subject.” (Böll 1971).

Examples of this kind of research regarding housing and housing roles are Åke Daun’s work reported, for example, in his ”Housing and life form” (Daun 1980).

## 4.6 Society

### 4.6.1 Self-sufficient systems

Societies are normally included in the sociosystems. See, e.g., Bunge (1979:177). However, the conceptual apparatus and methodology applied in this work leads to society having to be perceived as a new kind of system whose subsystems are to a greater or lesser extent sociotechnical systems.

In a sociotechnical system, there is a more or less advanced artifact production and artifact use. A *society* can be said to be an essentially self-sufficient system composed of sociotechnical subsystems.

Simpler societies are characterized by a low degree of specialization of its sociotechnical system. The degree of self-sufficiency of the subsystems is large. The old peasant households that were largely self-catering as well as the industrial communities of older times were thus more societal in nature than today's highly specialized production units in agriculture and industry. However, more advanced artifact production requires specialized production units. The development of these put great demands on coordination and collaboration. From these relations between the sociotechnical systems, the more complex society emerges with all its properties, its rules, and its institutions.

According to my interpretation, Israel supports this view (1984:54-57). He identifies three levels of sociological analysis. The lowest is made up of the individuals and their interactions. At the intermediate level, there are ”organizations”. These include factories, companies, families, etc. It is within these ”microsystems” that the ”social production process” is realized. The highest level is made up of macrosystems that are societies with their societal institutions.

Apart from other differences, the difference between Israel's and my presentation is my emphasis on the importance of artifacts for sociotechnical systems and society. This approach also allows for a clear division between different classes of social relations, the biosocial, the sociotechnical and the societal.

Thus, *society* here refers to more or less complex compilations of socio- and sociotechnical systems with a high degree of integration that allows self-sufficiency. Historically, community formations have been small and based on biological and natural means of transport. Depending on the mode of livelihood, different types of society can be distinguished. The earliest are the hunter, gatherer, and nomadic communities. Later, the farming community with its farming villages and then the urban communities has developed. In modern times, the artificial means of transport have evolved so that urban communities have been transformed into urbanisms. A system-theoretically based definition of the concept of urbanism has been prepared by Broberg (1974:227).

Societies can also be classified with respect to their prevalent technology e.g., Stone Age, Bronze Age and Iron Age. Hartvig Frisch (1966:66f) speaks in his ”Cultural History of Europe” about the sociotechnical system ”axe man” that forms the basis of the culture known as the younger Stone Age or the Neolithic culture. This culture is, moreover, the first to be extended to the whole area that we today perceive as Europe.

Urban and peasant communities, in turn, interact for economic, cultural and political reasons in different supersystems. Among these, the nation can be said to constitute a new level of system. In doing so, the nation will take over both some of the external properties of the urban and peasant society, such as defense, and some of the internal properties such as certain legislation and the exercise of authority.

With the rise of urbanism, some of the nation's former functions can be brought back down to society. The ideas of regional self-government should in many cases be seen as a result of the integration efforts of the new urban regions (Broberg 1974:206).

### 4.6.2 The composition and environment of society

The composition of society consists of various socio- and sociotechnical systems such as households, companies, authorities, etc., common to these is that they, through collaboration, give rise to society's internal couplings.

However, not all sociotechnical systems are considered to belong to society. The environment of society include those things that affect or are influenced by society but are not considered to belong to it. The environment may include other societies with which one collaborates or competes, for example, for natural resources or political influence. The environment of society also includes criminal and revolutionary organizations that put society at risk.

In the event of cooperation, different kinds of societal supersystems can also arise, e.g., nations and nation systems. To the latter belong the European Union, EU, and the United Nations, UN.

The ecosystem constitutes the comprehensive supersystem of societies. Its existence means that only certain kinds of connections are possible between and within its subsystems of various kinds. Environmentally destructive activities and artifacts belong to the ecosystem's environment.

Societies depend on the natural environment for their livelihood. Today's industrial societies are characterized by the exploitation of, among other things, fossil, non-renewable sources of raw materials. They are thus dependent on an environment whose duration is limited. Thus, even the type of society is of limited duration.

### 4.6.3 The structure of society

The external relations of society include the connections with other societies, whereby various supersystems of the type of nations and intersocietal organizations are formed. External relations also include the connections with the natural environment of the ecosystem, for example in the extraction of raw materials for artifact production and supply.

External relations are both control relations, which affect the environment in the desired direction, and information relations, which allow qualitative changes in society itself.

To the internal relations of society belong the exchange of goods and services between the sociotechnical systems. To enable the exchange, goods and services must be given exchange values. The exchange value is an attribute of goods and services. The *exchange value* is determined by the market.

Even models of goods and services, such as *money*, can have exchange values. Money has symbolic similarity with goods and services. They designate exchange values. The exchange values of money, like those of goods and services on the market, are determined by agreements in the sociosystems.

The relations, societal, sociotechnical, or social, mediated through communication between the members of the sociosystems are not natural laws like the relations of action in the natural or technological systems. Social relations depend on agreements. They are *rules* of various kinds. However, these rules, like the laws of the natural systems, are relations between the parts of the systems.

The properties of society as a whole are grounded in the properties of the parts. This means that society can have different properties depending partly on the artifacts that are part of the system and partly on the composition of the social subsystems and the rules that apply to the behavior within them. It is thus possible for members of society to influence the properties of society, among other things, by changing its rules as they are expressed in, for example, legislation and morality.

The importance of artifacts for the properties of society must not be underestimated. With different artifacts, communities acquire different properties. Karl Marx, according to Joakim Israel, believes that ”The hand mill gives rise to a society of feudal lords, the steam mill a society of industrial capitalists” (Israel 1984).

Since the production of artifacts is not only legal, but also rule-driven, the development of society is not mechanical or ”blind”. One can imagine that Marx's feudal lords so effectively control their subordinates that they are not allowed to develop steam mills or that a society of steam mills does not allow industrial capitalists. The lawfulness of technological progress lies in the fact that a tool can only be used for the manufacture of certain artifacts. The regularity of this development lies in the fact that decisions are made only on the manufacture of certain artifacts among many possible ones.

### 4.6.4 Subsystems of society

Against the background of the division of work into economic, cultural, and organizational, society can be considered composed of four separate subsystems: the kinship, the economic, cultural and the political systems. The latter are also referred to as the three artificial subsystems (Bunge 1979:204).

Of course, this division between the artificial subsystems is to some extent arbitrary and cannot be done without taking into account the relations between the subsystems and that there is an understanding that the same members of society can be included in all three subsystems at the same time or at different times.

The division corresponds to Marxism's categorization of social phenomena into economic, political and ideological (Brante 1980:120). However, Bunge's categorizations are based on the concept of systems as he developed it in his ”Treatise” and are on ontologically firmer foundations than the categories of traditional Marxism.

The most characteristic feature of the economic subsystem and that which in this presentation is of the greatest interest is the participation of its members in the production of economic artifacts. Similarly, the cultural subsystem is characterized by the fact that its members produce cultural artifacts. Finally, the members of the political subsystem have the task of controlling various social behaviors and of organizing and monitoring economic and cultural work. In all three systems, all three different types of work are performed.

The different types of social subsystems are usually classified into *sectors of society*. A sector of society can be seen as a special class of sociotechnical systems. Characteristic of centralized societies, however, are the tendencies for sectors to integrate into large systems (Bunge 1979:193).

One example is the development of the housing sector during the post-war period in Sweden. The structure of this supersystem consists of, among other things, established plans, building codes and financing rules. Such a development has both advantages and disadvantages. Advantages include, for example, resource equalization between different social groups. Disadvantages may lie in difficulties in local adaptation of a comprehensive regulatory system.

### 4.6.5 Society's production of artifacts

Artifact production, as mentioned earlier, occurs in sociotechnical systems. However, it is only through the emergence of society that the more advanced artifact production can take place. This requires specialization and coordination between the producing sociotechnical systems that cannot be implemented without the emergence of a higher level of integration, that of society.

The properties of artifacts are determined by the structural relations in the form of natural laws and social rules that prevail both in their production and in their use. The properties of the artifacts that depend on the properties of the producing systems are called *production conditions*. Two main types of producing systems are distinguished depending on whether the production relates to economic or cultural artefacts.

The *economic production systems* perform material work by processing the environment. This processing results in economic artifacts (goods and services) termed the material output of the system (ibid:199).

At the stage of material production, cultural and organizational work is also carried out. The cultural inputs are those that contribute thoughts, ideas, and guidelines for material production. The organizational efforts are those that control the performance of the material and cultural work (ibid:200ff).

Thus, the production of economic artifacts depends on labor, raw materials, and energy, as well as on knowledge and control. Furthermore, production results in goods and services, as well as waste. The products (goods and services) can be returned to the producing system through feedback (ibid:209). The production of the economic artifacts is thus dependent on both people and natural resources, as well as on what is conceivable and what is permitted. The latter two may vary within societies with similar material foundations. Housing construction in New England is almost exclusively focused on single-family houses, while up to half of the total amount of households in Scandinavia live in multi-family houses.

The production of the cultural artifacts takes place in the *cultural production systems*. In this context, cultural work is carried out in the form of the production of thoughts, ideas, and feelings that intend to influence people and animals. This influence occurs through the cultural artifacts whose meaning is interpreted by the members of the sociosystems.

The prime example of cultural artifacts is language with its letters, words, and phrases. In this sense, language is concrete things, e.g. meaning-bearing air vibrations, human signs, or paper-borne ink. Other examples of cultural artifacts are money, books, gramophone records, music, theater, and film.

In the cultural production of artifacts, economic and administrative work is also carried out. The economic work carries out the material representation of the cultural artifacts. The administrative work controls the material and cultural work. For example, the economic workforce in cultural production includes the maintenance staff of a university and the university administration (ibid:211).

The production of cultural artifacts and the influence of people’s thoughts, feelings, and ideas depend on cultural workers, artifacts, and energy, as well as on material production and administrative control (ibid:212).

The properties of cultural workers include their skills as researchers, artists, educators, artists, etc. The cultural tradition also determines the result of cultural production. It determines the problem that is considered relevant to be treated through its ”zeitgeist”.

The economic system determines the material properties of the artifacts put into practice in cultural production. The political system determines which thoughts, ideas and feelings are allowed to be communicated in society.

The *political conditions of production* of artifacts determine the properties of both economic and cultural production. These conditions or determinations take the form of rules for organization, administration, and control of the activities of the economic and cultural systems. In construction, for example, there are several authorities that regulate the design and use of buildings. These authorities include the Swedish National Planning Board, the Housing Board, the National Board of Occupational Safety and Health, the Swedish Transport Administration, county administrative boards, municipal authorities, etc.

Considering this study of the concept of systems and its use in describing the interaction between man and the artifacts in sociotechnical systems and in society in general, it is now possible to describe the somewhat more specific relation man- building. The following chapters begin with the description of buildings as a specific kind of artifacts.

# 5 THE SYSTEM MAN - BUILDING

## 5.1 Buildings

### 5.1.1 Place

Buildings are artifacts given specific properties that make them useful to man in various activities. These properties include forming a material environment and a spatial delimitation. However, this is not unique to buildings, but is also made possible by the natural environment. Things with these properties are called ”place”.

A *place* is a concrete thing that forms a material environment and a spatial delimitation for man in his activities. A place is designed to enable the intended activities.

”Place” can also refer to a position or location of a thing relative to a frame of reference (Bunge 1977:310). Thus, ”place” can mean both a relation between things and things themselves. Here, ”place” refers to the concrete thing.

A place also has cultural properties. It can give rise to thoughts, feelings, and ideas in a user and viewer. The cultural properties emerge from the human interpretation of the place. The concept of interpretation is discussed in more detail in Section 5.7.

Norberg-Schulz (1980) has dealt with the cultural properties of places that he calls ”genius loci ”. This is an ancient Roman designation for the ”spirit” that ”hovers over” a place, the ”soul” of the place. Perceived as the cultural properties of the place, the ”genius loci” are mutually secondary (subjective) properties of the place and its users and/or viewers.

### 5.1.2 Definition of buildings

Buildings are artifacts with the property of place. The question of which things should be included in the building is essential for the further description of their properties. Beyond being places and artifacts, buildings have in common that they require some form of processing of the soil. They have a subsystem that is given the designation ”ground” (BSAB 1972:17).

Each building has a spatial extension and a ground structure. When using land for different purposes, it may be appropriate to have a common designation for all those artifacts that are places and have a ground construction. It is these things that are here given the designation *of buildings*.

*Ground constructions* are different types of processing of the ground for it to obtain the desired properties, such as excavation, drainage, terracing, filling with gravel and macadam and piling. To the subsystem ground, different types of ”superstructures” are then built, resulting in different buildings. With superstructure ground on a draining layer, arable land is obtained. If this is planted with grass, you get a green surface. A park has green surfaces and is planted with trees and shrubs. To build streets and squares, a load-bearing and draining layer is supplemented with a wearing surface made of asphalt, concrete, or paving stones. Houses consist of a load-bearing and draining ground construction, complemented by foundation, walls, floor and ceiling, etc. Thus, *building refer to what is normally associated with this concept i.e., houses, streets, squares, canals, ponds, etc.* See Figure 5.1.

Buildings generally belong to the economically useful artifacts and are produced within the economic subsystems of society. Their most important feature is the economic benefit i.e., the practical (material) properties to be used for different functions.

Like other artifacts, buildings can also be produced for their cultural utility to give rise to experiences in the form of thoughts, feelings and ideas of an interpretive subject. Some buildings occupy a special position in that the cultural aspect of their use is particularly prominent. Examples of such include castles, churches, triumphal arches, monuments, and parks. Even buildings originally constructed with mainly material utility as their purpose may eventually have higher cultural than material value. They get ”C”-labeled (culturally valuable) and if they are considered valuable, they get moved to open-air museums.

| Subsystem | | Buildings |
|---|---|---|
| | soil, grass, trees, and shrubs | = park |
| | wearing layer | = road |
| Ground construction + | building shell, plumbing, water, electricity | = house |
| | foundation and span | = bridge |

Figure 5.1. Composition of various buildings.

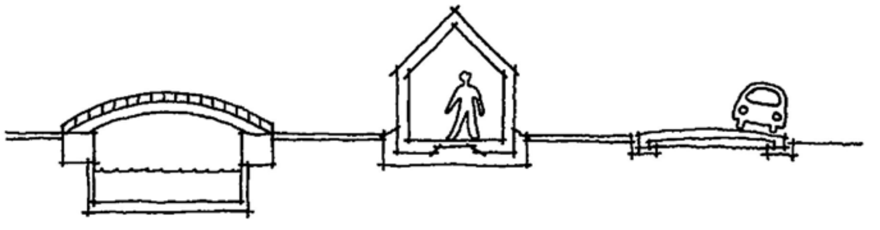


Figure 5.2. Examples of buildings.

*Buildings are not machines*. Their purpose is not to replace human labor by producing things. The purpose is for them to be places that enable various activities such as housing, work, transport, beauty experiences, symbolic acts, and ceremonies.

The above account of the properties of buildings can be summarized in the following definition. The class *of buildings* includes things with the properties

1. to have an artificial ground construction and
2. to form a place for man in various material and cultural activities. Examples include activities that require the influence of the climate, protection from intruders, rooms for stay, surface for transport, and aesthetic and symbolic expressions.

The buildings differ by their collective properties from other artifacts such as clothing, machinery, means of transport, mass media systems and paintings. With classificatory concepts, one can speak of buildings as a genus which is included in the family non-living among the group of artifacts. Kinds of buildings are e.g., houses, bridges, canals, streets, parks, landscaped green spaces, etc. with their different cultural and economic varieties. See Figures 5.2 and 5.3.

### 5.1.3 Building complexes

A building complex is an aggregate of buildings. The concepts of building complex and built environment have similar meanings. Both are made of buildings. ”Built” environment can be distinguished from ”natural” environment. Used in this way, the term built has the meaning of artificial. Both a single building and a building complex are, in this sense, built environment.

In this context, *building complex* refers to a system or aggregate of buildings. Sociosystems are not part of building complexes. In a building complex, the strength of the connections between the buildings can be different. Between a street and a house, the connection is, as a rule, weak as in the joint between the foundation of the house and the walkway. Between the district heating pipes in the street and the pipes in the house, the connection is strong so that the excess pressure in the pipes can be counteracted.

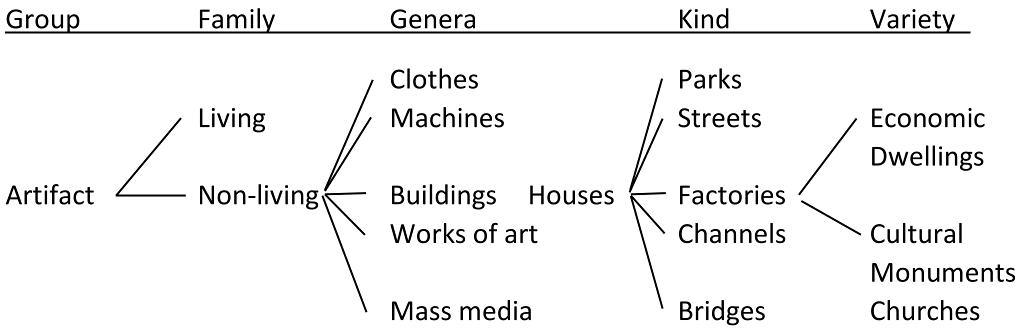



Figure 5.3. Classification of buildings.

Whether the building complex is to be regarded as a system or aggregate of separate buildings depends on the properties of the building complex to which the study relates. If the intention is to determine the spatial properties of the building complex at a given time, there is no reason to introduce the concept of the system. If, on the other hand, the intention is to study energy consumption, it is advantageous to consider the building complex with its houses, streets, and pipeline networks as a technical system.

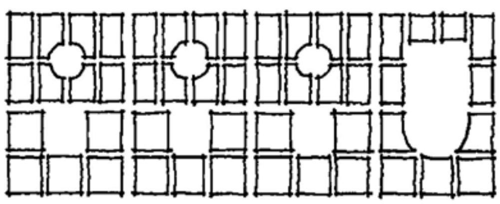


Figure 5.4. Example of a building complex pattern.

The spatial structure of a building complex is usually referred to as a *building complex pattern*. See, for example, Linn (1974:21). The building complex pattern is decisive for the properties of the building complex in terms of social interaction, walking distance, population density, traffic intensity, exploitation rates, etc. The building complex pattern is also important for the spatial experience. The shape of a city can be linear-shaped or concentric or have some combination of these shapes. See Figure 5.4.

Buildings can have different spatial extents, ranging from the small allotment cottage to the neighborhood-sized megastructure, or from the relatively small system-forming surface sections of the paved street to the regionally connected pipeline and track systems of the water pipes and railway tracks.

The buildings in a building complex are part of different technical and sociotechnical systems that determine the building complex pattern. These include the housing system, the school system, the water and sewage network, the district heating system, the electricity network, postal distribution, the sanitation system, and the transport system.

Buildings and building complexes, as well as artifacts in general, can be considered as 1) parts of sociotechnical systems such as the household, village, or city and 2) technical systems whose environment consist of, among other things, producers and users.

### 5.1.4 Environment of buildings

The environment of buildings are things that, without being considered to belong to the building, affect and/or are affected by this. These include the land where the building is erected, precipitation such as rain and snow, as well as the air with wind strength, pollution, temperature, humidity, etc. The producers and users of the building also belong to the environment. Together, the latter are part of various sociotechnical supersystems, such as the user-house system and the road user-street system.

The properties of the building are determined, on the one hand, by the supersystems in which it is to be included and, on the other, by the systems producing its parts. Of the supersystems, here the sociotechnical ones are of the greatest interest. However, the ecosystem is also one of the supersystems of buildings. In view of this, the energy consumption and use of resources of buildings are of great importance.

The properties of buildings that depend on producing systems can be called *production conditions*. These emerge from the design, production and assembly of the building. The manufacturing tools often have limitations that to some extent characterize the products as *instrument effects*. The properties of buildings are also determined by their purpose. This can be called *use conditions* and are based on the requirements of the user systems for, for example, function, service life, changeability, beauty, and symbol values.

Production and use conditions are both material and cultural in nature. The difference between machine-made and manually produced parts, such as machine bricks and handmade bricks, lies in the more valuable experience-rich properties of the latter. The manual manufacturing with the human-caused variation of the brick means, among other things, increased opportunities for experiences and communication between manufacturers and users.

### 5.1.5 Composition of buildings

One problem in describing the composition of buildings is that it varies between different buildings. Site building and pre-manufacturing enable different types of parts. With similar function in use, the parts may be different. The wall can be composed of prefabricated parts, such as bricks, wooden studs and plasterboard, or be cast in place from concrete.

Another complication in the description of the parts of the building is that when putting together parts, things with new properties emerge. A corner of the building is a mutual feature of two angular walls. But a corner can also be produced as a part. Parts that can be perceived also have experiential qualities. They can be interpreted as signs if they are part of any communication system. However, the composition of the building refers to its concrete parts, and not its signs.

In connection with the use, the building and the users form the *user-building system*. This is a supersystem to the building. When designing the building, it is the desired properties of the user-building systemthat determine the properties of the building. At the same time, the producing systems (construction industry and financiers) determine the factually possible parts, as well as the resources available.

Thus, it is crucial for the determination of parts both that they can be manufactured by the producing systems and that they can be used by the using systems. Therefore, a conflict easily arises between production requirements for parts and utility requirements for parts. The requirements for parts at the use stage regarding maintenance, change, or symbol values are not the same as the requirements for parts that a rational manufacturing and contracting process imposes. The parts of the building are the result of a balance between these two main types of requirements for properties.

The parts of the building can be divided into different levels (classes). The relation between the levels is a precedence relation. A lower level precedes a higher level if all things in the latter are composed of things in at least one of the previous levels. See section 3.2.8. Characteristic of a thing in a higher level is that it has new properties that are not possessed by its parts in lower levels.

When dividing the parts of buildings into levels, it is not enough for a composite whole to weigh a little more or be slightly larger than its parts for it to be classified in a higher level. It must be something fundamentally new. The difference between wall and house or between brick and wall is such a level-separating dissimilarity. The fundamentally new properties can mean that parts in different levels have different types of producers and users. The brick belongs to the producing system mason-brick while the brick wall is included in the system builder-user. See Figure 5.5.

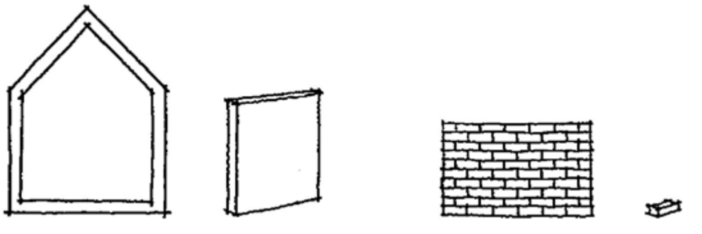


Figure 5.5. Level separating difference between house/wall and wall/brick.

According to the above principles, buildings can be considered as composed in the following five levels

1. buildings,
2. the overall subsystems,
3. building parts,
4. building components and
5. building materials. See Figure 5.6.

A sixth level is made up of the *raw materials*. These do not belong to the compositional order of buildings because their properties have not been determined in relation to buildings.

Between parts of a lower and a higher level, the part-whole relation prevails. See section 2.1.3. A characteristic of this is that things in lower levels are included in the composition of things in higher levels. Thus, building materials are included in building components, which in turn are included in building parts, etc.

A description of buildings in the direction ”top-down” means to consider it as a subsystem of the user- building supersystem. The subsystems of buildings, in turn, have properties that are fundamental to the functions of the building. Based on these properties, the building is composed of three main subsystems; load-bearing, enclosing, and installation systems (Baehre 1974, Kärrholm 1981:6). In the BSAB system, the subsystems are somewhat finer divided into Ground, Building, Installations - piped and ducted, Installations – electrical, and Transport (BSAB 1972:115). The main subsystems, in turn, are composed of building part s. The load-bearing frame consists e.g., of columns, beams, and slabs; the space enclosing parts consists e.g., of walls, ceiling, and floor; the water network consists e.g., of pipes, sinks and sewers, etc.

Viewed from below in the direction ”bottom-up”, all the parts of which the building is composed can be given the designation of *construction product*. The concept of ”product” implies the property of being able to be pre-manufactured for sale in a market. This use of the term construction product (Swedish: byggvara) is found in the classification systems SfB and BSAB (Svensk Byggtjänst 1971:27, BSAB 1972:20). According to the SfB system, construction products are: ”all products used to build houses and other buildings and thus placed or built into the finished buildings ” (Svensk Byggtjänst

1971:27). The SfB system distinguishes between three different types of construction products, namely *formless products*, *formed products* and *finished products*. These correspond most closely to building materials, building components, and building parts respectively.

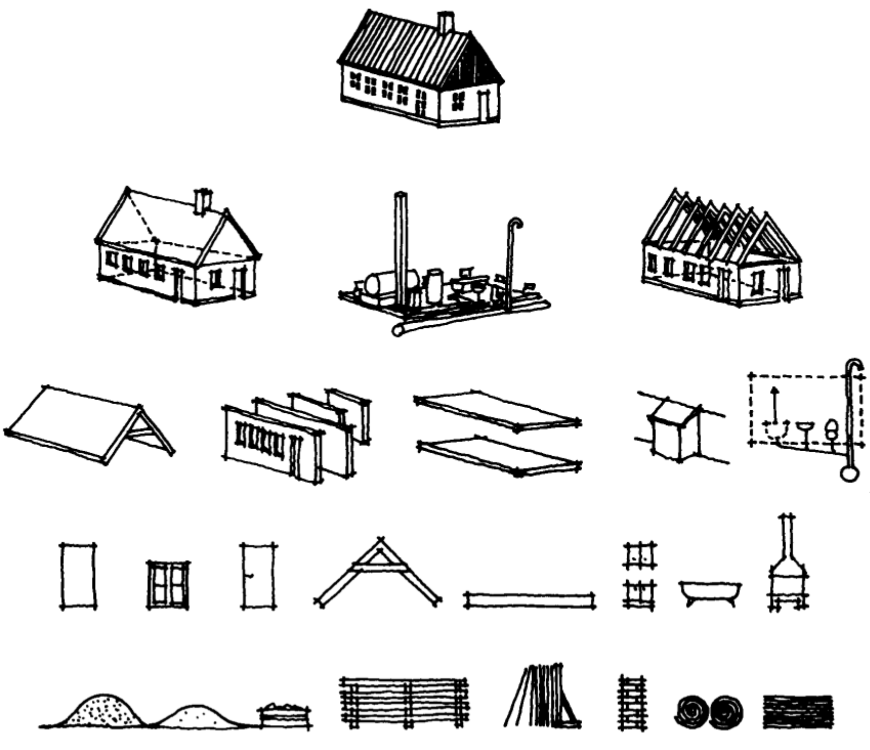


Figure 5.6. The five composition levels of buildings are building materials, building components, building parts, the main subsystems, and buildings as a whole.

From the point of view of production, parts are assembled through work into constructions. Considering their increasing complexity, the constructions can be said to be composed of raw materials such as gravel, gypsum, clay, and water. The raw materials are used in constructions of building materials. These can be studs, bricks, and nails, which in turn are compiled into building components such as windows, doors, and joist elements. Building components are finally compiled into building parts, the main subsystems of the building and the building as a whole.

It is not all compilations of products that result in things belonging to a higher level. Building components stacked in a building materials store do not form building part s. Such is a specific composition of building components and building materials. Windows, doors, and wall elements must be compiled in a certain way to turn into a wall. Walls, ceilings, and floors must be organized so that they form rooms to have the properties of buildings.

Building materials and building components can mainly be called *basic products*. The reason is that many different buildings can be composed of the same specific kind of basic products. Building parts and subsystems of buildings are mainly *special products* because only a few structures can have the same specific kind of special goods. The basic products are more universal than the special products. The amount of buildings with the same basic products is greater than the amount of buildings with the same special products. The concept of universality is also dealt with in sections 5.3.1 and 5.6.4.

The properties of buildings, main subsystems and building parts are mainly determined in relation to a specific building with regard to their ability to be manufactured. The properties of building materials and components are determined to a greater extent by the manufacturing systems, considering that they can be included in different buildings. Therefore, building materials and building components can often be *mass-produced*.

The assembly of buildings takes place through processes whose results are increasingly complex constructions at ever higher levels. See Figure 5.7. Compare also Claxton and Wilson (1966-68). The raw material clay is processed, shaped, dried, and burned to make up the building material brick. Bricks and mortar are joined by masonry either into a building component, such as a reinforced brick beam or into a building part, such as a wall. The wall interacts with other building parts to form one or more of the building's main subsystems, e.g., the subsystem house. The main subsystems together form a new whole with all the properties of the finished building.

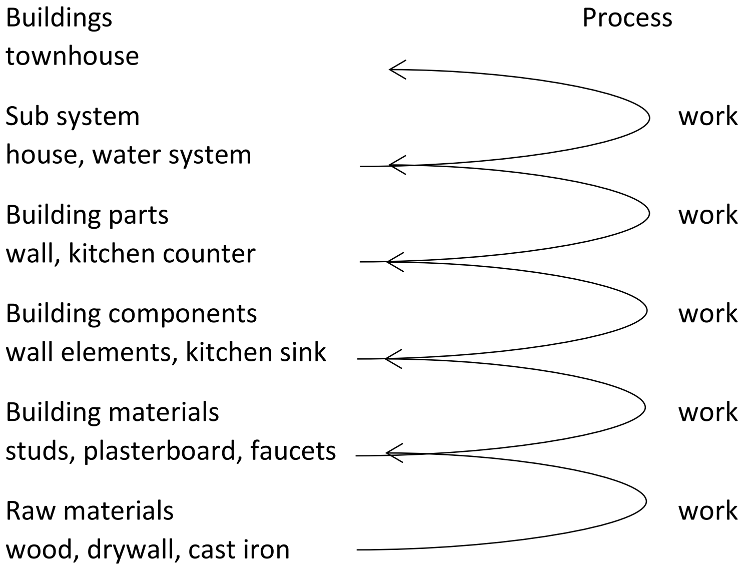



Figure 5.7. Assembly of the parts of buildings into constructions through work.

The production of artifacts requires processing the natural environment. The initial processing of natural resources through various kinds of work such as mining, cutting down and collecting results in the production of *raw materials*. A characteristic of raw materials is that they have not yet been determined regarding their properties as building materials. They can be included in many different technical systems in addition to the building. The raw materials include gravel, clay, iron ore, gypsum, oil, water, timber, electrical energy, etc.

*Building materials* are produced from raw materials. Some raw materials can be used directly as building materials without changing their composition, e.g., pure fresh water (in concrete) and lake bottom gravel (as capillary-breaking layer). Other raw materials may need to be processed by sorting, mixing, forming, burning, casting, etc., before they can be said to be building materials. The production of building materials is characterized by the fact that it often takes place at the sources of raw materials. This applies, for example, to the production at sawmills of sawn timber. Production is often large-scale with a few producing units.

The properties of building materials have been determined by their intended inclusion in buildings. They have the character of basic products and can be used in all types of buildings. Examples of building materials are gravel, concrete, mortar, joists, plasterboard, brick, glass, mineral wool, glass wool and sheet metal. Due to their nature as a basic products, nails and screws can also be counted here. The building materials can be included in the composition of both building components, building parts, main subsystems and buildings. The properties of the building materials are fundamental to the properties of the other parts of the building. See Figure 5.8.

Figure 5.8. Examples of building materials.

The building materials must be further processed, for example, cut, bent, nailed or screwed in order to be included in the finished building. They often have the character of semi-finished products that are further processed by other producers before their properties are determined relative to the finished building.

The production of buildings from building materials can be done in essentially two ways. Namely, as a) site construction and b) pre-fabrication. In site construction, building materials are assembled directly into the finished building. Any intermediate levels are not necessary to discern. In pre-manufacturing, building materials are compiled into building components, building parts or subsystems. Common to these parts is that they are pre-manufactured finished products. In addition to the actual assembly, little or no additional processing is required at the construction site.

The *building components* are assembled from building materials. Their properties need not have been determined relative to any specific building. They can be used in a wide variety of buildings. As they are finished goods, production requires a more extensive knowledge of how they are used in the finished building than the production of building materials requires. Building components are such compilations of building materials that lead to the emergence of things with completely new properties, such as the compilation of frames, glass, putty, screws, etc. into windows or doors, the compilation of joists, insulation, boards and plastic foil into wall elements and the compilation of concrete, rebar, and molded timber into floor elements. Also, milling a wooden stud into a skirting board or a window sill leads to the intended kind of things with new emergent properties. See Figure 5.9.

Figure 5.9. Examples of building components.

Characteristic to building components is that they must form a finished part of a building part . Such building components are thus the above-mentioned windows, doors and joists but also plumbing equipment such as bathtubs, sinks and toilet chairs and electrical equipment such as cables, meter cabinets and luminaires.

*Building parts* can be compiled from building components and building materials. They can be site-built or pre-made as ”large elements”. The building parts are further characterized by the fact that their properties are determined to a greater extent than those of building materials and building components in relation to specific buildings. This means that they are not produced as stock products but are produced only after the building has been designed. Examples of building parts are roofs, walls, floors, balconies, and bay windows. See Figure 5.10.

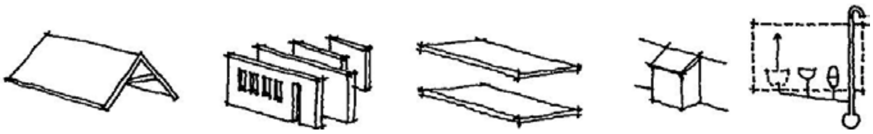


Figure 5.10. Examples of building parts.

The main subsystems of buildings include the assembly of building materials, building components, and building parts that have a coordinated range of the properties of the building as a whole. The subsystem of house has the buildings’ properties to form an enclosed space with, for example, the functions of protecting against rain, wind and cold. This subsystem is usually built on site but can also be pre-manufactured as volume elements ready to assemble on a prepared foundation. See Figure 5.11.

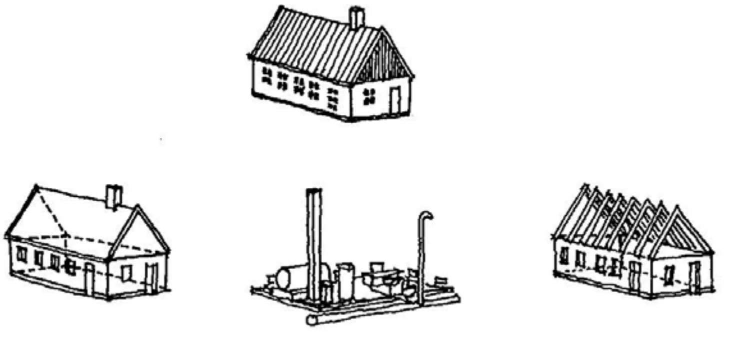


Figure 5.11. Examples of buildings and the main subsystems.

It is not obvious or even possible to delimit the subsystems of the building in an unambiguous manner. Each part of the system, whether ground, house or otherwise, is composed of building parts with several different functions in the building. A typical example of such a building part is the wall that can be included in most of a building's subsystems. It can form part of the foundation (with the risk of moisture damage). It is included in the heating system by its insulation and tightness. It carries wires for plumbing and electricity and delimits and carries some of the parts of the elevator system.

The rationale for distinguishing certain compositions of building components as main subsystems is that not all the properties of a building can be owned by a single type of building part . This also includes the fact that their production requires special knowledge and tools and that they form functional units in the whole. However, some parts of the building advantageously have several properties. Concrete walls are soundproofing and load-bearing, have a high heat capacity, etc. Stud walls are easily removable. Concrete hollow joists can be utilized as heat exchangers, etc. This complexity of buildings is reflected in their design, where decisions on the properties of one subsystem usually have a major influence on the properties of another subsystem.

### 5.1.6 BSAB's and SWEET's classification systems

The terminology of the BSAB system (and also SfB) is based on the needs of the construction site. Everything that is added to the construction site from outside is given the designation products or resources. These are collected in the BSAB system's Resource Table 1, Construction products (BSAB 1972:20). At the construction site, the products are assembled through work into constructions. Different constructions are collected in Product Table 1 (ibid:16). This classification of the parts of the building follows the principle of ”bottom up” and is production-oriented. To link to a use- and function-oriented approach, the parts of the building are also classified in Product Table 2 (ibid:17). This table follows the ”top down” principle and contains the subsystems of the building and subdivisions of these into different building part s. I have not been able to find any theoretical basis for the classification beyond the one described above. However, it is consistent with the theory presented here.

With the help of systems theory, the relation between Building parts belonging to Product Table 2 and Constructions belonging to Product Table 1 can be reported. The latter are composed of Construction products by means of various work techniques. Among all the factually possible constructions, some belong to the different levels of the compositional order of the building. Thus, some masonry structures are building part s, for example, walls. Some element constructions are load-bearing frames, etc. Product Table 2, in fact, contains constructions that are building part s. In the table, these are organized into groups constituting the subsystems of the building. Figure 5.12 shows the principle of the structure of the level order in the BSAB system.

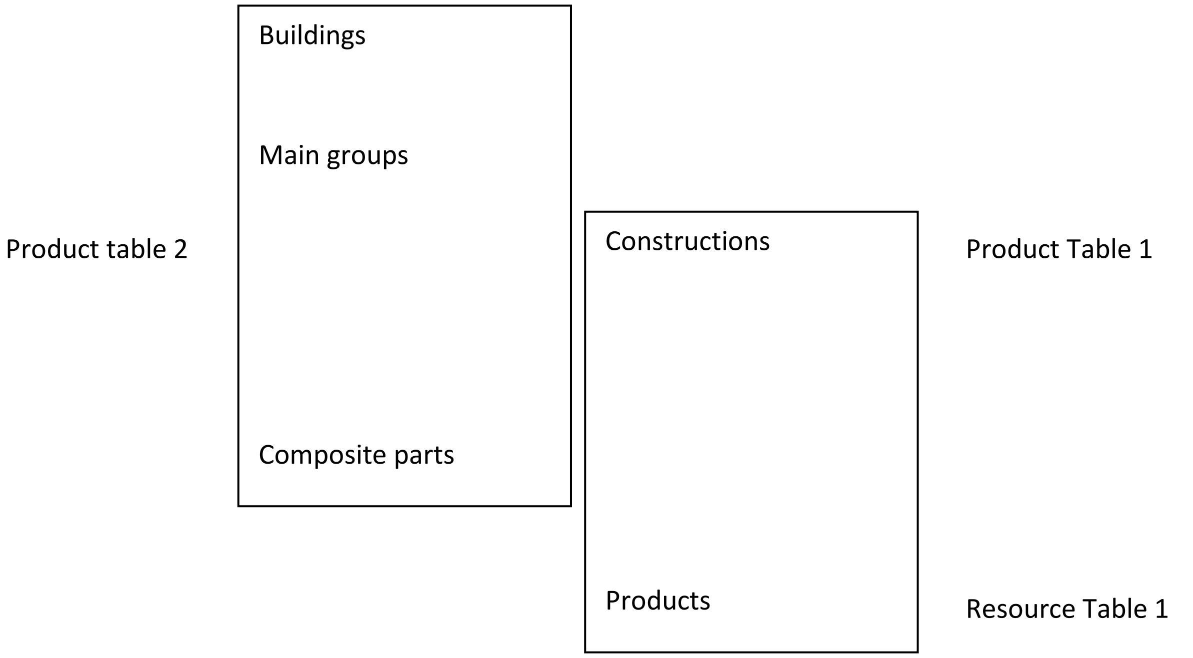



Figure 5.12. The level structure of the BSAB system.

The figure shows that the BSAB system aims to coordinate the producers' and users' aspects of the composition of the building. Product Table 2 is responsible for the user aspect and Product Table 1 together with Resource Table 1 for the producer perspective.

The ”bottom up” aspect of the BSAB system can be said to be a rather rough sorting instrument for the parts of the building. There is no distinction between different degrees of complexity of the parts arriving at the construction site. All of them are called construction products. In Resource Table 1, however, a distinction can be discerned between the simpler products and the more complex ones. These latter also have the designation building components such as windows and doors. But really, BSAB makes no distinction between nails and prefabricated volume elements based on their property as building products.

It should be possible to designate different prefabricated parts according to their composition and properties relative to each other and the finished building, which I argued for in my proposal for level ordering. In my example, the main groups of the BSAB system correspond to the main subsystems of buildings. The ”composite parts” of the building correspond to the building parts of the example. Both of these varieties are also ”constructions” which are composed of products. According to BSAB, products are of the three types of quantity products, form products and finished products. The quantity products and the form products together correspond mainly to the building materials of the example, while the finished products due to their highly varying complexity are scattered among the building components, building parts and subsystems of the example. According to BSAB, both screws and prefabricated houses are finished products, which makes the classification meaningless from a complexity point of view. In my example, screws are building materials and prefabricated house subsystems.

SWEET's American system for classifying the building's parts distinguishes between the basic material, unit, assembly, system, module, and facility levels (Ferguson 1975). *Basic materials* are glass, bricks, sealing masses, etc. *Unit* refers to, for example, door with frame, kitchen cabinet, etc. When it comes to *assembly*, a distinction is made between *built assemb*ly, e.g., a suspended ceiling or a partition wall, *network* e.g., the electricity supply network and *coordinated group*, for example a group of furniture. A *system* has at least three of the building's basic functions, such as an integrated ceiling or a load-bearing-enclosing-environmental control system. By *module* is meant a volume element of the type pre-made kitchen, bathroom, service core, etc. *Facility* refers to, for example, a single-family home or a greenhouse with all its functions.

This brief account of SWEET's classes, of course, gives no idea of the motives for the division. It might still be interesting to compare with my proposal for subdivision. It can be stated that facility corresponds to the concept of building and basic materials correspond to building materials. A unit has definite similarities with the things that should be classified as building components. Assembly, system and module correspond to building parts and subsystems. The concept coordinated group shows the need to be able to describe, for example, a furniture group in system terms. However, this is not possible without the introduction of a user who uses the furniture group in their activity. Further than that, the comparison cannot be stretched without access to information about the theoretical background of SWEET's classification.

## 5.2 Structure of buildings

### 5.2.1 Internal relations of buildings

The parts of buildings can be differently strongly integrated. Weakly integrated parts are called *unfixed* while strongly integrated parts are called *fixed*. Furniture and automobiles are examples of things that are unfixed and movable. Hence the names. The concepts of movable and immovable have legal application as designations of property. A real estate with land and buildings is fixed property. Movable property is property that is not included in fixed property, such as furniture and hand tools.

The integration between the parts of buildings is dependent on different forces. Some reinforce while others counteract integration. One can distinguish between internal and external forces. External forces include gravitational forces, wind forces, forces caused by pressure differences, impact forces, etc. The internal forces include joint forces through, for example, nails, screws, glue, welding, and friction.

The internal connections may be dependent on the action of external forces. Houses built of concrete boulders are heavy. They are not sensitive to wind powers but are more dependent on the effects of gravitational forces. The internal connections in such houses can consist of friction joints that become strong due to the action of the gravitational force. Light constructions made of, for example, wood must have joints that can occupy and withstand the action of wind forces. Other structures, such as roads, can be subjected to lateral ground movement and still others, such as basins and pipeline networks, must withstand pressure forces. Furthermore, buildings must withstand point loads and other local loads caused, for example, by impact or pressure.

The parts of the building must be able to counteract gravitational and wind forces by carrying and stabilizing. They counteract impact forces by delimiting and resisting and they counteract pressure forces by enclosing and directing flows of things. Being able to *carry*, *enclose* and *convey* can be said to be the three main categories of properties that characterize buildings and that are utilized in their use as tools. These different properties are not reserved for specific types of buildings or parts but can in varying extents be held simultaneously by the same parts. Compare Baehre 1974.

### 5.2.2 Action orders in buildings

Through the effects of actions, bonding relations emerge between parts of buildings and between these and the environment. The bonding relations mean that the parts of buildings are arranged in *agents* and *patients*.

Action can be mutual or one-sided. One-sided action is also called control. If the action is of the latter kind, the acting part is called agent and the affected part patient. The agent is said to affect the patient. In systems characterized by one-sided action between the parts, there is an action order.

The structure of a system in which the parts are arranged in agents and patients is also called a *hierarchy*. A hierarchy should not be confused with a level order. A hierarchy is an action order (control order) between parts of a system. A level order is an assembly order in which a set of parts precedes another set of parts in a system.

The parts of a hierarchy can be considered ordered higher or lower in the action order. In a house, the foundation wall has a higher rank in the hierarchy than the roof. In the pipeline network, the trunk line has a higher rank than the sideline. The ”shell” of the building has a higher rank than the outside air and rain that affects the building from outside. In a level order, the terms higher and lower refer to composition level, respectively, while referring to rank in the action order. See Figure 5.13.

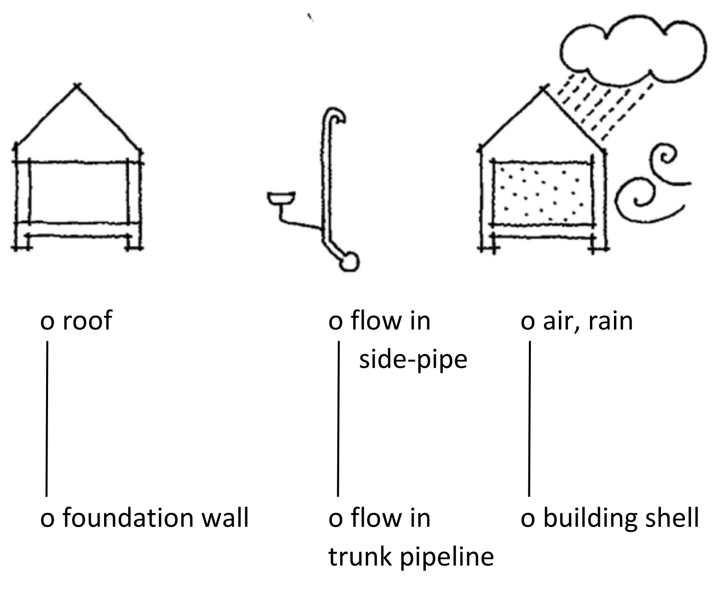



Figure 5.13. Examples of hierarchical relations between parts in buildings.

It is necessary to know the rank of parts in the various hierarchies of buildings because parts with a higher rank limit the possibilities to act on and change parts with a lower rank. This knowledge is fundamental for, among other things, method development in the design process.

John Habraken (1982:116) has in ”Transformations of the Site” described three types of hierarchies or action orders that he believes characterize the configuration of buildings, namely the order of gravity, the order of enclosure and the order of flow.

My account of the corresponding action orders differs from Habraken’s in some respects. Habraken analyzes how the parts of buildings are controlled by different powers and draws conclusions about the relations of the powers based on which parts they control. He holds the view that the power (e.g., a person) that controls a part with a higher rank in an action order will ”dominate” a power that controls a part with a lower rank in the hierarchy (ibid:28).

I have considered it essential to treat the action orders of buildings and sociosystems separately and only then to study the action order in the resulting man-building system. My hypothesis is that social relations determine which parts of the building different persons control. See also Chapter 5.6.

In the assembly of buildings, the parts are stacked vertically on top of each other in an assembly order that considers the effects of gravitational forces and counteracts the effects of wind powers. The purpose of e.g, a house may be to protect against climate and intruders, which is why the parts are joined together so that they enclose an internal space, and the connections are made so strong that they can withstand breakthrough attempts. The purpose of the house can also be to direct a flow of things, such as people, water, and sewage, which is why the parts are combined so that they form natural walkways and a pipeline network.

The action order that dominates the construction of the building and which strongly characterizes its structure and external shape is the hierarchy of gravity. The gravitational force arranges the parts of the building in supporting and supported. The supporting parts have a higher rank in the gravitational hierarchy than the supported parts. The fact that the action order has this direction can be justified by the fact that the supported parts fall if the supporting (influencing parts) are removed. The gravitational order can be illustrated in the design of the parts of the building. In classical Greek architecture, the division into supporting and supported parts is of the greatest aesthetic importance. See Figure 5.14.

Figure 5.14. The classical temple expresses the supporting - supported relation.

A flow of things and a pipe form a flow system. The flow is caused by, for example, pressure differences, potential differences, and gravity. These give rise to a flow hierarchy between the parts. The pipe that collects the incoming flow or distributes the outgoing flow is called connecting pipe or main pipe. The pipe that supplies the incoming flow or receives the outgoing flow is called connected pipe or side pipe. See Figure 5.15. The flow in a connecting pipe has a higher rank in the flow hierarchy than the flow in a connected pipe. If the flow in a connecting pipe is throttled or blocked, the flow in the connected pipe is affected. If instead the flow in a connected pipe is being throttled or blocked it does not affect the flow in the connecting pipe system.

Figure 5.15. Flow order. On the left, an output flow is distributed. On the right, an incoming flow is received. In both cases the wider pipe is the most connecting, and with the highest rank.

The division into connecting and connected parts often expresses itself in the external form of the parts. Thus, most often the former are wider or coarser than the latter. The flow order can be observed in the river arms of a river delta, the ventilation drums in a suspended ceiling and the road network in a settlement. The flow order is of fundamental importance as an organizing principle for the building in a settlement. In a street network, streets are divided into main streets and side streets. For example, according to the Swedish SCAFT norms in primary routes, secondary routes, feeder streets and local or entrance streets. This division is based on the rank of the traffic flow in the flow order and is independent of whether the flow is supplied and collected or distributed and received.

The flow designation has also been used by Linn in connection with his definition of flow routes in a settlement. By flow paths, Linn refers to ”communication routes for man such as walkways, stairs, elevators; supply and sewer channels such as water-gas and electricity lines, chimneys, garbage disposal routes” (Linn 1974:32).

An action order that is of great importance for the structure and shape of a building is the *enclosing hierarchy* that arises between *enclosing* (*delimiting*) and *enclosed* (*delimited*) things. These things can either be parts of a building or belong to its environment. This hierarchy exists only when there are bonding connections between the enclosing and the enclosed things. It does not relate solely to their spatial relations.

The enclosing order may have its practical application when buildings are erected to protect their inhabitants or their contents from climatic conditions, intruders, noise, etc. The same purpose, but conversely, has the prison that encloses the prisoner or soundproofing walls that enclose and form rooms for noisy machines such as printing presses. If a building must exclude wild animals or intruders, the part of the building being attacked must have a higher rank in the enclosing order than the animals or the intruders. The higher rank must be held by all the enclosing parts of the structure where an attempt at break-in may be made. See Figure 5.16.

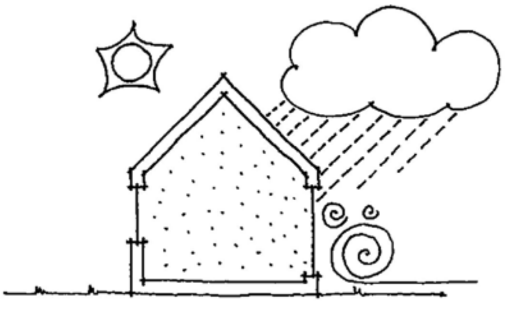


Figure 5.16. The walls of the house, the floor, and the roof have a higher rank in the enclosing order than the climatic factors of the surroundings.

### 5.2.3 Lawful change

The existence of an action order in a system means that changes to the system must take place lawfully, i.e., taking into account the connections that exist between the parts. One can speak of a *law of change*. This law states that a thing with a higher rank in an action order cannot be changed without a thing with a lower rank also changing and that a thing with a lower rank can change without a thing with a higher rank changing. An action order can in fact be defined as the internal structure of a system in which this law of change prevails between the parts.

The law of change means that if you move a supporting part, you must also move the supported parts. See Figure 5.17. But supported parts can change position without changing the supporting parts. If an inner wall is moved to a different position relative to a reference grid, the paintings hanging on the wall also change position relative to the reference grid. The same applies in a flow network.

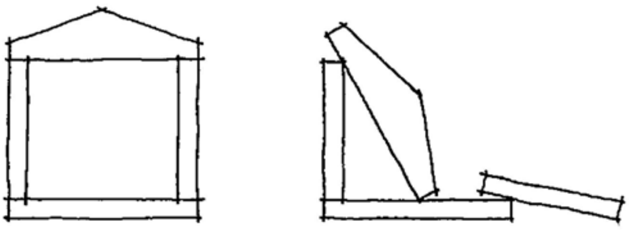


Figure 5.17. If a supporting part is moved, the supported parts are also moved.

If the flow in a connecting pipe stops, for example by tightening a tap, the flow is also stopped in the connected pipes. Conversely, you can stop the flow in a connected pipe without stopping the flow in the connecting pipe. Similarly, if enclosing parts are moved so that the enclosed space changes, the possible positions of the enclosed parts change. Conversely, the enclosed parts can change position within the given space without changing the enclosing parts. For example, if a bookshelf is made smaller, there will be less space for books, but in the same bookshelf the books can be moved without affecting the bookshelf.

The type of lawfulness discussed here only prevails when the parts are linked by bonding connections. A spatial relation alone, for example of the type enclosing-enclosed, is not sufficient for a hierarchy of change to occur.

### 5.2.4 Configuration of buildings

The internal relations of buildings also include its *configuration*, i.e., the spatial structure. The configuration of the building as a whole is determined by the spatial relations of the parts. It belongs to the primary properties of buildings, but the relations are non-bonding relations.

It is not correct to say that buildings are composed of concrete parts and spaces. Space is a relation and relations cannot be compiled, which concrete things can. The spatial relations do not belong to the functions of the building, but the configuration is crucial for the building to have its functions. A characteristic of buildings is precisely that they have specific space-forming properties that allow for different activities.

The properties of enclose and direct are used by the using systems to create buildings with two main types of configurations, namely concentric spaces, and linear spaces. These occur partly purely and partly in combinations. Streets are a typical example of buildings with a linear configuration while squares have a concentric configuration. See Figure 5.18. A corridor has linear configuration while a living room has concentric configuration. A standard housing plan includes both configurations.

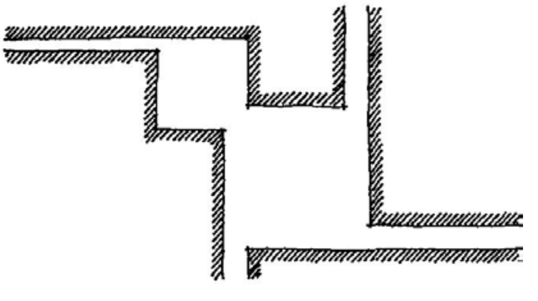


Figure 5.18. Linear and concentric spaces.

Louis Kahn has called a linear configuration of building parts for servant space and a concentric configuration of building parts for served space. The same division into linear and concentric configurations has been applied in the elaboration of the so-called Tissue method at SAR in Eindhoven (SAR

1976:2.6). In an action order, the spatial properties of affected parts depend on the spatial properties of the acting parts. This principle applies to the gravitational order as well as the enclosing order and the supply order. A supporting part affects a supported part, which also means that the position of the supported part is limited to the area within which it is carried by the supporting part. The configuration of the partitions is limited to the area of the joists. An enclosing part affects an enclosed part. The configuration of the room's air is limited to the area inside the enclosing building parts. A connecting part affects a connected part. The flow in a connecting pipe affects the flow in a connected pipe. For example, in a connected pipe, the position of the flow is dependent on the position of the flow in the connecting pipe.

The spatial properties of buildings depend on the properties of the supporting, enclosing and supplying parts. The configuration of a supporting frame can be organized in different ways, considering the load-bearing properties. A distinction is made between, for example, frame systems with load-bearing walls, load-bearing pillars, load-bearing arches, and load-bearing shells (Handboken Bygg 1982:128 ff). Support systems can be divided into classes with an even greater degree of fineness in terms of composition and structure. Thus, one can distinguish between systems with load-bearing walls parallel to the direction of the house with or without a heart wall and between systems with several or fewer load-bearing transverse walls (Wallinder, Hedborg and Hillbertz 1976:17).

Even the enclosing subsystem can be organized in different ways and thus have different space-forming properties. For example, a distinction is made between buildings whose enclosing parts have been organized mainly into a linear configuration and those organized into a concentric configuration. Examples include churches with naves and central churches.

Finally, one can speak of the configuration of buildings as determined by the location of the communication spaces. See e.g. (Wallinder et al. 1982:7ff). Attic buildings can be distinguished from buildings by stairwells.

### 5.2.5 Extrinsic relations of buildings

The extrinsic relations of buildings include the *transformation relations*. These are determined by the purpose of the building and refer to the action of the building on the surrounding air, subsoil, encroaching people, and animals, etc. Even the prison's locked in prisoners can in some respects be affected by the prison building's transformation relations, namely as they do not use the building as a tool for their everyday life but try to break out. In this context, it is the prison guards who use the prison building as a tool to restrain the prisoners.

The *tool relations* of the building are the connections with the users. These relations also belong to the internal relations in the user-building system. The tool relations can be divided into general and specific, e.g., residence and kitchen, bathroom and bedroom or office as well as study, dining room and reception.

The tool relations and the transformation relations are bonding relations and together constitute the functions of the building, such as bedrooms and rain shelters. The performance concept is linked to the concept of function and refers to the operability of the building. The *performance* of the building is a measure of how well it fulfills its purpose. Expected or ideal properties are put in relation to the actual properties. The concept of performance has been treated by, among others, Cronberg (1975).

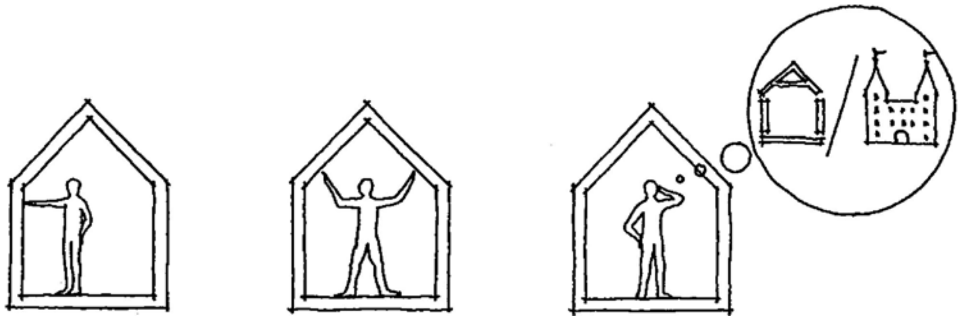
Buildings also have *spatial relations* with the environment. These relations are not binding. The configuration of the building must be coordinated with the configuration of the surrounding things, e.g. that of the user system and the natural environment. The determination of the configuration of the building and its coordination with the surrounding systems with regard to use and experiences is one of the main tasks in the architectural design of buildings.

Important method development in the design has been made at the Dutch research foundation SAR with, among other things, the Support and Tissue methods. The support method aims to enable a systematic evaluation of the configuration of a residential building against varying configurations of the housing system. The tissue method is a method of describing the spatial properties of a settlement.

The *interpretation relations* between buildings and an interpreting subject are the thoughts, feelings, and ideas that a sensing subject experiences in the epistemic and semiotic interpretation of the building. The interpretation relations are secondary properties of the building. See section 5.7.

The relations of the building to the social systems are shown in Figure 5.19. In summary, they are

1. primary (functions i.e., tool relations and transformation relations as well as spatial relations),
2. secondary (epistemic and semiotic interpretation relations).



Functions Spatial Relations Interpretation relations

Figure 5.19. The building's relations with the users.

## 5.3 Change in buildings

### 5.3.1 Versatile buildings

Since the mid-1960s, the National Board of Building has investigated what properties buildings should have to enable changes in the activities in the building. Among other things, attention has been paid to the properties a building must have to be used by different users in a longer time perspective. The results have been applied both in the form of regulations and in practical construction (Byggnadsstyrelsen 1984, Westerman 1981, Ahrbom 1980).

In the following, the concept of *versatility* is addressed using the system concept. If a building can be used as a tool in several different activities without changing its composition and internal structure, it is *universal*. This means that the same building without changes can have several different functions (external connections). If the functions of the building can be changed by changing its composition and internal structure, it is *adjustable*.

The function of a house building does not change if its joists are allowed to carry different people with the same weight. However, the function changes if the people at different times weigh different amounts or are different in number. This is an example of the fact that the internal properties of the building do not need changes even though the function changes. The building is said to be *universal*. The universality of the building means that in the set of really possible systems of users and buildings, the properties of the building are universal and the properties of the users (persons who carrying out activities in the building) specific.

All buildings are both universal and adjustable. A universal building is characterized by the fact that the same parts can have different functions. A bedroom can also be used as a study and the kitchen can be a dining area. However, the adjustability can be very different since building parts of different types are differently easy to change. The parts of the building also include the furniture. These are loose and easy to move. Most buildings are adjustable with respect to furniture placement because the activity of a building normally requires removable furniture. Unless the walls are to be an obstacle to the exercise of various activities, the wall placement in the building must be universal. Further activities will be possible if the walls are made adjustable.

A system whose internal properties (composition and internal structure) can be changed by action of the system's environment is said to be an *open* system. A building whose floor plan can be changed, for example, by the adjustability of its non-load-bearing interior walls is an open system regarding its floor plan properties. Whether a system should be considered closed or open depends on the possibility of implementing a change. Different changes require different kinds of impact. Furniture can be moved by hand force. Moving walls requires tools. In general, large changes are more difficult to implement than small ones.

However, it is not enough to study a building only if one is interested in its adjustability. The building and its parts are used by a sociosystem and its members. If the building changes, the sociotechnical system also changes and thus the sociosystem is also affected.

### 5.3.2 Level of adjustability

In a building with its users, the change can be graded both according to the nature and extent of the work effort required to carry it out and considering the relative number of activities in the work organization that will be affected by the change. Taking these aspects into account, five *levels of adjustability* have been identified within the National Board of Building (Ahrbom 1980:171).

The grading can be said to express the degree of openness and closedness of the man-building system. The lowest level of adjustability (level 0) refers to the so-called *building-linked parts*, e.g., frame, stairs and shafts. Level 1 applies to such so-called *business- linked parts* that are expected to be changed at some point during the building's useful life, e.g., non-supporting interior walls and air handling systems. The scale of the change may be such that large parts of the building cannot be used during the redevelopment. Levels 2, 3 and 4 refer to *business- linked parts* that change several times during the useful life of the building and that require progressively less specialized personnel and fewer disruptions to the activities going on in the building.

The changeability levels defined by the National Building Board can be classified in the previously reported division of changes into *deep* and *superficial*, as well as *large* and *small*. A change in the building-linked parts of level 0 can be considered a deep and large change. In this case, the properties of the building are changed so that it must be considered to belong to a new species as when a water tower is converted into a residential building. Changes in business-linked parts to the extent corresponding to level 1 are also deep and species-sensitive changes because the business is expected to undergo a corresponding profound change. The change can be either large or small depending on the extent of the work effort and the number of activities involved. Changes belonging to levels 2, 3 and 4 are superficial as they do not relate to the nature of the building. They can be large as in a ”total renovation” of a residential building or small as when painting and wallpapering an apartment.

## 5.4 Production of buildings

### 5.4.1 The construction sector

Together with user systems and production systems, the buildings are included in supersystems that determine the properties of the building. The production system in construction together constitute the so-called *construction sector* of society. This includes planners, material producers, contractors, state and municipal authorities, research and teaching institutions and others who are in any way engaged in the production, maintenance, or demolition of buildings.

The production systems determine the properties of the building by means of the conditions of production in the design, production and compilation of the building and its parts. See also section 5.1.4. Examples of manufacturing conditions are the knowledge and practical skills of the designers, the machines of the material manufacturers, the qualities of materials, the skill of the workforce, the assembly methods of contractors and the regulations of the control authorities.

The producing systems in the construction sector belong to the economic part of society system. Both goods and services in the construction sector are economic artifacts i.e., their main purpose is the material benefit. However, due to their essential experiential significance, buildings must also be designed in terms of their cultural utility.

### 5.4.2 Industrialized production

Characteristic of a production system are properties of its production forces i.e., work force, working relations, working methods, implements and raw materials. The modern production systems produce buildings through *industrialized production*. These production methods have been developed through a change in technology from handicrafts to *mechanization*. Product production and process control have thus been transferred from humans to machines. The latest step in this change is machine use for process control. This is also commonly referred to as *automation*.

The driving forces behind the focus on increased *mechanization* are the possibilities for

1. reduced production costs through *mass production* made possible by the machines' capacity for repetitive work,
2. improved control of product quality through the *precision* of the machines,
3. *independence* from labor and
4. production of new *products*.

The means that make mechanization possible are access to local energy sources, the materials iron and steel, engines, access to capital, large markets, etc. These factors are interdependent and reinforce each other.

In this context, the interest is linked to how mechanization affects the properties of products. In this respect, three main consequences should be noted, namely mass production, standardization and prefabrication (off-site) of building parts. Mechanization also enables the production of completely new products that cannot be made manually. Building materials made of steel, reinforced concrete and plastic are such new types of products.

However, the properties of the products are influenced by the producing systems in other ways as well. Mechanization and automation are only one of the means to achieve the previously mentioned goals. System building and integration of the producing systems from the raw material producers to the contractors, is another means of reducing production costs and increasing control over product quality.

With the *integration* of producers into different levels, the products can be more easily coordinated in terms of their properties. This means that the properties of the products are coordinated, for example, to provide the lowest possible production costs. Coordination can take place between independent producers or between sub-producers within a company.

The concepts of typization, standardization, pre-manufacturing, coordination, integration, etc. can be discussed in relation to the schema with the compositional levels of the building.

### 5.4.3 Standardization and typization

*Standardization* and *typization* both involve a reduction in the number of different classes of things. Typization is more often used to denote the reduction of the class of buildings and more complex wholes, while standardization is usually reserved as a designation for the corresponding reduction of the class of building components and materials.

Standardization and typization do not mean that the number of things decreases, but that the number of classes of things decreases. Therefore, this means that if the number of things in the set is constant, the number of things of the same class increases. For example, a city plan may stipulate that only buildings belonging to the building types described in the plan may be erected in the area.

The purpose behind the standardization is to enable the mass production of equal individuals belonging to a small number of different classes. The introduction of building systems for industrial production in the 1950s and 60s often resulted in experientially uniform buildings. The reason for this was an excessive standardization of the building components, which led to a strong typization of the building.

Standardization requires less resources for stocking products. The requirement for knowledge of different products decreases with standardization, and repairs and maintenance are facilitated. Standardization requires coordination of different products for them to be merged into wholes at higher compositional levels.

Standardization of parts at a lower level in the compositional order of the building does not have to entail an undesirable typization of things at a higher level but can of course have such effects. With 2”x4” standardized studs, many different structures can be built, but typization of entire structures results in uniformity and unnecessary limitation of opportunities for experiences.

### 5.4.4 Prefabrication

Prefabrication involves processing of the parts of the building before the assembly in the finished design. Prefabrication is therefore dependent on transport distances. The closer to the construction site, the larger and heavier products can be prefabricated. Building materials such as cement are shipped all over the world. The overall subsystem of the building, e.g. prefabricated volume houses, has a more limited radius of delivery.

A concrete wall in the building can be site-built. However, its parts are prefabricated. The steel mold is prefabricated, as are the concrete mix and reinforcing bars. *Site-built* is the product that is produced in its place in a construction. *Prefabricated* is the product that is mounted in its place in a construction.

Prefabrication requires a subdivision of the building into parts. What the parts are is determined by both the producing and the using systems. If the using systems cannot influence the producing systems, the division takes place entirely on the latter’s terms. This problem is particularly evident in the determination of building parts and subsystems.

Prefabrication affects the building’s properties, among other things, through the transition from ”wet” to ”dry” compilation processes. Wet processes are those in which casting, or masonry takes place on the site. This enables, for example, the construction of larger entire building parts without joints between building components, which is important for, for example, façade design of houses. The composition of the building frame depends on whether it was produced by prefabrication or as site-built. If the frame is prefabricated, it can be made demountable. In this case, individual parts can also be replaced.

The degree of prefabrication and site construction in the compilation of buildings varies. The most extreme form of site construction involves directly producing the finished building from building materials. Excavation of an earthen cavity or sliding casting of, for example, a chimney is close to the extreme site construction. The opposite is the extreme prefabrication. This involves transporting the finished building to the construction site, including foundations. But since the processing of ground is included in the definition of a building, it cannot be produced in this extreme way. Thus, a caravan cannot be classified as a building. Prefabricated buildings in the form of volume elements involve the prefabrication of the subsystem houses, while ground preparation and foundation must be site-built.

### 5.4.5 Modular coordination

To *coordinate* means to create relations between things with the aim of enabling the functioning of a system. Coordination refers only to the creation of non-bonding relations. Colors, for example, can be coordinated as well as the spatial relations between an engine's parts.

In construction, *modular coordination* occurs, which means that the spatial properties of the products have been coordinated. For example, the variation in size can be an even number of modules. A module is a unit of measurement that is common to the products that are modular coordinated. If the module is 1M, i.e., 10 cm, this means that all products have spatial properties that are even multiples of 1M. This often applies to the interior elements of the building, e.g., the length of the partitions. The 3M module is common for the building frame.

Modular coordination is a form of standardization but relates only to the spatial properties of the products. Coordination of the properties of products is necessary for them to be merged into new products with the desired emergent properties.

### 5.4.6 Industrial manufacture of the parts of buildings

The previously reported schema of the compilation levels of the building included the main levels

1. building,
2. the main subsystem of the building,
3. building parts,
4. building components and
5. building materials.

The possibilities of mass production and prefabrication are different for products of different levels. A general rule is that these methods are better suited to the production of things in the lower levels such as building materials and building components. Mechanization requires relatively simple products that can be produced in a predetermined process. The more complex the product, the more difficult it is to produce mechanically. Building materials such as sheet metal, joists, pipes, bricks, nails, and screws are typical machine products. Building components are more complex and their production more difficult but still quite possible to mechanize. This applies, for example, to windows, doors and concrete elements. Building parts such as walls, floors and ceilings can hardly be mechanized, but are usually added by supplementing the mechanical work with manual work such as in site construction or prefabrication of large elements for walls. The same applies to the overall subsystems of the building and the building as a whole.

Mass production is ideal for the products in the lower composition levels up to and including the building components. These products can be assembled into more complex things such as building parts, the main subsystems of the building, and buildings without the latter's properties being unambiguously determined by the standardized properties of the former. Standardization of house buildings may refer to certain properties such as number of floors, roof slope and façade materials. However, standardization of floor plans and facades leads to uniformity. Thus, entire buildings are not suitable for industrial production. They are difficult to produce directly with machines and unwieldy to prefabrication and should not be fully standardized, nor should they be mass-produced. However, typization of buildings is common, especially in the case of residential buildings. However, such a procedure does not bring any benefits from the point of view of mass production, since this production cannot be mechanized. Rather, the advantages are of an administrative and organizational nature. It is easier for an organization to build 100 equal apartments or single-family houses than 100 different ones.

Yngve Öberg (1965) has in an article ”Industrialization - how?” made an excellent account of the meaning of industrial construction. He puts forward five factors that speak against the industrial production of entire buildings, namely

1. the volume and weight of the building and the low value per unit of weight make transport difficult, which is why production usually takes place on the construction site where industrial production is inappropriate,
2. the building is precious, has a long service life and is firmly connected to the ground,
3. the building’s creation process is long and complicated and requires the involvement of many specialists of various kinds, i.e., coordination of the production phases are difficult to achieve,
4. the building is not a uniform product, a whole host of different types of buildings must be produced to satisfy varying needs and external conditions,
5. construction is locally dispersed and has a lack of continuity of demand.

The clear difference in the conditions to produce buildings, subsystems and building parts vis-à-vis products at the lower levels of compilation also corresponds to the division of production systems in the construction sector. These can be divided into building materials manufacturers and contracting companies.

Building materials manufacturers produce all the products that can be prefabricated. These mainly belong to the compositional levels up to and including building components. The contracting companies produce finished buildings partly with the help of prefabricated products and partly through site construction.

### 5.4.7 Horizontal integration

Starting from the level order of the building, various relations between the production systems can be discussed. The relations between these systems are based on the relations between the products. Products of the same level must be coordinated to be integrated into new products at higher levels. For example, the window must fit in the hole in the wall element. This means that the producing systems must be integrated ”horizontally”. Horizontal coordination of product properties can be carried out by means of agreements between producers belonging to different systems or between producers within the same system. The agreements can be created through voluntary adaptation or through various forms of coercion. Laws and norms are examples of agreements aimed at coordinating producers.

*Horizontal integration* means that producers of products of the same level belong to the same system. This does not mean that they necessarily belong to the same company but that they have bonding links between them.

### 5.4.8 The relation producer-consumer

The manufacturer of products is called a *producer*. The person who uses a product is a *consumer* or *user*. When compiling a product in a higher level, the producer uses products in lower levels. This means that each producer is also a consumer. The contractor completing the building may be a consumer of building materials and building components. The user who uses the building in his activities is a consumer of the building. However, the user is also the producer of the sociotechnical system that arises from the building’s use.

Between consumers and producers, the influence takes place, among other things, through consumers' choice of product. The impact can also occur before product production through various forms of vertical integration. *Vertical integration* refers to integration between producers and consumers of the same product.

The influence of consumers on producers can take place in different ways. In a market with competing producers, the consumer may choose between different products. If there is no competition in the market, the influence can possibly be made by refraining from buying. If the need is compelling, such as the need for housing, the possibility of forgoing is not a real possibility, and the consumer cannot influence the product via the market mechanisms.

The influence of the consumer on the producer can also be through vertical integration i.e., consumer and producer can be the same system. The producer of building materials may be the same as the producer of building components which may be the same producing building parts and entire buildings. This type of vertical integration is common in construction.

However, vertical integration ceases after the production of the building unless its users are included in the system. However, if the construction company produces for itself, e.g., its own head office, the vertical integration exists throughout the chain of producers and consumers. For the sake of completeness, society as a ”consumer” of the sociotechnical systems should also be included in the chain.

For users or consumers of products such as buildings that are not ready in a market, the influence through vertical integration is desirable. This has traditionally been done by the building's consumer, the client in this case, hiring an architect to design a building in accordance with the wishes of the client. In this situation, the influence in terms of product design occurs mainly in the direction from consumer to producer, which is often the norm. However, the influence can also occur in the opposite direction, for example if access to the product is scarce. Then the producer influence is greater than the consumer influence. For example, the major influence of contracting companies on the design of buildings during the days of the Swedish Million Program.

The products of which the building is to be compiled have properties that are fundamental to the properties of the building. The production systems to which construction product manufacturers and building contractors belong affect the properties of construction products and buildings through their production methods and product use.

The production of buildings may require large investments in production forces. In this context, vertical integration between different producers is a natural way to gain increased control over costs and qualities. To further increase vertical integration, modern construction has focused on systems building.

### 5.4.9 Systems building

*Systems building* refers to the integration of producing systems with different tasks in the construction process, i.e., both design, production and assembly are included in the same system. Systems building integrates ”the entire process, starting with programming, planning and design while covering production, transport, compilation, operation and maintenance as well as post-completion evaluation” (Dluhosch 1980).

From Dluhosch's definition systems building is aimed at both horizontal and vertical integration of producers at different levels. It can be noted that design in the traditional construction process was a developer-and user-controlled activity but in systems building, construction is controlled by the contractor.

Systems building has always existed in the sense that there has been influence between the parties in the construction process. However, there has been a marked shift in power over building design from users to producers since the 1960s (Eriksson 1980).

The emergence of design/build contracting and the associated increase in the number of building codes characterize the development towards systems building. This is a development that is regretted by the architects because they have less influence on the detailed design of the building.

## 5.5 The system user-building

### 5.5.1 Activities of sociotechnical systems

The previous sections outlined some general properties of the sociosystems and of the building. The purpose of this section is to describe the relations between these two systems in the user's use and experience of the building.

Among the issues to be discussed here is how the building limit or enable human activities. Activities are goal-oriented actions. As an aid in carrying out the activities, people use various tools. This creates a new kind of system, the sociotechnical systems, the composition of which consists of both man and the tools. Thus, the properties of sociotechnical systems include the activities made possible using tools. The sociotechnical systems are of different types depending on the activities and the tools used. A sociotechnical system can be described based on the activity that the system performs.

The purpose of the tools is to affect things so that human activities are made possible. See Figure 5.20. Using clothes as a tool, man changes the state of the air in its immediate vicinity. The clothes can be seen as an artificial, portable, and protective environment. With machines, humans influence the environment in a much more extensive way and transform it into things with new properties. Houses, like clothing, have climate-affecting and protective properties but are stationary and tied to the ground.

| Subsystem | | Sociotechnical system |
|---|---|---|
| | Clothing | = The climate-controlling man |
| | Machines | = The manufacturing man |
| Man + | Building | = The resident man |
| | Artwork | = The experiencing man |
| | Mass media | = The communicating man |

Figure 5.20. Examples of sociotechnical systems

Clothing, machinery, and buildings have as their main purpose their material properties but are also significant as cultural artifacts. Examples of things that are designed specifically for their experiential qualities are works of art and mass media. The latter may also include language. Works of art and mass media can be considered tools for sensory experiences and conceptual transfer between people.

To enable human activities, many kinds of tools are used. For example, in work, clothes, tools, machines and buildings are used. Buildings are just one category among many others. The further account is limited to those activities where the buildings are particularly important tools.

### 5.5.2 The system user-place

Buildings may have the property of place. A place is a thing with a spatial extent that encloses or forms the foundation for man in his activities. When people carry out their activities, the design of the place is usually a necessary condition for achieving the intended purpose. Places can be used as tools.

They are then, together with man, part of the system that carries out the intended activity. The properties of the place both enable and limit the implementation of the activities. A place is therefore also an environment to the activity that can be practiced on it. See Figure 5.21.

| Subsystem Buildings | Sociosystem | User building system /activity |
|---|---|---|
| | Household | = Home/ ”to live” |
| | Company | = Office, industry / ”to work” |
| Building ∔ | Pleasure-seekers | = Restaurant/ ”to enjoy oneself” |
| | Congregation | = Church/ ”to believe” |
| | Road users | = Traffic system/ ”to travel” |

Figure 5.21. Building, sociosystems and supersystems and activities.

Specific activities require specific places, and the factually possible places determine the factually possible activities. Football games require a level playing field; school education requires a climate-protected place free from noise and other external disturbances; livestock farming may require fenced places, etc. Places also have cultural properties and can be given a special symbolic character to enable ceremonies such as church services, spectacles, and competitions.

Most activities require specially prepared places to facilitate and enable the activities. A natural place is complemented by different types of tools such as fences, furniture, special ground treatment and lighting. Places can be more or less artificial. A forest glade is a great place to rest on an excursion, while a building is required to allow for a more permanent stay.

In connection with the human use of a place for his activity, just as in the case of other use of tools, a sociotechnical system is formed. This can be called the user-place system. The following account is limited to dealing mainly with places belonging to the class of buildings. Consequently, the interest will therefore also be specifically linked to the system that can be called the system user-building.

### 5.5.3 The system user-building

Buildings are manufactured and used by the members of the social systems for specific purposes. The purpose of the building is to be a place for various activities, such as those that require a modified climate, protection against intrusion and people’s views, a basis for stay and transport, as well as aesthetic and symbolic expression. In the human use and experience of buildings, the user-building systemarises.

The properties of the building and the users are fundamental to the properties of the user-construction system as a whole. Without the climate-protective properties of the building, for example, no settlement outside the tropical and subtropical regions of the Earth is possible, and without human activity, the city is reduced to a ghost settlement without life. ”Only the shell of the city remains” as Mumford would have put it (Mumford 1972:29).

Common to the user-construction systems are that they are composed of both buildings and sociosystems. Depending on the purpose of the activity of the sociosystem, the building is designed in different ways. See Figure 5.21.

The user-building systemis a *control system*. The purpose of the control can, for example, be ”climate control” with the help of various control mechanisms such as doors, windows, roller blinds, thermostats, taps and valves. In other activities, the control may also concern the spatial structure of the building, e.g., the location of the partitions in a house. In this context, the partitions were used as tools for the activity ”to live”, among other things because the walls of the building can reduce disturbances between some activities in the accommodation. The control may also concern the users and their activities in the use of the building. This case means that some users control other users as when the house manager controls the tenants.

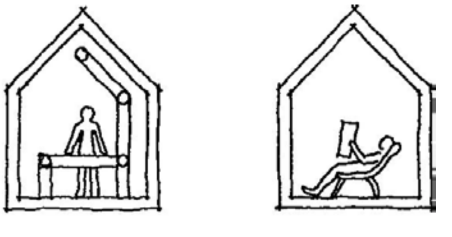
The user-building systemis also an *information system*. According to previous definitions, information is such influence that changes the state of a system in a qualitative way. In the user-building system, both buildings, and users can undergo qualitative changes. A qualitative change in a user can, for example, be a change in her user role.

User roles are different in a residential area with high-rise buildings and in a terraced house area (Daun I977). The emergence of different user roles in the use is one of the reasons why the "built environment" should not only be considered as an environment in a system theoretic sense but must also be seen as part together with man in the user-building system. A similar requirement is made in ecology, which requires that man is considered part of the ecosystem and nature, and that these are not considered solely as man's environment.

When a tool is used to enable an activity, a distinction can be made between the activity of the composite user-tool system and the activity the user performs. The user's activity is fundamental to the activity of the entire system but is not identical to this. For the user, typing a machine means, among other things, pressing keys while the machine press types against ribbons and paper. The user's activity and the tool's properties are fundamental for the entire system's future activity.

The properties of the user-building systemas a whole are in summary (see Figure 5.22)

1. material activities such as modifying the climate, rejecting intruders, enabling living and vehicular traffic,
2. cultural activities such as providing aesthetic experiences and communicating with the building as a symbol,
3. user roles that are the subset of the users' personality that is dependent on their use and experience of the building, and
4. technical, functional, and aesthetic qualities of the building.



Material activity Cultural activity
With the human's roles and the technical, functional, and aesthetic properties of the building.

Figure 5.22. The properties of the system user-building.

### 5.5.4 Environment of the user-building system

The environment of the user-building systemconsists of the things that affect or are affected by the system's activities, including the natural environment and other sociotechnical systems. Along with these, the user-building systemis part of the supersystems ecosystem and society.

The building can be both an environment and be part of the system during an activity. For example, when cooking, parts of the building are used as kitchen, which is formed by, among other things, walls, floors, ceilings, kitchen cabinets, stoves, refrigerators, and cooking utensils. The control system when cooking includes cooking utensils and the ingredients of the food. Storage cabinets, stoves and refrigerators are only checked for certain properties such as open or closed door and temperature, but not for others such as spatial placement. The parts that are not controlled but to which the cooking system has bonding connections belong to the environment of the system. Examples of such parts are walls, floor and ceiling, as well as kitchen cabinets, stove and refrigerator with regard to their position in the kitchen. See Figure 5.23.

Figure 5.23. Cooking system (black in figure) and environment (sgraffed in the figure).

In principle, a distinction can be made between those parts of a tool whose properties change during an activity, and those parts whose properties remain unchanged. In the case of buildings, the change may, for example, relate to spatial position. Furniture is such parts whose spatial position often changes, while solid furnishings such as storage cabinets and partitions are considered given in the activity. They belong to the environment of the system but are nevertheless necessary for the implementation of the activity. When the activity for some reason cannot be carried out with the given restrictions, the environment is changed, if possible.

Thus, the environment of the user-building system also include those parts of the building that are only used but not controlled during an activity. The relation between different activities and how the parts are controlled in the systems is further discussed in the section on their structure.

### 5.5.5 Society and the system user-building

The user-building system can be viewed from two directions. From above as subsystems of society, and from below as composed of sociotechnical parts. The levels of society are:

1. society,
2. the subsystems of society and
3. parts of society.

The user-building system has the levels

1. the user-building system,
2. subsystems of the user-building system and
3. parts of the user- .

Characteristic of the parts and wholes of these level orders is that they are sociosystems that carry out activities using various tools. The properties of the parts are fundamental to the activity of the whole. Viewed from above, the user-building system with its activities can be perceived as subsystems of society. Its properties are fundamental to the properties of society as a whole. The activities of the user-building system belong to the internal relations of society. As with other systems syntheses, only those systems that obtain the desirable emergent properties can be included in the supersystems. This means that only those activities that are beneficial to society are included in society. Industries, housing, and transport systems must be adapted to the functions that are socially desirable.

Viewed from below, society and its parts can be described as ”constructions” of users who, with the help of various tools, including buildings, carry out their activities. The user-building system can have different complexities and be anything from the simplest, when a user uses a building part as a chair, to the most complex when a sociosystem uses a ”megastructure” where the total amount of activities has societal features. Thus, it cannot be argued that the user-building system belongs only to the level of social parts. It can also belong to higher levels as the subsystem of society and even be an entire society. See Figure 5.24.

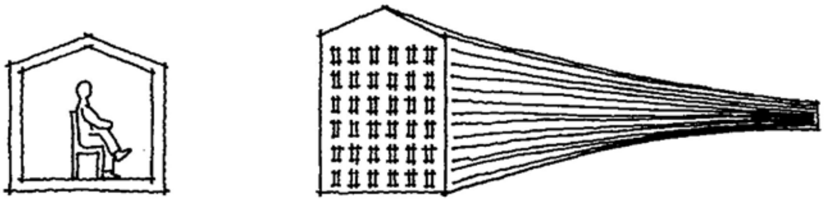


Figure 5.24. The user-building systemcan have different complexity.

Here, then, the same problem of coordinating the two main aspects bottom-up and top-down in the level order occurs as in the description of buildings. The BSAB system has drawn attention to this problem and accepts two principles for describing the parts of buildings: Partly as constructions of products and partly as functionally determined parts of buildings. One can imagine a corresponding description scheme for the parts of society that consider these partly as ”constructions” of sociotechnical ”products” and partly regard them as functional parts and subsystems of society. It is not possible to draw up such a scheme within the framework of this project. Instead, a division of the description is made in such a way that the composition of the user-building system and the composition of society are treated separately.

### 5.5.6 Composition of the user-building system

In the user-building system, the parts of the building are also included in the building seen as a technical system. Correspondingly, the people who carry out activities with the help of the building also belong to other sociosystems. The activities of the user-construction system are therefore dependent both on the laws that prevail in the building and the laws and regulations that apply in the sociosystems.

What primarily characterizes the user-building system is not the building but the activity of the social system that is carried out with the building as an aid. The buildings are not the only tools used in the various activities of the users, but they are essential aids and, through their configuration, characterize the supersystems user-building and society. The building must be adapted to a building complex pattern. This is important for the properties of society such as transport distances, school routes and nature contact, and is controlled at the societal level. The building can be, for example, houses, streets, squares, canals, parks, and green spaces. The social organizations can be, for example, families, companies, healthcare teams and school staff.

*Parts of the user-building system* are the smallest units that have activities that contribute to the system’s activity as a whole, such as living, working or traveling. See Figure 5.25. Examples include the family at the breakfast table, a repairman in a greasing pit or a cyclist on the road. In these activities, the interior parts of the building in the form of furniture and other equipment are often used as tools.

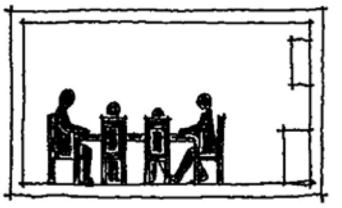


Figure 5.25. The family at the table is part (black in the figure) of the user-building system.

These smallest parts with their activities are merged into independent *subsystems in the user-building system* which have a coordinated set of the system's emergent properties as a whole. See Figure 5.26. Examples of the kinds of activities in question are in living ”to cook and eat food” and ”to wash”. In healthcare, the subsystems can have the activities ”to diagnose”, ”to X-ray” and ”to operate”. The car dealership subsystem has such activities as ”selling cars”, ”repairing cars” and ”supplying cars with oil and gasoline”.

The subsystems often use spatially delimited parts of the building specially designed and equipped so that they have the desired properties that enable the activities. For the activity ”to live”, the building is given, among other things, the properties living room, laundry room and kitchen with dining area. The car company distinguishes between sales premises, workshop premises and gas station, and in healthcare it distinguishes between examination department, X-ray department and surgery department, among other things.

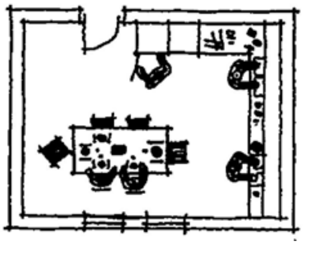


Figure 5.26.-The family that cooks and eats is a subsystem (black in the figure) of the user-building system.

The subsystems are coordinated and integrated to form the *user-building system*. The household, the hospital and the car dealership are examples of this kind of wholes of users and buildings. What characterizes the above examples is that the configuration of the building has been coordinated with the users and their activities. The parts of the building form places and rooms where the activities take place.

A household, a healthcare organization or a company may use as a tool for its activities part of a building, the entire building or several buildings. There are many different combinations of users and buildings that are possible. The part of a building used by a family for the activity of ”living” is called an apartment. Are the corresponding spaces used for the activity ”to work” it is called office or workshop.

For the activities to be carried out, the building must be adaptable. Since the building is a technical system with lawful relations between its parts, the change of the building must comply with these laws. The relation between the laws of the technical system and the laws and rules of the social system is discussed in future sections on the structure of the user-building system.

### 5.5.7 Society

There have been and still are societies with different forms of culture than the Western, industrialized one, where there is no distinction between ”living” and ”working”; Both of these activities are interwoven in ”to live”. The object of work is mainly material benefit while upbringing, education, pleasures and ceremonies belong to the cultural activities of man. Åke Daun (1980:12) has shown examples of how the material and cultural activities as late as 1800s Sweden were integrated into the overall activity ”to survive”.

In all societies there is a certain differentiation of activities, including the division between agriculture and other crafts. Agriculture must take place in the fields, while many other activities are advantageously carried out inside buildings, in protection from the climate. This differentiation is both social and spatial. The material and cultural development of modern industrial society has led to today’s (historically?) extreme social specialization and spatial differentiation of activities.

Through the increasing specialization and differentiation of activities, societies have also become ever larger. In peasant society, the village with the agricultural land was the smallest self-sufficient unit. It had both material and cultural activities on a sufficient scale. Modern societies today take the form of municipalities and urban regions. The nations are societies with their own armed forces.

When analyzing society, it is important to pay attention to the reductionist trap that consists in society being considered composed of only sociosystems and that the tools, for example, the building complex, are considered only environment. In this context, it is impossible to see the whole that is formed from the user’s use of the tools. Furthermore, subsystems and parts of which these system entities are composed are also not detected.

Another trap lies in considering a building complex as a community. The spatial extent of a society does not have to coincide with the configuration of the building complex. The community may include several building complexes such as an agricultural community with its farms and lands. It may have the same extent as its building complex, as, for example, a mining village and it may be just part of a building complex such as a municipality in a built-up urban region or an ethnically delimited neighborhood in a big city like Harlem in Manhattan or Chinatown in San Francisco. See Figure 5.27.

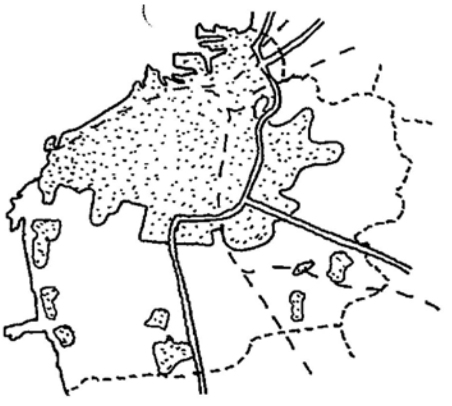


Figure 5.27. The community of Malmö municipality has a greater extent than the buildings in the municipality.

A society is a self-sufficient entity. The village in peasant society was a community if by the village you mean not only the building complexes but also its population, animals and lands. With industrialization, the agricultural village as the dominant form of society was replaced by the industrial city, which is now being replaced by so-called post-industrial societies. Just as sociotechnical systems are characterized by far-reaching differentiation, industrialized societies have become increasingly specialized in economic and cultural terms. This development is made possible through regional, national and international cooperation.

### 5.5.8 Composition of society

*Societies* have been defined in section 4.6.1 as essentially self-sufficient systems whose composition consists of sociotechnical systems of varying complexity. Society can be divided into the economic, cultural, and political subsystems. These main subsystems can in turn be subdivided into sectors of society, which in turn are composed of the smallest social parts, the sociotechnical systems.

The *economic subsystems of society* include the food sector, the housing sector, and the industrial sector. Systems of users and buildings belonging to the food sector are, for example, agricultural businesses and slaughterhouses. The housing sector includes tenant-owner associations and construction companies, and the industrial sector includes, for example, car manufacturers and boatyards.

The *cultural subsystems of society* include, for example, 1) the school sector, 2) the entertainment sector and 3) the religious communities. The systems of users and structures belonging to these sectors include 1) schools and universities, 2) folk parks and cinemas, and 3) churches and Sunday schools.

The *political subsystems of society* include 1) the judiciary, 2) the state apparatus and 3) the municipal sector. The systems of users and buildings belonging to these sectors are 1) courts and prisons, 2) parliament and county administrative boards and 3) building boards and social administrations.

The *parts of society* are made up of individuals or groups of people who carry out activities with the help of various kinds of tools. They are sociotechnical systems, and their activity is fundamental to the properties of society as a whole. Parts of society include households, companies, organizations, and institutions of varying complexity. Any system of which the composition includes a person or a social organization that uses everything from part of a construction to an entire building complex is a system of users and buildings and forms part of society.

These systems of users and buildings also include other artifacts. Thus, the buildings are not the only tools in these systems, but they are important parts and often necessary for the activities. The buildings can be, for example, houses and streets. The former are included in housing management systems and the latter in transport systems. Housing systems include public housing companies, tenant-owner associations, and all households. Transport systems include the road-bound motor vehicle-based passenger and cargo transport systems with motor vehicles and walking and cycling.

In the level orders presented here, the principle is that the things at lower levels are included in the composition of the things at higher levels. It is through human activity and the property of buildings that the user-construction system and its activity come into being. Similarly, it is the emergent properties of these systems that enable the emergence of the social subsystems and their activities. In turn, the subsystems of society as a whole are integrated with their particular, characteristic activities and other properties.

The level order reflects a developmental mindset that is consistent with Mumford's observation that human activity, the gathering place and the village can be seen as stages on the road to the city's development: ”Before the city there was the hamlet and the shrine and the village; before the village, the camp, the cache, the cave, the cairn; and before all these there was a disposition to social life that man plainly shares with many other animal species” (Mumford 1966:13).

The difference between the village and the city, according to Mumford, lies not in the spatial or material structure, but in the composition of social systems. The social base of the traditional village is the is the large family while the city's sociosystem is dominated by interest groups of a religious, political or mercantile nature (ibid:28,113).

A central question for community planning is which parts are necessary for the formation of society. In England, during the 1900s, about 30 new communities were built as so-called New Towns. Important factors for the formation of society in these are partly the number of inhabitants and partly the variety of activities in the form of different companies, administrative and political organizations, leisure activities, etc. Of crucial importance to social formation has been that a new city has its own political autonomy, i.e. the city must be its own control system in order to be able to be self-sufficient. Without self-government, the city develops into nothing more than a suburb of an already existing community. Something that can be seen in the Swedish ABC suburbs, such as Vällingby and Årsta, which do not have municipal autonomy (Paulsson 1970).

Thus, the formation of society is not something that has only happened in historical times, but new societies are constantly being formed and others are dying out. Societies consist of interacting sociotechnical systems. Some such compilations have incipient societal properties such as a settlement unit, a block, or a smaller urban area with housing and perhaps a primary school and a few more different gainful activities. Another step towards community formation consists of a neighbourhood unit or a larger urban area with housing, business centers, secondary schools and businesses in various sectors. From here, the step is not far to the complete society with housing, businesses, and municipal self-government. See Figure 5.28.

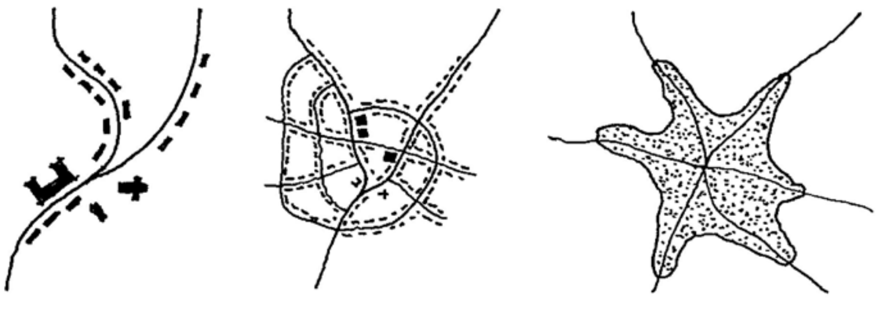


Figure 5.28. Formations of society at different stages.

The buildings have an extensive spatial extent and a characteristic external figure. By using buildings for their activity, sociosystems also acquire a spatial figure characterized by the building. However, the spatial extent of society and settlements is not identical. Human activities can extend over far larger areas than those that are built up.

### 5.5.9 Barker and Habraken

The understanding of the interaction between man and the environment in human activities has formed the basis for the formulation of the theory of ”behavior settings” (Barker 1968:18-23). By a ”behavior setting”, Barker refers to a concrete unit of activity and environment in which the environment encloses and is spatially coordinated with the activity. Activity and environment here have a mutual dependence that makes it possible to separate these as a unit from other such units. A ”behavior setting”, Barker also calls a ”synomorph” based on the spatial coordination between the behavior and the environment. He also believes that a ”behavior setting” is to be regarded as a community part but does not imply any social theory based on the concept of ”behavior setting”.

In Barker’s concept of ”behavior setting”, the activity exercised is of central importance. The environment of the activity consists of both artifacts and natural things with the property of being spatially coordinated with the activity. Barker’s concept of ”milieu (environment)” can therefore be assumed to have the same reference class and meaning as the concept of place as defined in section 5. In this regard, it can be stated that a ”behavior setting” corresponds to the user-place system rather than to the user-building system.

Dahlgren et al. (1973) refer to Barker's research. It notes that human activities involve the use of ”physical components” and concludes that the study of human activities must be done as the study of so-called activity systems whose composition consists of users and physical components.

John Habraken has noted with the terms ”support-infill” that a building and its users together constitute a control system. Different parts of the building can be controlled by different users, whereby the social relations between the users are correlated with which parts each user category controls.

Buildings are composed of different types of parts with regard to who in the user system controls them. The parts of a building that are jointly controlled by the users have the name *support* while the parts of the building that are controlled by individual users have the name *infill* (Habraken 1972). The terms ”support-infill” do not have to do with the properties of the building, but with the control of the building's parts. However, the term ”support” often refers to the load-bearing and climate-protective parts of the building. The term ”infill” is used for various complementary parts such as non-load-bearing partitions, cabinet equipment and appliances.

The background to the development of the concepts of ”support-infill” was Habraken's desire to design residential buildings that could enable the residents of apartment buildings to decide for themselves over the design of their housing. This right is considered self-evident for those who have their own single-family house. For Habraken, living is not a passive use of a given building but living means actively taking part in the design of one's own life: ”to dwell is to take action” (Habraken 1968). Thus, human life is different activities, and the dwelling is included among the tools used to achieve the purpose of the activities. According to this view, the right to shape one's own life presupposes the right to design or in essential respects decide on, among other things, the design of the dwelling.

Considering this principle, Habraken and his collaborators at the Dutch research foundation SAR developed a design method called the ”Support Method”. This method makes it possible for a systematic evaluation of the house's properties to be supplemented with various ”infills” with a definite ”support” (Habraken et al. 1976). The method is particularly useful in the study of the basic spatial properties of the ”support” parts and how these, using the complementary ”infill” parts, make possible the resulting spatial properties of the building as a whole.

Barker's and Habraken's theories and concepts lead to an in-depth knowledge of the man- building interaction. They are systemic in that the compilation of the parts give rise to new things with emergent properties. They are also anti-reductionist in that the parts are not reduced to being only buildings or only sociosystems, but already the smallest parts are sociotechnical systems.

## 5.6 The structure of the user- building system

### 5.6.1 Use and control of tools

The relations between buildings and users arise when people use the building as a tool for some activity. The bonding connections between the user and the building include the relations between the user and the parts she controls, as well as the relations with the parts of the building that she uses but does not control. The latter parts belong to the environment of the user- building system. Both kinds of relations are tool relations, but only the former are also control relations. A distinction should therefore be made between use and control of a tool.

In human activities, tools are used and controlled. Depending on the purpose of human activities, social systems and tools are organized in different ways. Four main categories of use and control can be distinguished depending on whether sociosystems use different tools or the same tools and whether they control the tools individually or collectively.

The main categories are as follows:

1. sociosystems use and individually control different tools (1 in Figure 5.29);
2. Sociosystems use different tools separately but control the tools jointly (2 in Figure 5.29).

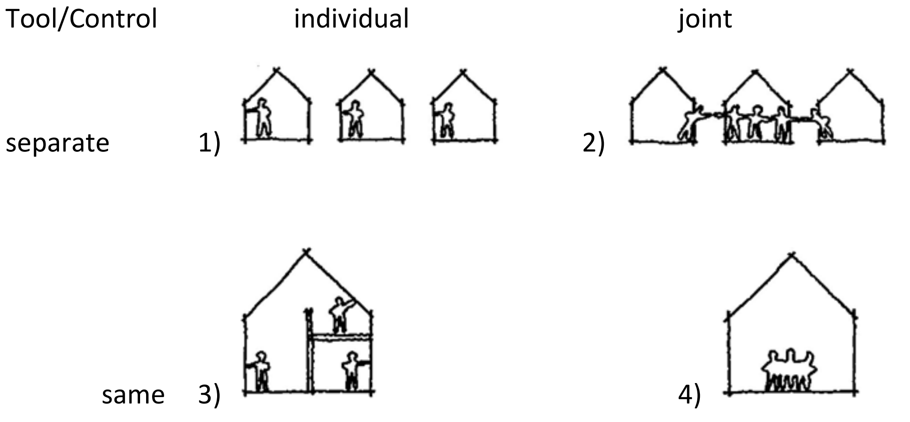



Figure 5.29. Different sociosystems use different tools or the same tools and control them individually or collectively.

3. Sociosystems use and control the same tools separately (3 in Figure 5.29).
4. The sociosystems use the same gear separately and control the gear jointly (4 in Figure 5.29).

It can be stated that case 3 is not a stable sociotechnical system but must lead to a reorganization to one of cases 1, 2 or 4.

The above principles apply generally but can be exemplified by several typical cases taken from the use of buildings. *Case 1* corresponds to the situation in a single-family house area where households separately use the houses and individually control them, for example through property rights. Some roads are both used and controlled in a similar way, such as private roads or farmers' land roads.

A situation such as in *case 2* means that separate houses are used by separate households but that the control of the houses takes place jointly. Such joint control may relate to different properties and be organized in different ways. The control can refer to the aesthetic design of the houses, as when you want to protect a culturally valuable building. The control can also relate to the activities in the houses. For example, if it should be accommodation or other activities.

Control of the tool does not always have to be exercised by those who stay in it. A house can be used for more activities than accommodation, e.g., as an investment object. The owner may not live in the house himself. Control of activities and tools can also take place with the aim that the properties should fit the properties of society. Such control is exercised by various authorities, such as planning authorities and building boards. In connection with the control of the properties of the house, the persons of authority belong to the system that uses and controls the house.

*Case 3* means that users with completely different activities and purposes use and control the same building. It can be a house or a road without any kind of joint control, something that in practice is impossible. The situation leads to conflicts that can be resolved in three ways. One solution involves bringing about a situation such as in case 1, for example, by dividing the house into separate parts with separate use and control such as a semi-detached house or townhouse. The second solution is to bring about a situation like in case 2 by dividing the house for separate use but with some kind of joint management organization to coordinate the different household control of the house (houses). Such a total division of a house into technically separate houses is rarely possible, which is why some parts such as a joist, a wall or a roof must be used in common. Parts used jointly by different households must be controlled through joint control organization. This relation is an example when case 4 arises.

*Case 4* involves separate households using the same building and controlling this jointly. Above all, this situation is common in the use of so-called public roads and places. As a rule, the control of these does not take place at the time of use itself, but in connection with construction and redevelopment. The same situation prevails in the case of the use of a common house by separate households. As mentioned above, the frame, exterior walls and roof are used jointly by the residents and therefore these parts are also controlled jointly or by some superior authority. However, the control of these parts is difficult to exercise due to the composition of the parts. The parts are large, heavy, and energy-intensive to handle. As in the case of roads, control of these parts is most often exercised solely in connection with new construction and reconstruction.

The roads are part of transport systems along with vehicles and other means of transport. Vehicles, in contrast to roads, are separate tools that are used and controlled by different social systems. A corresponding ratio prevails in the use of certain building parts. Furniture and furnishings are among the tools used and controlled as separate parts of different social systems. This use is thus an example of case 1.

The joint use and control of a tools which, in case 4, is thus rarely carried out in a purely controlled manner. Usually, the tools are used and controlled as combinations of cases 1, 2 and 4. How use and control are organized is partly a question of which social organization and which social relations one prefers and partly a question of the possible properties of the tools. If, from a social point of view, preference is given to individual use and individual control, the aim is to design tools that make this possible. If, on the other hand, you want joint use and control, you strive to design tools for this. Thus, when designing tools, for example when designing buildings, one must not only think about the use of the tool, but also about how and by whom it is to be controlled. Regardless of what you want, some tools must be common, for example for resource reasons such as roads or bridges and for other reasons such as land and sea.

### 5.6.2 Use and control of places

A place can be used and controlled by different sociosystems. Depending on the activities one wants to practice, use and control are organized in different ways. A place may be divided in terms of use into parts for common use and parts for individual use according to cases (l), (2) and (4). The parts used jointly are jointly controlled as in the case of example 4; while the parts used individually can be divided into those that are controlled jointly and those that are controlled individually, i.e., according to the principles described above in cases 1 and 2, respectively. See Figure 5.30.

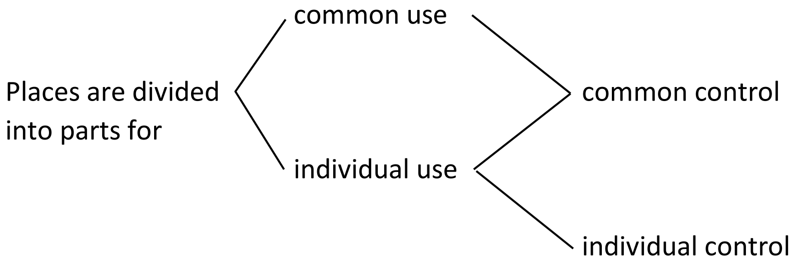



Figure 5.30. Subdivision of places of joint and individual use and control.
Parts that are individually controlled are called individual parts (I) and parts that are controlled jointly are called common parts (C). See Figure 5.31. The common parts (C) of an apartment building are those that John Habraken calls ”support” and the individual parts (I) are those that he calls ”infill” (Habraken 1972).

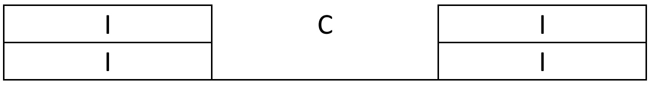



Figure 5.31. Subdivision of ground in individual and common areas

The problems that arise when using and controlling a place include how this can be organized for joint and individual use and for joint and individual control. The problems will be slightly different depending on the structure of the place. If the place is a system with a relatively strong integration between the parts, one sociosystem can influence another through its activity in the use of the place. This problem must be solved by the place being jointly controlled by the sociosystems according to any of the cases 2 or 4, or some combination of these.

When using a land area for cultivation or settlement, there is usually no significant impact between parts of the land used for different activities. Use and control can therefore be organized according to case 1 in separate areas for individual use and control. See Figure 5.32. Areas of transport are often used jointly and are therefore also jointly controlled according to case 4. The division of land into these different categories is discussed in more detail in the sections on territories 5.6.12-13.

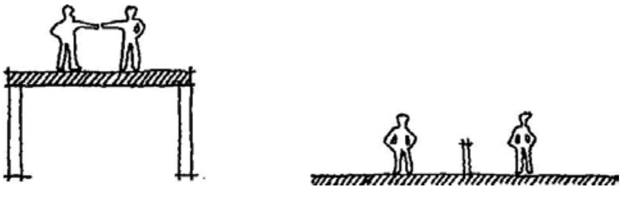


Figure 5.32. Floors must be controlled jointly while land can be controlled individually.

In buildings, use and control must be coordinated with the action orders in the sociosystem and the building. This is further addressed in sections 5.6.7f on the coordination of social and technical hierarchies.

In the use and control of tools by man, the possibility of communication emerges. Human interpretation and experience of buildings is further dealt with in section 5.7 on interpretation relations.

### 5.6.3 Use and control of buildings

A building such as a house can be used by different social systems for different activities. A joist can be divided into areas for individual use and joists can be built in separate floors. A joist differs from an area of land in that it is composed of strongly integrated parts. If different social systems are to use the same floor for their different activities, it must be used and controlled according to case 2. It is then divided into areas for individual use, but it must be jointly controlled by the users. See Figure 5.32. In the same way, the parts of the frame of the house that carry several joists must be checked jointly by those who use the joists.

Like a land area, a house can be divided into parts for common and individual use and for joint and individual control. In an apartment building, a stairwell and a laundry room can be used and jointly controlled according to the principle in case 4. The house's joists, load-bearing walls, and facades form apartments. These parts are used individually but must be checked jointly according to the principle in case 2. Within the apartments, non-supporting interior walls, cabinet equipment and furniture (infill) can be both used and checked individually according to the principle in case 1. See Figure 5.33.

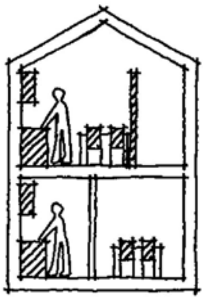


Figure 5.33. Subdivision of a house into parts for joint control (light) and individual control (shaded).

### 5.6.4 Rank and universality of parts of buildings in the user-building system

The properties of the parts of buildings are fundamental to the properties of buildings as a whole. It has previously been pointed out that in a system with an action order, parts with a higher rank are more fundamental to the properties of the system as a whole than parts with a lower rank. For example, when building parts are assembled in the order determined by their mutual rank, the resulting construction becomes increasingly complex. The properties that emerge in the early stages of the assembly process are fundamental to the properties that emerge in later stages of the process.

The properties of parts of higher rank can also be called a *framework*. They limit the possible states of the whole that arise according to their composition with parts of lower rank in the hierarchy. A building frame has a certain strength and a certain configuration, these properties limit the possible weight of the parts that can be carried by the frame and limit the spatial extent of the parts that can be housed in the building.

The parts of buildings are fundamental to the activities that can be carried out with the help of a building. The parts of buildings with the highest rank are the most universal. They are used and controlled jointly by different users. The more specifically useful parts are used and controlled separately by different users. For a house to be used as a residential building, the common parts must be designed so that they enable the kind of housing activity to be exercised, for example, family housing in separate households. The individual components, on the other hand, should allow for the variety of housing activity that is desirable in view of the differences in the composition and activities of families. This reasoning is based on the fact that some housing activities are general, i.e. they are the same for all households and that other housing activities are specific, i.e. they distinguish the individual household.

Activities as having pets, going to the sauna, and collecting porcelain are specific and vary greatly between households. Activities such as socializing, cooking, sleeping, and washing are general and do not vary to the same extent. Even within the individual household, housing varies over time.

In principle, this means that the parts of buildings can be divided into different classes based on the degree of universality of use. In a residential building, three classes of parts can be distinguished, namely *basic building parts*, *built-in parts*, and *interior parts*. See Figure 5.34. Regarding their rank in the various hierarchies of the building, they are *primary*, respectively, *secondary* and *tertiary*. This classification is because it provides appropriate opportunities for variation of the activities of the using systems during the lifetime of the house. The number of classes can be both fewer and more, depending on the desired opportunity to vary the activities. The use of loose furniture, for example, is of relatively late date. See Figure 5.34.

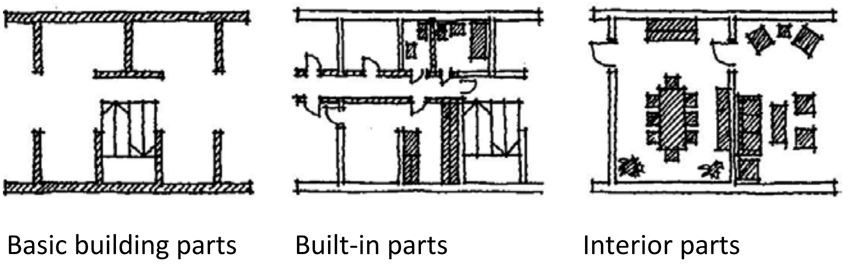



Figure 5.34. Designations of different parts of buildings based on the degree of universality of use.

The *basic building parts* are those that are fundamental to the most general properties of buildings such as climate protection, strength, and general spatial structure. These primary parts include the building's frame, external walls, roof, and trunk pipes. The *built-in parts* are fundamental to the properties that characterize the individual dwelling such as room division and furnishings. These secondary parts include the building's non-load-bearing walls, fixed furnishings and branch pipes and lines for water supply and electricity. The built-in parts may change if the household's activities change but are universal for the household's housing activity over a longer period. The *interior parts*, the tertiary parts, are fundamental to the specific housing activities of the household. They can be changed without the need to control the secondary parts. The tertiary parts include loose furnishings such as furniture, fixtures, cords, and taps.

The division of building parts into primary and secondary is also done by Dluhosch and Kader (1978:4). The division can be related to the classification of the National Board of Building into building-related and activity-related parts. The former can be considered primary while the latter are secondary. Building control then also uses an even finer classification principle in connection with the classification of different levels of changeability. The levels from 0 to 4 correspond to a division of building parts into five different classes with a successive rank (Byggnadsstyrelsen 1984).

Buildings can be divided into areas for the control of building parts of different ranks. In this context, three categories of areas can be distinguished according to the rank of the building parts to which the control relates. The area within which the primary parts are checked can be called the *primary area*. It covers the entire building and really the entire area of a property that is allowed to be built on. The area within which secondary building parts are controlled can be called *secondary area*. The division into secondary areas can be made within the space enclosed by the primary parts of the building. Examples of secondary areas are apartments. Finally, the area within which tertiary building parts are controlled can be called *tertiary area*. Examples of tertiary areas include living spaces. They are delimited by both base building parts and built-in parts. See Figure 5.35.

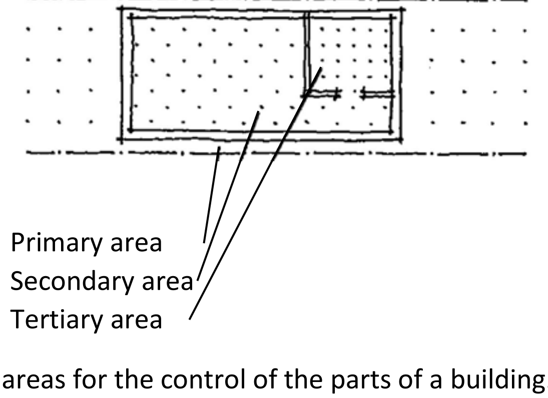



Figure 5.35. Subdivision into areas for the control of the parts of a building.

### 5.6.5 Change of activities

A change of a property corresponds to a change in the composition or structure of the thing that has the properties. For the activity of the user-building systemto change, it is necessary that the building, the user or the relations between them change.

Changes can be superficial or deep, as well as small or large. The change in an activity can vary from superficial and small such as shifting from conversing to watching TV, to deep and large as transitioning from housing to industrial production.

To be able to change an activity in which a building is used as a tool, it is advisable that the properties of the building are such that superficial and small changes in activities correspond to the same changes in the building. Shifting from conversing to watching TV may require a change in seating furniture. Deep and major changes in activities may require corresponding changes to the building. Transitioning from housing to industrial production may mean that the building must be rebuilt so that it has a greater room height, more powerful joists, etc. See Figure 5.36.

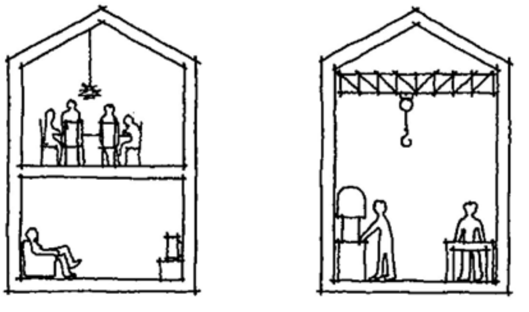


Figure 5.36. The change of a residential building to industrial building is a deep and major change.

Different activities require different tools to be performed. Some parts of a building are used for all activities, such as frame and exterior walls, while other parts such as furniture are used for a limited number of activities. The parts that are used frequently can be organized either so that they do not need to be changed for the activity to be possible (you do not build a house every time you sleep, except during the tent holiday!) or so that they are easy to change when they are to be used (such as a tent or a chair on wheels). The former belong to the environment of the system while the latter are included and controlled within the system.

The user who wants to change her activity must control the parts of the building that prevent or enable the change. To change the activity from conversing to watching TV, the user must control the furniture she uses. Correspondingly, the household must check the partitions in the apartment if the change of activity requires a change in room division. To be able to change activity from housing to industrial production, users must control both the structure of the building and the new subsystems required.

Changes in the activities of the user-building system can be classified with respect to the building parts that change. Thus, it is possible to change interior parts, built-in parts and basic building parts. The former are affected by all changes, even minor and superficial ones, while the latter are only affected by major and deeper changes in activities.

### 5.6.6 Level, activity, and control of buildings

The user-building systemis composed of parts in different levels. The parts have activities that are fundamental to the activity of the system as a whole. For example, a *household* has *subsystems* with the activities ”to cook” and ”to wash”. The users of these subsystems use some parts of the house in common and other parts individually. The individual parts can be controlled within the respective subsystems, while the common parts must be controlled by the subsystems together.

The household members who cook control the kitchen equipment, and those who wash control the washing equipment. Both user categories use the floor, ceiling, and walls of the building. Of the building parts, the wall between the kitchen and the laundry room can be controlled by those who cook and wash together, for example, if you want to expand the kitchen at the expense of the laundry room. Thus, such parts of the building that the household members decide on together are controlled by the household as a whole. The *household* is a system in a higher level.

If several households use the same building, common parts must be controlled by higher-level systems than those of households. This common system can be called a *management system*. The management system controls the joint systems, load-bearing frame of the building, walls, roof, heating system, etc. See Figure 5.37.

| Level | Control | Parts |
|---|---|---|
| Management system | → | Frame, roof, etc. |
| Household | → | Interior walls |
| Household subsystem | → | Kitchen and laundry equipment |

Figure 5.37. Levels and control of elements of a management system.

Different parts of the building are controlled by systems belonging to different levels. As a principle, *building parts used jointly by separate systems of users and buildings at the same level are controlled jointly in their supersystems in the next higher level.*

### 5.6.7 Coordination of technical and social hierarchy in the user-building system

As between the building parts, there are hierarchies between users belonging to the social subsystem of the user-building system. User hierarchies are related to the purpose of the entire system in that users who carry out the most general activities in the system have a higher rank than those who carry out more specific activities. In the user-street system, traffic rules express the hierarchical relations between the different road users. In Sweden, for example, road users at a roundabout have priority over road users from connecting streets. The purpose of ‘flowing’ traffic is facilitated by this provision. The most general activity is to move and to avoid traffic jams. The accommodation activities require a technically well-functioning house. Users responsible for the maintenance of the house have the highest rank. The users of the social subsystem are divided according to their rank in the hierarchy of the system into *primary*, *secondary*, and *tertiary*. In a management organization, the board can be primary, the household secondary, and a subsystem of the household tertiary.

In a building, there is an order of action between the parts. In the case of an activity, it may be necessary to control an acting part which may cause that an activity exercised with an affected part may be disturbed. This means that the activity involving the control of the acting parts of the building must be considered more important for the purpose of the entire user-building than the activity that requires control of the affected parts. One consequence of this is that the person who controls an acting part must have a higher rank than the person who controls an affected part.

Considering the gravitational hierarchy of the building, this means that people whose activities require control of the load-bearing parts of the building have a higher rank than people whose activities require control of the building’s borne parts such as partitions or furniture. The enclosing hierarchy means that people whose activity requires control of the outer shell of the building have a higher rank than people whose activities require control of the interior walls or furnishings of the building. The same applies in the flow hierarchy. People whose activity requires control of the trunk pipes of the house have a higher rank than people whose activity requires the control of side pipes and fixtures.

The control of the tool is then organized so that users with the highest social rank control the parts that have the highest technical rank. Users with lower social rank control parts with lower technical rank. The most universal parts of a building can be used for all activities in the building. These parts are controlled by people of the highest social rank. People with higher ranks can thus make more fundamental changes to activities than people with lower ranks. The higher the rank of the building parts that one controls, the more fundamentally one can influence the activities that depend on the use of buildings as tools.

John Habraken (1982:28) has dealt with the relation between technical and social hierarchy. He draws attention to, among other things, how among people who control parts with different ranks in a technical system there is a dominance relation such that those who control parts with higher rank dominate people who control parts with lower rank. Habraken assumes that control of things determines social rank. In this thesis, the starting point is that the social rank is primary and that the dominance relation already exists when decisions are to be made about the control of parts with different ranks.

### 5.6.8 Hierarchies and levels of the user-house system

As an example of the principles mentioned in section 5.6.7, we can mention decision levels and decision-making hierarchies in a system of users and houses, e.g., a tenant-owner association. The different households use the house for the activity of living. By using the same tools for your activity, the tools must be shared. The house is divided into areas (apartments) where each household can decide individually how to live as long as they do not conflict with the wishes of other households. As for the use of building parts, this means that the household can decide on the location of non-load-bearing partitions and the laying of wires within their apartment.

If a household wants to change any part of the building that is also used by other, this must be discussed at the level of the housing association, for example in the association's board. The board decides which activities are compatible with the purpose of the association and controls the parts of the building that are fundamental to the most general activities of the association. Such parts are the load-bearing frame, roof, and facades, as well as main tubes and lines for electricity, water, and sewage. Within each household, the individual family members often have their own spaces within which they can determine their accommodation, among other things, by controlling the loose furnishings such as furniture, fixtures and paintings. The family member, together with the parts she controls, forms a part of the system in the household.

In a tenancy management system, residents traditionally have no opportunity to influence the design of either the house or the apartment. Such decisions are made by the management organization, for example, a private property owner or a person in a public housing company. These people are responsible for the economic value of the property and prioritize the investment activity before the accommodation, which means that the residents are not allowed to make decisions about such parts of the building that may affect its value. Such parts are usually all the firmly integrated parts from frame to wallpaper.

The social hierarchy and the number of decision-making levels in the user-house system are in reality more extensive than that reported in the example. Superior to the manager, there are several different authorities that decide on the properties of the system. Examples include the state loan granting bodies, the municipal building board, etc. The activity ”to live” is an intrinsic relation in society and must contribute to the desired properties of society as a whole. The authorities decide on such parts of the building whose properties affect the members of society. For example, the base building parts whose spatial properties must be adapted to a specific building pattern and whose exterior (facades) must be adapted to surrounding buildings in proportions and choice of materials. The common parts of the grids for electricity, water and sewage must also be adapted to the requirements of the authorities. The Building Board has given such common parts the designation ”community-related parts”.

The authorities represent the interests of society. They belong to the environment of the user-house system because they do not use the house to live and they delimit the properties of the system. Trustees and residents control the house within the framework of these restrictions. In the case of new construction of a larger area where a house is placed in one block in the area, the situation is different. Here it may be appropriate to include the planning authorities in the system since their decision on the properties of the house has not yet been determined.

However, it is of particular interest in the design of buildings to describe how the parts of the building are controlled. Such a description can be carried out in two separate ways. One way is to describe how decisions about building parts of different ranks are made at different levels of the user-construction system. The second way is to show how the hierarchies in the user system are coordinated with the hierarchies in the building. Both modes of description can be presented in a joint presentation that can be read in two ways, partly from the level aspect and partly from the hierarchy aspect. Figure 5.38 presents an example of decision-making levels and the coordination between the social hierarchy and the three technical hierarchies in the house-user system.

| Parts | Social hierarchy | Gravitation hierarchy | System level |
|---|---|---|---|
| Primary | Manager | Frame | Administration |
| Secondary | Household representative | Non load-bearing walls, cupboards | Household |
| Tertiary | Household member | Wall cabinets, paintings | Household subsystem |

| Parts | Social hierarchy | Enclosing hierarchy | System level |
|---|---|---|---|
| Primary | Manager | Exterior walls, roof, floors/ basic space | Administration |
| Secondary | Household representative | Internal walls, fixtures / built-in space | Household |
| Tertiary | Household member | Furniture, equipment /furniture space | Household subsystem |

| Parts | Social hierarchy | Flow hierarchy | System level |
|---|---|---|---|
| Primary | Manager | Duct piping | Administration |
| Secondary | Household representative | Side-piping | Household |
| Tertiary | Household member | Hoses | Household subsystem |

Figure 5.38. Examples of hierarchies and decision levels in the user-house system

The above three schemes can be summarized in a common scheme. See Figure 5.39.

| Parts | Social hierarchy | Flow hierarchy | System level |
|---|---|---|---|
| Primary | Manager | Basic building parts | Administration |
| Secondary | Household representative | Built-in parts | Household |
| Tertiary | Household member | Interior equipment | Household |

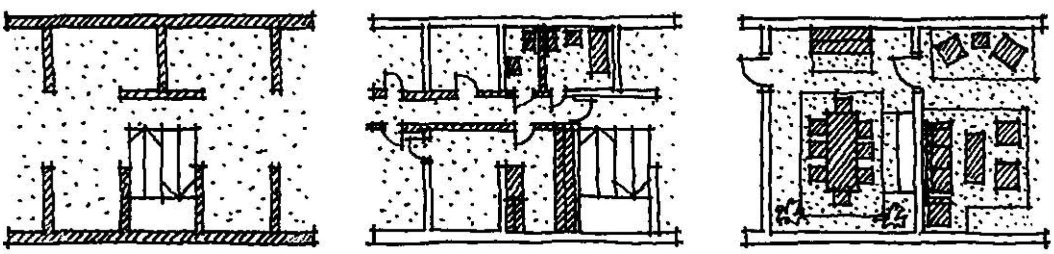
| | | | |
|---|---|---|---|
| | | parts | subsystem |

Figure 5.39. Summary of hierarchies and decision levels in the user-house system.

Section 5.6.6 set out the principle that building parts used jointly by different systems at the same level are jointly controlled in their supersystems. In the above example, this means that the household subsystems together use the entire building but only control the tertiary parts such as interior parts of the type luminaires, furniture, and cords. The primary and secondary parts of the building form the environment of the household subsystem. Within the household, both interior parts and built-in parts are controlled, i.e., both tertiary and secondary parts. However, the household environment includes the primary parts of the building, the basic building parts. These can be controlled together by households at the level of the management system. Thus, the management system can control both the primary, secondary and tertiary parts of the building.

The example illustrates the situation that is common in the management for a condominium. In the tenancy form, it is usually not allowed for the household to control the built-in parts of the building. Thus, the household is not allowed to control partitions, fixed furnishings or wiring in the apartment. The household as a level of decision-making regarding the properties of the building is eliminated and the need to specifically distinguish secondary building parts according to their universality is largely lost. If the manager alone inhabits the building, there are neither secondary nor tertiary members of the social system. In this case, the division of the parts of the building into primary, secondary, etc. becomes dependent only on the technological hierarchies. The members of the sociosystem have been given designations suited to the example but could of course have been others. In a company, they might have been the managing director, department head and subordinate staff.

In accounting for the enclosing hierarchy, I have called the space formed by the base building parts of the building *base building space*. The space formed by interior walls and fixtures can be called *built-in space* and the space bounded by furniture and interior equipment *furniture space*. The base building space can be divided into smaller built-in spaces, which in turn can be divided into different furniture spaces. See Figure 5.40.



Base building space Built-in space Furniture space

Figure 5.40. Designations of the spaces formed by the base building parts, built-in parts and furniture parts (including their use space) of the building.

In a house, a flow hierarchy arises not only in electricity, water, and sewer tubes and lines, but also through person traffic through rooms, corridors, and stairwells. Control over the flow is exercised in the above examples by the individual household member in his room, by the household representative in the apartment's communication areas and by the manager in the stairwell. See Figure 5.41.

| Parts | Social hierarchy | Flow hierarchy | System level |
|---|---|---|---|
| Primary | Manager | Stairwell/ basic building parts | Administration |
| Secondary | Household representative | Floor walkways/ built-in parts | Household |

| | | | |
|---|---|---|---|
| Tertiary | Household member | Room walkways/ Interior equipment parts | Household Household subsystem |

Figure 5.41. Flow hierarchies of person traffic in houses.

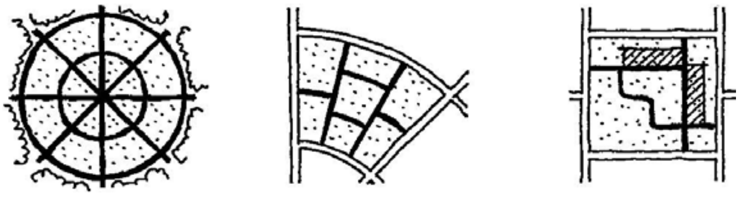
### 5.6.9 Hierarchies and levels of the user-street system

Similar schemes to those illustrated above arise in transport systems such as the user-road system. This consists of buildings specifically designed to enable road traffic and by road users with or without vehicles. The user-road system is a sociotechnical system. It has a spatial structure of various so-called catchment areas. *Catchment area* is the area in which users of a particular road have their starting and destination points.

The number of users in a road depends on several different factors. The road can be the closest or the fastest route, it can have attractive part goals, etc. The route with the most road users is the *most connecting* among the roads within an area. In a complex road network with many alternative routes, it is not a given which of the routes will be the most connecting as both passability and target points can vary over time.

In the user-road system, there is a flow hierarchy between road users in different routes. Road users in the most connecting routes of a transport system have the highest rank in the hierarchy of the elements of the system. The most connecting routes must also be the most universal in the transport system. They are used by most users for various transport activities. The routes that are most connecting are used and controlled jointly by all users throughout the catchment area of the transport system. The connected routes are used and controlled by a subset of the entire number of users in the transport system. If the road users' starting and destination points are evenly distributed within the catchment area of the traffic system, the most connecting route has the largest catchment area, i.e., the entire area. The catchment area for connected routes is part of the catchment area for connecting routes.

When planning for car traffic in urban areas, a distinction is usually made between *primary roads*, *secondary roads*, *feeder roads* and *local streets*. The former are considered more connecting than the latter. The catchment area of primary and secondary roads for car traffic can be the whole *city*. They connect different parts of the municipality, neighborhoods, and areas with each other. The catchment area for feeder roads and local streets is the *municipality part*, the *district*, and the *area*. They connect the city's quarters among themselves. The block lane connects the individual houses in the block and the catchment area is thus the *block*. See Figure 5.42.



| | | |
|---|---|---|
| Primary roads secondary routes | Feeder roads local streets | Neighborhood lanes |

Figure 5.42. Trails and catchment areas (dotted).

To protect against noise and pollution from car traffic, the aim is to lay the most connecting car traffic roads as primary and secondary roads outside the city center and residential buildings. In doing so, an attempt is made to make these roads attractive, for example by making them wide and safe in order to allow higher speeds. At the same time, an attempt is being made to reduce the attractiveness of the previously most connecting roads in the central parts of the city by, for example, one-way and banning transit.

Pedestrian and bicycle traffic has its own flow hierarchy of connecting and connected routes. In cities of older times, pedestrian and bicycle traffic used the same streets as car traffic, but with the increased motorization has followed a division into two separate traffic systems. In this context, pedestrian and bicycle traffic has continued to be able to use the streets of the central districts. The most connecting roads are usually the traditional business routes. They have a central location in the city and they are often easy to reach because they are close to the routes that road users use to quickly get into the center.

There is also an enclosing order in the user-road system. In particular, this applies to a vehicle-trafficked road network in an urban agglomeration. In doing so, the different roads delimit different areas. Neighborhood lanes demarcate plots of land. Local streets and feeder roads demarcate neighborhoods. Primary and secondary roads delimit areas, districts, and municipal parts. See Figure 5.43.

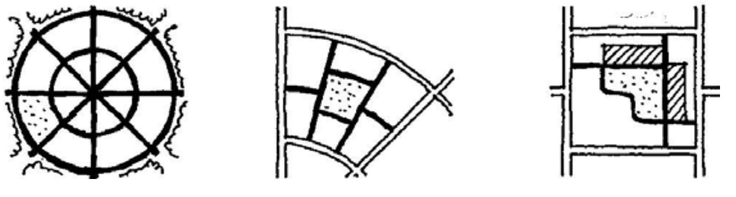



Figure 5.43. Trails and demarcated areas (dotted).

The traffic routes can thus have the dual property of both uniting and separating the areas of the settlement. The separating properties increase with increasing vehicle traffic and increasing vehicle speed. To counteract the separating effects of car traffic, most dense built-up areas have been provided with separate pedestrian and bicycle paths that can once again unite the areas previously separated by car traffic.

Traffic rules are an expression of the hierarchical relations between the parts of traffic systems, the road users. According to traffic rules, road users travelling on a connected road must give way to road users travelling on a connecting road, for example at the exit on the main road or to a motorway. If it is not possible to clearly discern which road is most connecting, the so-called right-hand rule usually applies, which means that road users give way to vehicles coming from the right.

The traffic rules are designed to enable the purpose of the traffic system, which can be said to be partly to connect as many target points as possible with each other and partly to enable road users to travel as fast as road safety allows. There are examples of times when this latter purpose changes such as when emergency vehicles, demonstrators and funeral processions are parts of the system. Such parts have a higher rank because their purpose is considered more important than that of other road users. The former Swedish ambassador Hägglöf mentioned on a radio program in 1985 that the Russian leaders in Moscow have free speed regardless of which roads they use. This is another example of cases where the purpose of certain road users is considered more important than the normal purpose of the traffic system.

The vast majority of traffic roads are public, i.e., they are used and controlled jointly by the users. The control is carried out through the authorities and representative bodies of various kinds. The conditions in the user-road system are thus not the same as in the user-house system, which has several different types of building parts that are controlled in several different system levels by people of different ranks. In the user-road system, there is a vanishingly small part of the roads controlled by individuals. There are ”private roads” located within private properties which are not accessible to public traffic. There are also ”private roads” managed by private road associations but still accessible to public traffic.

In the normal use of traffic roads, it is sufficient to distinguish between two types, those that are licensed for public traffic and controlled in the level of the traffic system as a whole, and those that are used individually and controlled at the level of the individual road user. The roads that are jointly controlled are primary while the roads that are controlled individually are secondary. See Figure 5.44.

The joint control of public transport routes is exercised by various authorities. This control may relate to conversion or new construction of roads, determination of speed limits etc. The private road user can only exercise this kind of control if she has a private road, for example, a land road to a farm or a garage road on a plot. The flow hierarchy in a traffic system is presented in Figure 5.45.

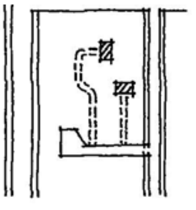


Figure 5.44. Public routes (continuous line) and private routes (dotted lines).

| Parts | Social hierarchy | Flow hierarchy | System level |
|---|---|---|---|
| Primary | Authority | Traffic in a public route:<br>Primary route---local street | Traffic system |
| Secondary | House owner | Traffic in a private route:<br>Land road, garage road | Traffic subsystem |

Figure 5.45. Flow hierarchies and levels in a traffic system.

In a longer time perspective than that applicable to individual transport activities, the route and design of the roads in the user-road system may need to be changed. The more connecting a road is, the higher the rank of its road users and the more road users are affected by the change. Decisions on the changes are made by planning authorities in different levels of society depending on the rank of road users in the transport systems.

The social systems referred to here are municipal parts, municipalities, and urban regions. They use and control land and civil engineering systems for various activities. Such parts that are used jointly are jointly controlled in supersystems of the next higher level. Thus, the most connecting roads in a traffic system are used jointly by several municipalities and are therefore controlled by systems at the regional level.

In connection with the control of different roads, a social hierarchy arises between the authorities that control different roads of the system. This social hierarchy is based on the fact that the properties of the most connecting roads are more important for the properties of the transport system as a whole than the properties of the connected roads. The road users of the most connecting roads have the highest rank in the flow hierarchy of the transport system. These roads are controlled by the authorities that have the highest rank in the social hierarchy. In a municipality, for example, the master plan authority can control the route of primary and secondary roads, while feeder roads and access roads are controlled by the detail planners.

This example of the social hierarchy in the planning system and the flow hierarchy in the traffic system is illustrated in Figure 5.46. The figure also shows the level of systems at which decisions on the properties of various roads are made.

| Parts | Social hierarchy | Flow hierarchy | System level |
|---|---|---|---|
| Primary | Authority for regional plan | Traffic in a regional route | Region |
| Secondary | Authority for general plan | Traffic in a primary or secondary route | Municipality |
| Third | Authority for detail plan | Traffic in a feeder route and a local street | Municipality part |
| Fourth | Private person house owner | Traffic in a plot road or garage road | Property |

Figure 5.46. Flow hierarchy and levels in a traffic system.

### 5.6.10 Hierarchies and levels of the system user-settlement

In the examples of the user-house system and the user-road system, I have presented the relations between hierarchies in sociosystems, and buildings and the levels of sociotechnical systems where the control of different parts takes place. Users in both systems use and control land and building parts with varying spatial extents ranging from the smallest areas occupied by the individual and the furniture to the community's use of entire regions. These two level orders together provide a description of how a settlement is used and controlled by systems in different levels. A characteristic feature is, among other things, that an area used by a system in a lower level is bounded by parts controlled by systems in higher levels.

For the user-house system, subsystems in lower levels use parts of buildings that are controlled by subsystems in higher levels. Between the parts of the building, there is an action order so that parts with a higher rank are controlled at higher system levels and parts with a lower rank are controlled in lower system levels. The ranking refers to the gravitational, enclosing, and flow hierarchies.

Similarly, for the user-road system, subsystems at lower levels use transport roads controlled by subsystems at higher levels. Between road users in different roads, there is an order of action that requires connecting roads to be controlled at higher system levels than connected ones. These systems also have an enclosing order whereby connecting roads delimit the catchment areas of the connected roads. This is particularly the case in denser settlements.

These level orders are also characterized by that the spatial extent of lower-level sociotechnical systems are part of the area occupied by sociotechnical systems at higher levels. A person sitting in a chair uses an area that is part of the interior area of the building. The building occupies part of the area of the property and the property is included in the municipal part area which· in turn, occupies part of the area of the whole municipality, etc. The results of these analyses can be compiled into two characteristic hierarchies and level orders that exist in the user-settlement system, an enclosing hierarchy and a flow hierarchy. See Figures 5.47 and 5.48, respectively.

Figure 5.47 shows both the delimiting parts of the building and the area enclosed. It is seen that building parts controlled by systems at a higher level delimit areas within which building parts are controlled by systems in lower levels. Figure 5.48 shows the roads and routes and their catchment area. A road belonging to a higher level delimits the catchment area of the road belonging to the immediately lower level.

The societal and sociotechnical levels and the ranking between the parts of the systems form the theoretical basis for the division of architects' tasks in spatial planning, including regional planning and urban design, as well as architecture including building construction, interior design, and furniture design. Thus, the difference between different tasks is not only a difference in scale, but also in the level of decision-making in the sociotechnical systems. For example, there is a difference between the decision-making processes in interior design issues and urban planning issues.

| Parts | Social hierarchy | Enclosing hierarchy | System level |
|---|---|---|---|
| Primary | Authority for regional plan | Traffic in a regional route | Region |
| Secondary | Authority for general plan | Traffic in a primary or secondary route | Municipality |
| Third | Authority for detail plan | Traffic in a feeder route and a local street | Municipal district |
| Fourth | Private person house owner | Traffic in a plot road or garage road | Property |
| Fifth/ Primary | Manager | Exterior walls, roof, floors/ basic space | Administration |
| Sixth/ Secondary | Household representative | Internal walls, fixtures / built-in space | Household |
| Seventh/ Third | Household member | Furniture, equipment /furniture space | Household subsystem |

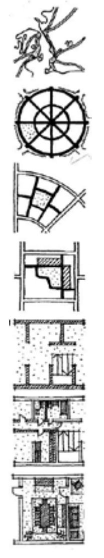


Figure 5.47. Enclosing hierarchy in the user-settlement system.

| Parts | Social hierarchy | Flow hierarchy | System level |
|---|---|---|---|
| Primary | Authority for regional plan | Regional route / region | Region |
| Secondary | Authority for general plan | Primary and secondary route / city | Municipality |
| Third | Authority for detail plan | Feeder route and local street / district | Municipal district |
| Fourth | Building committee property owner | Neighborhood lane / block | Property |
| Fifth/ Primary | Manager | Stairwell, / basic space | Administration |
| Sixth/ Secondary | Household representative | Corridor of internal walls / built-in space | Household |
| Seventh/ Third | Household member | Room communication areas / furniture space | Household subsystem |

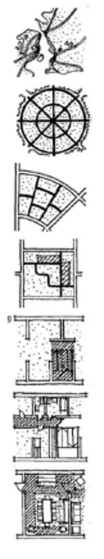


Figure 5.48. Flow hierarchy in the user-settlement system.

### 5.6.11 Activity space

Places, buildings, and sociosystems are characterized by having a spatial extent. The space that a sociotechnical system occupies can be called *activity space*. It is a combination of the spatial extent of the sociosystem, and the tool used in the exercise of an activity. The activity space of a sleeping place thus consists of the spatial extent of the bed plus the additional space necessary for a person to lie down, make beds and clean. This latter space is also commonly referred to as *serving space*.

Activity spaces can be determined by things and activities with varying configuration. A school occupies an activity space determined partly by the school building and the schoolyard and partly by the members of the school's social subsystem, teachers, school staff and students. These carry out school activities both within the school building and in the schoolyard. Preparation at home and the journey to school must also be included in the school activity. Hence it follows that the school's activity space must include spaces both in the home and in other parts of the settlement.

Spatial planning of places and activities involves, among other things, coordination of their requirements for activity spaces. The time factor is of essential importance in spatial planning. The same space can be used for many different activities if the usage times do not overlap. Lunch breaks at larger companies are often shifted in time between different departments so that the same dining room can be used by more employees than those who can only fit on one occasion. The temporal coordination of public transport between local and long-distance trains naturally also presupposes spatial coordination.

The complex of questions about the spatial and temporal coordination of things and activities on a regional and larger scale has developed into a special focus in social geography, the so-called time geography founded by Torsten Hägerstrand in Lund.

### 5.6.12 Territoriality

Thus, the activity space is the space occupied by a sociotechnical system in the exercise of an activity in a place. A special kind of activity that is practiced in a place is the *territorial activity*. The territorial activity means that one or more members of a social system control other members of the system with regard to access to as well as activities in a place. The place where the territorial activity is exercised is called *territory*.

Whether territories have an actual existence was questioned by Uexküll (1957:54) who argued that a territory ”is a completely subjective product because even the most in-depth knowledge of the environment does not give the slightest clue to its existence”. However, one cannot study territories independently of those who carry out the territorial activity. Territories therefore exist only to the extent that an area is used for territorial activity.

According to Malmberg, the fact that humans also exhibit territorial behavior is now considered to be clear. He stresses that the exclusive rights to an area with respect to use distinguish the modern definitions of the concept of territory or territory. The purpose of the territorial activity, according to Malmberg (198D:305), is to create ”space for action, protection and identification”. His own definition of the concept of territory reads: ”Human behavioural territoriality is primarily a phenomenon of ethological ecology with an instinctive nucleus, manifested as more or less exclusive spaces, to which individuals or groups of human beings are bound emotionally and which for the possible avoidance of others, are distinguished by means of limits, marks or other kinds of structuring with adherent display, movements or aggressiveness” (ibid:10-11).

Malmberg's definition includes the term ”space”, room. In explaining his definition, he also uses the term ”space” when talking about the kinds of territories included in his study: ”only spaces large enough to contain the human body are relevant”. One can criticize the use of the term ”space” because it does not represent a concrete thing but the spatial relation between things. The concept of ”place” is better because it represents a thing with, among other things, the property of spatial extent. Given that the territory is regarded as a concrete thing, a ”resource” (ibid:11), the concept of place is more relevant.

According to the previous definition, the concept of place has a much wider application than, for example, buildings. The broad definition of the concept of place and of the territorial use as a place for action, protection and identification means that there are many different types of territory in both buildings, settlements and the natural environment. Malmberg mentions furniture, buildings, areas and blocks of the city, neighborhood units, streets, parks, squares, suburbs, entire cities, as well as rural territories and other forms of territories.

Thus, a territory is an area within which a certain social control activity is going on. One must distinguish between an activity space in general and a territory. The existence of a sociotechnical system with an activity space does not presuppose that the activity of other sociotechnical systems in the area is controlled. Territorial control need not relate to all activities in a territory, but may be selective. The Swedish right of public access allows, for example, the picking of wild berries and mushrooms on someone else's forest or meadow land if no crop is destroyed.

Sociotechnical systems of users and place, e.g., nations, make laws that apply to certain activities within their territory. The control may also relate to the passage to or from the territory at the nation's borders. This strict access control has the nations in common with territorial systems on a much smaller scale such as households, shops, industrial enterprises and farms etc. where the business needs to be protected from outsiders. Even communities such as villages and towns are examples of systems that may need to exercise some control over access to and activities on their activity spaces.

Man's need for space for action, protection and identification characterizes the design of buildings. The territorial activity involves controlling within the territory other members of the social system. This has the consequence that a place that houses several social systems with the same territorial needs will be divided into several separate territories. The territorial systems divide places, buildings and settlements into territories of the type of real estate for construction, agriculture and forestry, patrolling districts for the police, defense areas e.g. FO South, sales districts, cultural regions, etc. Within each of these territories, some kind of territorial activity is practiced. The property gives the property owner certain rights. Within the patrolling districts, the officers on duty carry out guard activity, in the defense areas military activities are coordinated, the vendors divide the market into geographical areas, within the cultural regions there is a certain caution and skepticism of strangers, etc.

### 5.6.13 Private and public territories

Thus, territorial control may relate to various activities within the territory. When the control relates to access to the site, it is divided into private and public parts. The part of the territory to which users have joint access is *public*, while the parts of the territory to which users individually have access are called *private*. For those who do not have access to the territory, the entire site is private. See Figure 5.49.

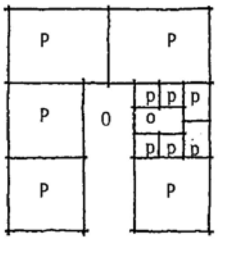



Figure 5.49. Example of subdivision of a place into private (P) and public (O) territories.

John Habraken (1982:29ff) has shown how places are divided into private and public according to corresponding principles. This use of the terms public and private also recurs with, among others, Oskar Newman and Torsten Malmberg (1983:43). Newman (1972:2-3) speaks of "defensible space" as an area "under the undisputed influence of a particular group" and that "they dictate the activity taking place within it, and who its users are to be". He also reports a division of the "defensible area" into degrees of control activity comprising the steps private, semi-private, semi-public, and public (ibid:9-10).

However, there is no simple one-to-one relation between a space and its territorial properties. Whether an area is private or public or an intermediate form of it cannot be determined on the basis of the spatial structure of the site, building or settlement alone. The same space can be divided into territories in many ways. This means that an area that is supposed to be semi-private can be used as if it were private or an area designed to be semi-public becomes public, i.e., completely without territorial control of the neighboring residents. The problem that is dealt with in ”Defensible space” is how the residents can gain increased control over their immediate environment so that it will be safer to stay in. The problem is how an environment controlled by criminals can be conquered by the residents.

The fact that an area is a private territory is often communicated by signs of various kinds. However, the control of the availability of places can be facilitated by its enclosing properties. Fortresses, castles, and prisons are examples of buildings with particularly strong enclosing properties. Even residential buildings with lockable doors have enclosing properties that make access difficult for intruders. Common to these examples is that the design of the building as a material obstacle supports the control exercised in the social system through communication.

The materially enclosing properties of a system can be strong without the enclosed space being a private territory. Conversely, territorial control can be strong without any material demarcation, for example, between two private places on a beach. The boundaries of a territory can be interpreted as signs that provide information about the territory. Border piles, signs, curbstones etc. are such signs that can designate the concept of private. These signs are not impediments in material terms but are intended solely to be interpreted as messages about the boundaries of the territory.

Territories can be both formal and informal. *Formal* means that the rights to the territorial activity are in some way legally regulated as in a property. *Informal* territories, on the other hand, are not legally regulated. Examples of these is a courtyard in a residential settlement. Those who live in the houses around a courtyard can experience the courtyard as theirs. The adults want to be involved in deciding on the courtyard’s use and equipment, while the children who play in ”their” yard can turn away children from other courtyards. The interpretation of the informal territories is an essential part of our experience of a settlement.

In a settlement, there are different degrees of privatization and publicity within an area depending on the accessibility of the area. A residential building is usually private while the street leading up to the house is public. If the house has a garden, you can expect it to be private as well. However, the availability of transparency can make it considered semi-private. The walkway outside the house is public, but if the proximity to the house makes it easy to guard from the inside and by the neighbors, the walkway can be perceived as semi-public. In dense urban agglomeration, the streets are public while the stairwells and courtyards of the houses are often private.

The same kind of system of users and place, e.g., housing areas or farms, can have territories on different scales. Apartments in apartment buildings make up smaller territories than detached villas with large plots. Allotments are smaller than estates. Nevertheless, the social subsystem can have the same composition, i.e., one or a few people. A settlement can be used by systems of users and places in many different levels. These have territories of varying extents. The territory of a system of a lower level is included in the territory of a system of a higher level. In a dwelling, the different family members may have their own territories, for example in the form of their own rooms within which access and activities are controlled. The common rooms such as living room and kitchen do not have to constitute any family member’s own territory, but these rooms are public to the family members.

However, it is not uncommon for furniture in common areas to be controlled by individual family members. It is common to have designated places, for example, at the kitchen table.

The territorial division of a settlement thus shows an order whereby a sociotechnical system at a higher level has a territory that can be subdivided into smaller territories by its subsystems at lower levels. If there is strict access control, the territory is divided into private and public areas.

## 5.7 Interpretation relations

### 5.7.1 Perception

The aesthetic qualities of a thing such as its beauty are the qualities we experience with our senses. The concept of aesthetics can be derived from the Greek ”aisthetikos” which means perception. The basis for perception is a sensation that can be caused by external or internal stimuli. Stimuli refer to an event in the environment or body that affects a sensory organ (Bunge 1983a:130). Perception is not a direct function of a stimulus but is dependent on previous perception and conceptualization. It gives rise to emotions and is the basis of thinking.

Perception is studied in *formal aesthetics*. Here, among other things, ”the conditions for the ”pure” perceptions to be perceived as valuable, ”beautiful” are studied (Hesselgren 1954: 23). Hesselgren divides perceptions according to the experience of stimulus

1. visual form,
2. color,
3. lighting,
4. texture,
5. tactile properties and
6. auditory properties.

Perceptions are mutually secondary properties in the relation between a thing (stimulus) and a subject. They are both subjective and objective in that they are relations between object and subject. They are experiences of a subject but may be consistent with the primary properties of the object. In the design of buildings, knowledge is applied about how the properties of the building can give rise to different perceptions of the living subject. One purpose may be, for example, to design beautiful buildings.

The experience of a thing does not stop at perception and the aesthetic in a narrower sense but is also dependent on the formation of concepts and thinking. A special activity in thinking involves establishing conceptual relations between things and concepts. This activity is referred to as interpreting. The relations are called *interpretation relations*. See section 4.2.2. They can also be referred to as *information relations* because they can have information effect for the interpreter. Information effect means that the interpretation gives rise to new conditions of the interpreter’s central nervous system (CNS). New concepts that are formed in the development of knowledge are such qualitatively new states of the CNS.

### 5.7.2 Epistemic and semiotic interpretation

The interpretation relations belong to the internal relations in the user-building system. The activity of interpretation can be said to involve trying to understand a thing, e.g., a building. The understanding can refer partly to the building itself as a concrete system and partly to the building as a sign in a communication system. The former interpretation can be called *epistemic* while the latter is called *semiotic*. See Figure 5.50.

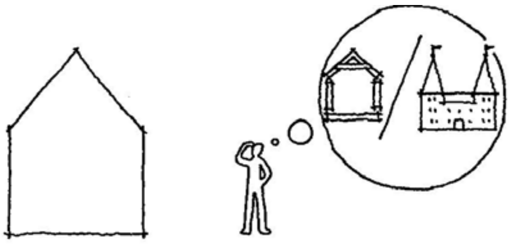


Figure 5.50. One can distinguish between epistemic and semiotic interpretation.

Knowledge of the meaning of signs in a social system is completely dependent on knowledge of the rules of designation. However, even knowledge of actual properties of things can be said to be more or less dependent on conventions. Knowledge has a social dimension that has attracted attention from, among others, Kuhn (1970: 37) in his paradigm theory. This social dimension regulates, for example, which hypotheses are to be considered interesting or fruitful and suitable to support with funding, etc. However, science strives to get behind the conventional view of things through the application of a scientific method of interpretation. This includes the elaboration of hypotheses, contexts and theories and logical conclusions thereof as well as the performance of empirical studies and experiments.

*The epistemic interpretation relations* aim at understanding the building as a concrete system with special holistic properties determined by the purpose of the users. The understanding concerns both the composition and internal structure of the building, i.e., its material and construction, and its environment and external structure, i.e., its interaction with the natural environment and other artifacts and its relations with the users. The epistemic (cognitive) understanding is of fundamental importance, among other things, for the perceiving individual's opportunities for orientation in the outside world. Labyrinths are examples of configurations of, among other things, buildings that have been designed with a conscious purpose to complicate the epistemic interpretation.

If you can follow the construction of a building or its changes during use, you can get a good insight into its internal structure and history. If you study the use of the building, you also understand its external structure and what its environments are. The epistemic interpretation of the building is important because the user must understand its possible functions to use it. If the construction looks too weak, you do not venture out onto the bridge even though it might hold up to the load.

The epistemic interpretation is also important for man because he seems to have an innate need to interpret stimulating sensory impressions. In buildings and settlements there are rich opportunities to meet this need. In this context, attention is paid to such visual properties of things as line continuity, scale, proportions between parts, rhythm, themes, patterns, color, etc. These qualities serve as aids to interpretation. An effort in the aesthetic design of a building is to use these qualities to make the building experientially interesting and understandable.

The beauty experience is usually associated with the perception of an object. However, another aspect of the beauty experience is the experience of how well the building solves the problems it was designed to solve. The building can have a frame that effectively takes care of the acting forces. Its materials can be resistant. It can function in a desired way, etc. Skilled problem solving is one of the factors that contribute to the beauty experience. Something that is often pointed out in mathematics.

The beauty experience thus has both a ”shallower” dimension in perception and a ”deeper” dimension in conceptual understanding. Steen Eiler Rasmussen draws attention to the complexity of the experience of buildings when he distinguishes between the *simple properties* of the interpretation of the building and the *overall impression*, they give us. The simple interpretive properties in Rasmussen's analysis are hard, soft, light, heavy, taut, and slack, as well as surface texture and color (Rasmussen 1959:33). These ”simple” qualities are those that we can directly experience with our senses through perception. The overall properties, on the other hand, only emerge when we use the tools and buildings. ”It’s not enough to *see* architecture; you must experience it. You must observe how it was designed for a special purpose and how it was attuned to the entire concept and rhythm of a specific era. You must dwell in the rooms, feel how they close about you, observe how you are naturally led from one to the other.” (ibid:33).

If one wishes, it is possible to find in Rasmussen’s statement a distinction between different experiential properties corresponding to the categories of epistemic and semiotic interpretation. The overall properties are only apparent in a deeper conceptual interpretation of the building. Epistemic with respect to its ” designed for a special purpose ” and semiotic with respect to how it is ” attuned to the entire concept and rhythm of a specific era”. Thus, the properties of the building also include how it is experienced by the user and how it affects the user’s behavior, feelings, and thoughts. According to Rasmussen, the overall properties are thus something more than just the building’s own properties. They emerge only when they are used by the user also becoming part of the whole and in her own experiences and in her behavior the whole and its properties are *realized*.

The study of the building itself must be distinguished from the study of the socio/sociotechnical system that uses the building as a tool in its activities. However, not all the properties of the building can be understood if it is studied separately from the man’s use and experience. The opposite is also true that in some respects man and sociosystems can be studied separately from the tools used. However, essential properties of man and sociosystems cannot be understood in such a strictly delineated perspective.

The *semiotic interpretation relations* are those in which the building is interpreted as a symbol in a communication system. According to Rasmussen (1962:14), the building is not a particularly ”sensitive” medium for communication: ”architecture is incapable of communicating an intimate personal message from one person to another; it entirely lacks emotional sensitivity”. Indirectly, however, the building can say something about the architect’s or developer’s view of himself and his social status through, for example, the location of the building and the choice of building style and materials. Amos Rapoport (1982) has dealt with the symbolic properties of buildings in the book ”The meaning of the Built Environment”.

The semiotic interpretation is of great importance for our ability to orient ourselves in a city. Business signs and neon lights contribute to our ability to obtain information about the functions of the building. The difference between the design of a residential building and a hotel can be precisely the sign ”hotel ”. If the hotel is without a sign and looks like a factory and is located on the outskirts of the city, the owners cannot count on getting guests among the passers-by.

Buildings with their variation in the composition of parts can be interpreted as signs in a language, but for practical reasons it cannot convey more complex concepts and conceptual compositions as an advanced language. Rasmussen shows that buildings can designate simpler pairs of concepts such as heavy -light, tense -strong and hard -soft. Thiis Evensen (1982) has in his thesis ”Forms of expression of architecture” (Arkitekturens uttrycksformer) shown further examples of concepts conveyed by buildings. However, it can be difficult to discern whether the properties of a building have been determined to communicate a symbolic meaning or whether it has been designed to express the laws of nature and materials, consciously or unconsciously. The question is therefore whether the semiotic interpretation is justified or whether the properties of the building should only be interpreted epistemically.

However, wherever there are alternative choices between different designs, the possibility of communication opens between those who want to express themselves through buildings and those who want to interpret the symbolic meaning of buildings. However, all communication presupposes knowledge of the rules of designation. When designing a building, there are a variety of choice situations where constructive or functional reasons alone are not decisive. In these cases, the choice of material, construction and configuration acquires a special symbolic value for those who know the options. It may also be the case that the technical and functional properties of the building are determined by aesthetic reasons, i.e., by their epistemic and semiotic experience properties. This is the case in the construction of reconstructions of older buildings for cultural purposes as in the extensive reconstruction of central structures in the war-torn cities of Europe after the Second World War.

When designing new buildings, architects often try to express what characterizes the current time period in materials, technology and external form. The use of reinforced concrete, glass and stainless steel characterized the modernist style and represented the modern society of this time. The choice of aesthetic style was made during the eclectic period of the 1800s according to rules that, among other things, said that for a school suited Dutch Renaissance, for a factory Gothic and for a police station Classicism. The semiotic interpretation of the style of these buildings can thus provide information about the intended function.

The isms (styles) of architecture can be considered a kind of language. A style is a set of rules for the design of the parts of the building and for the semiotic interpretation of these. There are both international and regional styles. Modernism was the latest international style within which architects could communicate. Post-modernism in architecture can be seen as an attempt to launch a new international language of architecture.

## 5.8 Comments

### 5.8.1 Architecture, science, and technology

In the thesis, I have defined basic concepts and developed general theories regarding buildings and the man-building system. One purpose is to be able to treat these things as systems in research and design. This means distinguishing the composition, environment, and structure of buildings and the user-building system and their parts in different levels. Applied in this way, systems theory enables a problem to be divided into subproblems while at the same time considering the interrelation of the parts and the emergent properties of the whole. In this context, both the atomistic and the holistic approach can be avoided in favor of a systemic (analytical-synthetic) approach.

In my work, I have started from a conceptually and theoretically well-founded ontology and systems theory on the one hand and the concepts and theories of the field of architecture on the other. These two areas have been brought together with the aim of adapting and renewing the conceptual and linguistic tradition in the field of architecture. The application of systems theory has made it possible to relate the field of architecture to other scientific and technological disciplines and to the main areas of philosophy. These are ontology, semantics, epistemology, and ethics. Ontology studies the main features of concrete reality. Both ontology and the factual sciences thus study concrete things; ontology the most general properties and science the more specific properties. As a scientific field, architecture studies the man-building system.

In semantics, concepts are studied with respect to sense and reference. Semantics also studies interpretation. This may refer to signs and concepts and is then called semiotic interpretation. Architecture as a science must address the semantic problems in its field, e.g. questions about the sense and reference of architectural theories. The field of architecture must also address the semiotic problems, such as the interpretation of buildings as signs in communication systems.

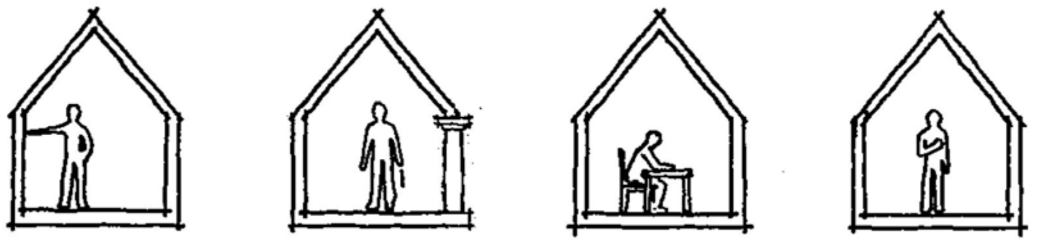
The theory of knowledge studies various aspects of human cognitive processes. The theory of knowledge includes the methodology that studies problem treatment in general; Each area of knowledge must treat the development of knowledge in its field as a specific problem. This also applies to architectural research. Design is the application of architectural knowledge. Methods for design are an area of architecture where the epistemological aspects are important.

Finally, ethics deals with theories of values, evaluation and the right course of action. Evaluation of buildings, for example regarding the question of what characterizes good architecture is an essential part of architectural knowledge. To the ethical aspects of the field of architecture also belong the questions of professional ethics and moral of architects.

Thus, in architecture as both science and technology, all areas of knowledge mentioned above are concerned. Corresponding specializations in the field of architecture can be called architectural ontology, architectural semantics, architectural epistemology, and architectural ethics. See Figure 5.51.

PHILOSOPHY

| Ontology | Semantics | Epistemology | Ethics |
|---|---|---|---|
| | Very general properties | | |
| | SCIENCE / TECHNOLOGY | | |
| | Specific properties | | |



| Architectural ontology | Architectural semantics | Architectural epistemology | Architectural ethics |
|---|---|---|---|

Figure 5.51. The field of architecture in relation to philosophy.

One can distinguish between basic sciences and applied sciences. The former include physics, chemistry, biology, psychology, and sociology. To the latter belong ecology, medicine, and geography. The applied sciences use knowledge from the basic sciences in the study of more complexly composed systems. Architecture as a science belongs to the applied sciences and uses knowledge from both basic and other applied sciences.

Architectural science studies the man-building system. This includes both people and buildings as parts. These are studied separately from a variety of aspects in different areas of knowledge. The knowledge of the building as a technical system is divided into sub-areas regarding, for example, strength, climate, and production technology. The knowledge of the human being is similarly divided into a multitude of areas such as physiology, psychology, sociology, literature, art, and music.

The field of architecture includes the knowledge of the properties of the system man-building as a whole (material and cultural activities). The knowledge also includes the building as a technical system with respect to its relations to man (technical, functional, and aesthetic qualities). Finally, the knowledge of man and sociosystems is included concerning their use and experience of buildings (user roles). See Figure 5.52.

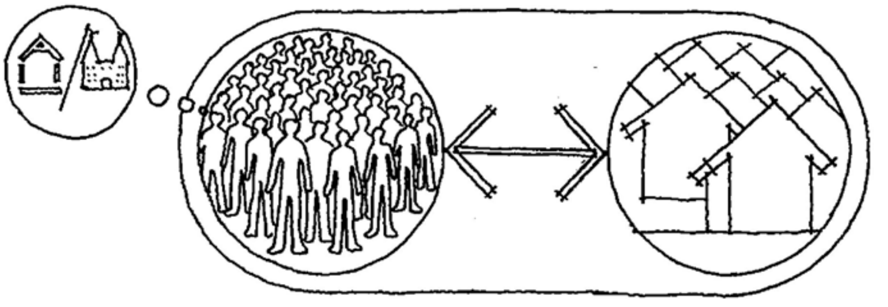


Figure 5.52. The knowledge object of the field of architecture is the man-building system.

Technology is the field of knowledge that deals with the application of scientific knowledge to human action. Technology answers the question: ”How to make A?”. Science answers the question: ”What properties does A have?”. The knowledge of the artifacts and their production belongs to technology. Architectural science is applied in design, which can also be called architectural technology.

A distinction must be made between the specific architectural knowledge and the knowledge needed in the design of the human-building system. In design, knowledge from a variety of areas such as civil engineering, economics, sociology, psychology, and architecture is applied. Design of the man-building system involves determining the properties of the system. In design, the material and cultural activities of the system are determined. Fundamental to these are the properties of the building and man. In the design of the building, the technical, functional, and aesthetic qualities are determined. In the design of the human being (user system), his user roles are determined, i.e., his use and experiences of the building. The determination of the properties of the building and man cannot be made independently of each other. Function and use respectively the aesthetic properties and experience are opposite sides of the same coin.

The traditional designation of the overall technical, functional, and aesthetic properties of the building is architecture. This has had an influence on the perception of what the field of architecture includes as an area of knowledge. It is a widespread misconception even among architects that the field of architecture includes only the knowledge of the architectural properties of the building and their design. The field of architecture includes the knowledge of both people and buildings in the human-building system.

### 5.8.2 Application of thesis’ results

The dissertation’s definitions of basic concepts and general theories of the man-building system can be applied

1. as an aid to structure research, teaching, and design in the field of architecture,
2. as a conceptual basis for communication in interdisciplinary project groups in architectural research and design,
3. as a theoretical background for the use of language in the construction sector,
4. as a background for the identification of research problems in the field of architecture.
5. as a basis for the development of a general design methodology,
6. as an example of theory development in an interdisciplinary research area,
7. as an example of the application of systems theory
8. as a reference to conceptual definitions.

# 6 ENGLISH SUMMARY

## 6.1 Background, objective, and method

The objective of this thesis is to contribute to a better understanding in research and design of the theoretical backgrounds within the field of architecture. Today this field is lacking general, scientifically developed concepts and theories of its object of knowledge. A basic hypothesis in the thesis is that the object of architectural knowledge is the system man-building. In the thesis basic concepts and general theories of buildings and the system man-building has been developed.

When man uses buildings her actions and experiences are affected. Man and building become parts of a common whole. The activities that are made possible by man's use and experience of buildings can be seen as properties of this common whole. Therefore, man and building must not only be studied in themselves but also together. *The field of architecture is characterized by its study of the system man-building in connection with man's use and experience of buildings*.

The field of architecture also includes the application of the knowledge of the system man-building in design. The thesis is delimited to an account of the most general properties of buildings and the system man-building. It does not include a theory of design of these systems. The question that can be said to summarize the problems of the thesis is: ”What are the properties of the whole that emerges with man's use and experience of buildings?”.

Scientific research is conducted partly in relation to background knowledge in the form of existing hypotheses and theories and partly in relation to empirical investigations. A scientific account of the system man-building must have as a starting-point a theory that makes it possible to treat man and building as parts of a common whole. The starting points of the thesis are ontological theories (especially systems theory), architectural theories and empirical investigations. In his ”Treatise on Basic Philosophy” Mario Bunge has dealt with Systems Theory as a part of Ontology. Bunge has shown that systems theories are ontological theories about very general properties of things. The application of Systems Theory makes it possible to divide a problem into subproblems so that one can at the same time consider the mutual interaction of the parts and the emergent properties of the whole. By applying a systemic (analytico-synthetic) point-of-view one can avoid both the atomistic and holistic approaches.

The structure of the thesis reflects the method to proceed from theories of very general properties of things to theories of more specific properties by successively adding further data and hypotheses. The first chapters of the thesis include a detailed account of basic ontological concepts with examples concerning buildings and social systems. In the light of this a schema of concepts and a method of description is developed that makes it possible to define and describe

1. sociosystems,
2. artifacts,
3. socio-technical systems,
4. societies,
5. buildings and
6. the system user-building.

## 6.2 Man and artifacts

Significant to man are the abilities of thinking and communicating. These properties are basic to the emergence of social systems and makes purposeful action possible. Significant to many of man's activities are the use of artifacts. These have both material and cultural properties. They can be used both in activities with the purpose of material action on the environment and in activities with the purpose to influence people's thoughts, feelings, and ideas.

Man's use of artifacts must be seen from an evolutionary point of view. Man's development into a social being is intertwined with the production and use of artifacts. Man's conceptual ability is basic both to the capacity of communication and of toolmaking. With man's use of tools a new whole is formed which can be called a socio-technical system. Society can be understood as composed of socio-technical systems. Like social systems artifacts are basic to the properties of society. The internal structure of society is seen as relations among socio-technical systems i.e., as activities.

## 6.3 Buildings

Buildings are artifacts with the property of being a place for man in activities that require a.o. a controlled climate, protection against intruders, enclosed space for dwelling, ground for transportation and aesthetical and symbolic expression. Buildings are places where one subsystem consists of an artificial ground construction. They are composed of parts in different composition levels. Parts in lower levels are the composition of wholes in higher levels. In each level new properties emerge so that the whole in some fundamental way differs from its parts. The levels are

1. buildings e.g., houses and bridges,
2. the principal subsystems of the building e.g., sewerage system and ground construction,
3. building parts e.g., walls and floor structures,
4. building components e.g., windows and roof trusses and
5. building material e.g., bricks and gypsum boards.

Industrial production including standardization and prefabrication is more suitable for parts in lower levels while parts in higher levels are more suited for onsite production.

The structure of buildings is characterised by three kinds of hierarchical action among the parts. The hierarchy of gravity divides parts into carrying and carried, the hierarchy of enclosure divides parts into enclosing and enclosed and the hierarchy of flow divides parts into connecting and connected. An acting part has a higher rank in the hierarchy than a part that is acted on. A part with higher rank determines more general properties of a construction than a part with lower rank. It has a higher generality. Different kinds of change can be achieved by changing different kinds of parts. Change of parts with higher rank are deeper than change of parts with lower rank. Parts with higher rank can be said to be a frame for parts with lower rank, the former delimits the factually possible properties of the latter. If a building can be changed then the building is an open system regarding the property that can change.

## 6.4 The system user-building

The buildings relations to the social systems are

1. primary (functions and spatial relations) and
2. secondary (epistemic and semiotic relations of interpretation.

The primary relations emerge with man's use of the building and the secondary relations emerge with man's experience of the building. At this the socio-technical system man-building is formed. These systems have different complexity, from one man's use of the more mobile parts of the building like furniture and other equipment, over the use of streets in a transportation system, to the use of a whole system of buildings in proto societies and societies like villages, neighbourhoods, parts of a town, towns or urban regions. Societies are self-supporting socio-technical systems. The spatial pattern of buildings (including streets) characterizes the configuration of societies. A society is not identical with its buildings.

The properties of the system user-building are

1. *material activities* e.g., controlling climate, keeping away intruders, dwelling and transportation,
2. *cultural activities* e.g., creating aesthetic experiences and communicating using the building as symbol,
3. *user roles* e.g., the subset of the users personality that depends on their use and experience of the building and
4. *technical*, *functional* and *aesthetical* properties of the building.

The system user-building can be described from two directions. Top-down they are seen as parts of societies and bottom-up they are seen as composed of socio-technical parts. The levels of a society are

1. society,
2. society subsystems and
3. society parts

The system user-building has the levels

1. the system user-building,
2. subsystems of the system user-building and
3. parts of the system user-building

The activities of systems in lower levels are basic to the activities of systems in higher levels. A household can be seen as a subsystem in a house management organisation e.g., a housing cooperative. ”To cook” and ”to wash” are activities of the subsystems of the household while the activity of the household as a whole is ”to dwell”.

It is necessary to distinguish between use and control of buildings. In order to use the building, it is not necessary to control its parts. You can stand on the floor or sit in a chair without having to change the properties of these parts. But if change of an activity means that the properties of the building must change then one also has to control the buildings parts. The previously mentioned three hierarchies hold between the parts of a building. There are also hierarchies between the members of the system user-building. The highest social rank is held by persons that represent those whose activity is the most general in the system. When controlling the parts of the building those members of the system that have the highest social rank controls the parts with the highest rank in the buildings three hierarchies.

In apartment houses one can distinguish three different classes of building parts according to rank and generality. These are

1. primary parts (basic building parts) e.g., framework, facing walls and duct piping,
2. secondary parts (built-in parts) e.g., light interior walls, stationary equipment and side piping and
3. ternary parts (interior equipment) e.g., paintings, mobile equipment and hoses.

The classification in system levels and the coordination of technical and social hierarchies with the objective to control the building can be illustrated in a schema which shows the situation in a cooperatively managed apartment house. See figure 1.

The management controls the basic building parts. The built-in parts are controlled by the households and the interior equipment is controlled by the subsystems of the households. This is only one of many possible ways for different social systems to use and control the same building. Similar orders for the use of streets in a transportation system, and for the even more complex system user-town in society are discussed in the thesis.

| Parts | Social hierarchy | Flow hierarchy | System level |
|---|---|---|---|
| Primary | Manager | Basic building parts | Administration |
| Secondary | Household representative | Built-in parts | Household |
| Tertiary | Household member | Interior equipment parts | Household subsystem |

Figure 1. Hierarchies and levels in the system user-house.

The purpose of these diagrams is to describe the parts and wholes in different levels that architects design. The diagrams can also be used as a basis for a description of how the architect's tasks are divided into physical planning including among others regional and town planning, and architecture including building design, interior design, and furniture design. The difference in tasks is not only one of scale but also of decision and system level in the socio-technical systems.

Among the primary relations in the system user-building are the territorial relations. Territorial activity is characterized by control of activities in a place. When control regards access the place is divided into private and public areas.

The secondary relations between man and building are formed by man's interpretation of buildings. The objective of epistemic interpretation is to develop knowledge of the building as a concrete system while the objective of semiotic interpretation is to understand the building as a sign in a communication system. However, the questions of interpretation has not been given a deeper consideration since systems theory must be supplemented by more semantics and epistemology to constitute an adequate theoretical basis for such a discussion.

In the thesis the most general properties of social systems, buildings and the system user-building are described. This knowledge can be used as a basic theoretical and linguistic background in research, education, and design in the field of architecture.

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