10. SYMPOSIUM "FERTIGUNGSGERECHTES KONSTRUIEREN"
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AN ILLUSTRATION OF HUBKA / EDER'S DESIGN SCIENCE

Werner Britten

Abstract

Categorising existing and elaborating new knowledge about designing is one of the major goals of design theory as described in Vladimir Hubka's and W. Ernst Eder's book 'Design Science' [1, 2]. This contribution focuses on a new illustration of the main ideas provided by this book. The figures presented have been created during a research stay of the author at the Royal Military College of Canada in spring 1999.

1 Design Science as condenser of scattered knowledge – Funnel Model

With respect to the morphology of statements [3] four main areas of the General Design Science (GDS) are established (practice, theory, object, process, see figure 1 bottom) and used as a template within the process of categorising scattered design knowledge.

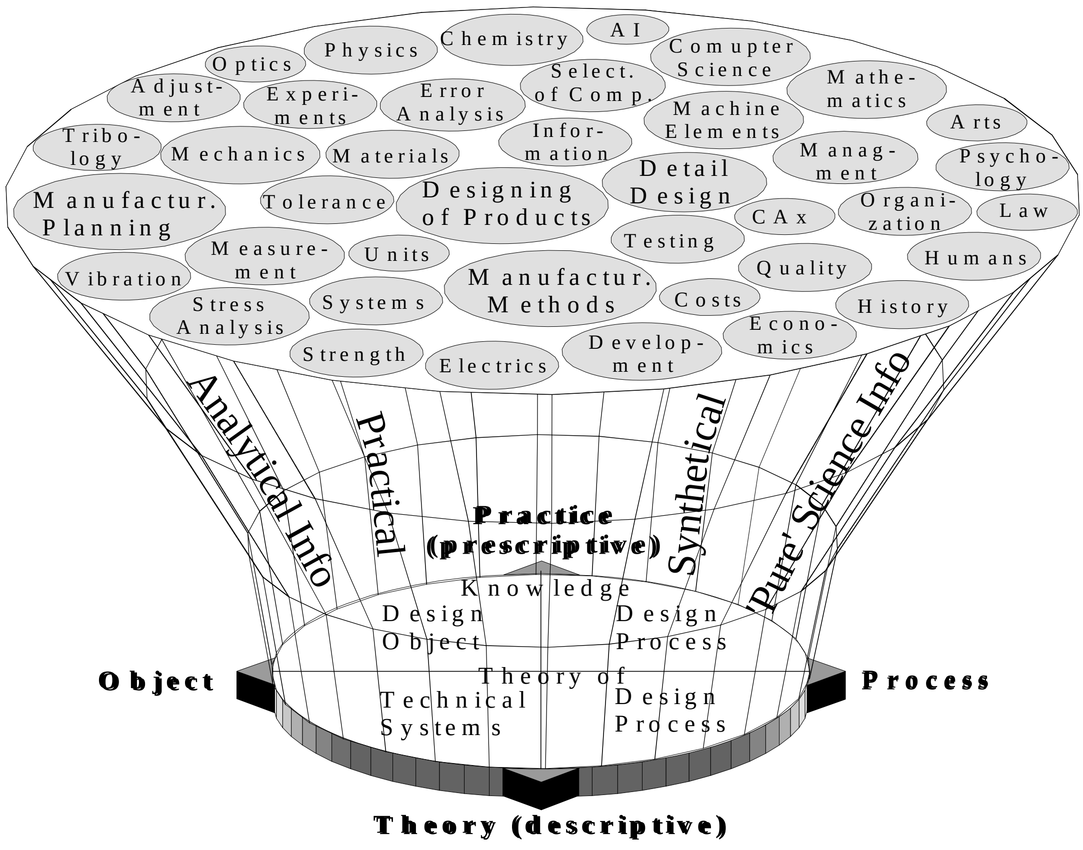

Figure 1 Categorisation of existing knowledge with GDS – Funnel Model

The prescriptive or descriptive character of knowledge on the one hand and the kind of knowledge (either concerning design objects or design processes) are decisive for the position of knowledge within the matrix of the General Design Science. The existing scattered islands of knowledge (upper part of figure 1) are 'poured' into the funnel and result in four parallel information fluxes from practical, analytical, synthetical and 'pure' science sources.

2 Hierarchy of Design Science – Parachute Model

The General Design Science categorises the knowledge of designing in general. Similar to that Specialised Design Sciences (SDS) help on various levels of abstraction and complexity to structure the knowledge of the domain (figure 2).

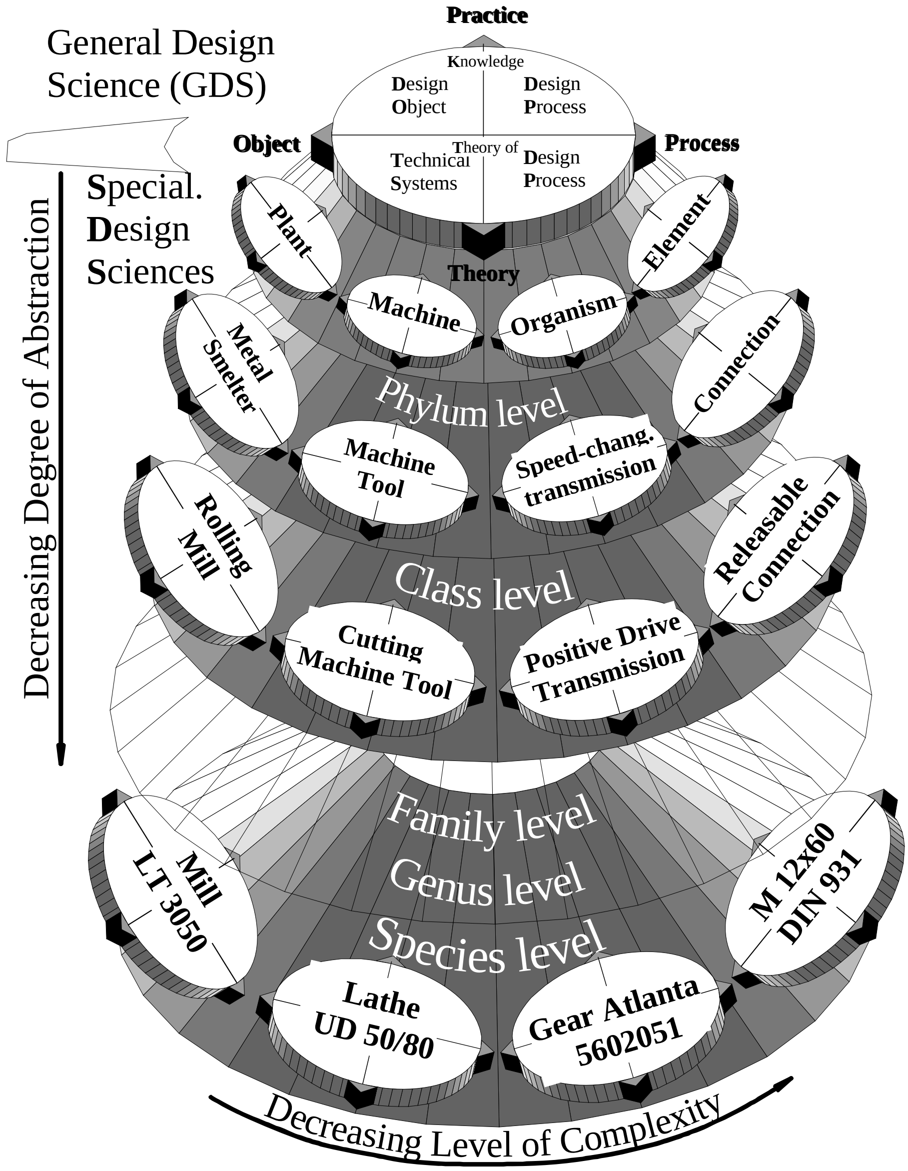

Figure 2 Hierarchy of Design Sciences – Specialised Design Sciences with different degrees of complexity and abstraction

Hubka / Eder use the classification of the botany and zoology to distinguish between the different degrees of abstraction. Therefore each parachute in the parachute sequence of figure 2 represents one level of abstraction, e.g. species or family level.

3 Transformation Process as Universal Principle

Transformation systems are introduced as a universal principle in Hubka's Theory of Technical Systems [4] and the Design Science (figure 3). The transformation system links broad needs of people with certain states and conditions of persons, things, energy and information that satisfy these needs.

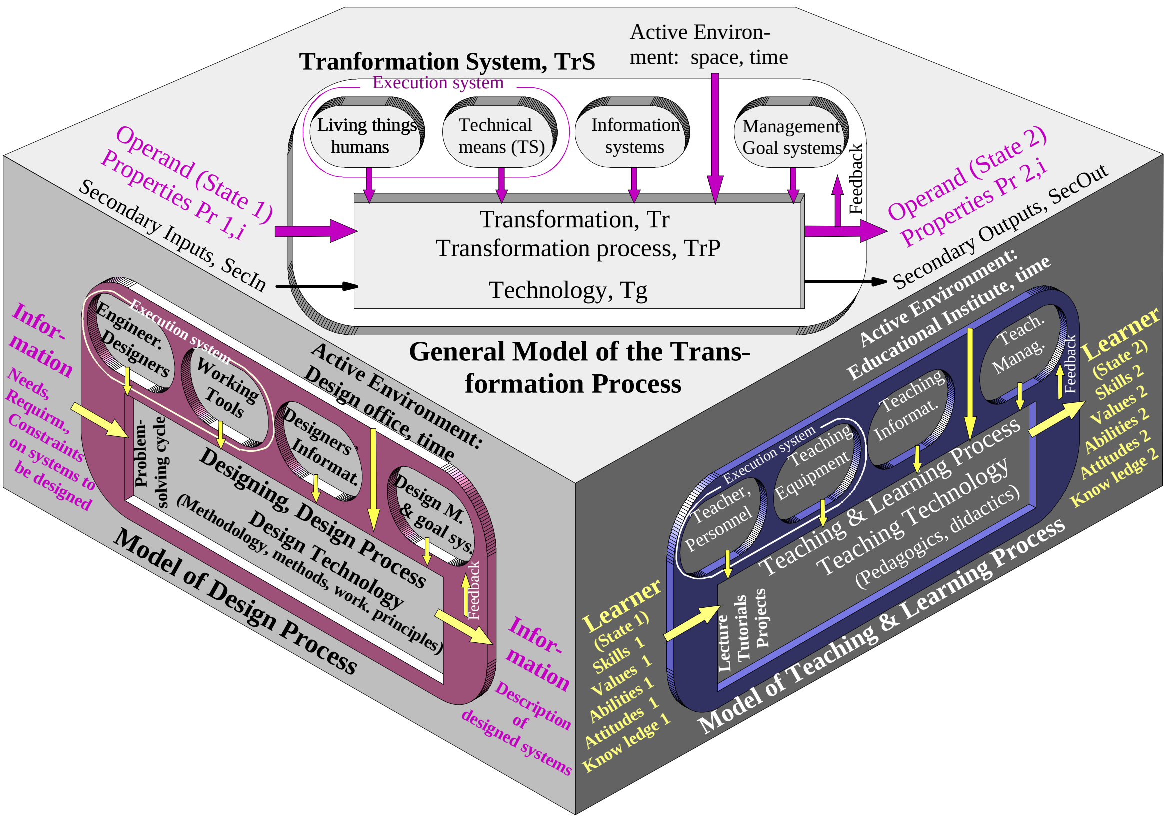

Figure 3 Transformation Models – a general principle adapted to the design process and teaching & learning process

In the general transformation system an operand in state 1 is transformed into a more desirable state 2. The execution system is the main operator within the transformation system. It consists of a human being and / or technical means and provides effects which perform the desired transformation of the operand (upper part of figure 3). An active environment imposes restrictions on the transformation process, and the information and management goal systems have an influence on the process, too.

Within the Model of the Design process (left front side in figure 3) information is the operand of the transformation system and the designer with the employed tools set up the execution system. The teaching & learning process of designers starts with a learner in knowledge state 1. This human operand is transformed during the learning process with the help of the teacher into a state 2 with a higher level of proficiency (right front side in figure 3)

4 Technical Systems – Life cycle and Properties

As already introduced in chapter 3 Technical Systems in the view of design science are suppliers of effects. However, they can also occur as operands within a transformation system and not only as operators in an execution system. In figure 4 the life cycle of a technical system and its duality is illustrated. From the first idea to recycling the new technical system TS is operand of a transformation system. In service, TS may provide an effect for a transformation process in which a new technical system TS_{n+1} is developed or manufactured.

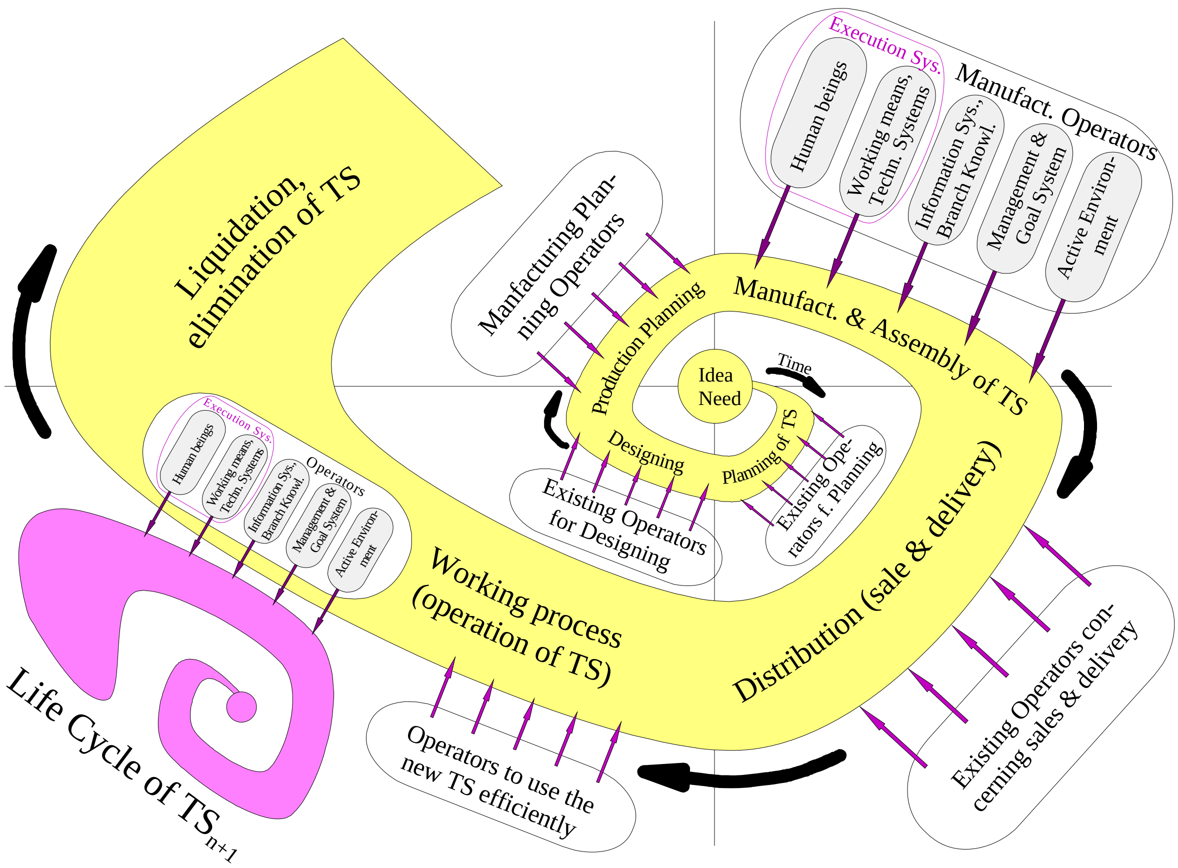

Figure 4 Faces of a Technical system – first operand than operator of a transformation

The properties of a technical system from the designer's point of view can be divided into external and internal properties. In the onion model of figure 5 the external properties constitute the surface of the onion and are determined by demands from the environment on the technical system. They can not be directly influenced by the designer. The internal properties that at the very beginning of the design process are hidden in the onion interior are under the direct control of the engineering designer. The (reverse) effect of the internal properties (Prof. Andreasen: ‘characteristics’) on the external properties is also well represented in the proposed onion or sphere model in figure 5.

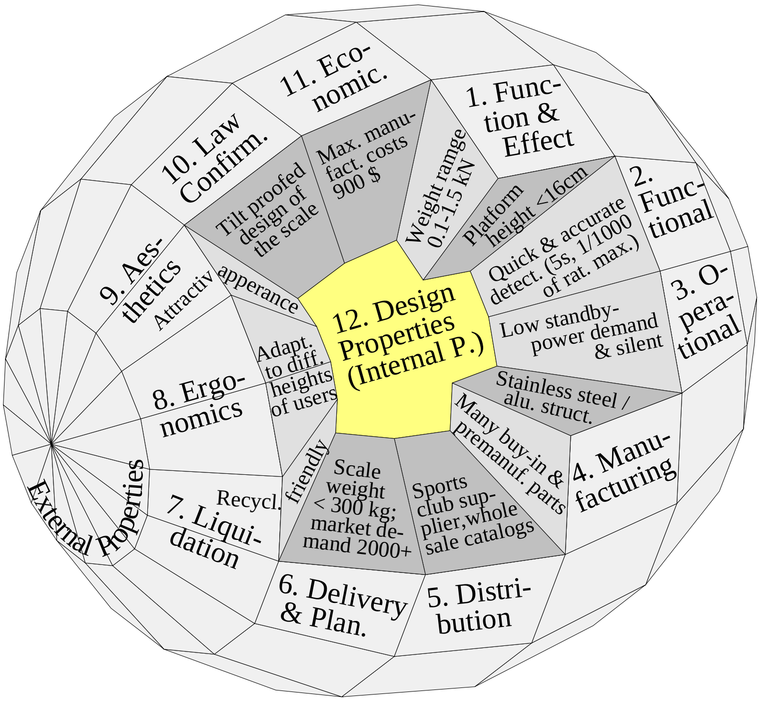

Figure 5 Inner and Outer Properties of Technical Systems – Onion Model

5 Interrelationship between the Design Object and the Design Process – Comb Model

There is no strict distinction between the theoretical description of the design object and the neighbouring description of the design process. It is more or less a seamless transition from the Theory of Technical Systems (object view) towards the Theory of the Design Process. The comb model in figure 4 may illustrate that continuos transition.

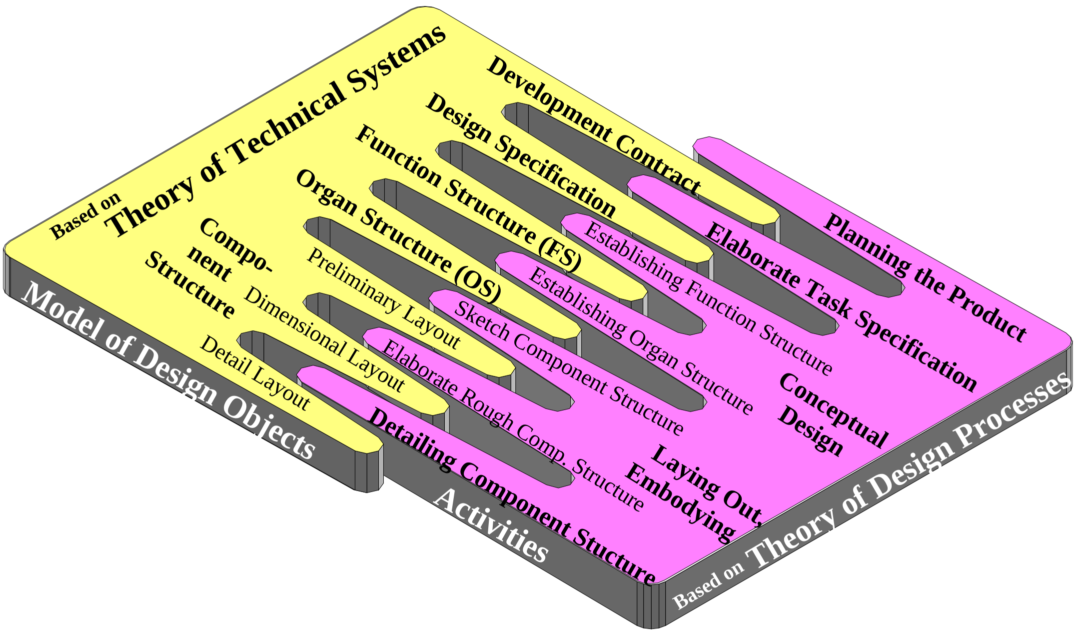

Figure 6 Design Object Model and Design Process Model – Comb Model

The VDI guideline 2221 represents a very similar sequential structure of process steps and results. The knowledge in that area within the general design science has already been elaborated.

6 Acknowledgement

The design science as described in Hubka / Eder's book 'Design Science' is illustrated in a new, more fashionable way. The figures presented have been developed in co-operation with Prof. W.E. Eder during the author's visit of the Royal Military College. The author wants to thank all researchers, students, friends and their relatives for their warm welcome in Canada and the great hospitality.

7 Literature

[1] Hubka, V.; Eder, W.E., ‘‘Design Science – Introduction to the Needs, Scope and Organization of Engineering Design Knowledge’’, London, Springer, 1996.
[2] Hubka, V.; Eder, W.E., ‘‘Einführung in die Konstruktionswissenschaft – Übersicht, Modelle, Ableitungen’’, Berlin, Springer, 1992.
[3] Hubka, V.; Schregenberger, J.W., ‘‘Eine Ordnung konstruktionswissenschaftlicher Aussagen’’, VDI-Z, Vol. 131 (1989) Nr. 31.
[4] Hubka, V., ‘‘Theorie Technischer Systeme’’, Berlin/Heidelberg, Springer, 1984.

Werner Britten
Institute of Engineering Design / CAD
Saarland University, P.O. 151150
D-66041 Saarbruecken, Germany
Phone: + (49) 681 / 302-3607; Fax: -4858
Internet: britten@cad.uni-sb.de